May 2006

Oil and the Global Economy

by Kenneth Rogoff, Harvard University♦

♦ An earlier version of this essay was presented at the International Energy Forum Secretariat meeting in Riyadh, Saturday, November 19, 2005. The author is grateful to Martin Sommer and Mark Allen for help on oil data, and to E. Dvir who is a co-author of the appendix paper, and to Brent Neimen for comments.

I. Introduction

With oil prices cascading to new highs over the past few years, the topic of energy prices has once again come to the fore. This paper gives an introduction to some of the key macroeconomic and policy issues surrounding energy developments. Before turning to some of the more fundamental questions, we begin with a brief overview of the current situation.

There is now broad consensus among that oil price fluctuations impact global economic growth are somewhat less than they did two to three decades ago ago. Yes, oil still packs a punch: mainstream empirical estimates, including those analyzed and extended here, still suggest the doubling of oil price increases between 2003 and 2005 cumulatively lowered global output by at least 1.5% to date, or about a 750 billion dollars. These same estimate suggest the effect is likely to be at least as large in 2006 as in either of the preceding years. But, as significant as these losses are, they still seem relatively modest – half or less -- compared to conventional assessments of the impact of the earlier oil shock episodes, which coincided (or nearly coincided) with far more massive declines in global GDP growth.

Instead, today, despite record high oil prices, global growth is strong across virtually all regions of the world and projected to remain so for the next year or two. Three or four years ago, trend global GDP growth was thought to be in the range of 4% (for purchasing power parity weighted GDP). Yet, today, the IMF (April 2006) is forecasting global growth of 4.9% in 2006 and 4.7% in 2007, after 5.3% in 2004 and 4.8% in 2005. That is, despite oil prices having risen from $25 per barrel in mid-2003 to nearly $70 as of this writing, growth is booming. Some of the answer, of course, lies in

the fact that recent oil prices increases have a strong demand component, but things are not that simple, since uncertainty over supplies in Iran, Nigeria and Venezuela are also having a clear effect.

If oil's impact has been diminished, then why has this happened? Is it because of the more efficient use of energy resources have simply reduced the overall size of energy consumption in global GDP by more than a third? Or is the reduced impact of oil simply another example of what economists have more generally labeled "The Great Moderation", that is, the marked and continuing trend decline in global output volatility that has taken place since 1985 across much of the world. That is, have deeper financial markets, increasingly flexible labor markets, and perhaps most concretely, better global monetary policy helped cushion oil shocks along with everything else? Or, is the reduced impact of oil shocks simply an illusion – perhaps like the Great Moderation itself -- due to a relatively quiescent period in global volatility that may someday pass? Is the world failing to prepare adequately for future energy shocks that may prove far more virulent than those of the past couple decades?

Or, is what we are seeing simply a change in the locus of oil's main impact, with richer countries now affected less but poorer countries affected more? Perhaps oil's effects are less magnified in rich countries than before, as oil consumption increasingly becomes concentrated in final goods consumption (mainly transportation and heating), rather than manufacturing. If then, as Finn (2000) suggests, the main impact of oil shocks is on capacity utilization, it is not surprising that the effect are less. But if energy prices are becoming less central for richer countries, then for developing countries, the situation is quite different (see figure 1.) The migration of the world's manufacturing

base from North to South has arguably left developing countries vulnerable to precisely the kind of economy-wide multiplier effects that OECD countries experienced in the 1970s. So far this effect may have been masked by strong overall global growth, but the concern is that this might prove temporary, and that problems will express themselves at some point further into the current expansion cycle.

The possibility of a delayed response is heightened by concerns that the effects of oil prices are being temporarily muted by a variety of policies around the world that may be unsustainable. In many fast growing developing countries, governments have shielded businesses and consumers from the price increases through various systems of controls. These controls protect short-term growth, but at the cost of exacerbating long-run risks to financial stability and government debt. In the US, energy consumers are being cushioned by the country's massive and sustained international borrowing. The United States, which is by far the largest consumer of oil (see figure 2), is claiming an unprecedented share of global excess savings (more than 70%). The constellation of global policies, taken together, may be helping shield the global economy from short-term effects, but at the risking risk of a larger systemic crisis over the longer term.

As we shall see, it is a mistake to focus solely on short-term oil market volatility. Because of the large fixed costs and long lead times involved in oil extraction projects, the industry has an acute tendency to become enmeshed in "cobweb cycles" of collective over and under-investment, leading in turn to price cycles. Today's high prices, for example, reflect the effects of the industry's underinvestment during the low-price 1990s. Five to ten years from now, however, the oil market may well be on the reverse side of the cycle, with prices again collapsing, despite the strong long-term upward pressures due

to growth in India, China and other emerging markets. Even with the ongoing deepening of longer term futures and forward markets, the ability to hedge significant quantities of production more than one to two years out is still extremely limited.

Indeed, as consuming nations become better adapted to deal with oil price volatility, the locus of risks has increasingly become concentrated in producing nations, both due to limitations in global financial systems and due to their own economic and policy rigidities. Helping producers manage volatility and better diversify economic risks is perhaps the single greatest problem posed by oil for the world economy today. Unfortunately, standard mechanisms for diversifying risk are sharply limited both by oil producers' strong preference for maintaining substantial national control over oil production (including a long history of nationalization even where private concessions are initially granted), as well as difficulties in designing instruments that deal with longer term moral hazard concerns. Weak domestic financial and macroeconomic institutions is also problematic. As a practical matter, there is a strong case to be made that more flexible exchange rate regimes, comparable to those of the "commodity currencies" like Canada and South Africa, would help oil producing economies diversify their economies by better shielding non-energy production from shocks.

This paper will review the evidence, trying to give some flavor of the enormous churn in the policy and academic debate on the role of oil prices in the macroeconomy. Section II reviews the canonical evidence on past oil price shocks which underlies the large impact estimates which characterized the literature until recently. Section III give a brief survey of various heroic attempts to rationalize the outsized effects oil seemed to have in the past. A disarmingly simple challenge to this entire literature is the fact that

with oil constituting only a relatively small share of global GDP (roughly 4%), it is not so easy to explain why oil supply interruptions of 5-10% should have the dramatic effect that simple correlations of oil and output suggest. We sketch a number of theories that highlight factors such as the difficulty in reallocating resources after a shock, the potential effect of oil price uncertainty on investment, and the effect of oil-induced income redistribution on global aggregate demand.

Section IV looks at whether monetary policy may have once played a major role in propagating and amplifying oil price shocks, along with a number of other factors that may have changed over the thirty years, including the deepening of global financial markets.

Section V then surveys various official estimates of oil price shocks – generally based on large-scale macroeconomic models, and compares them with estimates from the academic literature – generally based on either small-scale economic models or pure statistical models. Although the range of estimates is very wide, more recent studies appear to have coalesced a consensus estimate that a 10% increase in oil prices lowers United States growth by .10 to .15% after one to one and half years.

Section VI looks at longer term policy issues, focusing particularly on the problem of long-term price variability. We argue that the strong preference of many oil exporters for national control over resources substantially retards investment in production facilities, and helps maintain higher prices over the medium run. However, over the very long run, low investment may reduce revenues by catalyzing development and use of better conservation techniques and alternative energy resources. Section VII

concludes. An appendix gives further details on empirical estimates of the inflation and output response to oil shocks.

II. Oil and the economy: canonical evidence

Table 1, based on Hamilton (2005), gives what many take as primae facie evidence that major cuts in oil production lead to recessions in the United States (for clarity, Table 1 gives GDP shocks as deviations from trend growth, which for simplicity is assumed constant at 3% throughout the period. As the table indicates, the production shocks that occurred in these episodes would seem to have a significant exogenous component, so that the causality runs from exogenous geo-political, to a reduction in oil production, then to a United States recession. Straightforward statistical attempts to corroborate the importance of oil prices seem to support the important role of oil prices as a leading indicator of economic activity, as well. [1] (However, as we shall see, sorting out the supply and demand shifts is less straightforward than it appears.)

On occasion, dollar exchange rate volatility implies that oil prices move in sharply different directions when measured in different currencies, but as Figure 4 illustrates, oil price volatility swamps exchange rate movements, so the major oil shocks have generally been truly global. Thus, as figure 5 illustrates, each of these episodes (with the exception of 1978) also produced a global recession.

---

[1] A simple regression of US output *y* on lagged oil prices, *o*, seems to indicate the oil prices have strong predictive power for output, even after one controls for past values of output.

$$y_t = \underset{(0.18)}{1.14} + \underset{(0.09)}{0.20}\, y_{t-1} + \underset{(0.09)}{0.05}\, y_{t-2} - \underset{(0.09)}{0.10}\, y_{t-3} - \underset{(0.09)}{0.19}\, y_{t-4} - \underset{(0.026)}{0.004}\, o_{t-1} - \underset{(0.026)}{0.027}\, o_{t-2} - \underset{(0.026)}{0.034}\, o_{t-3} - \underset{(0.027)}{0.065}\, o_{t-4}$$

(Taken from Hamilton, 2005, standard errors in parentheses.) This relatively standard test, while "crude" is not easily overturned by more sophisticated methods.

In addition to oil's seemingly decisive impact in post-war recessions, oil prices also seem to be highly correlated with fluctuations in productivity growth in the United States, as Table 2 illustrates.[2] During "normal" periods, with the real price of oil around $20 per barrel in 2000 dollars, US productivity growth in manufacturing averaged between 1.18 and 1.99 percent per annum. During the period 1974-1985, however, when oil prices averaged over $43 per barrel (in real price adjusted terms), productivity growth was only 0.31% per annum. [3] (Europe and other industrial regions also saw a productivity slowdown after the 1970s oil price spike, though not as pronounced as in the United States, see Gordon 2004).

Given this apparently compelling evidence on the effects of oil price shocks, economists over the past 25 years have devoted considerable energy to trying to understand why the effects seem to be so dramatic. The bottom line, as we shall see in the next section, is that it is harder than one might think to explain why oil should matter as much as it seems to.

III. If oil is such a small share of income, how can it have an outsized impact?

The pure statistical relationship between oil and growth is striking, but trying to rationalize the magnitude of the effects is very difficult. The core problem is over the sample period, oil consumption averaged only 4% of US output, in value terms.

[2] (The measure of productivity used in the table controls for growth in capital per worker, so it is somewhat lower than conventional productivity measures that only look at raw output per worker, but the point would be the same with either measure.)

[3] Recently, of course, despite soaring oil prices, US productivity growth has remained exceptionally strong, with 3rd quarter 2005 labor productivity exceeding 4% and recent trend in excess of 2.5%

Assuming a competitive market, therefore, the direct impact of a ten percent reduction in oil consumption should only about 0.4% reduction of US GDP. (Of course, overall energy consumption is larger, but not by enough to change the basic puzzle.) How then can one explain why oil would have such a large impact? From the late 1970s through the early 1990, economists struggled to try to rationalize the tremendous productivity slowdown experienced by the United States and other industrialized countries.

> As Griliches wrote in 1988, "What is then culprit? Why has productivity growth grown so slowly over the past decade? My prime suspect remains the rise in energy prices and its macro consequences. It is not just that many industries had to face new prices, change the way they used factors of production, and scrap much of their now unprofitable capacity, but also a long worldwide recession induced by a fall in real wealth caused by OPEC, by the fall in aggregate demand caused the governments trying to control the resulting inflation, and the subsequent fall in U.S. exports and the increase in import competition in the early 1980s as a result of rising dollar exchange rates. These factors combined to produce one of the longest worldwide recessions from the which the world may not yet have emerged. The resulting prolonged periods of capacity underutilization in many industries is the proximate cause of much of the observed declines and slowdowns in productivity growth. This is also why one can find cross-country correlations between investment, price increases in energy and materials, and changes in productivity growth and find very little of the same at the detailed industry level within countries….The main mechanism is the overall macro one and that is still where economists must go looking for a solution.
>
> Of course, there may not be a single cause – one murderer. Perhaps it is more like Murder on the Orient Express – the all did it! (Griliches, 1988, p. 19.)

Amplification through variability of capacity utilization

Certainly, in light of the apparently overwhelming evidence on the effects of oil shocks on growth, economists have come up with a large number of clever explanations for why they might be so critical. One important line of research argues that oil price shocks can lead to pauses in production by making portions of the existing capital stock obsolete, temporarily idling both capital and workers in energy intensive industries. Finn (2000) shows that in principle, this obsolescence effect could explain a strikingly large effect for oil, so that a 1% increase in energy prices leads to a 2.5% drop in output after 6 quarters.[4] Finn's analysis, while quite compelling in many respects, does leave some questions. One problem is the models prediction that sharp oil price falls should lead to booms, but it is not obvious that this has happened in practice. The 1986 collapse in oil prices (down to $10 per barrel), for example, did not seem to produce a corresponding boom. This particular problem can probably be addressed along the lines of Morck (1988), the basic point being that high oil prices can lead to underutilization of capacity, but capacity constraints prevent low oil prices from having a symmetric effect.

A more serious issue, as noted by Barsky and Killian (2002) is that if capacity utilization is central to the puzzle, one would expect to see sharp drop offs in secondary market prices and rental prices for capital goods. However, there is no evidence to support this hypothesis in the admittedly small number of studies that have been conducted to date..[5] More importantly, if oil prices are making some types of capital equipment obsolete, it is puzzling that one does did not seem to observe any relationship between the energy intensity of various industries, and the way in which sectoral output

[4] See also Hamilton (1988).
[5] See Hulten, Robertson and Wykoff (1989).

and employment responded after the oil shocks of the 1970s.[6] Again, more research as needed as the 1970s may be anomalous (as we shall discuss shortly), and it is possible the effect might show up in more recent data. Indeed, if oil prices are changing the relative profitability of different sectors, frictions in reallocating labor and capital across sectors might further explain why periods of exceptionally low oil prices do not necessarily coincide with booms.

Amplification of oil shocks through variable markups

Rotemberg and Woodford (1997) explore a very different channel via which an oil price shock could produce an oversize output effect. They argue that in economies with high degrees of monopoly in product markets, oil shocks can set off large shifts in price markups that could in turn lead to booms and recessions. Unfortunately, whereas the Rotemberg-Woodford model is quite elegant, further study is needed to produce convincing evidence that markups show the volatility in response to oil shocks that their transmission mechanism requires.

Amplification via wealth transfers from high consumption to low consumption agents

An obvious channel of transmission is that oil price increases tend to transfer wealth from consuming nations with relatively high marginal propensities to consumer out of income to oil-exporting countries[7], some of which have much lower marginal propensities to consume out of income. Table A1 gives the increase in fuel exporters net exports during the 1973-76, 78-81, and 2005-06 oil price spikes. As the table shows the

[6] See Bohi (1991) and the related discussion in Barsky and Killian (2004).
[7] The oil exporting countries here are defined to include Algeria, Angola, Azerbaijan, Bahrain, Brunei Darussalam, Republic of Congo, Equatorial Guinea, Gabon, Islamic Republic of Iran, Iraq, Kazakhstan, Kuwait, Libya, Nigeria, Norway, Oman, Qatar, Russia, Saudi Arabia, Sudan, Syrian Arab Republic, Trinidad and Tobago, Turkmenistan, United Arab Emirates, Venezuela and Yemen.

shift is less than during the 1970s episode, but with net oil exports of the fuel exporting countries now exceeding $800 billion dollars (more than 2 percent of global GDP at market exchange rates), the total transfer may soon be larger. Another possible explanation comes from the drop in global aggregate demand the world experiences if oil producers do not spend their higher income nearly in proportion to the fall in non-oil consumption in oil importing countries.

While the transfer effects go in the right direction, they, too, do not seem large enough to explain the magnitude of GDP shifts illustrated in table 1.[8] In part, when an oil shock proves long lasting (and the most recent one is projected to at least partially reflect longer term price trends, see figure 6.) oil exporting countries do spend a significant portion of the increased revenue. During earlier episodes, the oil exporters' marginal propensity to consume appears to have been about 75 cents on the dollar (calculated simply by taking the ratio of the increased current account surplus after three years to higher oil export revenue (e.g., IMF, 2005). During the most recent episode, the marginal propensity to consume appears to have been even lower, with 75% of higher oil revenues from the 2003-2005 period spilling over into higher current account surpluses; IMF, 2006). Part of the reason for the low short-run marginal propensity appears to be concern that the latest increase may be temporary (a very reasonable conjecture as we shall see in a later chapter, although futures prices out to seven year reflect only a modest return to trend.) Some countries also initially used the higher revenues to pay down debts.

Even so, the effects of the oil countries relatively low propensity consumer has been substantially mitigated by a recycling of the oil funds back into consuming countries. This allows consumers to smooth out the effects, at least in the aggregate.

[8] See Obstfeld and Rogoff (1996).

(That is, the low marginal propensity to consume in oil exporting countries has been partially offset by a higher marginal propensity to consume in rich countries, with this process made possible by increased loans and investments by oil exporters into the rest of the world.) As we have already noted, the current oil shock has compounded global current account imbalances, with the oil exporting countries, for the moment, constituting the largest pool of current account surpluses (see figure 7), with concommitment longer term concerns about the sustainability of US consumption growth (see figure 8).

Oil price uncertainty leading to a pause in investment

In an elegant and influential paper, Ben Bernanke (1983) showed that oil price spikes might lead to a high degree of subsequent uncertainty that causes firms to hold up their investment projects, thereby leading to a dip in overall output. In theory, this effect could be important, though there is not yet much corroborating empirical evidence. [9] Also, one might conjecture that the investment pause model would seem to predict that oil dips would also lead to pauses in investment (because they, too, generate price uncertainty), but this is not at all obvious from the data. However, note that the model of Deaton and Laroque, which takes into account non-linearities as commodity consumers strive to avoid stock-outs when supply dips, price volatility tends to be highest during periods of spikes, so this channel may merit further investigation

Oil price volatility and Financial Market Frictions

A related factor that has not received much attention to date in the literature, but probably should, but should, is the role of financial markets. Oil price shocks, and the concomitant policy uncertainty, account for a significant fraction of overall

[9] As Barsky and Killian (2004) argue, evidence on car sales and consumer durables consumption – both of which should be impeded by oil price uncertainty – do not respond in any obvious way in periods of dramatic oil price uncertainty.

macroeconomic volatility faced by many countries. Table 3 estimates the effect on growth of a ½% decrease in macroeconomic volatility (which averaged a bit over 4% across the countries listed in the table). The fall in volatility has only a modest impact on annual growth for countries with highly developed financial systems (measured, by convention, as private credit to GDP.) However, for countries with very limited financial development, the effect can be quite dramatic, implying higher annual growth of .3% per year, a very significant impact when cumulated over a long period.[10] If, as the Deaton-Laroque theory suggest, periods of supply driven oil price spikes tend to have higher overall uncertainty, then one would expect to see particularly large falls in growth in countries with weak financial markets. Of course, many of the oil exporting countries themselves tend to have relatively weak financial markets, a theme we shall later return to.

IV. Was Monetary Policy the Real Culprit in 1970s and early 1980s Oil Episodes?

In the preceding section, we considered various arguments as to why oil shocks might affect aggregate activity disproportionately to the overall size of oil (or energy) in the economy. Another line of attack is to argue that, in fact, the apparently compelling evidence in Table 1 on the effects of oil shocks on growth, is highly misleading, and reflects correlation not causation.

Indeed, there is a fair case to be made that the real culprit in the oil price debacles of the 1970s and early 1980s was monetary policy. With the breakup of the Bretton Woods system of fixed exchange rates in the early 1970s, and the massive monetary

[10] Table 3 is calculated by extrapolating regression estimates from Aghion, P., Angeletos, G.-M., Banerjee, A., and Manova, K. (2005). In line with a growing body of related research, these authors find that countries with weak financial systems have more difficulty dealing with macroeconomic volatility of any type.

expansion by the United States Federal Reserve in 1971 and 1972, the monetary authorities of the world were ill-positioned to deal with a destabilization of inflation expectations set off by the post 1973-74 oil price shock. Even absent the oil price shock, the United States was already experiencing enormous inflation pressures and the central bank would have been forced to tighten in any case. In the event, the necessary tightening was almost certainly exacerbated by the oil price shock, and the dramatic post 1972 election rise in interest rates chilled the economy. Thus monetary policy played a major role in the 1973-74 recession, with monetary problems long predating the oil price increase, and even arguably contributing to it (by pushing the pre-OPEC prices farther out of line with market determined levels.)[11] One piece of corroborating evidence is the fact that the prices of many other commodities started rising sharply long before oil did (as noted, for example, by Frenkel, 2006).

The idea that monetary policy might have been at least as responsible as oil shocks for causing the recessions illustrated in Table 1 was first investigated formally by Hooker (1996), followed by Bernanke, Gertler and Watson (1997). Using a statistical analysis of interest rates, oil and commodity prices, output and inflation, Bernanke et al argued that once one controls for monetary policy shocks, the effects of oil price shocks are minor and even statistically insignificant. They find this result even when using Hamilton (1988) highly stylized measure of oil shocks, which is constrained to only take into account major jumps in nominal oil prices.

[11] Given many anomalies in the magnitude and timing of price hikes across the different episodes, there is a strong case that demand shocks also played a role of some of the shocks in Table 1. For example, the 7.2 percent global production cut following the outbreak of the Iran-Iraq war in 1980 is of a similar order of magnitude to the 8.8 percent production cut following the invasion of Kuwait in 1990, yet the price spike in 1980 was much larger, suggesting diverse factors may have been act work. See Barksy and Killian (2002).

However, some questioned Bernanke, Gertler and Watson's results because they only allowed for one year's lagged effect of oil shocks. Hamilton and Herrera (2004), for example, showed that these extreme results are reversed when much longer lag lengths are allowed for. In subsequent paper, Bernanke et. al re-estimated their results, allowing for longer lags, concluding that oil and monetary shocks appear to be of roughly equal importance. Leduc and Sills (2004) corroborate this finding using quite a different approach. However, using the same approach as Bernanke, Gertler and Watson, and three years more data, Dvir and Rogoff (2006) – see appendix to this paper – find significantly lower estimates.

A serious issue that plagues the entire literature is the difficulty of sorting demand from supply shocks. Barsky and Killian (2002) argue cleverly that most of the major turns in oil prices have a large endogenous component, reflecting spikes in demand, and not simply actual or anticipated interruptions in supply. We have already noted that the classic 1973-74 episode was predated by a massive building inflationary pressures. Barsky and Killian note that the recession of the early 1980s followed only with a considerable lag after the late 1970s oil price spike. They argue that the oil price spike instead marked a classic overheating business cycle that was doomed to collapse. Though their analysis does not necessarily lead to the conclusion that oil supply shocks are unimportant, they do illustrate the difficulties of separating supply from demand solely using prices movements, even by the non-linear Hamilton measure.

To deal with this problem, Killian (2006) has attempted to put together a time series to measure supply driven changes in global oil supplies (measured as deviations form trend.) The Killian series is intended to represent a more fundamentally exogenous

variable than anything that might be achieved solely by using prices. Killian finds that oil supply shocks (here measured as quantity shocks) have a significant negative impact on US GDP (and also on other G7 countries, Killian 2005). The order of magnitude, however, is considerably less than indicated in Table 1, especially for the 1973-74 episode, where the effects of oil supply shocks on global output appear relatively minor. Figure A1 in the appendix shows how strikingly different the two measures are, although as the Appendix also shows, both approaches show oil shocks to cause significant output drops (the two measures are not directly comparable either in that Hamilton's is a price shock and Killian's a quantity shocks. We will next turn to summarizing and comparing the estimates above together with those produced by a number of research groups housed in official international institutions such as the OECD and the IMF.

V. Estimates of the Effects of oil price shocks

We now turn to trying to compare a variety of estimates of the effects of oil shocks. Comparisons are difficult because the various studies use somewhat different metrics and the shocks are not necessarily exactly comparable. At a relatively simple level, some look at dollar changes in oil prices, whereas others look at percentage changes, where the difference can be quite dramatic as oil price levels change. Some, like Bernanke et al, make use of the Hamilton oil shock measure that is tailored to capture the big oil shocks of the 1970s and 1980s, while others are calibrated based on model simulations, and others still have a very large judgmental element. With these caveats, we will proceed to discuss some of the various official estimates, and then put them together in tables 4a-4d below with the academic estimates discussed above.

The 2003 International Monetary Fund World Economic Outlook, drawing on a 2000 analysis conducted using the IMF's original multi-country model, estimates that $5 barrel increase in the price of oil lowers global output by 0.3% the following year for the world as a whole.[12] Across regions, the effects is slightly larger for Asia and Europe than for the United States. With Brazil being largely energy independent and Mexico an exporter, the effects on Latin America are relatively minor (less than 0.1% of GDP), but for emerging Europe and Africa, the effects are twice as large (roughly 0.6% of GDP.)

More recent estimates by the IMF (World Economic Outlook September 2005) contains more up to date simulations, taking into account the global decline in oil intensity of GDP (now 38% lower than in the 1970s), better monetary policy, and the fact that the most recent shocks seems to be largely consumption driven, finds a somewhat smaller effect. The newer IMF estimate is that a demand driven shock that raises oil prices by 10% (e.g., from $50 per barrel to $55 per barrel) would lower global output by only 0.10 to .15%. [13] In any event, even the new somewhat lower IMF parameters suggest that global output is 1.0% to 1.5% lower than it would otherwise have been (500 to 750 billion dollars) due to the rise in oil prices since 2003. Presumably, had the rise in prices occurred due mainly to a true supply shock (rather than just higher demand), the estimates would be somewhat higher.

Another important set of official estimates is offered by the International Energy Agency (May 2004), based on simulations using the OECD's in-house large scale global

[12] As we have already noted, many other studies find even larger effects e.g. Jones, Leiby and Paik (2004) who find effects roughly twice as large, or Rotemberg and Woodford (1997) and Finn (2000), which find an even larger impact.

[13] It is not entirely clear how to compare this estimate to the earlier one, since the notion of a "demand driven" oil shock is not entirely well defined (there is clearly a big difference between the case where oil is merely acting as an automatic stabilizer to macroeconomic activity – rising when activity is strong, falling when it is weak – and the case where oil supply shocks are determined by supply side factors.

macroeconomic model. In these simulations, a rise of $10 per barrel (from a $25 baseline to $35) causes global output to fall by 0.4% after one year, roughly half way between the older and newer IMF estimates. The impact on transition and oil importing countries is found to be much larger. The effects on China and India to be two or more times that for the world as a whole, whereas the effects on highly indebted poor countries – many of whom face heavy import bills – is four times as large.[14]

Given the different assumptions and calibrations across the various studies on the empirical effects of oil prices, it is a bit difficult to translate the various results into a common denominator for comparison. We nevertheless attempt to do this in Table 4a, which extrapolates the results of various academic and official calibrations to explore the impact of a 10% rise oil prices on U.S. output. The range, as we can see, is quite substantial though the more recent studies appear to be coalescing around a consensus of -.10 to -.15 percent after four to six quarters, though some researchers (notably Rotemberg and Woodford, 1997 and Finn, 2000) can rationalize effects that are an order of magnitude larger; see table 4b. Table 4c gives Killian's (2005) for G7 countries based on a 10% drop in the global supply. The table reports the median estimates across individual G7 countries. Even the peak quarterly (annualized) drop in output is only 1.7%, significantly smaller than the magnitudes suggested by table 1. Killian finds the cumulative effect on output is just under 6%. Dvir and Rogoff (2006) – see Appendix A – find similar estimates looking at aggregated G7 data. However, they also find a

[14] It should be noted that both the IMF and the OECD estimates, while representing best available technique, are based on somewhat outmoded macroeconomic models that face many difficulties in trying to assess the importance of the many diverse factors affecting oil shock transmission, including the role of monopoly power, expectations, and systematic monetary policy. The IMF's newer "GEM" model (a "new open economy model along the lines of Obstfeld and Rogoff (1996) offers the prospect of much improved estimates in the future after it is fully extended to incorporate oil.

significantly smaller effect for the more recent period, with a 10% drop in world oil production having less than 1% impact on G7 output even at the trough, and a cumulative effect under 3%.

More recently, as more researchers have come to agree that monetary policy plays a significant role in the transmission of oil shocks, there has been increasing interest in the impact of oil shocks on inflation, not just output. Table 4d summarize Killian's estimates, where the peak inflation effect is 1.25% (with relatively little variation across countries) 7 quarters out. Dvir and Rogoff, looking at a G7 aggregate for the more recent post 1985 period, find that the same peak effect but that the peak occurs three years out and the cumulative effect on prices is slightly larger.

The tremendous uncertainty surrounding this consensus is highlighted by the fact that important academic papers vastly different estimates that are at least an order of magnitude apart. Despite the uncertainty over estimates, there is broad agreement that there has been a substantial structural change in how the world economy responds to oil shocks, especially since the mid-1980s.[15] (Updating the data from Bernanke et al to 2005 (the later paper has data through 2001) lowers further the estimated effects of oil on output regardless of monetary policy reaction, but preserves the main result that monetary policy accounts for at least half the effects of oil shocks.)

Table 6 focuses on the United States because that is the common denominator for most studies. To look more broadly at how oil shocks affect various regions around the globe, Table 7 (drawn from IMF, March 2005) looks at how oil shocks affect various major regions. In principle, the United States, with its extremely high oil dependence, is

[15] The fact that oil shocks seem to affect the world very differently before and after 1984 was first emphasized by Hooker (1996) and Bernanke et al (1997).

particularly vulnerable, although, as we have already alluded, cascading global imbalances may be temporarily covering up this effect.

VI. The Great Moderation

Figure 9, presented above, shows the dramatic trend decline in output volatility for the United States and the world as a whole, especially since 1985. As Table 4 shows, while this phenomenon has been most pronounced for the industrialized countries, it also holds across emerging markets and other, less financially integrated, developing countries.

Why has overall macroeconomic volatility been declining, and what are the implications for the vulnerability of the world today to oil price shocks? It is difficult to sort out the answers quantitatively, but one can name a few factors. First, monetary policy is vastly more stable today than it was thirty years ago, or even fifteen years ago. Innovations such as greater central bank independence, transparency, and an increased emphasis on stabilizing inflation have all played a role. So, too, has the fact that by promoting flexibility and competitiveness, globalization has made the political economy of maintaining low inflation easier than it was at the time of the first major oil shocks. Table 5 (updated from Rogoff, 2003) illustrates the stunning world-wide drop in inflation that has taken place in recent years. While there is some debate, a central estimate is that improved monetary policy may account for about 15-25% of the reduction in volatility.[16] A second factor is the ongoing deepening of financial markets, at both the domestic and international level. Deeper financial markets allow risk to be spread more efficiently around the economy to those who are best able to absorb the risk. This in turn lowers

[16] See Stock and Watson (2003)

overall volatility. A third factor is that the volatility of other shocks may simply have been less over this period, though this proposition is difficult to test.

In addition to changing the political economy of monetary policy, globalization-driven increased flexibility in price flexibility and competitiveness, have also forced both firms and workers to react more rapidly to dislocations and shocks. The process is particularly dramatic in the United States, but is seen to some extent across the globe. Even Europe has become more flexible, albeit at a slower pace than has occurred in the United States. Inter-alia, this greater flexibility in the face of disturbances implies that oil shocks, too, have less effect.

Last, but not least, in addition to becoming less oil intensive, oil consumption has increasingly been concentrated in the transportation industry. This shift has reduced the scope for oil price shocks to have large knock on effects by idling plants and equipment. (Of course, transportation also plays a role in the production process, but bulk of expenditures are for passenger vehicles and other components of final consumer demand.) The more oil use in concentrated in final demand, as opposed to being an intermediate input into production, the less the scope for its effects on output to be magnified.

VII. Longer Term Volatility and Policy Issues

Journalistic discussions of the oil market often describe price volatility as a result of the "tight correspondence between demand and supply." Of course, such a correspondence, in itself, makes oil little different from any other good whose price is determined in a market. What is notable about oil, and more generally about energy consumption, is that it is typically much more expensive for both consumers and

producers to adjust in the short run to high prices than in the long run. In the short run, consumers cannot just scrap oil inefficient cars, or move to more energy efficient homes. Producers, in turn, face five to ten year lags in discovering and opening new oil fields. Thus, markets are "tight" in the sense that neither demand nor supply is very sensitive to price, implying that very large price movements are needed to clear relatively small short-term imbalances between demand and supply.

Over the longer run, however, there is enormous scope not only for substituting to other sources of energy, but reducing energy dependence more generally. Indeed, modern industrial societies, steeped in individual automobile culture, have barely scrapped the surface of possible social conventions (e.g., car sharing), that might economize on scarce energy resources. Over longer periods, consumers can adjust, societies can adapt, and the likely effects of higher oil prices are likely relatively manageable, more in line with the size of oil and energy products in GDP. This share may rise over time due to trend price changes, but overall, higher trend oil prices are not likely to induce dramatic changes in standards of living across reasonable projections (e.g., if prices rise to $86 in coming decades as projected by the IEA, 2005.)

In contrast, the costs of longer term oil price uncertainty are extremely problematic for countries that depend heavily on oil production. (See figures 10 and 11). These countries are not only highly vulnerable to short run fluctuations in their revenues, but to longer run fluctuations that result from investment cycles in the oil industry. Given the long lead times in investing in new oil discovery and production, and the large capital expenditures involved, it is not surprising that one sees large long term swing in oil prices resulting from over and underinvestment. It would be extremely desirable for oil

producing countries to have access to means of diversifying their risks, either via sharing production costs and revenues, or by having access to much deeper oil futures markets where risk can be offloaded. The problem of helping oil producers better diversify risk has to be one of the major policy challenges posed today by volatile oil prices. Oil stabilization funds such as Norway and other countries have adopted can help, of course. Such funds can indeed help countries smooth expenditures in the face of the large government revenue swings they face as oil prices fluctuate. But protecting such funds from government expenditure binges can be difficult in practice and, moreover, they do not really insulate an oil exporter from large unexpected swings in oil prices, especially if sustained.

As oil producing countries develop, it is also important for more countries to adopt more flexible monetary policies and wean themselves of fixed exchange rates. Commodity exporters such as Canada, New Zealand, Australia and South Africa typically allow their exchange rates to move sharply in response to price changes for their major commodity exports, thereby helping to stabilize internal prices of nontraded goods industries, and overall output. (see figures 12*a* to 12*d*) Over time, oil exporting countries would similarly be able to better insulate the rest of their economies by allowing significantly more exchange rate flexibility, thereby promoting diversification and avoiding the high frequency of deflation that otherwise will occur.[17] The fact that oil contracts are typically priced in dollars does little to overturn this general principle (most commodity exporters set a significant share of total export prices in dollars also.)

For consuming countries, the main approach to dealing with oil price volatility has to be to continue to enhance flexibility. It should be noted however, that the poorest

[17] See Reinhart and Rogoff, 2004.

countries, mainly due to weak financial markets, have the most to gain from efforts to stabilize oil prices (e.g., from a 5 million barrel per day buffer for production, as recommended by the IMF, 2004.) Better access to loan market can also help in principle, though the long history of debt crises, and the failure of recycling to emerging markets in the 1970s, suggests caution in taking this approach too far.

VII. Conclusions

The exceptionally benign response of the global economy to the most recent oil price shock is partly an illusion, with poorer countries suffering considerably, and with the United States deferring the effects via expanded current account deficits that are a serious long-term vulnerability. Nevertheless, most oil consuming countries are indeed somewhat less vulnerable to oil price shocks than they were a couple decades ago. The reasons, varying in importance by country, include greater energy efficiency, a greater concentration of oil consumption in final demand, better anchored monetary policy, deeper financial markets, and more flexible labor markets. All in all, consensus estimates suggest that the global growth effects of a true oil supply shock (as opposed to the mainly demand driven recent oil price surge) are probably less than half of what they were once thought to be. That said, given the long-term risks of security-related disruptions to the global oil market, it would be very wrong to write off oil-induced recessions as a thing of the past.

Regardless of the effects on the global economy, both short and long-term oil price volatility remains a huge problem for producing countries. Some of the short-term volatility can be alleviated by a larger buffer stock of oil supplies, though only to a rather

limited extent. Perhaps some of the long term volatility could be reduced by greater transparency in the industry, though long-term cycles of over and under-investment are likely to remain a long-term characteristic of the industry. The most promising vehicle for reducing the impact of oil shocks on producers would be improving risk sharing mechanisms in production and in financial markets. Greater flexibility in exchange rates, as is practiced in some of the countries that have been relatively more successful in dealing with commodity export price volatility, would also help better cushion non-oil production.

All in all, whereas oil price volatility is more easily handled today than during the 1970s, it is likely to remain a major issue for businesspeople, consumers, and policymakers for decades to come. We will explore these issue further in the next two chapters.

References

Aghion, P., Angeletos, G-M., Banerjee, A. and Manova, K., 2005. "Volatility and Growth: Credit Constraints and Productivity-Enhancing Investment." Harvard University mimeo.

Barksy, Robert, and Lutz Killian, 2002. "Do We Really Know that Oil Caused the Great Stagflation? A Monetary Alternative," in Ben S. Bernanke and Kenneth Rogoff (eds.) *NBER Macroeconomics Annual 2001*, Cambridge, MA (MIT Press).

Barksy, Robert and Lutz Killian, "Oil and the Macroeconomy Since the 1970s," *Journal of Economic Perspectives* 18:4, pp. 115-134.

Bernanke, Ben S., 1983, "Irreversibility, Uncertainty, and Cyclical Investment," *Quarterly Journal of Economics*, February, 98:1, pp. 85-106

Bernanke, Ben S., Mark Gertler and Mark W. Watson. 1997. "Systematic Monetary Policy and Effects of Oil Price Shocks," *Brookings Papers on Economic Activity*, 1, pp. 91-148.

Bernanke, Ben S., Mark Gertler and Mark W. Watson. 2004. "Oil Shocks and Aggregate Macroeconomic Behavior: The Role of Monetary Policy. A Reply," *Journal of Money, Credit and Banking*, 36:2 , pp 287-292.

Bruno, Michael, and Jeffrey D. Sachs. 1985. *Economics of Worldwide Stagflation*. Cambridge, MA (Harvard University Press).

Chinn, Yu-chen and Kenneth Rogoff, "Commodity Currencies, *Journal of International Economics* 60 (February 2003), 133-160.

Deaton, Angus and Guy Laroque, "On the Behavior of Commodity Prices," NBER Working Paper 3439 (September 1990)

Finn, Mary G. .2000. "Perfect Competition and the Effects of Energy Price Increases on Economic Activity," *Journal of Money, Credit and Banking* 32, pp. 400-416.

Frankel, Jeffrey, 2006, "Commodity Prices, Monetary Policies and Currency Regimes," paper prepared for April 2006 NBER conference on Asset Prices and Monetary Policy, John Campbell, ed.

Gordon, Robert, 2004, "Two Centuries of Economic Growth: Europe Chasing the American Frontier." Centre for Economic Policy Research working paper.

Griliches, Zvi, "Productivity Puzzles and R&D: Another Non-Explanation," *The Journal of Economic Perspectives* No. 4, Volume 2, Autumn 1988, pages 9-21.

Hamilton, James. 1983. "Oil and the Macroeconomy since World War II." *Journal of Political Economy* 91, pp. 228-248.

Hamilton, James. 1988. "A Neoclassical Model of Unemployment and the Business Cycle." *Journal of Political Economy*, June, 96:3, pp. 593-617.

Hamilton, James, 2005. "Oil and the Macroeconomy," forthcoming in *Palgrave Dictionary of Economics*, Steven J. Durauf (ed.)

Hamilton, James, and Ana Maria Herrera. 2004. "Oil Shocks and Aggregate Macroeconomic Behavior: The Role of Monetary Policy," *Journal of Money, Credit and Banking*, 36, pp. 265-286.

Hooker, Mark. A. "What Happened to the Oil Price-Macroeconomy Relationship?" *Journal of Monetary Economics* 38, pp. 195-213.

Hulten, Charles R., James W. Robertson and Frank C. Wykoff. 1989. "Energy Obsolescence and the Productivity Slowdown," in *Technology and Capital Formation*, Dale W Jorgenson and Ralph Landau (eds.), Cambridge, MA (MIT Press).

International Monetary Fund, "Impact of Higher Oil Prices on the Global Economy," IMF Research Department, December 2000 (SM/00/275).

International Monetary Fund, "Oil Market Developments and Issues," March 1, 2005.

International Monetary Fund, *World Economic Outlook*, April 2004, "Will the Oil Market Continue to Be Tight,." (main author Martin Sommer), Washington 2004.

International Monetary Fund, *World Economic Outlook*, September 2005, Washington 2005.

International Monetary Fund, *World Economic Outlook*, April 2006, Washington 2006. (Chapter 2 on "Oil Prices and the Global Imbalances."

International Energy Agency. 2004. "Analysis of the Impact of High Oil Prices on the Global Economy." Paris. May.

Jones, Donald W., Paul N. Leiby, and Inja K. Paik. 2004. "Oil Shocks and the Macroeconomy: What has been Learned since 1996?" *Energy Journal* 25:2, pp. 1-32.

Keane, Michael P. and Eswar S. Prasad. 1996. "The Employment and Wage Effects of Oil Price Changes: A Sectoral Analysis," *Review of Economics and Statistics*, 78:3, pp. 389-400.

Killian, Lutz, "Exogenous Oil Supply Shocks: How Big Are They and How Much Do They Matter for the U.S. Economy?" mimeo, University of Michigan Department of Economics, January 2006.

Killian, Lutz, "The Effects of Exogenous Oil Supply Shocks on Output and Inflation: Evidence from the G7 Countries, mimeo, University of Michigan Department of Economics, November 2005.

Kim, In-Moo, and Prakash Loungani. 1992. "The Role of Energy Shocks in Real Business Cycle Models," *Journal of Monetary Economics* 29:2, pp. 173-189.

Lane, Philip R. and Gian Maria Milesi-Ferretti, "The External Wealth of Nations: Measures of Foreign Assets and Liabilities for Industrial and Developing Nations," *Journal of International Economics* 55 (December 2001), pp. 263-94

Leduc, Sylvain and Keith Sill. 2004. "A Quantitative Analysis of Oil Price Shocks, Systematic Monetary Policy, and Economic Downturns," *Journal of Monetary Economics* 51, pp. 781-808.

Loungani, Prakash. 1986. "Oil Shocks and the Dispersion Hypothesis," *Review of Economics and Statistics* 58, pp. 536-539.

Obstfeld, Maurice, and Kenneth Rogoff, 1996, *Foundations of International Macroeconomics*, Cambridge: MIT Press.

Obstfeld, Maurice and Kenneth Rogoff, "Global Current Account Imbalances and Exchange Rate Adjustments," in William Brainard and George Perry (eds.), *Brookings Papers on Economic Activity* 1:67-146, 2005.

Olson, Mancur. 1988. "The Productivity Slowdown, the Oil Shocks, and the Real Cycle." *Journal of Economic Perspectives*, Fall 2:4, pp. 43-69.

Prasad, Eswar, Kenneth Rogoff, Shang-Jin Wei and Ayhan Kose, *The Effects of Financial Globalization on Developing Countries: Some Empirical Evidence*, International Monetary Fund Occasional Paper 220, 2003

Reinhart, Carmen and Kenneth Rogoff. 2004. "The Modern History of Exchange Rate Arrangements: A Reinterpretation," *Quarterly Journal of Economics* 119(1):1-48, February.

Rogoff, "Globalization and Global Disinflation," in Federal Reserve Bank of Kansas City, *Monetary Policy and Uncertainty: Adapting to a Changing Economy*, 2004.

Rotemberg, Julio J. and Michael Woodford. 1996. "Imperfect Competition and the Effects of Energy Price Increases on Economic Activity." *Journal of Money, Credit and Banking*, Part I, November, 28:4, 550-77.

Yergin, Daniel. 1991. *The Prize: The Epic Quest for Oil, Money and Power*. New York, Simon and Schuster.

Appendix: Oil Supply Shocks, Output and Inflation (joint with Eyal Dvir)

Bernanke, Gertler, and Watson (1997, 2004) put forth the hypothesis that oil supply shocks are harmful to U.S. output mainly through their positive effect on interest rates. In the context of a structural VAR analysis, they counterfactually impose inaction on the Federal Reserve by keeping the federal funds rate constant in the face of an oil shock. In this way they show that approximately half of the downward effect of an oil price shock on U.S. output can be avoided by withholding rate hikes for 4 quarters (BGW 2004). Their analysis, while problematic from theoretical standpoint (agents assume that the Fed will react by historical standards to an oil shock and are surprised by its inaction), is useful in distinguishing the effect of an oil shock from the power of monetary policy to slow down the economy to prevent inflation from rising. In this appendix, we extend their analysis to include the recent oil price movements, which are commonly seen as demand-driven. In particular, we take a closer look at the definition of oil shocks, following Killian (2005, 2006), and examine how much of the effects BGW get can be called supply-driven with confidence.

We run the same structural VAR on U.S. quarterly data from 1957:1 to 2005:4. The five variables are: log of real GDP, log of the GDP deflator, the federal funds rate, log of a commodity price index, and an oil shock measure (see below). We choose 6 lags according to the AIC, as do BGW (who also show results with only 4 lags). We use two different measures of oil shock: one, following Hamilton 1996, is based on oil prices, and seeks to find those changes in price that can be thought of as shocks. An oil shock occurs, according to this methodology, when the price in a given period (quarter in BGW 2004

and here) exceeds the maximum price over the recent past (most recent four quarters). In this way we can hope to isolate true shocks from common volatility. Our second measure follows Kilian (2006), and is a quantity based measure, which identifies oil shocks based on actual production shortfalls. Killian identifies supply shocks using a host of tools, including production figures, professional reports, and political analyses. Once a shock has been identified, Killian creates a benchmark of oil production for the particular country in which the shock originated. This allows him to build a counterfactual series of production for this country, assuming its post-shock production evolves in the same way as its benchmark group does. For example, for the Iranian revolution of 1978/9, Killian identifies the shock as starting in the last quarter of 1978, when oil production in Iran dropped suddenly. From that quarter onwards, Kilian assumes that Iranian production follows that of the other countries in the OPEC bloc, except Saudi Arabia and Iraq, where oil production went up in response to events in Iran. This benchmark changes with events, so that Kuwait drops from the benchmark group when Iraq invades it in the second quarter of 1990.

Figure A1 exhibits these two measures side by side. It is immediately clear that in many instances the two measures disagree on the magnitude, or even existence, of many of the shocks over the period shown. In particular, after the large turbulence associated with the Iranian revolution, the Killian measure exhibits only mild shocks, with the Gulf War of 1991 a notable exception. The Hamilton measure, on the contrary, identifies several major shocks in this period apart from the Gulf War period. Figure A2 (panels a-d, solid lines) shows the VAR impulse responses, using Hamilton's measure. They are very similar in shape and magnitude to the impulse responses reported by BGW. An oil

price shock of 10% causes real GDP for example to fall by close to 0.6% at 7 quarters out, an effect only slightly weaker than the one BGW find. Inflation and the federal funds rate also respond as expected. The BGW specification, then, is relatively robust to the expansion of the time series.

Figure A2 shows also how the impulse responses change when the federal funds rate is forced, counterfactually, to remain constant four quarters out (panels a-d, dashed lines). As in BGW (2004), the response of real GDP is more than halved – it is only a quarter of a percentage point at 7 quarters out. The price level, as in BGW, declines by less when the federal funds rate is deactivated; the federal funds rate itself also responds more mildly. It seems then that at least half of the drop in output following an oil shock is indeed driven by the Fed's actions to prevent a surge in inflation.

Figure A3 shows VAR impulse responses using Killian's measure of oil shocks instead of Hamilton's series. Oil supply shocks as measured by Killian are strictly exogenous, given the way the series is constructed. Therefore we add them to the VAR as an exogenous variable, and replace the Hamilton measure by a measure of changes in average crude oil price. Killian (2006) demonstrates the limited effect of his supply shock measure on oil prices. It is also well known that oil is a relatively small component of the economy. It is therefore reasonable in the present context to view an innovation in price, given current and past supply shocks, as a shock to the economy.

Figure A3 depicts the responses of the endogenous variables to a 10% price innovation in oil, where the Killian supply shock is present as an exogenous variable in the VAR. Real GDP drops almost 0.3% at 6 quarters out, a relatively small drop compared with the Hamilton-based VAR. Prices react immediately to an oil price

innovation, rising by about 0.8% at 16 quarters out. The federal funds rate first rises then falls, not moving more than 15 basis points in either direction.

Figure A1: Measures of Oil Shocks

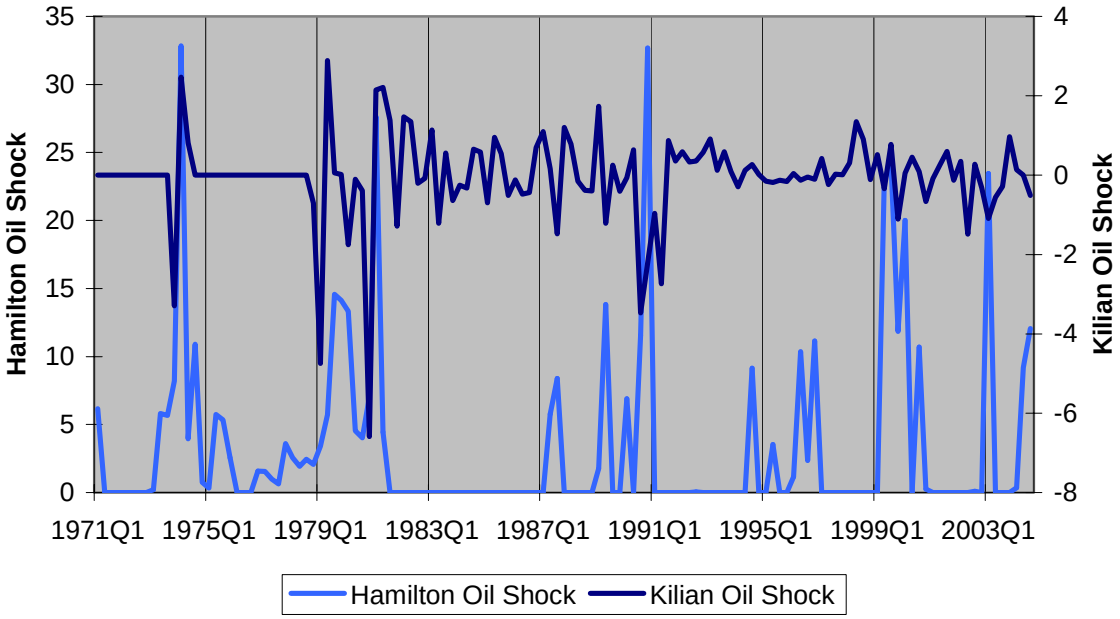
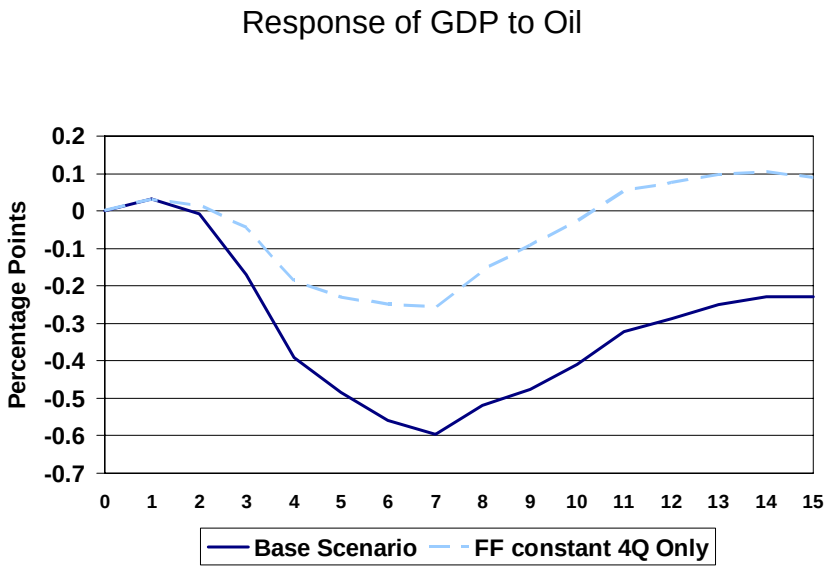


Figure A2: Response to a 10% Hamilton Oil Shock



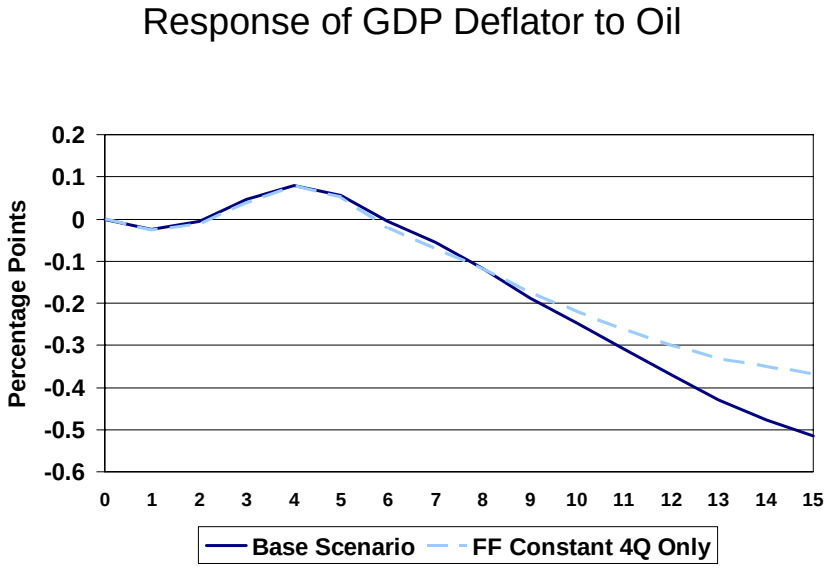
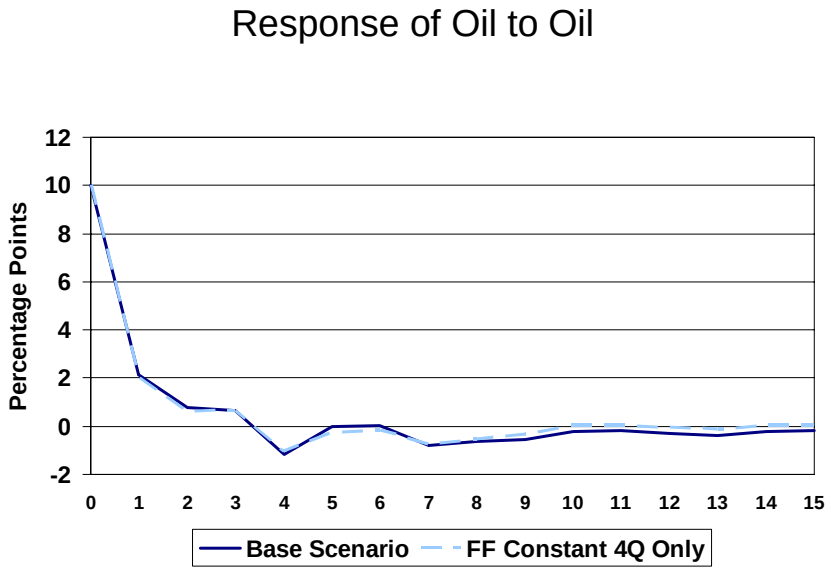


Figure A2 (continued): Response to a 10% Hamilton Oil Shock



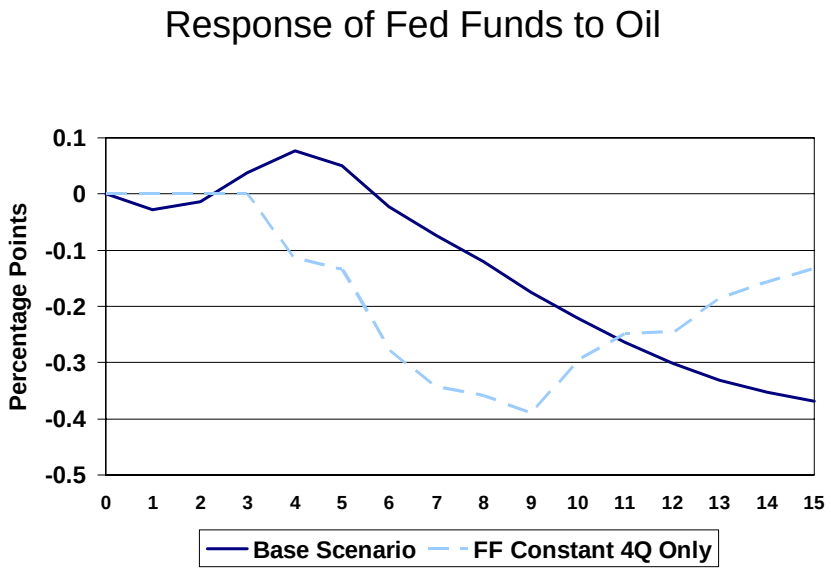


Figure A3: Response to a 10% Kilian Oil Shock

Table 1
Exogenous disruptions in world petroleum supply

Date	*Event*	*Drop in world oil production*	*Deviation in U.S. real GDP*
Nov. 56	Suez Crisis	– 10.1%	–5.5%
Nov. 73	Arab–Israeli War	– 7.8%	–6.2%
Nov. 78	Iranian Revolution	– 8.9%	–3.6%
Oct. 80	Iran–Iraq War	– 7.2%	–3.5%
Aug. 09	Persian Gulf War	– 8.8%	–3.1%

Source: Hamilton (2003), Barsky and Killian (2003). In this table, we assume trend US GDP is 3% throughout the period

Table 2
Growth in Total Factor Productivity and the Real Price of Oil Imports

	1950–59	*1960–73*	*1974–85*	*1986-2001*
Real price of oil	20.47	17.72	43.42	20.82
TFP growth (percent)	1.99	1.18	0.31	1.34

Source: from Barsky and Killian (2003). The productivity series is annual multifactor productivity in the private manufacturing sector. The oil price index has been deflated by the U.S. GDP deflator and expressed in 2000 dollars.

Table A2: Increase in Fuel Exporters' Net Oil Exports

Episode	US CPI-Deflated	% World GDP	% Own GDP
1973-81	$436 bill	1.9	48.9
1973-76	$239 bill	1.1	27.8
1978-81	$218 bill	1.8	14.5
2002-05	$437 bill	1.2	33.2

Source: IMF, 2006 World Economic Outlook

Table A1: Changes in Net Oil Exports, 2002-05

Country grouping	$ Billions (constant 2005 $)	% World GDP	% Own GDP
Fuel exporters	437	1.24	33.2
US	-124	-0.35	-1.1
Other Advanced	-198	-0.56	-1.3
CHINA	-53	-0.15	-3.8
Other Developing	-53	-0.15	-1.2

Source; IMF, 2006

Table 3: Effect on growth of a 10% reduction in macroeconomic volatility

country	Index Private Financial Market Development	Effect on average annual growth of a reduction in output of .45% (one tenth of average volatility across countries)
Zaire	4.1	0.30
Sierra Leone	5.1	0.30
Ghana	5.1	0.30
Haiti	7.7	0.28
Nepal	7.7	0.28
Syrian Arab Republic	8.8	0.28
Niger	13.1	0.25
Bolivia	13.1	0.25
Guatemala	13.3	0.25
Peru	13.3	0.25
Bangladesh	13.5	0.25
Paraguay	14.5	0.24
Argentina	15.7	0.24
Sri Lanka	16.2	0.23
Ecuador	18.0	0.22
Dominican Republic	19.1	0.22
India	19.5	0.21
Guyana	20.5	0.21
Pakistan	20.8	0.21
Papua New Guinea	20.8	0.21
Uruguay	21.2	0.20
Brazil	21.4	0.20
Costa Rica	21.8	0.20
Togo	21.9	0.20
Colombia	22.1	0.20
Kenya	22.8	0.19
El Salvador	22.8	0.19
Mexico	22.9	0.19
Zimbabwe	23.0	0.19
Fiji	23.7	0.19
Honduras	23.9	0.19
Mauritius	24.4	0.19
Jamaica	24.5	0.18
Belgium	25.6	0.18
Philippines	27.0	0.17

Calulation based on regressions in Aghion, P.; Angeletos, G.-M.; Banerjee, A.; and Manova, K.; (2005)

Index of financial market development is ratio of private credit to GDP (1960-1995 period average)

Table 3: Effect on growth of a 10% reduction in macroeconomic volatility

Senegal	27.5	0.17
Chile	27.8	0.17
Trinidad and Tobago	31.4	0.14
Venezuela	33.1	0.13
Iceland	34.8	0.12
Greece	36.7	0.11
Israel	37.4	0.11
New Zealand	37.6	0.11
Panama	40.2	0.09
Barbados	40.6	0.09
Denmark	42.4	0.08
Malta	44.0	0.07
United Kingdom	46.3	0.06
Malaysia	46.9	0.05
Thailand	47.3	0.05
Ireland	49.1	0.04
Finland	51.8	0.03

Calulation based on regressions in Aghion, P.; Angeletos, G.-M.; Banerjee, A.; and Manova, K.; (2005)

Index of financial market development is ratio of private credit to GDP (1960-1995 period average)

Table 4a: Effects a 10% Oil Price Shock on US GDP
Kenneth Rogoff

Study	*Lag*	*Change* (in %)
IMF (2000)	1 year	–.15
IMF (2005)		
a. Temporary increase	1 year	–.10
b. Sustained increase	1 year	–.15 to –.2
IEA (2004)	1 year	–.10
Bernanke et al.** (1997)	1-2 years	Statistically insignificant
Bernanke et al.** (2004)	1 year	–.20
	2 years	–.12
Bernanke et. al updated	1 year	–.05
with 2002-2005 data	2 years	–.08

Table 4b: Effects of 10% Oil Price Shock on US GDP
Kenneth Rogoff

Study	*Lag*	*Change* (in %)
Rotemberg-Woodford (1997), and Finn (2000)	5 to 7 quarters	2.5

Table 4c: Effects of 10% Global Oil Production Shock on G7 GDP **(Killian 2005 measure)**
Kenneth Rogoff

Study	*Trough*	*Cumulative effect*
Killian 2006 (median across G7 countries) 1971-2003	-1.7% (annualized) (11 quarters)	-5.9%
Dvir-Rogoff (G7 output) 1985-2003	-.9% 6 quarters	-2.3%

Table 4d: Effects of 10% Global Oil Production Shock on G7 inflation **(Killian 2005 measure)**
Kenneth Rogoff

Study	*Peak*	*Cumulative effect*
Killian 2006 (median across G7 countries) 1971-2003	-1.25% (7 quarters)	4.0%
Dvir-Rogoff (G7 output) 1985-2003	1.25% 12 quarters	5.1%

Table 5: Global impact on real GDP growth of a rise in oil prices from $45 to $80 in 2005*

United States	–0.8
Euro Area	–0.6
Japan	–0.7
United Kingdom	–0.4
	–0.6
All Industrial Countries	–0.8
Africa	–0.8
Developing Asia	–0.8
Western Hemisphere	–0.8

Table 6: Average Volatility of Income Growth

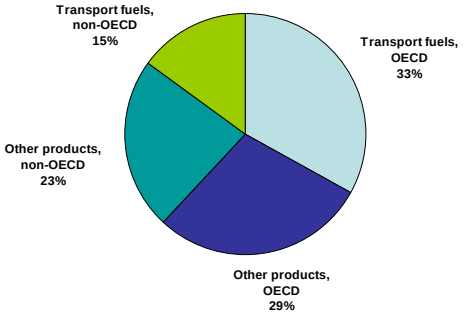
	1960-99	1970s	1980s	1990s
Industrial countries	2.73	2.99	2.54	1.91
Emerging Markets	5.44	5.43	5.45	4.78
Other developing economies	7.25	9.64	7.56	4.59

Source: Prasad, E, Rogoff, K., Wei, S. and A. Khose (IMF 2003)

Table 7: Inflation is sharply down everywhere:
World CPI Inflation (Updated from Rogoff (2003), using WEO data base)

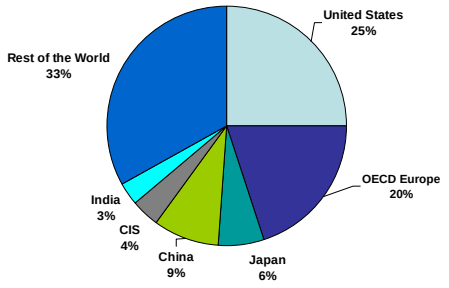
	80-84	85-89	90-94	95-99	00-04	2005
World	14.1	15.5	30.4	8.4	3.8	3.6
Industrial economies	8.7	3.9	3.8	2.0	1.9	2.2
Developing countries	31.4	48.0	53.2	13.1	6.3	5.9
Africa	16.8	17.9	39.8	20.6	10.6	7.7
Asia	9.0	11.5	10.5	7.3	2.7	3.9
Central and eastern Europe	20.8	31.6	84.5	36.5	14.4	5.2
CIS and Mongolia	2.8	1.4	383.9	66.8	16.1	11.4
Latin America	82.4	185.9	232.6	17.2	7.7	6.0
Middle East	18.6	22.5	30.4	29.6	6.6	8.6

Fig. 1: Consumption by Products



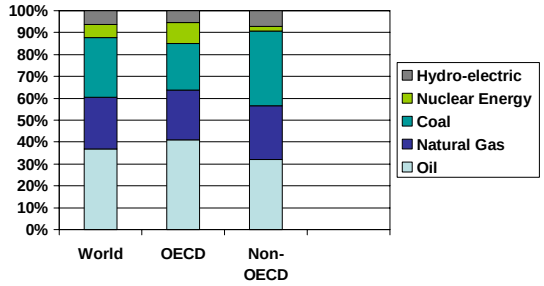
Kenneth Rogoff

Fig 2 : Oil Consumption by Countries and Regions, End 2004



Kenneth Rogoff

Fig. 3: Energy Consumption by Fuel, End-2004



Kenneth Rogoff

Fig. 4: Real Oil Prices: in $ and in major non-$ currencies

(Jan 1973 – Aug 2005, in 2005 dollars) Kenneth Rogoff

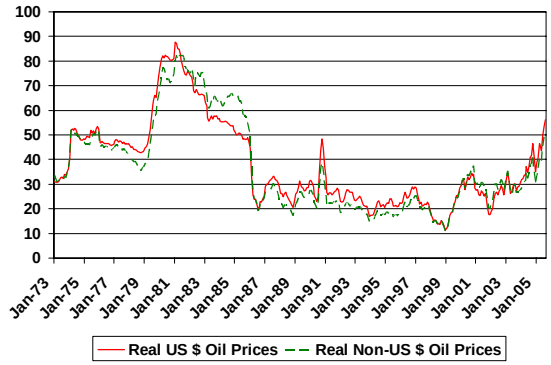
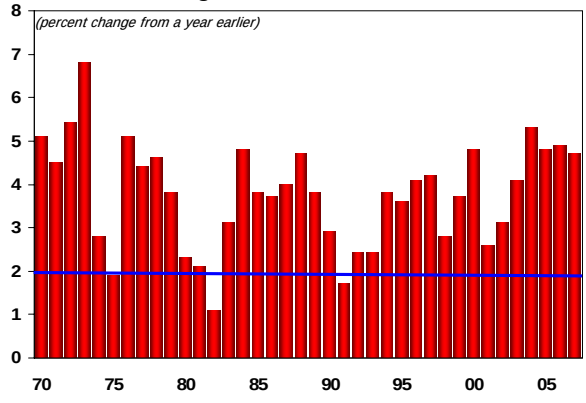


Figure 5: World GDP



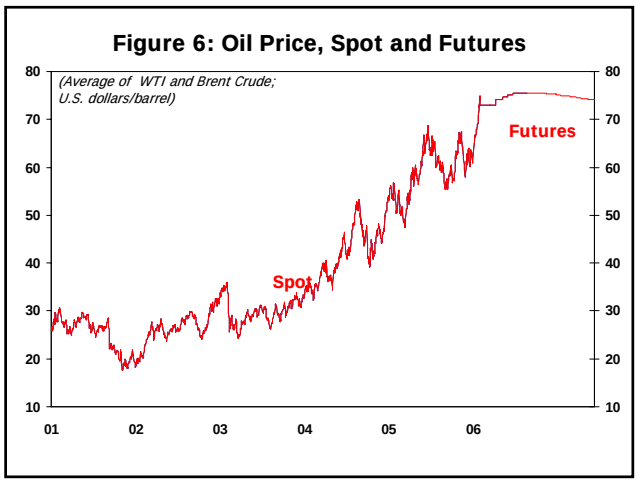


Figure 6: Oil Price, Spot and Futures
(Average of WTI and Brent Crude;
U.S. dollars/barrel)
Futures
Spot
80
70
60
50
40
30
20
10
01
02
03
04
05
06

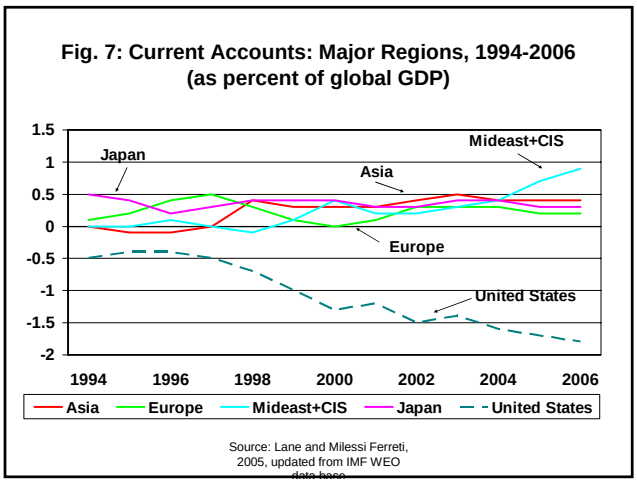


Fig. 7: Current Accounts: Major Regions, 1994-2006
(as percent of global GDP)
Japan
Asia
Mideast+CIS
Europe
United States
1.5
1
0.5
0
-0.5
-1
-1.5
-2
1994
1996
1998
2000
2002
2004
2006
Asia
Europe
Mideast+CIS
Japan
United States
Source: Lane and Milessi Ferreti,
2005, updated from IMF WEO
data base

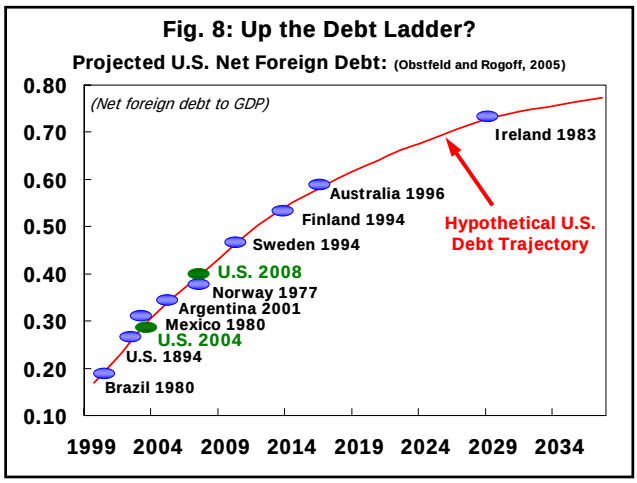


Fig. 8: Up the Debt Ladder?
Projected U.S. Net Foreign Debt: (Obstfeld and Rogoff, 2005)
(Net foreign debt to GDP)
Ireland 1983
Australia 1996
Finland 1994
Sweden 1994
U.S. 2008
Norway 1977
Argentina 2001
Mexico 1980
U.S. 2004
U.S. 1894
Brazil 1980
Hypothetical U.S.
Debt Trajectory
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
1999
2004
2009
2014
2019
2024
2029
2034

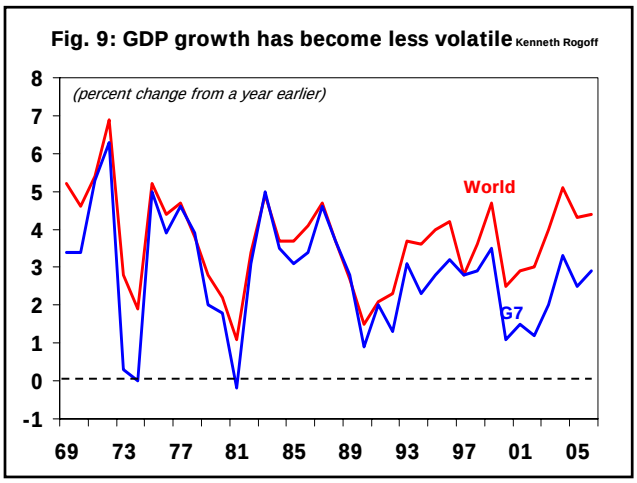
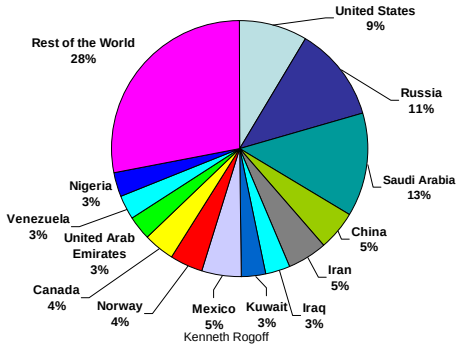


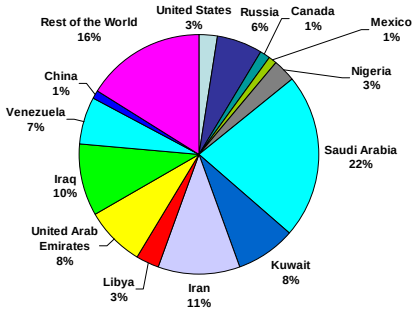
Fig. 9: GDP growth has become less volatile Kenneth Rogoff
(percent change from a year earlier)
World
G7
8
7
6
5
4
3
2
1
0
-1
69
73
77
81
85
89
93
97
01
05

Fig. 10: Main Oil Producers, End 2004

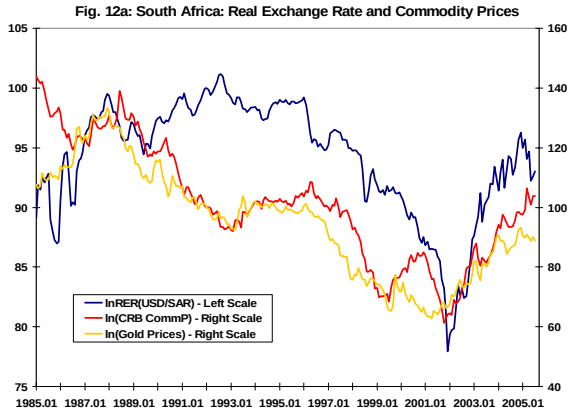


Kenneth Rogoff

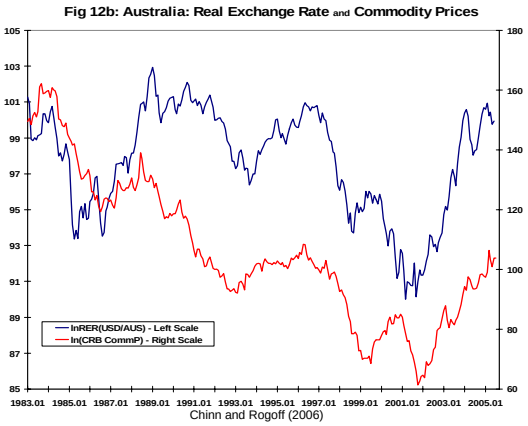
Fig. 11: Proven Oil Reserves, End 2004



Kenneth Rogoff

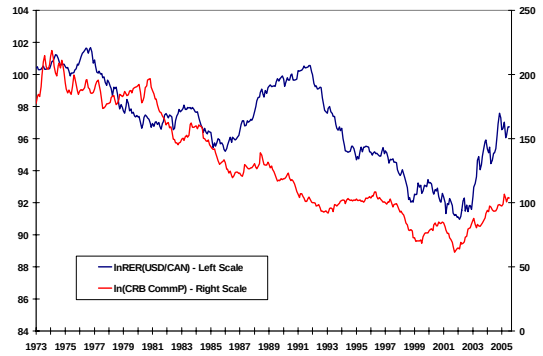


Chinn and Rogoff (2006)



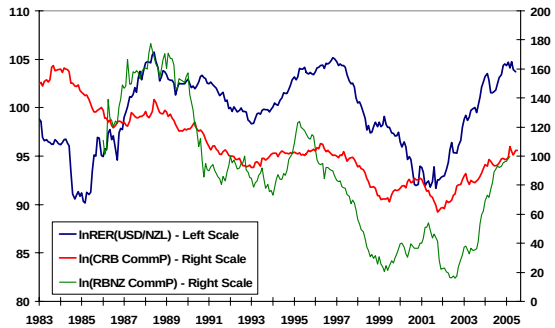
Chinn and Rogoff (2006)

Fig 12c: Canada: Real Exchange Rate and Commodity Prices



Chinn and Rogoff (2006)

Fig 12d: New Zealand: Real Ex. Rate and Commodity Prices



Chinn and Rogoff (2006)

Fig A4: Market Oil Prices in 2000 US$

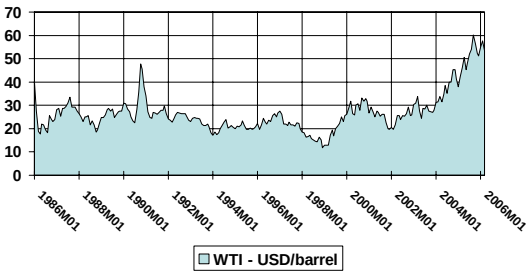


Fig A5: Real Commodity Prices in Long Run

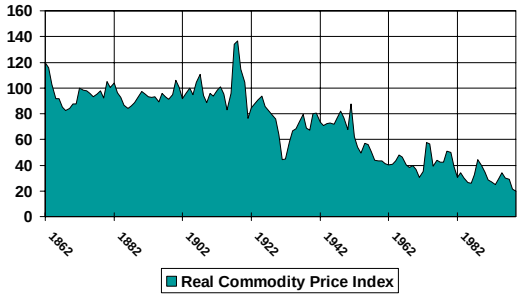


Fig A6. Real Price of Silver in Very Long Run

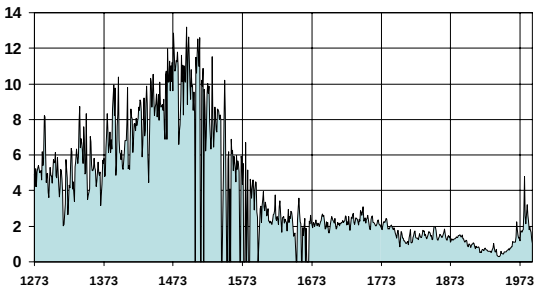


Table A3: Unit Root Tests

Series	Median-Unbiased Autocorrelation Estimate	Median-Unbiased 90% Confidence Interval
Oil (1986-2006)	1.00	[1.00,1.00]
Commodities Index (1862-1999)	0.854	[0.758,0.965]
Silver (1273-1991)	0.980	[0.961,1.00]

Table A4: Structural Breaks

Series	Median-Unbiased Autocorrelation Estimate	Median-Unbiased 90% Confidence Interval
Oil (1986:1-**2003:6**)	0.920	[0.861,0.997]
Commodities Index (1862-1999)		
Silver (**1550**-1991)	0.947	[0.918,0.977]