What oil export levels should we expect from OPEC?

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Abstract:

We analyze the levels of oil exports that should be expected from OPEC over the next 25 years. We search for a long-term, market-adaptive, robustly optimal strategy that best serves OPEC's interests, and conclude that OPEC export profits will be higher if OPEC expands its oil exports by enough to maintain OPEC exports' share of non-OPEC demand. Yet the incentives for this export expansion are relatively small – only a few percent in terms of discounted export profits – and it requires that OPEC be farsighted, because the higher export profits from faster export growth won't be significant within the next decade. Moreover, if OPEC does maintain its exports' share of non-OPEC demand, the continued rapid growth of OPEC's own oil consumption will require that OPEC oil *output* will have to increase 60% by 2030, which will be a major challenge.

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1. Introduction

This paper addresses the question of what levels of oil exports should we expect from OPEC and its key producers over the next 25 years. We search for a long-term, market-adaptive, robustly optimal strategy that best serves OPEC's interests, given the unavoidable uncertainty about the underlying parameters that characterize the world oil liquids market. Within this long-term analysis, we incorporate the likely transition from current levels of oil prices (above $70 in July 2006), that are widely viewed as unsustainably high, to price levels in the $40 to $50 range.

Using an annual model of the world market for oil liquids (not just conventional oil), calibrated to data from the International Energy Agency (IEA), we analyze various OPEC export strategies and their implications for OPEC export profits (export revenue less the costs of production and capacity expansion[1]), under a wide range of assumptions about the parameter values that characterize the growth and price responsiveness of world oil demand and non-OPEC supply.

Given the complexity of the world oil market and the unavoidable uncertainty about its key parameter values, it is essential to analyze a wide range of assumptions for parameters such as the income and price elasticities of oil demand and non-OPEC supply. It is futile to search for a single "optimal" price path, because optimality is dependent upon the parameter assumptions that underlie the analysis. Price-paths with sustained high prices that may be very advantageous for OPEC under some parameter assumptions (such as high income-elasticities and low price-elasticities) would be disastrous for OPEC under different assumptions. Indeed, such price-paths would not even be feasible under some assumptions, insofar as

[1] Extraction costs per barrel were assumed to be $1.50 in Saudi Arabia, Kuwait and UAE, and $5 elsewhere in OPEC; opportunity costs of being unable to sell that oil in the future were ignored. Capacity expansion costs were assumed to be $4000/barrel in Saudi Arabia, Kuwait and UAE, and $5000/barrel elsewhere in OPEC. Source: US Department of Energy, *International Energy Outlook 2001*, p.34.

they would imply implausibly low levels of OPEC oil exports. Instead of a single optimal path, we seek to identify a *robustly optimal strategy* for OPEC that will serve its interests as well as possible relative to other strategies, regardless of the unavoidable uncertainties that underlie the world oil market.

We focus on *market-adaptive* strategies, in which the levels of both price and OPEC exports respond to changes in market conditions. An example of a market-adaptive strategy would be one in OPEC aims to maintain a constant market share for its oil exports as a fraction of world demand. Depending upon the parameter values assumed for the income and price elasticities, this strategy would generate different paths for *both* price and OPEC exports. In contrast, a strategy that is not market-adaptive (such as a price-path with 2% annual growth) would always generate the same price-path regardless of the underlying parameter values assumed, with all the effects of different market conditions being reflected in different paths for OPEC exports.

We focus on OPEC oil *exports* (not oil OPEC output) and OPEC *oil export profits*, because OPEC values its oil *export* profits far more than profits realized from domestic oil consumption, if any[2]. Moreover, this focus on OPEC's oil exports avoids a contentious issue about the likely under-projection of OPEC domestic oil consumption by the IEA and by the U.S. Department of Energy's *International Energy Outlook 2006* (DOE 2006) – now about 7 million barrels per day (mbd). Despite the fact that OPEC's oil consumption has increased at least as fast as its income (1.5 times as fast since 1971, and about as fast as income since 1987), both DOE and IEA project that OPEC's oil consumption will grow less than two-thirds as fast as its income growth.

[2] See Mitchell (2006) for a more detailed discussion of the importance of oil *exports* to the economies of OPEC members and their dependence upon that sector. Another reason for ignoring the profits from OPEC's domestic consumption is the inadequacy of revenue and cost data for OPEC's own oil consumption. As discussed below, only for gasoline and diesel oil are domestic retail prices available for most OPEC countries.

What should we expect from OPEC and its key producers?

- We should expect them to pursue their own best interest, politically and economically.
- We should *not* expect them to expand their output as rapidly as the demand for their oil is increasing – unless that strategy makes them *substantially* better off.

While these points may not seem controversial, as recently as 2000-2001 both DOE and IEA were projecting that OPEC would *double* its output by 2020, at prices below $25. We argued then that such projections were implausible because they relied on supply behavior by Gulf producers that is not in their own self-interest; see Gately (2001).

These issues were analyzed subsequently in Gately (2004) and by Horn (2004) – prior to the rapid increases in price of 2004-2006. The current paper revisits these issues, now that oil price is about $70 and OPEC's profits have surged, in order to determine the sustainability of the recent price increases and to determine the implications for future OPEC behavior.

The outline of this paper is the following. Section 2 provides context for the analysis, by summarizing recent projections by DOE (2006), IEA (2005), and OPEC (2004). These projections provide different views of the likely paths for prices and quantities: world oil demand, non-OPEC supply, the Call on OPEC, and the growth of oil consumption within OPEC, which could constrain the growth of OPEC oil exports. Section 3 analyzes alternative strategies that OPEC might pursue, especially three market-adaptive strategies in which OPEC targets a given path over time for the share of OPEC oil exports as a fraction of non-OPEC oil demand. It summarizes the sensitivity of the model's projections for these three strategies across alternative cases – sets of assumptions about whether world oil demand and non-OPEC supply grow faster or slower than our Reference Case assumptions, and whether the price-responsiveness

of world oil demand and non-OPEC supply are higher or lower than our Reference Case assumptions. Section 4 analyzes the relative attractiveness for OPEC of the alternative strategies, and Section 5 presents the conclusions. Appendix A summarizes the historical data and most recent projections of DOE and IEA for income and oil consumption within OPEC and its eleven members. Appendix B contains a description of the model's structure and assumptions.

2. Recent Long-term Projections for the World Oil Market

In order to put into context our own projections for the world oil market, consider some recent projections made by leading institutions: DOE (2006), IEA (2005), OPEC (2004), and Exxon Mobil (2005). All project that:

- world oil demand will continue growing, by 50% over 25 years to about 120 mbd by 2030
- non-OPEC supply will grow slower (IEA) or faster (DOE) or may peak within a decade (OPEC)
- the Call on OPEC will continue to increase, either slower (DOE) or faster (OPEC).

These projections of the Call on OPEC do not necessarily imply that OPEC will be willing to produce such output levels. Indeed, both IEA and Exxon-Mobil remain cautious about whether the increasing Call on OPEC would bring forth the required increases in OPEC output. Exxon-Mobil notes carefully that "We believe that the resource base will support this increase, assuming that the required investments in development are made in a timely fashion."

The most obvious differences among these projections relate to non-OPEC supply – whether and how soon it will peak. Yet there is also considerable uncertainty on the demand side of the market – witness the surprising growth in demand since 2003, even in the face of dramatic increases in price. Our own analysis in Gately-Huntington (2002) suggests higher income-elasticities of demand within the

developing countries, due partly to faster growth in vehicle ownership: see Dargay-Gately-Sommer (2006). In particular, projections of oil consumption within OPEC countries by DOE and IEA of oil consumption within the OPEC countries seem much too low. Table 1 and Figure 1 summarize the historical experience from 1971 to 2003: oil consumption in these countries[3] grew 1.5 times faster than did their income. Even if we were to eliminate the years when OPEC income was stagnant, from the late 1970s through the mid-1980s, OPEC oil consumption since 1987 has grown *as fast as* income[4]. Yet both DOE and IEA project that OPEC oil consumption to 2030 will grow *much more slowly* than income. The projected ratio of OPEC's oil consumption growth to its income growth is less than 0.6 for IEA, while for DOE[5] it is less than 0.4. This is especially important for the world oil market, insofar as rapidly growing oil consumption within OPEC will constrain their ability to increase oil exports.

In our projections below, we assume that OPEC oil consumption will grow as fast as income, to 20 mbd by 2030. In contrast, IEA and DOE projections of OPEC oil consumption would be, respectively, 7 or 10 mbd lower than ours by 2030. However, our projection of OPEC's internal oil consumption is independent of our analysis of OPEC strategies, which focuses only upon the growth of OPEC oil *exports*.

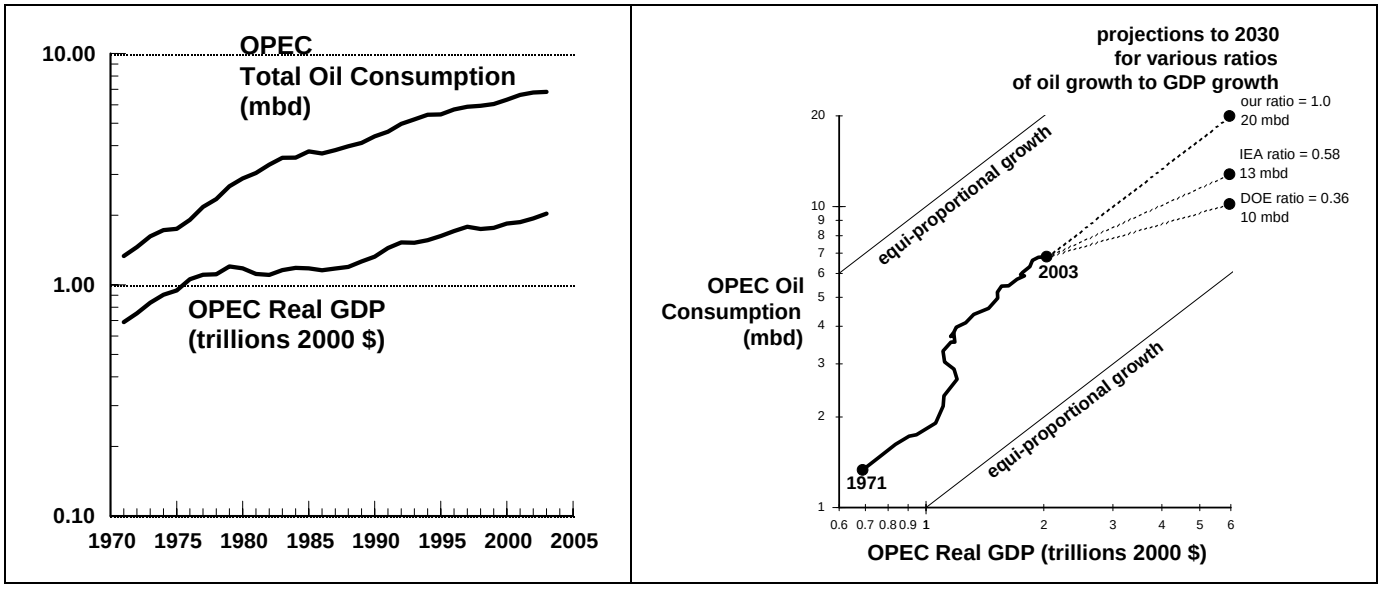
[3] Data for OPEC's own oil consumption exclude product exports. IEA's estimate of 2003 OPEC oil consumption (6.82 mbd) is similar to that of BP(2006), which reports 5.7 mbd for OPEC countries but does not include Iraq, Libya, or Nigeria.
[4] Contributing to this rapid growth in consumption are the very high fuel-price subsidies within OPEC: in eight of the eleven OPEC members the retail prices of gasoline and diesel are lower than the world price for crude oil. The OPEC member with the *highest* retail prices for gasoline and diesel (Nigeria) has lower prices than 88% of the countries in the world, and most OPEC members have domestic retail prices less than half of those in Nigeria: see Menschies (2005, pp. 64-65). In addition, all the heavily populated countries in OPEC still have low levels of vehicle ownership, from which we can expect ownership to grow at rates *twice* as fast as income for the next 25 years; only a few members (Saudi Arabia, Kuwait, UAE, and Qatar) already have vehicle ownership levels as high as levels some countries in Europe (Dargay-Gately-Sommer, 2006).
[5] In Gately and Huntington (2002), we estimated that the non-OECD oil exporting countries' income elasticity of demand was about 1.0 for both oil and energy. In DOE (2006) projections for the Middle East region, the ratio for oil consumption growth (1.5%) to GDP growth (4.2%) is 0.36, and the ratio of energy demand growth (2.4%) to GDP growth is 0.57.

Table 1: OPEC Oil Consumption and Real GDP: Historical and Projected

	Historical: 1971-2003				Projections to 2030				
						assumed ratio of oil growth to GDP growth			
	1971	2003	average annual growth rate %	*ratio of growth rates: oil growth to GDP growth*	assumed annual GDP growth %	*ratio = 0.36 (DOE)*	*ratio = 0.58 (IEA)*	*ratio = 1.0 (since 1987)*	*ratio = 1.5 (since 1971)*
OPEC Total Oil Consumption (mbd)	**1.33**	**6.82**	**5.2%**	***1.5***		**10.2**	**12.8**	**20.0**	**33.7**
Transport Oil	0.36	2.64	6.4%	*1.9*					
of which: Gasoline	0.19	1.51	6.7%	*1.9*					
Residual Oil	0.57	1.26	2.5%	*0.7*					
Other Oil	0.41	2.93	6.4%	*1.8*					
OPEC Real GDP (trillions 2000 US $ using PPP)	**0.69**	**2.03**	**3.4%**		**4.1%**	**5.96**	**5.96**	**5.96**	**5.96**

Note: see Appendix A for details of aggregate OPEC projections.

Figure 1. OPEC Oil Consumption and Real GDP (logarithmic scales): Historical and Projected



3. Strategy Choices for OPEC

What strategy should we expect OPEC to follow? Should we expect them to pursue a target price-path, or a target path for their output growth, or a target path for their share of the world oil market? If and when market conditions depart from their target path, how should we expect them to make an adjustment? Parenthetically, we consider OPEC only a loose association, with limited ability to impose its will on uncooperative members; yet its consultative, coordinating role is well established and we consider it the appropriate focus for collective decisions. Intra-OPEC decisions and bargaining are discussed elsewhere, in Gately (2004).

All such strategies employ targets – price, or output, or market share – as *instruments*, not as goals in themselves. Goals such as *profit maximization over time* are not easily incorporated into economic models of the world oil market, given the enormous uncertainty about the underlying parameters of the market, such as growth rates of world income and Non-OPEC supply, and the price-responsiveness of world demand and Non-OPEC supply.

The advantages of target price-paths are simplicity and transparency. Price is easy to observe and monitor continuously, which facilitates coordination of decision-making and action within OPEC. However, a given price-path is often unsustainable – either too high (as in the early 1980s) or too low (as we have observed in the past few years). Under such conditions, the target price-path must be abandoned and a new path determined. Thus, to define completely a pricing *strategy*, it is also necessary to specify the conditions under which a given price-path would be abandoned, and how a new price-path would be determined. This is not an easy task. In general, price-paths are not *market-adaptive,* insofar as they are unresponsive to an implied demand for OPEC oil that is implausibly small or large.

Similar issues arise in the definition of export-path strategies for OPEC (for example, 1% annual output growth), in which the market-clearing price is determined so that the difference between non-OPEC oil demand and non-OPEC supply is exactly equal to the projected level of OPEC exports. Such strategies are similarly not adaptive to market conditions. They ignore what OPEC would do, if anything, when market conditions would cause abrupt price changes. Should OPEC export plans be modified if price were to drop precipitously, or to prevent price shocks to the world economy?

Instead we focus on strategies that are *market-adaptive*[6], such as target market-share strategies. Previously, in Gately (2004), we had examined target paths for OPEC output as a fraction of world oil demand. In the current paper we examine target paths for OPEC exports as a fraction of non-OPEC demand, such as maintaining a constant share over time. These strategies differ from following a price or export path, which may necessitate relatively large changes in the adjusting variable -- OPEC exports or price, as the case may be. In contrast, with a target export-share strategy, if the Call on OPEC exports were to increase substantially in a given year, there would be complementary increases in *both* OPEC exports and price so as to achieve OPEC's target market share. With a given target *price*, all the adjustment to the increased Call on OPEC exports would have to be achieved only by the increase in OPEC exports. Similarly, with a given target for OPEC *exports*, all the adjustment would be achieved only by increasing the price.

[6] In the systems analysis literature, these would be called feedback or state-contingent policies, while price-paths are "open-loop" policies.

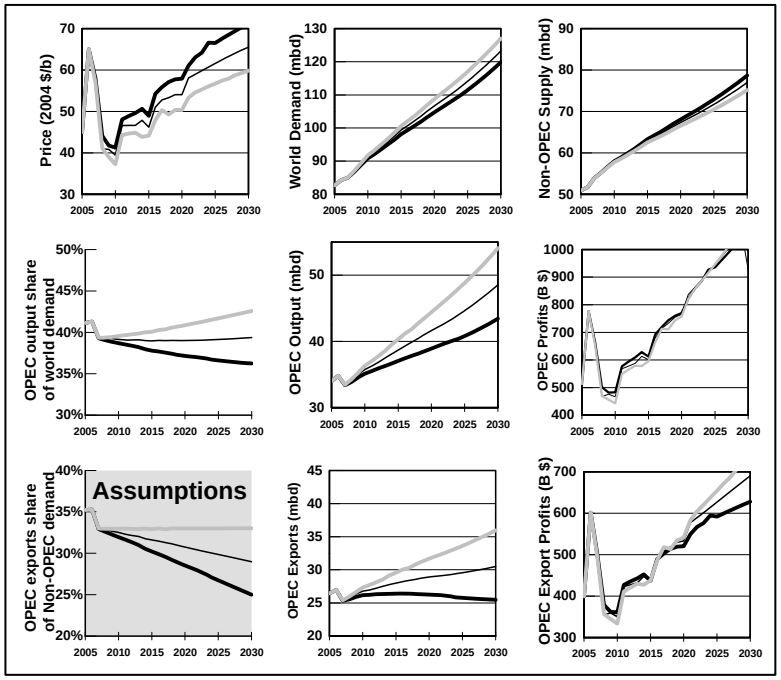
We analyze three strategies in which OPEC exports achieve a given target share of the non-OPEC oil demand (world consumption less OPEC consumption):

- OPEC share stays fixed at 33% from 2007 through 2030 (grey curve)
- OPEC share declines steadily, from 33% in 2007 to 29% by 2030 (thin black curve)
- OPEC share declines faster, from 33% now to 25% by 2030 (heavy black curve)

For each of three target paths for OPEC's export share of non-OPEC demand (lower left graph), in each year the market-clearing price and quantities are determined so that OPEC exports achieve the target share of non-OPEC demand.

Our calculations utilize a model of the world oil market that is described in Gately (2004); Appendix B contains a summary description of the model's assumptions. Figure 2 summarizes the 2005-2006 data and 2007-2030 projections for our Reference Case parameter assumptions.

Figure 2. Reference Case Projections for three OPEC export-share strategies (33% grey, 29% thin black, 25% heavy black), 2005-2030



Shown from left to right and top to bottom, we graph the following:

- Oil price (2004 $/barrel)
- World oil demand (mbd)
- Non-OPEC supply (mbd)
- OPEC output share of world demand (%)
- OPEC output (mbd)
- OPEC profits (billions, 2004 $)
- OPEC exports (mbd)
- OPEC export share of non-OPEC demand (%)
- OPEC export profits (billions, 2004 $)

We assume that OPEC's own oil consumption grows about as fast as its income, so that OPEC oil output equals its oil exports plus its own oil consumption; by 2030 OPEC is projected to consume nearly 20 mbd of its own output. This is about 6 mbd higher than the 13.6 mbd projected by DOE and IEA, which assume that OPEC oil consumption will grow less than two-thirds as fast as its income. As noted above, however, our analysis of OPEC strategies focuses only upon the growth of OPEC exports.

Comparing across the three target paths in Figure 2, the higher the target share of OPEC exports as a fraction of Non-OPEC demand, the lower would be the market-clearing price, the higher would be world demand, the lower would be non-OPEC supply, and the higher would be OPEC oil exports and output. OPEC *export profits* increase faster the higher is OPEC export share, although the differences are not significant for at least a decade. However, OPEC *profits* are about the same for the three strategies; this calculation assumes that domestic consumption is valued as highly as oil exports – yet, as noted above,

there are very high fuel-price subsidies within OPEC: in eight of the eleven OPEC members the retail prices of gasoline and diesel are lower than the world price for crude oil.[7]

The values for 2005-2006 are given by the latest *IEA Oil Market Report;* we assume the 2006 price will average $65 for the year. Model calculations begin in 2007. For 2007 we assume that OPEC oil exports equal 33% of non-OPEC demand; this results in a drop of price from $65 in 2006 to $47 in 2007 and about $40 in 2008. If instead we had assumed that OPEC attempted to maintain a constant price of $65 from 2006 to 2007, this would require OPEC to export a smaller share of non-OPEC demand.

Admittedly, this is a relatively arbitrary assumption for starting the model in 2007 with OPEC's export share at 33%. Yet it is important to attempt to integrate the short-term considerations within the long-term model – unlike DOE and IEA which keep separate their short-term and long-term modeling efforts. Each of these institutions project long-term prices lower than in 2006, yet neither analyzes the process by which this will occur.

Starting the model's calculations in 2007, in the aftermath of a price-doubling, poses the difficult problem of capturing the dynamic adjustment of demand and non-OPEC supply within a long-run disequilibrium. The capital-stock decisions made within the past decade – both non-OPEC supply capacity decisions and the fuel-efficiency of oil-using capital equipment such as vehicles – were based upon an expectation of oil prices below $30, and need to be modified now that price has more than doubled. This requires an estimate of what fraction of the long-run adjustment to the recent price doubling has been accomplished so far, and what adjustment remain to be completed. It should *not* be assumed that current levels of demand and non-OPEC supply reflect all, or even most, of the long-term adjustment. This was an

[7] Menschies, *International Fuel Prices 2005,* pp. 64-65.

important issue for the ten models participating in the Stanford Energy Model Forum's *World Oil Study*, which were calibrated in 1980 in the midst of the 1979-80 price doubling. These models over-projected the demand for OPEC oil and under-projected non-OPEC supply in the early 1980's, and thus overestimated the price level that OPEC could defend.[8]

3.1 Current prices are unsustainably high

One conclusion from our calculations is that the current price level of $70 is unsustainably high. We believe it to be unlikely that price could remain high for an extended period of time, unless there were significant interruptions of some OPEC member's exports. For price to remain high would require that world income continues its rapid growth *and* that neither world oil demand nor non-OPEC supply exhibits much responsiveness to 2004-2006 price-doubling. Eventually, price will have to return to levels well below the $70 level. This conclusion is based upon the following assumptions:

- the world oil market was in equilibrium prior to the 2004-2006 price jump;
- standard assumptions for world income growth, plausible parameter values for price and income elasticities of demand and non-OPEC supplies, and continuing adjustment in the future to the 2004-2006 price jump, by both demanders and non-OPEC suppliers

This means that OPEC has already exploited the short-term revenue gains from the 2004-2006 price doubling, and that there is little remaining to exploit. What OPEC now faces is a period of managing the price decline so that it does not lose its market by maintaining price at an unsustainably high level.

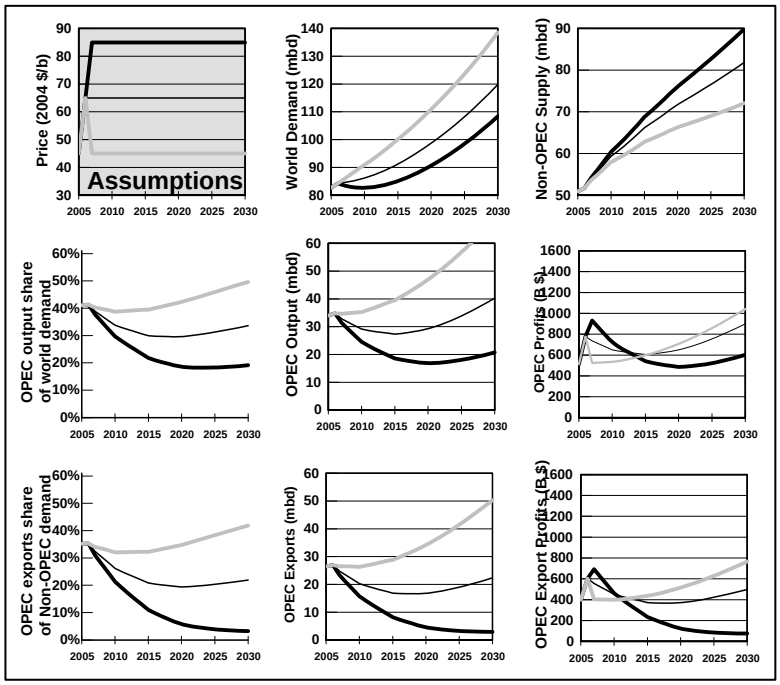
This process of reversing a price overshoot will be painful for OPEC, but it is necessary, and the sooner the better. Recall the damage done to OPEC's oil export market in the early 1980s when it made futile attempts, over several years, to defend the 1979-80 price doubling: its oil exports fell from 29 mbd in

[8] See Gately (1984) and Huntington (1994).

1979 to 13 mbd in 1985. This was the aftermath of its euphoric 1979-80 doubling of price and revenue, the immediate effect of which was a charmed outcome for OPEC, resulting from the lack of price-responsiveness – in the short run – of either world demand or non-OPEC supply. OPEC produced less oil, and its output reductions were more than offset by the price increases, so that OPEC revenues and profits surged. In contrast, when price needs to be adjusted downward, the increased OPEC output causes price declines that more than offset the output increases, resulting in short-term declines in OPEC revenues and profits. Moreover, to the extent that world demand and non-OPEC supplies respond asymmetrically to price changes – with less response to price decreases than to price increases[9] – price will have to drop even further for OPEC to be able to market its increased output. This is the main risk for OPEC if price is kept too high for too long – that it cannot just reverse the price increase in order to reverse the demand reductions and non-OPEC supply increases that have been stimulated by the price increase. It must reduce price even further, and keep it low for longer, in order to win back its market. During 1979-1985 OPEC lost more than half of its export market and, despite price cuts in 1981-86 that more than reversed the 1979-80 price doubling, after nearly three decades OPEC *still* has not gotten back to that 29 mbd level of oil exports, much less to its share of a growing market.

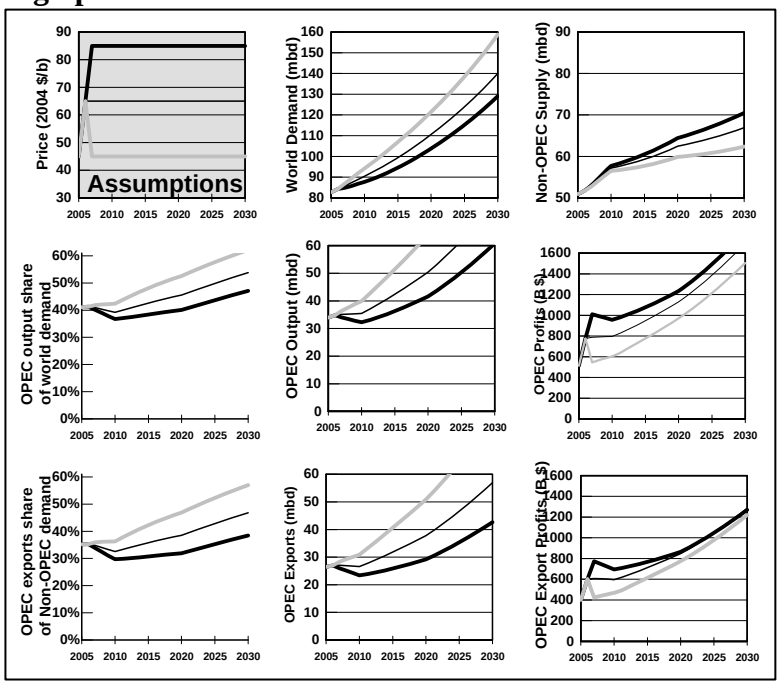
[9] See Gately and Huntington (2002) for evidence that oil demand has responded less to price declines than to price increases, and Gately (2004, Appendix A) for similar evidence regarding non-OPEC supply.

Figure 3. Model results for three constant price-paths, 2007-2030 ($45 grey, $65 thin black, $85 heavy black), using Reference Case parameter values



To illustrate this conclusion about the unsustainability of current prices, we graph in Figure 3 our model's results for Reference Case parameter values (see Appendix B), using three alternative constant-price-paths for 2007-2030: $85, $65, and $45. Given the $65 path, the Call on OPEC exports would fall below 20 mbd about 2010 and remain flat for the following two decades; OPEC export profits would never be as high as in 2006. With $85 oil, OPEC exports and export profits would decline even faster. On the other hand, $45 oil would allow the eventual growth of OPEC exports and export profits.

Figure 4. Model results for three constant price-paths, using parameter values most favorable to high prices



Given that some readers may find it implausible that current prices are unsustainably high, we repeat the calculations in Figure 4 using parameter values that are all more favorable to high prices: the lowest price-elasticities of demand and non-OPEC supply, the highest income-elasticities of demand, and the lowest projection of non-OPEC supplies[10] (IEA). Comparing the same price-path in Figure 3, world demand grows faster, non-OPEC supplies grow more slowly, and the Call on OPEC exports and output does not decline sharply. Under these assumptions, $65 oil *is* sustainable, and better than $45 oil for OPEC export profits. Even better for OPEC than $65 oil is $85 oil. Yet the sustainability of such high prices requires that *several* of these assumptions are made, simultaneously.

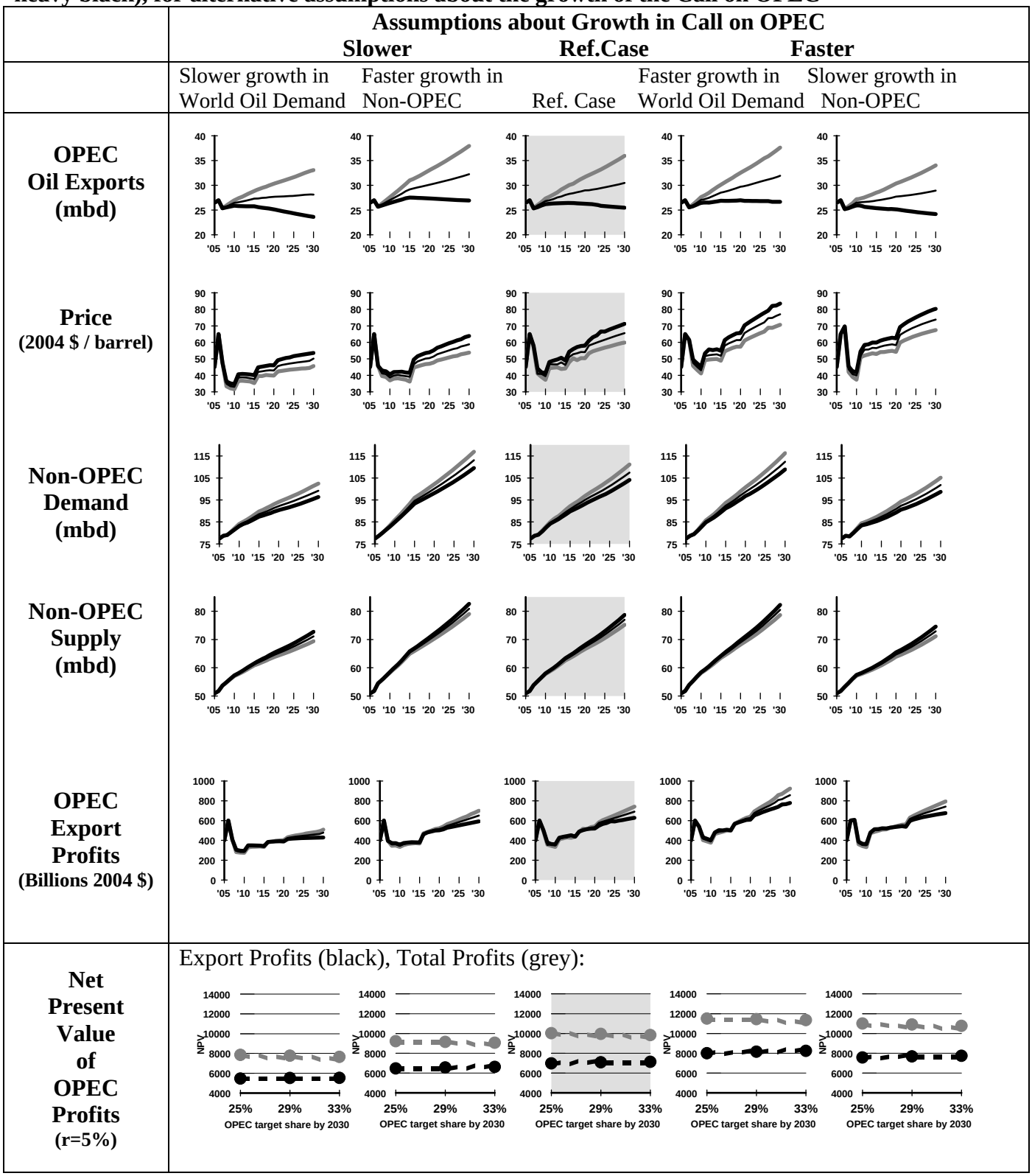
[10] These parameter values correspond to assuming *all* of the following, simultaneously: the price elasticities of world oil demand and non-OPEC supply are higher than in the Reference Case, world oil demand shifts out faster and non-OPEC supply grows more slowly than in the Reference Case. See Appendix B for parameter values used. Figures 6 through 9 consider cases in which each of these alternative parameter assumptions are evaluated one at a time, rather than all four simultaneously.

3.2 Sensitivity of Model Projections to Underlying Assumptions about the Growth and Price-Responsiveness of World Oil Demand and Non-OPEC Supply

One essential fact about modeling the world oil market is the unavoidable uncertainty about the parameters that underlie the world oil market, especially income growth rates, the price responsiveness of world oil demand and Non-OPEC supply, and the income-responsiveness of world oil demand. Price and income elasticities can be estimated but not known with certainty. Future income growth rates can be assumed, but their true values are unknowable in advance.

Given this uncertainty about the world oil market, we need to search for a *robustly optimal* strategy – one that will serve OPEC relatively well compared to other strategies, regardless of what parameter values eventually turn out to be the true values. To illustrate how sensitive are world oil projections to changes in the underlying parameter assumptions (described in Appendix B), we examine two dimensions of uncertainty – how price-responsive is the Call on OPEC, and how fast it shifts out over time. Additionally, each of these uncertainties about the Call on OPEC can result from changes in either of its components: world oil demand and Non-OPEC supply. Reference Case projections are compared in Figure 5 with four other cases that have faster or slower growth in world demand or non-OPEC supply, and compared in Figure 6 with four different cases with higher or lower price-elasticities.

Figure 5. Projections for three OPEC export-share strategies (33% grey, 29% thin black, 25% heavy black), for alternative assumptions about the growth of the Call on OPEC



In the Reference Case (central column of Figure 5), we see that maintaining OPEC export share at 33% – compared with letting it decline, to 29% or 25% – results in higher OPEC exports and lowers the price-path, which increases demand faster and slightly slows the growth in non-OPEC supply. Conversely, letting OPEC share decline keeps exports roughly constant, which raises the price-path, slowing demand growth and stimulating non-OPEC supply. However, there is little impact on OPEC export profits before 2020, after which faster OPEC export growth will increase export profits slightly.

Relative to the Reference Case, faster growth in the world oil demand curve – for any given export share strategy – will increase world demand and OPEC exports, pushing price higher, stimulating non-OPEC supply growth, and increasing export profits. However, the effects of slower growth in non-OPEC supply are different, for any given export share strategy: slowing the growth of non-OPEC supply lessens the market-share pressure on OPEC to increase its own exports. The combined slowdown in supply raises the price-path, which slows demand growth to match the slowing growth in supply; the price increases offset the slowdown in OPEC export growth, which reduces the impact upon OPEC export profits.

Thus the source of the increased Call on OPEC makes a difference in the way that OPEC responds. Faster growth in world oil demand pressures OPEC to *expand its exports* in order to achieve a given export share strategy, while slowing the growth of non-OPEC supply allows OPEC to *slow its own export growth* and yet achieve a given export share strategy. While both outcomes have similar effects on pushing up price, there are opposite effects on OPEC exports.

In the Reference Case, the Net Present Value of OPEC Export Profits, 2006-2030 (discounted at 5%), is 7128 Billion (2004 $) for the strategy that maintains OPEC export share at 33%, which is 0.7% higher

than for the share-decline-to-29% strategy and 2.2% higher than the share-decline-to 25% strategy. This is the incentive – positive but small – for OPEC to increase its exports fast enough to maintain its export share. Moreover, OPEC must be patient, because the higher export profits are not significant until 2015.

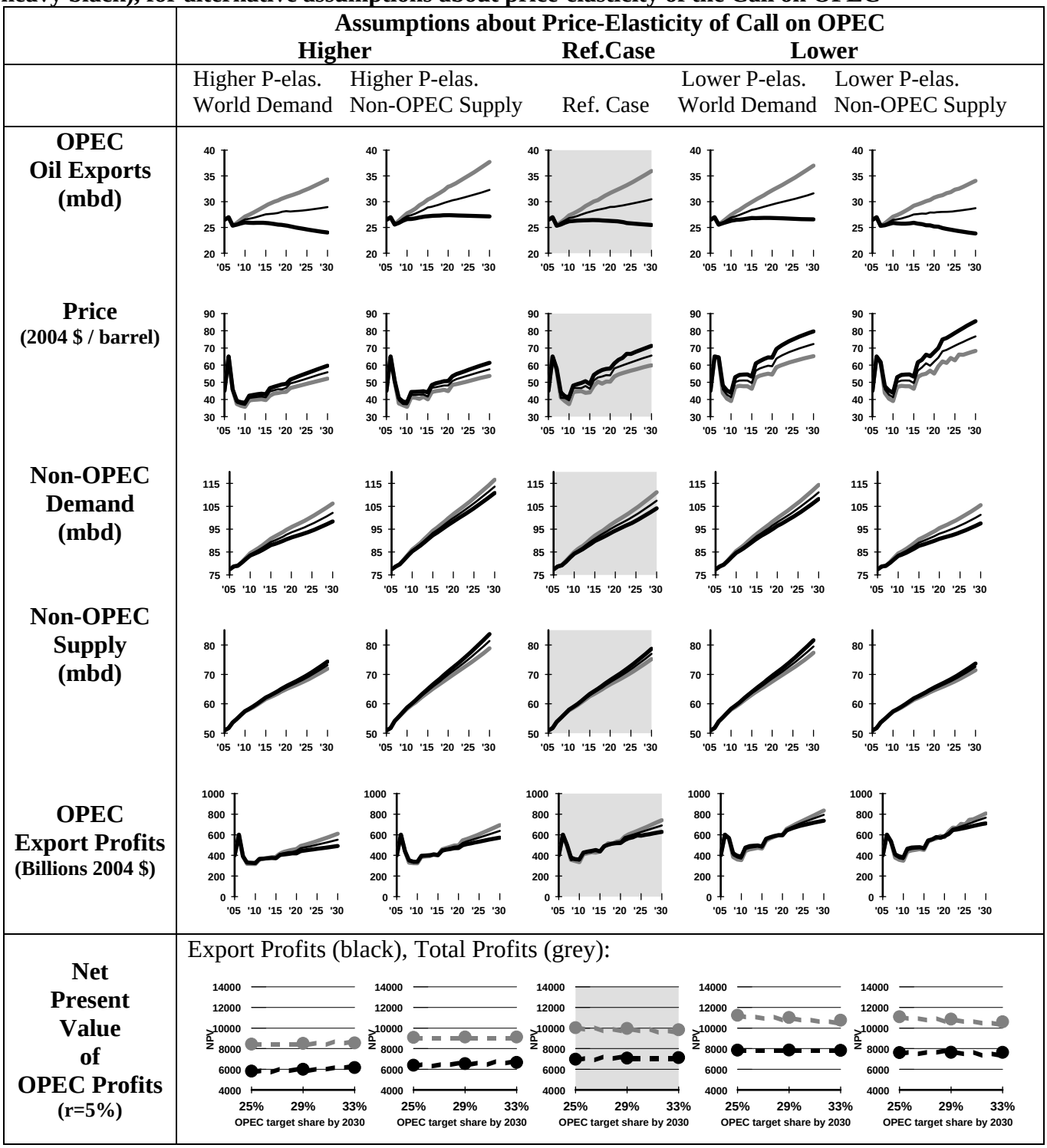
The NPV of OPEC *Total* Profits – including domestic oil consumption as well, at world prices[11] – is 9840 Billion (2004 $) for the share-maintenance strategy, which is 1.3% lower than the share-decline-to-29% strategy and 2% lower than the share-decline-to 25% strategy. The share-maintenance strategy expands OPEC exports, slows the increase in world prices, which lessens Total Profits relative to share-decline strategies.

The NPV differences across strategies are similar for the other cases (columns), and are discussed further in Tables 2 and 3 below.

There are similar differences in results across price-elasticity cases in Figure 6. For a given OPEC export-share strategy, lowering the price-elasticity of demand causes world demand to grown faster, thereby requiring an increase in OPEC's exports to achieve its export share. This pushes up price faster, which stimulates non-OPEC supply. Likewise, lowering the price-elasticity of non-OPEC supply slows the growth of non-OPEC supply, which lessens the market-share pressure on OPEC exports to achieve a given target share; this twofold reduction in supply cause price to increase faster, which slows demand growth to match the slowdown in supply growth. Differences in discounted profits are similar to those in Figure 5.

[11] However, this overstates the profits from domestic consumption within OPEC. As noted above, in eight of the eleven OPEC countries the *retail* prices of gasoline and diesel are lower than the world price of crude oil (Menschies, *International Fuel Prices 2005*, pp. 64-65).

Figure 6. Projections for three OPEC export-share strategies (33% grey, 29% thin black, 25% heavy black), for alternative assumptions about price-elasticity of the Call on OPEC



Thus across the three strategies, the discounted profits are relatively flat[12]: the long-run price-elasticity of the Call on OPEC is close to 1. In terms of export profits, there is relatively little incentive for OPEC to increase exports enough to maintain its export share. In terms of total profits, there is *negative* incentive: OPEC would be better off letting their export share decline slowly, in part because the higher price would value their domestic consumption more highly. This "flatness" of discounted OPEC profits allows OPEC substantial latitude in its choice of output policies *among the strategies evaluated*. It does not imply that OPEC can do *anything* that it pleases, without financial penalty – as was demonstrated in the early 1980's by OPEC's disastrous defense of the 1979-80 price doubling: by 1985 OPEC's share of non-Communist world production had plunged from 60% to 35% within eight years.[13]

With five alternative assumptions for the growth of the Call on OPEC (Figure 5) and five alternative assumptions for price-elasticities (Figure 6), there are 25 alternative cases for which we have evaluated each of the three export-share strategies[14]. Table 2 summarizes OPEC's *export*-profit incentive to maintain its export share, for each of the 25 cases, as measured by the % difference in NPV of export profits between the share-maintenance strategy and the share-decline-to-25% strategy. Similarly, Table 3 compares OPEC's *total*-profit incentive. For the Reference Case, there is a slight export-profits incentive (2.2% higher NPV) for OPEC to maintain its export share of non-OPEC demand at 33% rather than let it decline to 25%. However, the total-profits incentive – valuing domestic OPEC oil consumption as highly as exports – is negative (-2%), because expanding exports enough to maintain OPEC share will lessen the world price, which is used to value not only OPEC's exports but also its domestic consumption.

[12] This relative flatness of discounted profits is not sensitive to the discount rate used; discounting at 10% yields similar results.

[13] Gately (1995) discusses the flatness of discounted OPEC revenue and the associated literature, which argues that the phenomenon of many "near-optimal" depletion paths might be expected to be a relatively common characteristic of oil and similar markets.

[14] See Appendix B for detailed assumptions.

Table 2. Export Profits incentive to maintain OPEC Export Share:
% NPV increase of maintained 33% share over 25% share

	slower growth in World Oil Demand	faster growth in Non-OPEC Supply	Ref.Case Call on OPEC	faster growth in World Oil Demand	slower growth in Non-OPEC Supply
lower P-elas. Non-OPEC Supply	-0.7%	0.5%	0.2%	0.8%	0.0%
lower P-elas. World Demand	-1.3%	0.1%	-0.2%	0.2%	-0.6%
Ref. Case P-elas.	1.3%	2.4%	2.2%	2.9%	2.1%
higher P-elas. Non-OPEC Supply	3.5%	4.3%	4.3%	5.1%	4.5%
higher P-elas. World Demand	5.1%	5.7%	6.0%	6.4%	6.0%

Table 3. Total Profits incentive to maintain OPEC Export Share:
% NPV increase of maintained 33% share over 25% share

	slower growth in World Oil Demand	faster growth in Non-OPEC Supply	Ref.Case Call on OPEC	faster growth in World Oil Demand	slower growth in Non-OPEC Supply
lower P-elas. Non-OPEC Supply	-5.0%	-4.0%	-4.4%	-3.9%	-4.8%
lower P-elas. World Demand	-5.2%	-3.9%	-4.3%	-3.9%	-4.7%
Ref. Case P-elas.	-2.7%	-1.8%	-2.0%	-1.4%	-2.2%
higher P-elas. Non-OPEC Supply	-0.3%	0.4%	0.3%	1.0%	0.4%
higher P-elas. World Demand	0.9%	1.4%	1.5%	1.8%	1.4%

Comparing across cases in a given row, we see that increasing the growth in the Call on OPEC has modest effects on the incentives for OPEC to maintain its export share. Faster growth in world demand increases slightly the incentives for OPEC to maintain its export share, but slower growth in Non-OPEC supply has virtually no effect on the incentives. Likewise, comparing across cases down a given column, we see that increasing the price-elasticity of world demand or non-OPEC supply will slightly increase the export- profits incentive to maintain its share, and make the total-profits incentive change from slightly negative to slightly positive. With higher price-elasticity, the faster expansion of OPEC exports does not depress price so much, because less of a price decrease is necessary to stimulate world demand and deter non-OPEC supply, making room in the market for increased OPEC exports. Conversely, lowering the price-elasticity will decrease the export-profits incentive to maintain OPEC share (changing it from small positive to small negative) and make the total-profits incentive even more negative – as the lower price-elasticity causes price to decline further in order to stimulate demand and deter non-OPEC supply, to make room for the increase in OPEC exports.

4. What is in OPEC's best interest and what is OPEC most likely to do ?

What can be said about the relative attractiveness of the three strategy choices for OPEC?

- For the range of cases examined, the constant-export-share strategy (33%) yields the highest possible NPV of export profits, or within 1% of the highest, compared with the other two strategies. The larger the price-elasticities, the greater the NPV advantage of the constant-share strategy, although the difference is often slight.
- Maintaining OPEC's export share will depress price slightly, relative to a strategy that allows OPEC export share to decline slowly. Until about 2015 the higher export level will just offset the lower price, resulting in roughly the same level of export profits across strategies. Beyond 2015, however, export profits will be higher for the higher export-share strategy. This is the basis for higher NPV of export profits, especially with higher price-elasticities. The greater the price elasticities, the less that price will be suppressed by higher OPEC exports, in the process of stimulating demand and slowing non-OPEC supply growth.
- If OPEC were to allow its export share to decline slowly, to 29% by 2030, its export levels would remain roughly constant through 2030. (If OPEC export share declined more rapidly, to 25% by 2030, its export levels would decline slightly, to about 20 mbd.) Price would be higher, and would offset the export share decline for about a decade, as export profits would remain comparable to those of the export-share-maintenance strategy. Beyond 2015, export profits would continue to increase steadily – for all three strategies under all cases – but the rate of increase would be faster if export share were maintained.

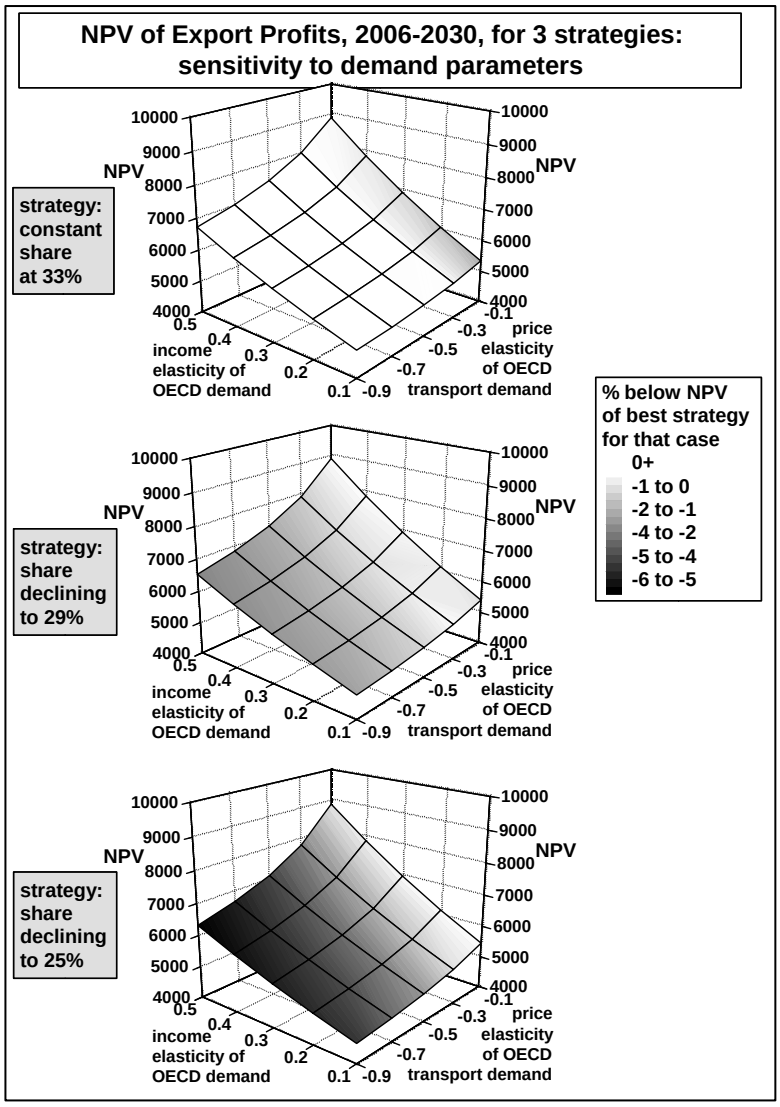
Even higher payoffs will accompany strategies that would increase OPEC's export share of non-OPEC demand. However, we believe that OPEC will have more than enough challenge just maintaining its export share.

This relative ranking of the three strategies is robust to reasonable changes in parameter assumptions that make the Call on OPEC increase faster or slower, or that make it more or less price-responsive.[15] To test this conclusion further, by making systematic variations in the price and income elasticities of demand, we examined the effect on the NPV of OPEC export profits for the three strategies[16]. Results are summarized in Figure 7.

[15] Unlike the work of Lempert *et al.* (2003) on robustly optimal strategies for climate change, we have not found parameter values that reverse the strategies' relative ranking, using the criterion of NPV of OPEC export profits. However, using a different criterion – the NPV of OPEC *Total Profits* – makes the strategy of export-share-maintenance inferior to a strategy that allows for slowly declining export share.

[16] We also explored the effects of using different non-OPEC supply assumptions, such as the lower IEA projections of non-OPEC supply or the higher DOE projections, in combination with each of the demand elasticity variations, but it did not change the relative ranking of the three strategies.

Figure 7. NPV of OPEC Export Profits for 25 combinations of price and income elasticities of demand, for each of three OPEC export-share strategies, assuming Reference Case projections of non-OPEC supply.



Each of the three graphs in Figure 7 shows a single strategy's NPV of export profits for each of 25 combinations of price and income elasticities of demand[17]. For example, in the top graph (for the constant 33% share strategy), the upper-left point plotted on the 3-dimensional surface shows the NPV (6726), at which we assumed -0.9 price-elasticity of OECD transport oil and 0.5 income elasticity. We also see on the top graph that the NPV is lower for lower values of income-elasticity and for higher (absolute) values of price-elasticities. Indeed this is true for all three of the graphs in Figure 7.

The shading of different parts of each of these three surfaces indicate the *relative performance of the strategies* for a given combination of price and income elasticities. *White* indicates the strategy with the highest NPV for that combination of elasticities. *Darker* shading indicates *relatively worse performance*

[17] The price elasticity of transport demand, in the OECD only, varies from -0.1 to -0.9; the price elasticity of other non-residual/heavy oil demand is assumed to be twice as high as that for transport. The income elasticity of OECD demand from 0.1 to 0.5, in steps of 0.1; there are similar changes for "Other Countries", from 0.4 to 1.2 in steps of 0.2.

for that strategy, measured by the % below the NPV of the best strategy for that combination of elasticities. Thus, the 33% share strategy yields the best NPV *relative to the other two strategies* for most combinations of price and income elasticities. The worst strategy usually is that with OPEC share declining to 25%; its NPV is often 4% or more below the NPV of the best strategy (constant share), especially for the higher elasticity combinations. Only for the lowest price and income elasticities (rightmost in graph) is the constant-share strategy not the best. Yet for the lowest elasticity combination (.1 for income and -.1 for price), the constant-share NPV (5343) is within 2% of the NPV for the best strategy, that with share declining to 25% (NPV=5448).

However, given the conclusion that the export-share-maintenance strategy is robustly optimal, it must be admitted that the incentive for OPEC to increase its exports by enough to maintain its exports' share of non-OPEC demand is relatively slight. The promise of faster growth in export profits after 2015 might not be sufficiently persuasive. Moreover, given that OPEC will need to increase its output significantly just to satisfy the growth of its own oil consumption (an increase by 2030 of 13 mbd, if its own oil consumption grows as fast as its income)[18], it may prove too difficult for OPEC to manage significant increases in its oil exports as well. Maintaining OPEC's export-share of non-OPEC demand would require an *additional* 7 mbd exports by 2030. Thus OPEC would have to produce 50 mbd in 2030: far more than it has ever produced. Although OPEC output projections of 50 mbd have long been made in IEA and DOE Reference Cases, the challenges for OPEC to produce such output levels are significant.

An alternative possibility is IEA's Deferred Investment Scenario, described in detail in IEA (2005), in which OPEC output remains below 40 mbd through 2030. Given IEA's projection of 7 mbd increase in

[18] This is much less of a problem if IEA or DOE projections of the increase in OPEC's own oil consumption are accurate. IEA projects an increase of 7 mbd by 2030, while DOE projects an increase of 3 mbd; see Table 1 and Appendix A.

OPEC's oil consumption, this would allow a modest increase in OPEC's oil exports. But if OPEC's oil consumption grows as rapidly as OPEC's income (as we project), then such a modest increase in OPEC output would require a decline in OPEC oil exports – similar to our lowest export-share path (declining to 25% by 2030), and OPEC would be consuming *half* of its oil output.

Similarly, the most recent DOE (2006) Reference Case projects an increase in OPEC oil liquids output to 45 mbd by 2030, but with a projected increase of OPEC's own consumption of only 3 mbd. This would allow OPEC oil export levels to increase modestly, roughly maintaining its export share of non-OPEC demand. However, if OPEC's own consumption were to grow as fast as its income – an increase of 13 mbd by 2030 – then if OPEC output grew only to 45 mbd by 2030, OPEC export *levels* could barely be maintained, and its exports' *share* of non-OPEC demand would decline significantly.

Finally, although we do not analyze sub-OPEC strategies for output expansion, we believe that OPEC members with special ability to expand their exports can benefit substantially. As we had observed in Gately (2004), OPEC members that expand their share of OPEC's exports will benefit disproportionately. Only if other OPEC members match those export increases might the result turn out to be a constant-sum game, with little advantage for either group. However, few OPEC members have the ability to expand their oil exports significantly, so this lessens the risk of OPEC overexpansion for those willing and able to do so.

5. Conclusions

The current level of price (above $70 in July 2006) is unsustainably high given standard assumptions for world income growth, plausible parameter values for price and income elasticities of demand and non-OPEC supplies, and continuing adjustment in the future to the 2004-2006 price increases. Thus OPEC should defend not the current price level but instead should defend its current share of the market, allowing the price to decline as necessary.

OPEC's own oil consumption is likely to grow much faster than is projected by DOE and IEA, perhaps as fast as OPEC income. Now at 7 mbd (more than 20% of OPEC output), it could grow to 20 mbd by 2030 if it grows as fast as OPEC income, as it has since 1987, and comprise 40% to 50% of OPEC output, constraining OPEC's ability to increase oil exports. Both DOE and IEA project much slower growth of OPEC consumption, to 10 or 13 mbd, respectively, by 2030. Their projected ratios of OPEC's consumption growth to income growth are less than 0.4 and 0.6, respectively – much lower than the 1987-2003 ratio of 1.0 and 1971-2003 ratio of 1.5.

OPEC's robustly optimal strategy is to maintain its exports' share of non-OPEC demand, and increase its exports as necessary. However, the NPV advantage is slight and higher export profits would not occur until after 2015, compared with strategies that have little or no increase in OPEC oil exports. Hence OPEC would need to be farsighted and patient. Moreover, such a slight economic incentive for export expansion leaves ample room for other factors to influence oil policy, with relatively little penalty in terms of economic opportunities foregone.

If OPEC maintains its oil export *levels*, letting its export share of non-OPEC demand decline slowly, then price and OPEC export profits will still increase, albeit more slowly. Even if OPEC oil exports decline slowly, perhaps due to OPEC's growth in oil consumption exceeding its output growth, the price increase could offset the decline in exports and OPEC export profits could increase slowly, but this is risky for OPEC.

Any OPEC members that are willing and able to expand their oil exports will have a strong incentive to do so, given the likely constraints on export expansion elsewhere in OPEC.

We should not rely upon OPEC's export-share of non-OPEC demand remaining constant. We might not even be able to count upon OPEC being able to maintain its *level* of oil exports. Still, for the next 25 years, the real oil price over a sustained period need not be much higher than the current level, given reasonable assumptions about the price-responsiveness of demand and non-OPEC supply.

We could see a future in which OPEC investment in capacity expansion is too slow and the world's need for OPEC oil goes unmet. Sharply higher prices that overshoot a long-term equilibrium path could be the short-term result, together with lower economic welfare worldwide. We could witness low-cost oil reserves in OPEC remaining underutilized while high-cost substitutes are over-utilized elsewhere – in economically wasteful cycles.

Appendix A: OPEC Oil Consumption: Historical and Projected

Since neither IEA nor DOE provide projections of oil consumption for all OPEC members, we created a composite estimate in Table A1. We utilized the IEA(2005) projections for the eight OPEC members in the Middle East and North Africa. For Indonesia, Nigeria, and Venezuela, we employed these three countries' respective regional projections of DOE(2006) for growth in GDP and oil consumption. The "IEA" projected annual growth rates for the aggregated OPEC are 2.4% for oil consumption and 4.1% for GDP: a ratio of 0.58.

Projections for OPEC consumption from DOE(2006) would be even lower than our composite "IEA" estimate. DOE (2006) projects average annual growth to 2030 for the Middle East region of 1.5% in oil consumption and 4.2% in GDP growth: a ratio of 0.36. If all eleven OPEC members were to grow at these rates, OPEC oil consumption in 2030 would be 10 mbd – which is *half* the level we project for 2030.

Table A1. OPEC Oil Consumption and GDP growth: Historical and Projected

	MidEast OPEC						Other OPEC					MidEast OPEC Total	OPEC Total
	Iran	Iraq	Kuwait	Qatar	Saudi Arabia	UAE	Algeria	Indones.	Libya	Nigeria	Venez.		
Historical Growth, 1971-2003 (average annual %)													
GDP	**3.2%**	**-3.8%**	**0.6%**	**2.6%**	**4.3%**	**6.8%**	**4.1%**	**6.0%**	**-0.5%**	**3.1%**	**1.3%**	**2.8%**	**3.4%**
Total Oil Consumption	**5.0%**	**5.9%**	**2.9%**	**13.0%**	**5.6%**	**15.9%**	**5.2%**	**6.3%**	**9.5%**	**6.7%**	**2.1%**	**5.4%**	**5.2%**
Transport Oil	5.6%	6.6%	4.4%	10.6%	9.9%	12.5%	5.0%	7.0%	8.5%	7.6%	3.7%	7.0%	6.4%
of which Gasoline	8.7%	6.1%	4.3%	8.8%	10.1%	10.9%	4.5%	7.0%	7.0%	8.3%	3.6%	8.4%	6.7%
Residual (Heavy) Oil	3.3%	5.0%	1.2%		0.5%		-2.5%	5.9%	8.9%	6.1%	-1.0%	2.4%	2.5%
Other Oil	5.3%	6.2%	6.9%	15.2%	11.3%	16.5%	6.1%	5.7%	11.4%	5.2%	1.7%	7.8%	6.4%
Ratio: Historical Oil Consumption Growth to GDP Growth, 1971-2003													
Total Oil Consumption	**1.6**	**-1.6**	**5.2**	**5.0**	**1.3**	**2.3**	**1.3**	**1.0**	**-18.6**	**2.2**	**1.7**	**1.9**	**1.52**
Transport Oil	1.8	-1.8	7.9	4.0	2.3	1.8	1.2	1.2	-16.6	2.4	2.9	2.5	1.9
of which Gasoline	2.7	-1.6	7.8	3.4	2.4	1.6	1.1	1.2	-13.8	2.7	2.8	3.0	1.9
Residual (Heavy) Oil	1.0	-1.3	2.2		0.1		-0.6	1.0	-17.3	2.0	-0.8	0.8	0.7
Other Oil	1.7	-1.6	12.4	5.8	2.7	2.4	1.5	1.0	-22.3	1.7	1.3	2.8	1.8
2003 Level of Oil Consumption (Thousand B/D)													
Total Oil Consumption	**1,381**	**458**	**296**	**105**	**1,772**	**338**	**241**	**1,170**	**252**	**287**	**521**	**4,351**	**6,822**
Transport Oil	597	133	69	32	530	107	100	503	94	189	286	1,468	2,640
of which Gasoline	354	65	44	14	266	50	43	252	43	154	230	792	1,514
Residual (Heavy) Oil	247	135	133	0	300	156	3	146	51	38	47	971	1,257
Other Oil	537	190	95	74	942	75	139	521	106	60	187	1,912	2,926
IEA Projected Growth, 2004-2030 (average annual %): country projections: DOE for 3 italicized, IEA for others													
GDP	**3.7%**	**7.2%**	**3.2%**	**4.0%**	**3.6%**	**3.4%**	**3.1%**	***4.6%***	**3.3%**	***4.4%***	***4.0%***	**3.8%**	**4.1%**
Total Oil Consumption	**1.9%**	**2.7%**	**2.2%**	**4.2%**	**2.6%**	**2.2%**	**2.8%**	***2.3%***	**2.7%**	***2.3%***	***1.9%***	**2.4%**	**2.4%**
IEA Projected Ratio: Oil Consumption Growth to GDP Growth, 2004-2030													
Total Oil Consumption	**0.53**	**0.37**	**0.69**	**1.03**	**0.71**	**0.64**	**0.90**	***0.50***	**0.82**	***0.52***	***0.48***	**0.63**	**0.58**
Projected Total Oil Consumption (Thousand B/D) in 2030 for various assumed ratios of Consumption growth to GDP growth													
IEA ratio: 0.58 (average)	2,447	1,381	485	197	3,098	570	390	2,384	422	567	968	7,796	**12,797**
ratio 1987-2003: 1.0	3,673	2,983	688	307	4,607	827	550	3,942	609	917	1,502	11,792	**19,986**
ratio 1971-2003: 1.5	5,912	7,266	1,038	516	7,338	1,279	822	7,092	938	1,611	2,511	19,153	**33,677**

Historical Data Sources:

Oil consumption: International Energy Agency. Transport Oil is calculated as the sum of gasoline, jet fuel, and diesel (assumed to be half of gasoil consumption).

GDP: *Source OECD* Database

Appendix B: Model Description

The model used in this paper is similar to Gately (2004); the detailed specification of the equations can be found there. The main difference is that oil demand is now calculated for three oil products (transport oil, residual/heavy oil, and other products), for all 80 of the countries and regions identified in the IEA *Annual Statistical Supplement*. The model is calibrated to IEA data, and projections of GDP growth rates are taken from IMF *World Economic Outlook.* Non-OPEC supply (for all oil liquids not just conventional oil) is calculated from Reference Case projections provided either by DOE or IEA or a weighted average, that corresponds to an assumed Reference Case price-path, then modified by an assumed price-elasticity for prices above/below the given Reference Case price-path[19].

Table B1 summarizes the income and price-elasticities of demand and non-OPEC supply that are used in the 25 alternative cases used in Tables 2 and 3. The Reference Case parameter values are summarized in the top rows of Table B1. Demand elasticities are based upon Gately and Huntington (2002) and subsequent analysis of product demand. Supply elasticities were estimated judgmentally, to bracket the range of projections in the literature.

[19] This simplified, *ad-hoc* specification of non-OPEC supply was used because alternative specifications that rely upon structural relationships – such as Moroney and Berg (1999), which uses Pindyck's model of exploration, reserve additions, and production – have formidable data requirements that cannot be met for most non-OPEC countries.

Table B1. Summary of parameter value assumptions used in 25 cases

	Long-run Elasticities of World Oil Demand						Non-OPEC Supply	
	Transport Oil		Residual (Heavy) Oil		Other Oil		Standard	Long-run Price
	Income	Price	Income	Price	Income	Price	Projections	Elasticity
Reference Case parameter values								
Demand regions:								
OECD	0.4	-0.3	0.0	0.0	0.4	-0.6		
China	1.0	-0.3	0.0	-0.2	1.0	-0.6		
Oil Exporters	1.0	0.0	0.7	0.0	1.0	0.0		
Other Countries	1.0	-0.3	0.1	-0.3	1.0	-0.6		
Non-OPEC Supply regions							.5*DOE + .5*IEA	0.27
Higher Price-Elasticity of Demand								
Demand regions:								
OECD		-0.9				-1.8		
China								
Oil Exporters								
Other Countries								
Lower Price-Elasticity of Demand								
Demand regions:								
OECD		-0.1				-0.2		
China								
Oil Exporters								
Other Countries								
Higher Price-Elasticity of Non-OPEC Supply								0.48
Lower Price-Elasticity of Non-OPEC Supply								0.14
Slower Growth of World Oil Demand								
Demand regions:								
OECD	0.1				0.1			
China	0.6				0.6			
Oil Exporters	1.0				1.0			
Other Countries	0.6				0.6			
Faster Growth of World Oil Demand								
Demand regions:								
OECD	0.6				0.6			
China	1.2				1.2			
Oil Exporters	1.0				1.0			
Other Countries	1.2				1.2			
Slower Growth of Non-OPEC Supply							IEA	
Faster Growth of Non-OPEC Supply							DOE	

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