Price and Income Responsiveness of World Oil Demand, by Product

By

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Abstract

Oil demand is estimated using price decomposition terms to analyze the effects of price and income upon world oil demand, disaggregated by product: residual oil (used primarily for generating electricity) and other oil. Equations are estimated for each of six groups of countries, using data from 1971-2006. Most of the demand reductions since 1973-74 were due to fuel-switching away from residual oil, especially in the OECD. Demand for other oil has been much less price-responsive, and has grown almost as rapidly as income. Assuming constant real prices and our estimated elasticities, we project slightly weaker near-term demand growth than the International Energy Agency (IEA) and the U.S. Department of Energy (DOE), but *much* stronger long-term growth: 17% higher by 2030.

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1. Introduction

Gately-Huntington(2002) analyzed the per-capita demand for energy and for oil, as a function of per-capita income and the real price of crude oil, in various groups of countries using 1971-97 data. That analysis allowed for the possibility that demand might respond asymmetrically to increases and decreases in price or income.

This paper employs a similar model to analyze oil demand *disaggregated by product*: residual oil (used primarily for generating electricity) and other oil, using almost another full decade of data, for almost all countries of the world. The analysis explores the sensitivity of the model's elasticity estimates to the additional decade's data and compares projections from these models with those of IEA and DOE.

We find that most of the demand reductions since 1973-74 were due to fuel-switching away from residual oil, especially in the OECD. These fuel-switching demand reductions were not un-done when oil prices collapsed in the 1980s – strong evidence of asymmetric price-responsiveness – and thus cannot be re-done when oil prices increase again. However, the world still uses 10 million barrels per day (mbd) of residual oil – 12% of total demand, down from 28% in 1973 – making further reductions possible. Demand for other oil has been much less price-responsive and has grown almost as rapidly as income, especially in the Non-OECD countries.

Given the declining share of residual oil – with its higher price-responsiveness – we expect that total oil demand will be less price-responsive in the future than in the past, given that the easiest demand reductions have already been achieved by fuel-switching away from residual oil in electricity generation. Likewise, given the growing Non-OECD share of total world demand and its higher income-responsiveness, we expect that the growth in world oil demand will continue to be strong. With constant real prices and no major policy changes, we project slower demand growth than IEA and DOE for the next decade, as the world adjusts 2004-2006 price doubling. Beyond 2015, however, we project much faster demand growth than IEA and DOE, so that by

2030 our projections are 20 mbd higher than theirs. Such rapid demand growth is unlikely to be supplied at constant real prices, which would necessitate significant price increases from current levels.

In Section 2, we summarize how oil demand – disaggregated into residual and other oil – has changed over time and relative to income, by country group. Section 3 describes the demand equations that we shall use, and Section 4 summarizes the econometric results, for each of the groups of countries. Section 5 presents our demand projections and compares them with the short-term and long-term projections of IEA and DOE. Section 6 presents our conclusions. Appendix A describes the data sources, Appendix B the groupings of countries, and Appendix C presents additional econometric results.

2. Background Issues

Figure 1 presents world oil demand data[1], both over time and relative to real income, in absolute terms and per-capita, 1965-2006. The scales in the bottom graphs are logarithmic, which facilitates growth-rate comparisons between oil growth and income growth. Movement parallel to the diagonal lines indicates equi-proportional growth in oil demand and income; steeper [less steep] movement indicates that oil is growing faster [slower] than income.

There are dramatic differences between residual oil and other oil. Residual oil demand, which increased even faster than income prior to 1973, stopped growing after the 1973-74 price shock, and declined significantly after the second price shock in 1979-80. Other oil demand grew slightly faster than income before 1973, declined slightly after the two price shocks, and has grown almost as fast as income since the mid-1980s.

[1] British Petroleum (2007) is the source of world demand data that are used in Figures 1, 7, and 8. Everywhere else in the paper, IEA is the source of the data, by country and by product.

Fig. 1. World Oil Demand and Real Income, Total and per capita, 1965-2006

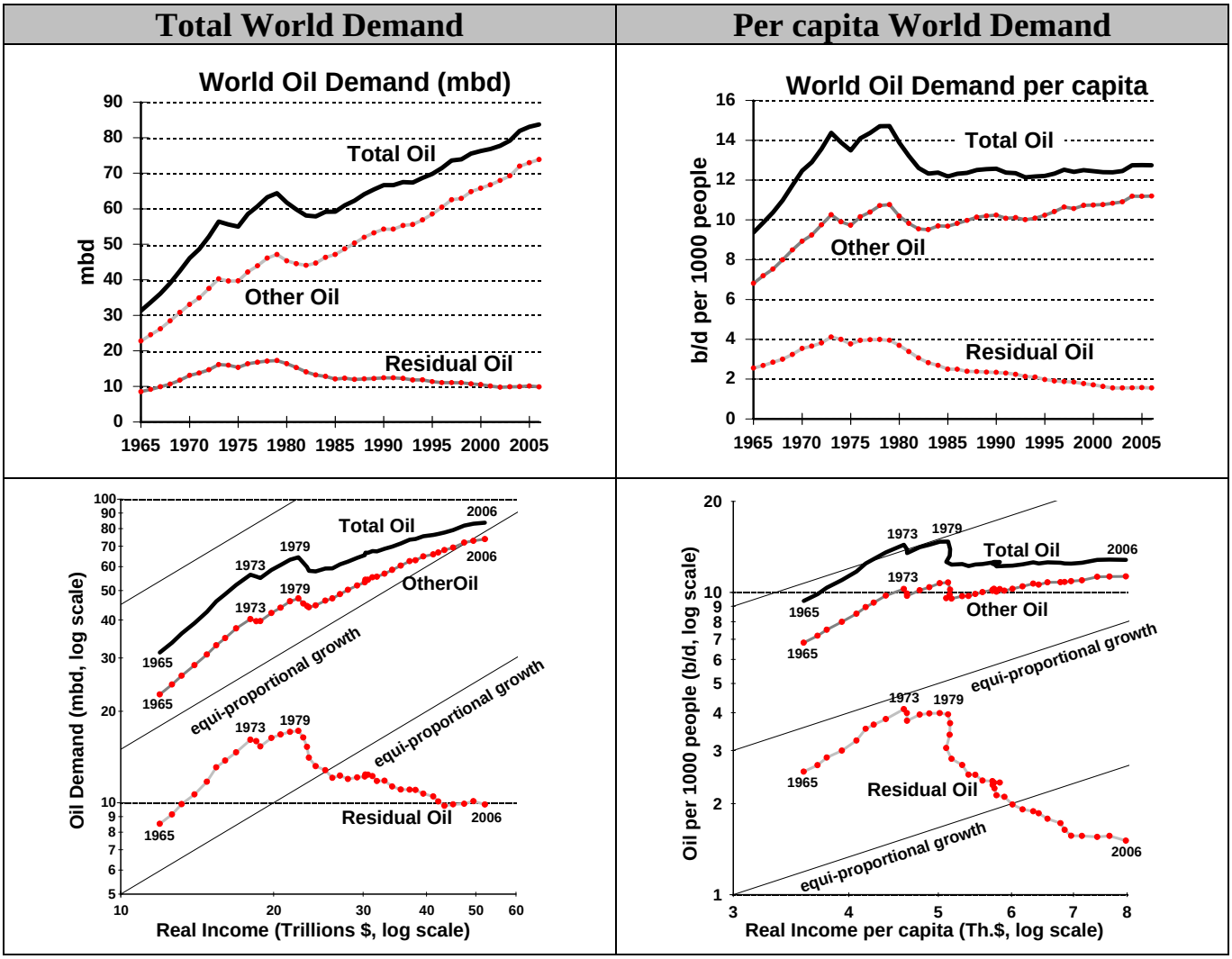
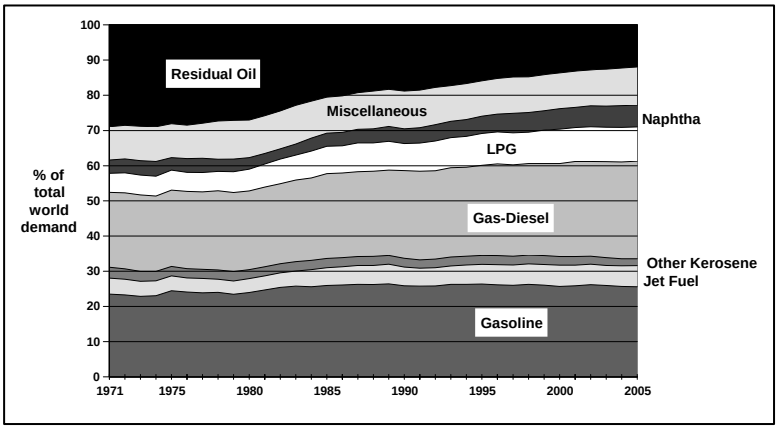


Fig. 2 World Oil Product Shares, 1971-2005



We disaggregate total oil demand by product, distinguishing between residual oil (heavy fuel oil) and "other oil" – all other oil products: gasoline, jet fuel, other kerosene, gas-diesel, LPG, naphtha, and miscellaneous. The share of residual oil has declined steadily since 1973, while every other oil product's share has increased or held constant, as shown in Figure 2. The changes over time among all other products' shares are dwarfed by the changes in residual oil's share.

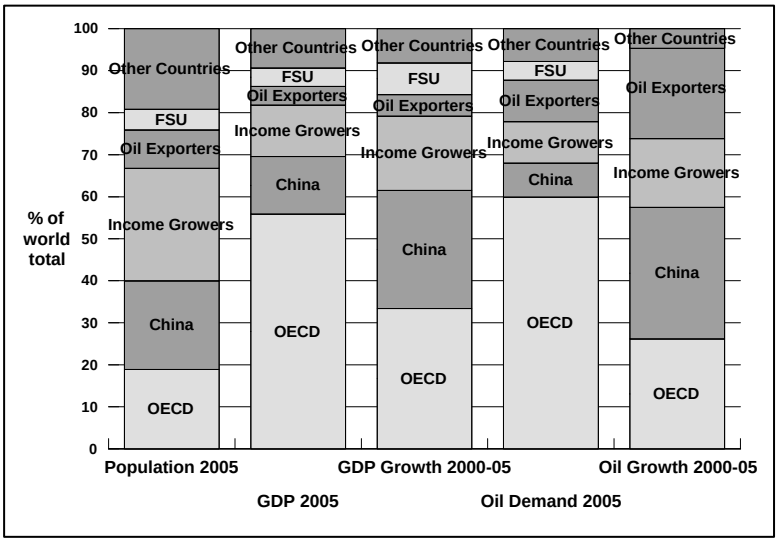
There are important differences across countries in the growth of income and oil demand, and their relationship to each other. We divide the world into six groups of countries, similar to the clusters of countries used in Gately-Huntington(2002):

- OECD, with 30 current members, including South Korea, Czech Republic, Hungary, Poland, Slovak Republic.
- China
- Former Soviet Union (FSU)
- Oil Exporters
- Income Growers: 17 countries with an average annual growth rate in per-capita income of at least 3% since 1971 and annual increases in at least 27 of those years
- Other Countries: 49 other countries

The detailed listing of countries is presented in Appendix B.

These groups differ in their income levels and income growth rates, and in their historical relationships between oil demand, income growth, and oil prices. Fig. 3 summarizes these six groups' share of world population, income, and oil demand in 2005, and their share of growth of world income and oil demand[2] from 2000-2005. Four large groups – OECD, China, Income Growers, and Oil Exporters – represent 75% of world population and 85% of world GDP and world oil demand.

Fig. 3. Shares of Population, GDP, and Total Oil Demand in 2005, and of Growth in GDP and Total Oil Demand 2000-2005.



[2] Since oil demand in the Former Soviet Union declined from 2000 to 2005, it is excluded from the rightmost stacked column.

Figure 4 summarizes each of the six country groups' oil demand, both over time (left column) and relative to per-capita income (right column): 1971-2006 for OECD and China, 1971-2005 for the other four groups. For China and Former Soviet Union, the left graphs also show domestic oil production. All six groups show residual oil per-capita to be flat or declining relative to per-capita income, while other oil per-capita has grown about as fast as per-capita income (although more slowly in the OECD). There are important differences across these country groups, both in levels of per-capita demand and its changes:

- OECD per-capita demand is about ten times higher than most of the developing world, although only three times higher than that of Oil Exporters;
- OECD per-capita demand has been relatively flat since 1971, while demand elsewhere has grown almost as rapidly as per-capita income;
- OECD countries' oil demand appears to have been more price-responsive and less income-responsive than for any other group;
- Income Growers' other oil demand has grown as rapidly as income for three decades, and its residual oil demand grew substantially after the oil price collapse in the mid 1980s;
- China's other oil demand has behaved similarly to the Income Growers for the past two decades, growing about as fast as income;
- Oil Exporters' oil demand has grown fairly steadily, even when its per-capita income was declining in the 1980s
- Former Soviet Union's consumption fell sharply after the 1989 collapse of the Soviet Union and the rapid decline of oil production. Consumption declined symmetrically with the income decline. Since 1997 its residual oil demand has continued to decline but other oil demand has increased, albeit slowly.
- Other Countries' other oil demand has moved symmetrically with changes in income, and its residual oil demand has declined in per-capita terms since the 1979-80 price shock.

Fig. 4A. Oil Demand and Real Income, per capita, since 1971: OECD, Income Growers & China

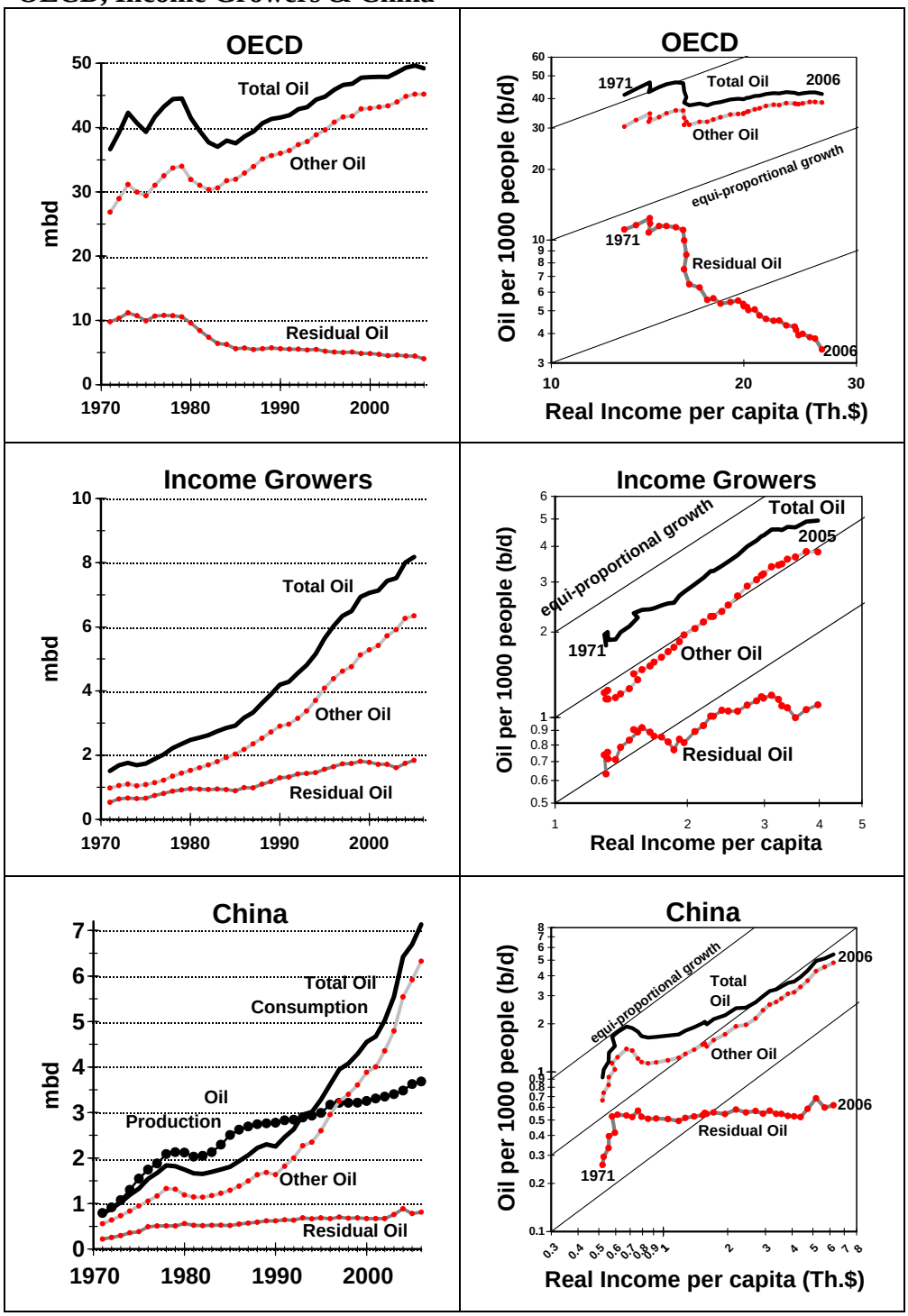
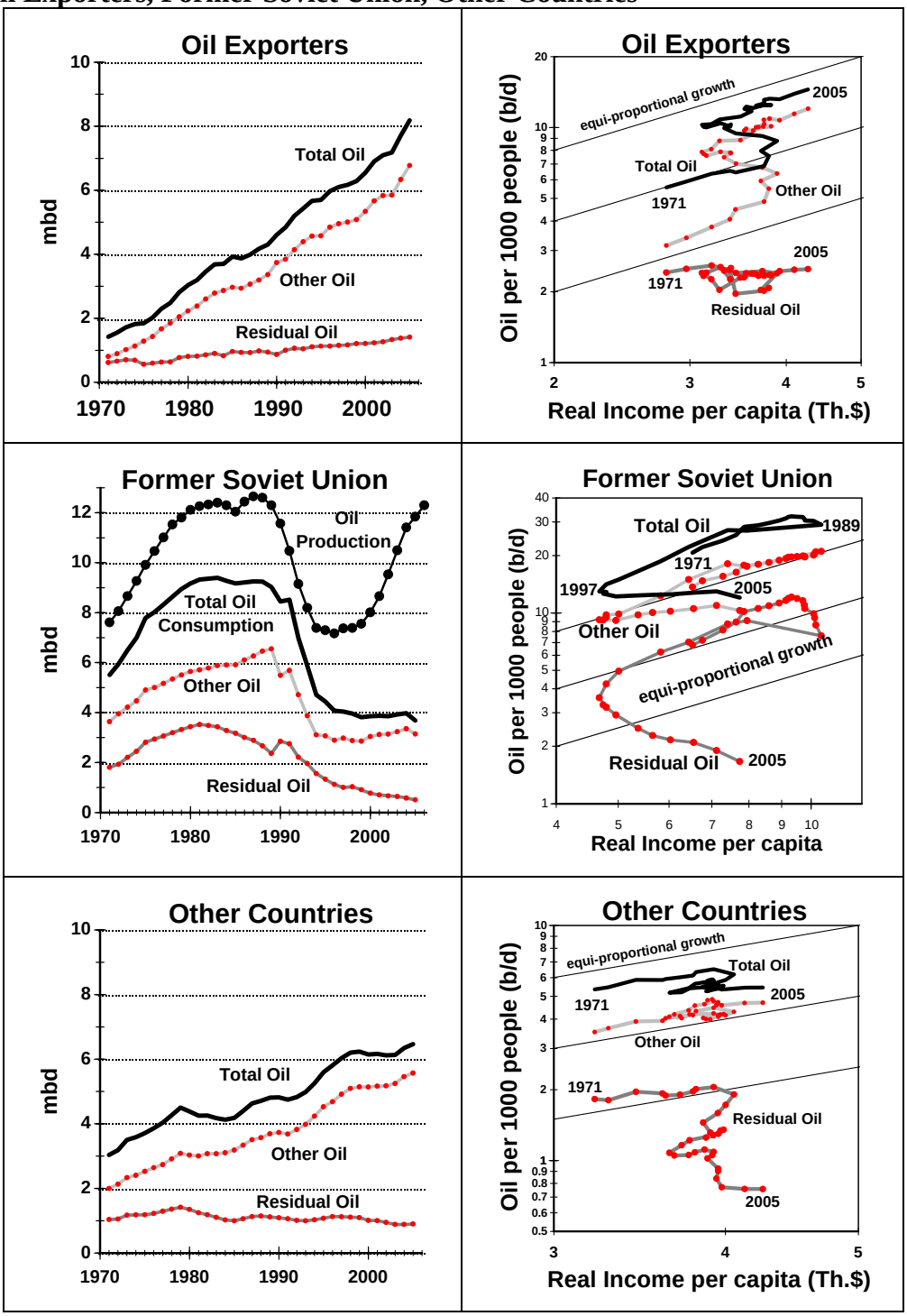


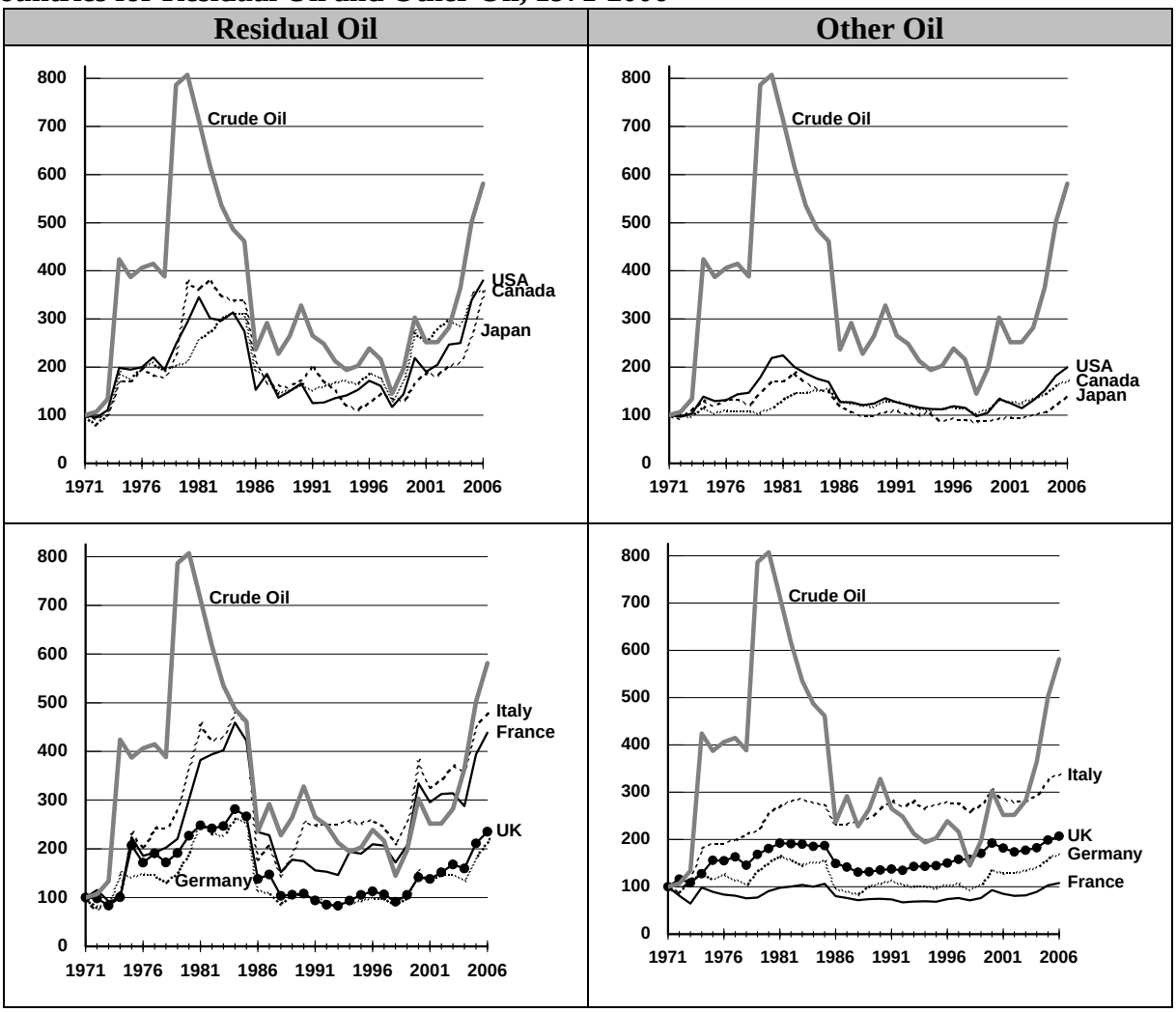
Fig. 4B. Oil Demand and Real Income, per capita, since 1971:
Oil Exporters, Former Soviet Union, Other Countries



Shown in Figure 5 are real price indices (1971=100) for world crude oil and for end-user prices in the G-7 countries (USA, Canada, Japan, France, Germany, Great Britain, and Italy). Note the following about these real price indices:

- The variation in crude oil prices has been much greater than the variation in end-user prices;
- The variation in end-user prices for residual oil has been much greater than for other oil;
- Despite the 2004-2006 doubling in crude oil price, it remains about 25% below its 1980 peak;
- For both residual and other oil, end-user price increases in the past decade, especially since 2004, have brought prices back to their previous maximum levels of 1980.

Fig. 5. Real price indices (1971=100): world crude oil price and end-user prices in the G-7 countries for Residual Oil and Other Oil, 1971-2006



One important issue in the econometric analysis of oil demand is whether or not demand has responded symmetrically to increases and decreases in price. Gately-Huntington (2002) and earlier papers have argued that the demand reductions in response to the price shocks of the 1970s were not reversed when prices collapsed in the 1980s. That is, demand responded asymmetrically – large demand reductions when price increased but little or no demand recovery when price decreased. Figure 6A depicts these possibilities; on the right, demand responds symmetrically to price increases and decreases[3], while on the left demand responds asymmetrically: the demand reductions caused by the price increase are only partially reversed by the price cuts. Analogously, Figure 6B illustrates the possibility of asymmetric response to income changes, with symmetric response on the right and asymmetric response on the left.

Figure 6A. Demand Response to Oil Price Changes: Asymmetric and Symmetric

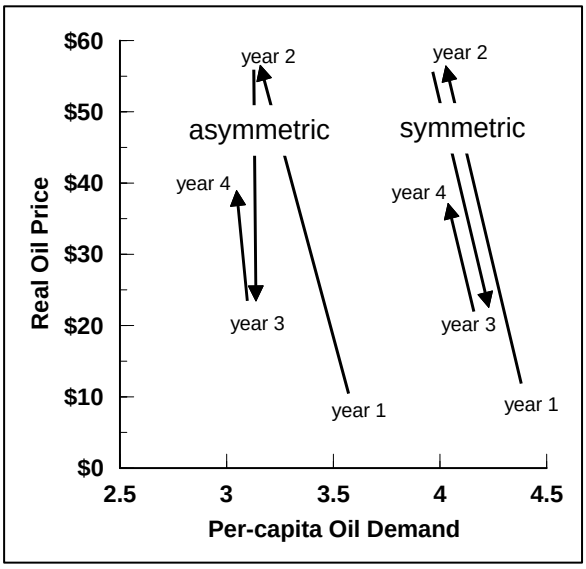
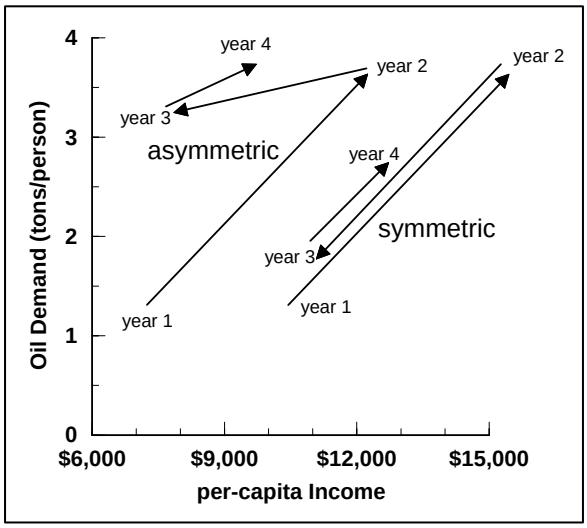


Figure 6B. Demand Response to Income Growth and Decline: Asymmetric and Symmetric



[3] The slight offsets in the symmetric curve are intended to convey symmetric movement up and down a single curve, and are not intended to imply that the curve shifts.

Figures 7 and 8 illustrate the asymmetric price-responsiveness of world oil demand, 1965-2006, plotting price on the vertical and per-capita world demand on the horizontal (Fig. 7) or the demand/income ratio on the horizontal (Fig. 8). These suggest that the response of residual oil demand has been very asymmetric to price changes: large demand reductions when price increased but no demand increases when price decreased. Other oil demand has also responded asymmetrically to price increases and decreases, although less so than residual oil.

Fig. 7: Crude Oil Price (2006$/b) and per-capita World Oil Demand (b/d per 1000 people)

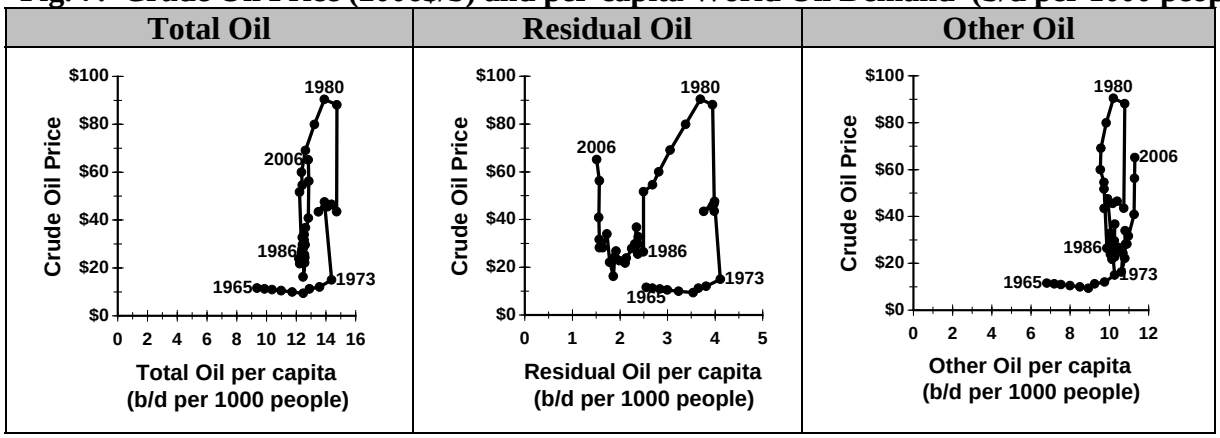
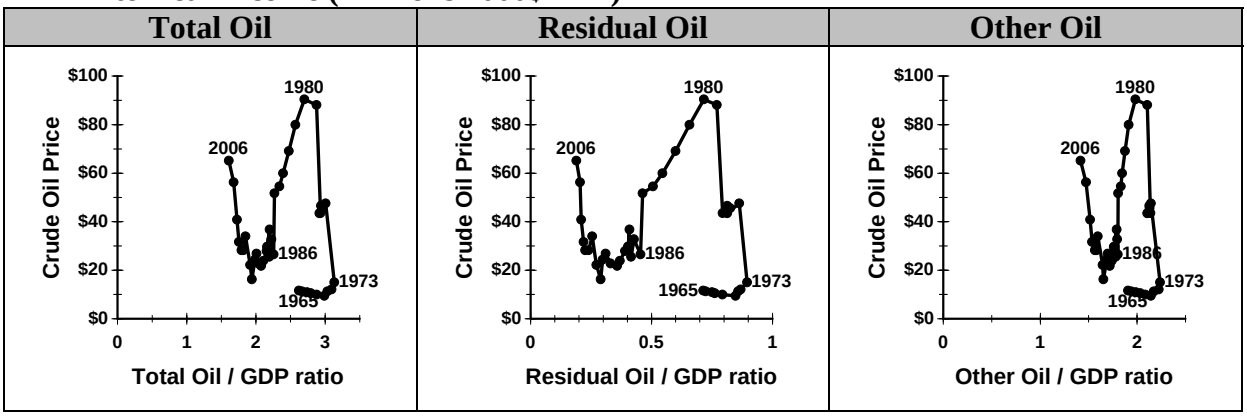


Fig. 8: Crude Oil Price (2006$/b) and the Ratio of World Oil Demand (mbd) to Real Income (Trillions 2000$ PPP)



3. Demand Model

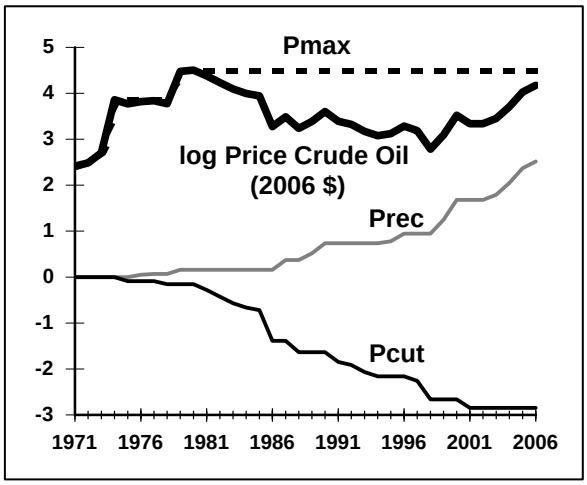
As in Gately-Huntington (2002) we use pooled cross-section/time-series data for various groups of countries to explain per-capita oil demand for each country as a function of per-capita income for each country, and the price of oil, with a separate constant estimated for each country – what is called a "fixed effects" model.

In order to allow for the possibility of asymmetric demand responses to increases and decreases in price and to prices above maximum historical levels, we decompose the logarithm of the price variable into three series (Figure 9):

- The maximum historical price $P_{max,t}$
- The cumulating series of price cuts $P_{cut,t}$
- The cumulating series of sub-maximum price recoveries $P_{rec,t}$

Similarly, to account for the possibility of asymmetric demand response to increases and decreases in income, we decomposed the logarithm of income. This decomposition is described in more detail in Gately-Huntington (2002).

Fig. 9: Decomposition of Crude Oil Price



In the most general specification, in which both income and price are decomposed, and the lagged-adjustment coefficients for income and price are estimated separately, we estimate the following regression:

$$
\begin{aligned}
(1)\ D_{c,t} = {} & k_{1c} + (\theta_p + \theta_y) * D_{c,t-1} - (\theta_p * \theta_y) * D_{c,t-2} \\
& + \beta_m P_{max,\,t} + \beta_c P_{cut,\,t} + \beta_r P_{rec,\,t} \\
& - \theta_y * (\beta_m P_{max,\,t-1} + \beta_c P_{cut,\,t-1} + \beta_r P_{rec,\,t-1}) \\
& + \gamma_m Y_{max,c,t} + \gamma_c Y_{cut,\,c,t} + \gamma_r Y_{rec,\,c,t} \\
& - \theta_p * (\gamma_m Y_{max,\,c,t-1} + \gamma_c Y_{cut,\,c,t-1} + \gamma_r Y_{rec,\,c,t-1})
\end{aligned}
$$

where k_{1c} are the constants for the individual countries and the other parameters are the same across countries.

We used Wald tests of coefficient equality to determine whether or not the decomposed-price coefficients are equal to each other, and similarly for the decomposed income coefficients. Significance tests (at the 5% level) were used to eliminate variables from the general specification, to arrive at the specific formulations of equation (1) that are used for particular groups of countries

- For OECD and for Other Countries: symmetric response to income changes ($\gamma_m = \gamma_c = \gamma_r$), no lagged adjustment to income changes ($\theta_y = 0$).

  (2) $D_{c,t} = k_{1c} + \theta_p D_{c,t-1} + \beta_m P_{max,\,t} + \beta_c P_{cut,\,t} + \beta_r P_{rec,\,t} + \gamma Y_{c,t} - \theta_p \gamma Y_{c,t-1}$
- For Income Growers: symmetric demand response to price changes ($\beta_m = \beta_c = \beta_r$) and income changes ($\gamma_m = \gamma_c = \gamma_r$), and no lagged adjustment to income changes ($\theta_y = 0$).

  (3) $D_{c,t} = k_{1c} + \theta_p D_{c,t-1} + \beta P_t + \gamma Y_{c,t} - \theta_p \gamma Y_{c,t-1}$
- For China: a simple specification that omits price and uses only current year's per-capita income and a constant term.

  (4) $D_t = k_1 + \gamma Y_t$
- For Oil Exporters and Former Soviet Union: specification excludes price and uses decomposed income, and lagged adjustment to income changes:

  (5) $D_{c,t} = k_{1c} + \gamma_m Y_{max,c,t} + \gamma_c Y_{cut,\,c,t} + \gamma_r Y_{rec,\,c,t} + \theta_y * D_{c,t-1}$

The basic specification includes fixed country effects (dummy variables for each of the countries k_{1c}) but not fixed time effects (dummy variables for each of the years). Holtz-Eakin and Selden (1995) and Schmalensee, Stoker, and Judson (1998) use fixed time effects in their pooled estimates of carbon dioxide emissions, because their specifications exclude prices and technical progress, two key explanatory factors. In our work, the oil demand specifications include not

only price but also the possibly asymmetric effects of price increases and decreases, in an attempt to capture *price-induced* energy-saving technical change. Adeyemi and Hunt (2007) show that this approach is superior for explaining OECD industrial energy demand than using fixed time effects as proxies to measure energy-saving technical change (and other unspecified variables), as Griffin and Schulman(2005) had done. Moreover, Huntington (2006), using the Griffin-Schulman data, shows that when fixed time effects are added, symmetry in the response to price continues to be rejected. One interpretation of asymmetric price effects is that (some) price increases induce energy-saving technical change, which is not un-done when prices fall. Examples are efficiency improvements in vehicles and heating systems: see Walker-Wirl(1993) and Haas-Schipper(1998). In addition, these fixed time effects generally exhibit large changes from one year to the next, especially in years around major price increases, and therefore must be incorporating the effects of price as well as other unspecified variables that affect all countries similarly.

4. Econometric Results

4.1 Results for OECD Countries

The following equations for per-capita demand -- for Total Oil, Residual Oil, and Other Oil – use equation specification (2), with asymmetric price-response, symmetric income response, with lagged-adjustment for price but instantaneous adjustment for income. Table 1 shows results for all 30 OECD countries using crude oil prices. Table 2 compares these with results for only the G-7 countries using either crude oil prices or end-user product prices.

Table 1. OECD Results, using Crude Oil Prices, 1971-2006

			equation coefficients					long-run elasticities			
	Prices used	Countries	Income	Pmax	Pcut	Prec	lagged price adjustment	Income	Pmax	Pcut	Prec
Total Oil	Crude Oil	30 OECD	0.88 (t=19.1)	-0.040 (t=-12.)	-0.017 (t=-5.7)	-0.028 (t=-7.6)	0.93 (t=120.)	0.88	-0.55	-0.22	-0.38
				reject symmetry							
Residual Oil	Crude Oil	30 OECD	0.57 (t=3.0)	-0.072 (t=-4.4)	-0.027 (t=-2.2)	-0.047 (t=-3.1)	0.98 (t=88.6)	0.57	-3.05	-1.14	-1.99
				reject symmetry							
Other Oil	Crude Oil	30 OECD	0.94 (t=21.1)	-0.030 (t=-9.9)	-0.017 (t=-6.4)	-0.026 (t=-7.4)	0.94 (t=131.)	0.94	-0.48	-0.27	-0.42
				reject symmetry (except Pmax=Prec)							

Notes:

i. All coefficients are statistically significant at the 5% level.

ii. For decomposed price coefficients, we performed a Wald test of the null hypothesis that the three coefficients are equal, using a 5% cutoff for the F-statistic probability. For all equations shown in this table, the Wald test allowed us to reject the null hypothesis that the decomposed-price coefficients were equal.

iii. Similar Wald tests were also done for price-increase symmetry between the coefficients for P_{max} and P_{rec}, and for symmetry between the coefficients for P_{cut} and P_{rec}. Those tests allowed us to reject those types of symmetry in all cases except for Other Oil, for which price-increase symmetry could not be rejected.

iv. The Adjusted R^2 for almost all specifications were very high, usually above 0.99.

v. The above specifications used AR terms as follows:
Total Oil and Residual Oil: no AR terms; Other Oil: AR1 only.

Given the graphs of OECD data in Figure 4, these econometric results are what one would expect and are generally reasonable[4]. Income elasticity is higher for Other Oil than for Residual Oil, while the price elasticity is higher for Residual Oil than for Other Oil. Asymmetric price-responsiveness was found for all three product groupings, with the asymmetry being greatest for Residual Oil: its P_{max} elasticity was three times greater than its P_{cut} elasticity. Some of this

[4] The coefficient for lagged-price adjustment implies implausibly slow adjustment to price changes; somewhat faster adjustment is found for the G-7 countries only: see Table C1 in Appendix C.

asymmetric response may have been the result of government policy regarding electricity generation, to switch permanently from residual oil to alternatives such as natural gas, coal, and nuclear. Undoubtedly, this asymmetry reflects fuel-switching, rather than improved energy efficiency.

Table 2. Comparison of elasticities, using crude oil prices versus end-user oil product prices, for 30 OECD countries and for G-7 countries only

			long-run elasticities			
Product	Prices used	Countries	Income	Pmax	Pcut	Prec
Total Oil	Crude Oil	30 OECD	0.88	-0.55	-0.22	-0.38
					reject symmetry	
	Crude Oil	G-7 OECD	0.91	-0.39	***-0.02***	-0.18
					reject symmetry	
	Oil Products	G-7 OECD	1.02	-0.84	***-0.02***	-0.61
				reject symmetry (except Pmax=Prec)		
Residual Oil	Crude Oil	30 OECD	0.57	-3.05	-1.14	-1.99
					reject symmetry	
	Crude Oil	G-7 OECD	0.97	-1.99	***-0.26***	-0.49
				reject symmetry (except Pcut=Prec)		
	Residual Oil	G-7 OECD	1.09	-2.38	***-0.49***	-0.73
				reject symmetry (except Pcut=Prec)		
Other Oil	Crude Oil	30 OECD	0.94	-0.48	-0.27	-0.42
				reject symmetry (except Pmax=Prec)		
	Crude Oil	G-7 OECD	0.92	-0.29	-0.06	-0.19
					reject symmetry	
	Other Oil	G-7 OECD	0.87	-0.36	***-0.02***	-0.24
				reject symmetry (except Pmax=Prec)		

Notes:

i. The elasticity corresponding to a coefficient that was not statistically significant at the 5% level is boldfaced, italicized and underlined.

ii. For decomposed price coefficients, we performed a Wald test of the null hypothesis that the three coefficients are equal, using a 5% cutoff for the F-statistic probability. For all equations shown in this table, the Wald test allowed us to reject the null hypothesis that the decomposed-price coefficients were equal.

iii. Similar Wald tests were also done for price-increase symmetry between the coefficients for P_{max} and P_{rec}, and for symmetry between the coefficients for P_{cut} and P_{rec}. Those tests allowed us to reject those types of symmetry in all cases except as noted, in which case a specific type of symmetry could not be rejected.

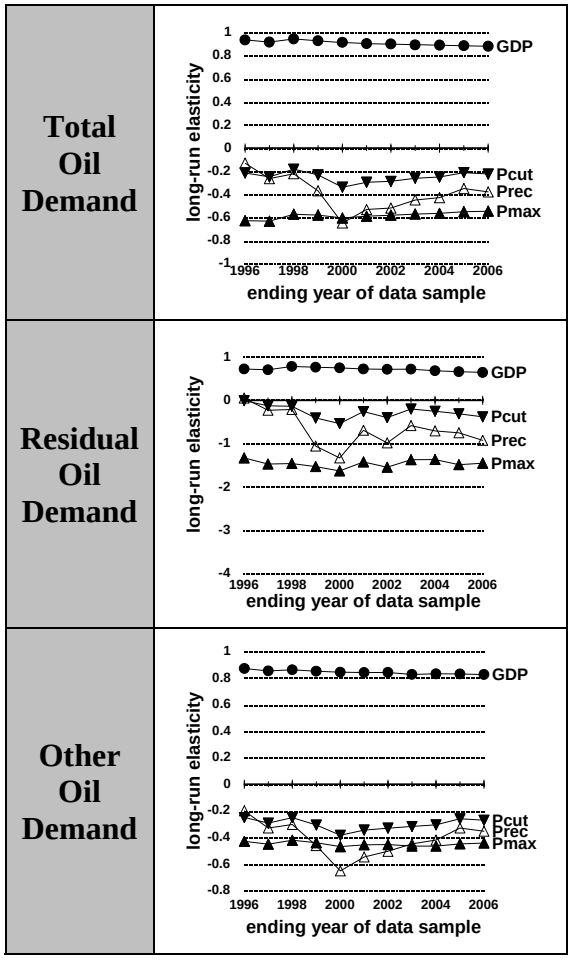
iv. The Adjusted R^2 for almost all specifications were very high, usually above 0.99.

v. No autoregressive terms were found to be significant except for the following: AR1 for Residual Oil in G-7 countries using crude oil prices, and for Other Oil in 30 OECD countries using crude oil prices; AR1, AR2 & AR3 were used for Other Oil in G-7 countries using Other Oil product prices.

This table allows comparison of results for the G-7 subset of OECD countries with those for the entire OECD, and for the G-7 countries using either crude oil prices or end-user product prices. For Total Oil, the G-7 results are similar to those for the entire OECD but the response to price decreases is close to zero and not statistically significant. The G-7 countries' demand is much

more responsive to increases in end-user prices than to increases in crude oil prices, as would be expected if refinery margins and taxes did not change very much when crude oil prices varied. For Other Oil, the G-7 results are also similar to those for the entire OECD. The response to price decreases is negligible, and much smaller than for the entire OECD. As with Total Oil, the G-7 countries' demand is more responsive to end-user prices than to crude oil prices.
For Residual Oil, the G-7 results show less responsiveness to P_{max} but *much* less responsiveness (if any) to price cuts, in comparison with the entire OECD.

Fig. 10. Sensitivity of long-run elasticity estimates of OECD oil demand to ending year of the data sample. All 30 OECD members, World Crude Oil Prices used in equations.



These three graphs in Fig. 10 – respectively for Total Oil, Residual Oil and Other Oil – show the effect on the long-run elasticities when different ending years are used for the data set. We show the elasticities when the data set is ended in 1996, then ending it in 1997, and so forth until we have the full results for the data ending in 2006. In general, the elasticities have been fairly stable for the last five years, and in some cases for longer than that. All the coefficients have been statistically significant for all ending years, with the following exceptions: for Residual Oil the price-cut coefficient has almost never been significant, and for all three oil products the price-recovery coefficient has not been significant until after the 1998-99 price recovery data is included. For all three oil products, symmetry of all three price coefficients can be rejected for all ending years of the data. Similar graphs are shown in Table C2 of Appendix C for the OECD G-7 countries, using either crude oil prices or end-user product prices.

4.2 Results for Income Growers

This group of countries with steadily growing per-capita income has experienced comparably steady growth in per-capita oil demand[5], about as fast as income growth: see Figure 4.

The equation specification (3) assumes symmetric demand response to price changes and income changes, and no lagged adjustment to income changes.

Table 3. Income Growers' Results, using crude oil prices, 1971-2005

	equation coefficients			long-run elasticities	
	Income	Price	lagged price adjustment	Income	Price
Total Oil	0.79 (t=12.9)	-0.03 (t=-3.4)	0.82 (t=40.)	0.79	-0.18
Residual Oil	0.41 (t=3.4)	***-0.02*** (t=-1.3)	0.85 (t=39.)	0.41	***-0.15***
Other Oil	0.92 (t=15.)	-0.03 (t=-3.3)	0.81 (t=40.)	0.92	-0.17

Notes:

i. A coefficient that was not statistically significant is boldfaced, italicized and underlined.
ii. The Adjusted R^2 for almost all specifications were very high, usually above 0.99.
iii. No AR terms were used in these equations.

These results show relatively high income elasticities and low price elasticities, especially in comparison with those of the OECD. Undoubtedly, some of the low response to crude oil prices reflects the fact that government policies do not allow delivered prices to move fully with crude oil prices in many of these countries. The income elasticity of Other Oil is 0.92, so that Other Oil demand will grow almost as rapidly as income in these countries.

These elasticity estimates are not very sensitive to the ending year of the data, when the last year of data is extended from 1996 to 2005: see Table C2 in Appendix C.

[5] The criteria for inclusion of countries in this group: increases of per-capita income in at least 27 of 32 years from 1972-2005 and an average annual growth rate of 3%.

4.3 Results for China

As we see in Figure 4, there has been substantial variation in the growth rates of China's per-capita oil consumption and its income, and in their relationship to each other. During 1971-77, per-capita income grew slowly (2.7% annually) and oil demand grew four times as fast (11% annually). From 1977 to 1990, per-capita income grew rapidly (7.7% annually) but oil demand grew very slowly (0.9% annually). Since 1990, per-capita income has grown very rapidly (8.9% annually) and oil has grown about three-fourths as fast (6.5% annually).

Using the entire data set 1971-2005, we find that standard specifications with world oil prices perform poorly: the coefficient for price is never statistically significant and often has the wrong sign. This is not surprising, given that China had long been isolated from the world oil market; its oil consumption remained lower than its domestic oil production until the early 1990s.

We find reasonable econometric results with a simpler specification (4) that omits price and uses only current year's per-capita income and a constant term[6]. However, the income elasticities are very sensitive to the *starting* year of the data, with a sharp break[7] about 1977; see Figure 11. If the data start in 1977 or later, then the income elasticity estimates are fairly stable: 0.9 for Other Oil, 0.75 for Total Oil, less than 0.1 for Residual Oil. But if the data start before 1977, the income elasticity estimates are only half as large. Using different *ending* years for the data sample has relatively little effect, except that the inclusion of data years since 2004 results in somewhat higher income elasticities.

[6] The income coefficient equals the income elasticity. The specification also used an autoregressive AR(1) term; an AR(2) term was not statistically significant.

[7] In studying whether Chinese exports induced economic growth, Kwan and Kwok (1995) used a dummy variable (=1 if 1978 or later; otherwise, 0) to incorporate the impact of the "1978 Four Modernizations" which promoted an outward-looking approach where China's real export growth rose steadily.

Fig. 11 Sensitivity of China's income elasticity to different starting and ending years of the data sample

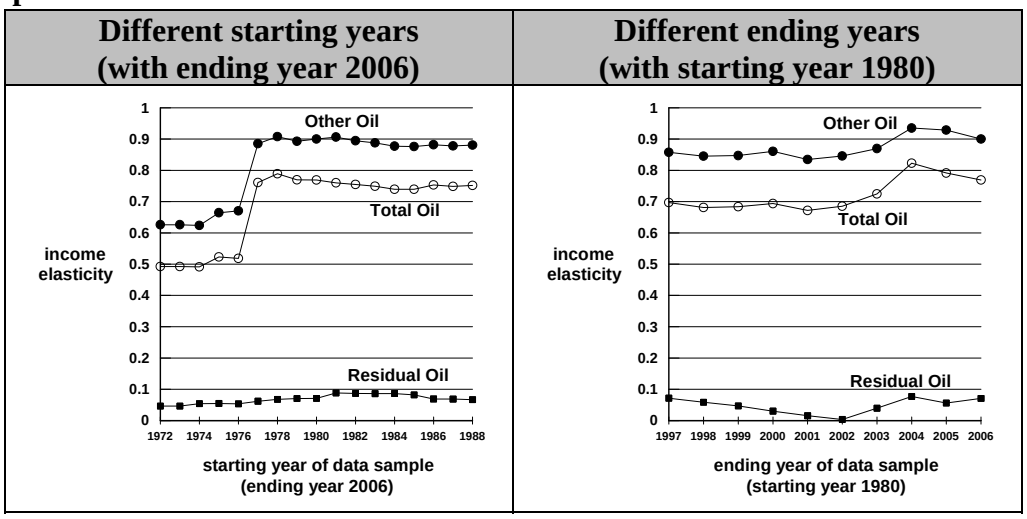


Table 4. China's Income Elasticities, using 1980-2006 data[8].

Total Oil	0.77 (t=9.)
Residual Oil	0.07 (t=2.3)
Other Oil	0.90 (t=14.)

Using data from the period 1980-2006, we find income elasticities (Table 4) that are consistent with China's demand growth and its relationship to income for the past quarter-century, as we can observe in Figure 4.

[8] IEA data 1971-2005 for China was extended to 2006 using the 2006 growth rates from BP(2007) for China's demand for residual and other oil.

4.4 Results for Oil Exporters

The oil demand behavior of this group of countries is quite different from that of those countries that import some or all of their oil. As we see in Figure 4:

- Demand for Other Oil almost always grows faster than income (even when income is declining), sometimes much faster;
- Growth in demand for Residual Oil is erratic, and has no clear relationship with income growth;
- Total Oil Demand grew about as fast as income, except in the euphoric decade after 1973-74 when it grew much faster than income.

The equation specification that was used (5) excludes price, uses decomposed income to capture the possibility of asymmetric demand response, with lagged adjustment to income changes.

Table 5. Oil Exporters' Results, using asymmetric income responses, 1971-2005

	equation coefficients				long-run elasticities		
	GDPmax	GDPcut	GDPrec	lagged adjustment	GDPmax	GDPcut	GDPrec
Total Oil	0.161 (t=44.)	0.049 (t=4.0)	0.097 (t=3.1)	***0.851*** (t=0.78)	1.08	0.33	0.65
	reject symmetry						
Residual Oil	0.085 (t=40.)	-0.015 (t=1.99)	***-0.144*** (t=-0.5)	0.842 (t=2.3)	0.54	-0.09	***-0.91***
	reject symmetry						
Other Oil	0.131 (t=36.)	0.034 (t=2.9)	0.095 (t=1.99)	***0.807*** (t=1.89)	0.68	0.18	0.49
	reject symmetry						

Notes:

i. A coefficient that was not statistically significant at the 5% level is boldfaced, italicized and underlined.

ii. The Adjusted R^2 for all specifications were very high, usually above 0.99.

iii. No AR terms were used in the Residual Oil equation, AR1 was used in the Other Oil equation, and both AR1 and AR2 were used in the Total Oil equation.

4.5 Results for Former Soviet Union

The 1971-2005 period has been tumultuous for the Former Soviet Union: growing income and oil consumption until the early-1980's, followed by stagnation and then collapse in the early 1990's, then oil production recovering substantially in the past decade, with oil consumption recovering much more slowly.

We used equation specification (5), the same as for the Oil Exporters, with decomposed income and lagged-adjustment for income changes. Results are shown in Table 6, but are not especially satisfactory, unsurprisingly. For Other Oil we can reject symmetry of income response coefficients. Income elasticities for income recovery – currently being experienced – are relatively low: 0.36 for Other Oil and 0.12 for Total Oil. These are consistent with the post-1997 experience shown in Figure 4.

Table 6. Results for Former Soviet Union, using asymmetric income responses, 1971-2005

	equation coefficients				long-run elasticities		
	GDPmax	GDPcut	GDPrec	lagged adjustment	GDPmax	GDPcut	GDPrec
Total Oil	***0.136*** (t=1.3)	0.486 (t=6.3)	***0.047*** (t=0.7)	0.596 (t=8.71)	0.34	1.20	0.12
	reject symmetry but not Ymax=Yrec						
Residual Oil	***-0.270*** (t=-1.)	0.265 (t=2.3)	***-0.173*** (t=-0.)	0.855 (t=10.1)	-1.86	1.82	-1.19
	cannot reject symmetry						
Other Oil	0.486 (t=4.3)	0.678 (t=8.8)	0.232 (t=3.8)	0.349 (t=4.58)	0.75	1.04	0.36
	reject symmetry						

Notes:

i. A coefficient that was not statistically significant at the 5% level is boldfaced, italicized and underlined.

ii. The Adjusted R^2 for almost all specifications were very high, usually above 0.99.

iii. No autoregressive terms were used in any of these equations.

4.6 Results for Other Countries

This group of 49 oil-importing countries with sporadic income growth has experienced especially slow growth in oil demand. We use equation specification (1) with decomposed income, decomposed price, and lagged adjustment for price but instantaneous adjustment for income (θ_y=0). Elasticity results in Table 7 are similar to Gately-Huntington (2002). There is evidence of asymmetric price responsiveness for Residual Oil but not for Other Oil or Total Oil, and evidence of asymmetric income responsiveness, with greater response to income cuts than to income increases.

Table 7. Other Countries' Results, using crude oil prices, 1971-2005

	equation coefficients							long-run elasticities					
	asymmetric income			asymmetric price				asymmetric income			asymmetric price		
	Ymax	Ycut	Yrec	Pmax	Pcut	Prec	lagged price adjustment	Ymax	Ycut	Yrec	Pmax	Pcut	Prec
Total Oil	0.40 (t=2.8)	0.65 (t=9.1)	0.33 (t=3.5)	-0.039 (t=-4.5)	-0.026 (t=-3.9)	-0.019 (t=-1.98)	0.923 (t=88.)	0.40	0.65	0.33	-0.50	-0.34	-0.25
	reject symmetry			cannot reject symmetry				reject symmetry			cannot reject symmetry		
Residual Oil	***0.09*** (t=0.2)	0.90 (t=4.8)	***0.25*** (t=1.0)	-0.054 (t=-2.3)	***0.006*** (t=0.3)	***-0.006*** (t=-0.2)	0.921 (t=81.)	***0.09***	0.90	***0.25***	-0.68	***0.07***	***-0.08***
	reject symmetry at .1 not .05			reject symmetry				reject symmetry only at .10			reject symmetry		
Other Oil	0.54 (t=3.8)	0.67 (t=8.4)	0.39 (t=3.7)	-0.022 (t=-3.2)	-0.027 (t=-4.1)	-0.020 (t=-2.0)	0.902 (t=79.)	0.54	0.67	0.39	-0.23	-0.28	-0.20
	reject symmetry at .1 not .05			cannot reject symmetry				reject symmetry only at .10			cannot reject symmetry		

Notes:

i. A coefficient that was not statistically significant at the 5% level is boldfaced, italicized and underlined.
ii. The Adjusted R^2 for all specifications were very high, usually above 0.99.
iii. The autoregressive term AR1 was used in each of the equations shown.

These Other Countries' income elasticity for positive income growth – 0.5 or less – is much lower than for either the Income Growers or Oil Exporters group. For most of these countries, modern commercial fuels – especially oil – must be imported. Due to economic difficulties within these countries (as evident in their slow and uneven growth in income) and their common practice of extensive import controls and restrictions on foreign exchange use, the very slow growth of oil demand may not truly measure *consumers*' income elasticity, but rather reflect the *governments'* behavior in limiting imports of oil. The price-elasticity of oil demand – higher than for other Non-OECD groups – might be explained similarly, as reflecting the behavior not of consumers but of government allocation of scarce foreign exchange in response to changes in world crude oil prices. Such a conjecture might also explain these countries' unusual income-asymmetry for oil demand: oil demand falls much more when income declines than it increases

when income rises. Such income decreases were common in these countries, and were often caused by decreases in export earnings, which prompted tighter import controls by the government that could have reduced oil consumption disproportionately.

4.7 Summary of Elasticities of Demand with respect to Income and the Price of Crude Oil

Table 8 summarizes our econometric results for the world's country groups. These elasticities can be compared with others in the literature, in the most recent survey by Dahl(2007).

Table 8: Long-run elasticities of demand, by country group

Country Group	Oil Product	Long-run elasticities of demand							
		Income				Price			
		symmetric	asymmetric			symmetric	asymmetric		
		Income	Ymax	Ycut	Yrec	Price	Pmax	Pcut	Prec
OECD	Total Oil	0.88					-0.55	-0.22	-0.38
	Residual Oil	0.57					-3.05	-1.14	-1.99
	Other Oil	0.94					-0.48	-0.27	-0.42
Income Growers	Total Oil	0.79				-0.18			
	Residual Oil	0.41				***-0.15***			
	Other Oil	0.92				-0.17			
China	Total Oil	0.77							
	Residual Oil	0.07							
	Other Oil	0.90							
Oil Exporters	Total Oil		1.08	0.33	0.65				
	Residual Oil		0.54	-0.09	***-0.91***				
	Other Oil		0.68	0.18	0.49				
Former Soviet Union	Total Oil		***0.34***	1.20	***0.12***				
	Residual Oil		***-1.86***	1.82	***-1.19***				
	Other Oil		0.75	1.04	0.36				
Other Countries	Total Oil		0.40	0.65	0.33		-0.50	-0.34	-0.25
	Residual Oil		***0.09***	0.90	***0.25***		-0.68	***0.07***	***-0.08***
	Other Oil		0.54	0.67	0.39		-0.23	-0.28	-0.20

Several generalizations can be made:

- Asymmetric price elasticities appear much more pronounced for OECD than for Non-OECD, and for residual oil compared with other oil.
- OECD price elasticities for residual oil are much higher than for other oil. Non-OECD responses are more similar between the two product groupings.
- Income elasticities for other oil are close to unity, even for OECD.

5. Projections

Here we make oil demand projections, annually to 2030, as a diagnostic tool for understanding other publicly available oil market projections. We make no attempt to insert our own assumptions about key determinants of future oil demand, such as the oil price path, economic growth or major policy changes. These projections use the following assumptions:

- Constant real crude oil prices, 2006-2030
- Projected growth rates for GDP and population, for each of our six country groups, are taken from DOE (2007), for each five-year period to 2030 – except that we assumed Other Countries' GDP would grow 1% more slowly than Income Growers. These world growth rates are considerably faster than those used even as recently as several years ago.
- For OECD and Income Growers, we used estimated parameters from our equations for Residual and Other Oil. Note that, although price is assumed to be constant in the future, the price elasticities are needed to calculate the lagged effects of the 2004-2006 price increases.
- For the Oil Exporters, we assumed that their income elasticities for Residual and Other would be the same as that for Income Growers, but there would be zero price-elasticity. This would be consistent with these countries continuing their policy of subsidizing energy-intensive economic activities, despite the higher opportunity costs.
- For China, FSU&FYU and Other Countries, we assumed the same price elasticities as for Income Growers. Income elasticities for Residual Oil in China and FSU&FYU were assumed to be half as large as those for Income Growers, and income elasticities for Other Oil assumed to be 80% that for Income Growers[9]. Other Countries' income elasticities were assumed to be half those of Income Growers.
- We calibrated the 12 equations (6 country groups, 2 products) to 2003 data – assuming long-run equilibrium for demand in 2003, given world oil prices. That is, given the short-run elasticities and lag speed, we calculated the constant term for 2003 so that simulated-equation-demand for 2003 was exactly equal to 2003 historical data. We then

[9] If instead we assumed that China's income elasticity for other oil would be what we had estimated (about 0.9, instead of 0.74 assumed here) then world oil demand would be 5 mbd higher by 2030, at 145 mbd.

used actual prices and per-capita GDP for 2004-2006 projections, and the assumed price (constant) and GDP growth rates for 2007-2030 projections of residual and other demand, which we summed to get total demand.

- Consistent with the DOE assumption of a baseline scenario, there would be no new major policy developments that would mitigate the growth of oil demand due to energy security, pollution, or climate change concerns.

Table 9. Elasticity assumptions used in our projections

	OECD	Income Growers	China	Oil Exporters	FSR & FYU	Other Countries
long-run income elasticity:						
Residual Oil	0.57	0.41	0.20	0.41	0.20	0.20
Other Oil	0.94	0.92	0.74	0.92	0.74	0.46
long-run price elasticity:						
Residual Oil	-1.99	-0.15	-0.15	0.00	-0.15	-0.15
Other Oil	-0.42	-0.17	-0.17	0.00	-0.17	-0.17

Table 10. Comparison of this paper's projections to 2030 with those of IEA and DOE

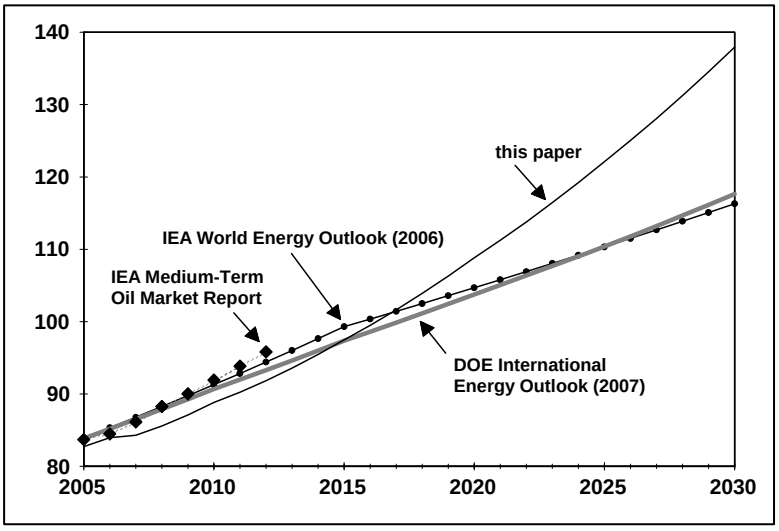
			Ratio of Oil Demand Growth to Real Income Growth						annual World GDP growth to 2030 (%)	projected World Oil Demand (mbd)	
Source of Projections	projection years	Assumed real-price-path for oil	OECD Total	Non-OECD Total	China	MidEast	FSU & E.Eu.	World Total		2015	2030
DOE: IEO 2007	2004-2030	constant, 2006-2030, about $70	0.23	0.44	0.54	0.51	0.24	**0.34**	4.07%	97	118
IEA: WEO 2006	2004-2030	constant, 2006-2030, about $70	0.26	0.53	0.61	0.55	0.30	**0.39**	3.40%	99	116
this paper	**2006-2030**	**constant, 2006-2030, about $70**	**0.40**	**0.64**	**0.67**	**0.75**	**0.52**	**0.52**	**4.00%**	**97**	**138**
Others:											
IEA: WEO 2004	2001-2025	constant, 2001-2025: about $30	0.36	0.63	0.68	0.70	0.49	**0.50**			
DOE: IEO 2003	2001-2025	constant, 2001-2025: about $30	0.48	0.55	0.53	0.58	0.54	**0.58**			
DOE: IEO 2007	2004-2030	decline to $30 by 2015 then constant	0.41	0.54	0.63	0.62	0.36	**0.46**			

Notes: In this table, the MidEast region used by IEA and DOE is compared with our group of Oil Exporters.

Our world demand projections are lower than those of both IEA and DOE until after 2015, but our projections grow much faster than IEA and DOE beyond 2015; see[10] Figure 12. For 2030, we project world oil demand at 138 mbd (of which only 12 mbd is Residual Oil), while DOE projects 118 mbd; we use the same assumptions about price and income. IEA projects 116 mbd for 2030, but uses slightly lower GDP growth rates. These differences for the next decade are likely due to our projections' greater adjustment to the 2004-06 price changes, which suppresses demand growth. However, once demand is fully adjusted to the 2006 price level – say beyond 2015 -- the IEA and DOE demand projections imply much lower income-elasticities and/or greater effects of government policies and technological change.

[10] Since IEA and DOE publish demand projections for only a few years, such as 2015 and 2030, we interpolate using constant annual growth rates between such years.

Fig. 12 Projections of World Oil Demand (mbd)



6. Conclusions

The story of world oil demand over the period 1973-2006 is a tale of two oil products. Demand for Residual Oil has fallen by one-third, while the demand for Other Oil has doubled.

Most of the reductions in oil demand were due to reductions in residual oil after the two price shocks of the 1970s – the result of fuel-switching to coal, natural gas, and nuclear for electricity generation, especially in the OECD, rather than improved technological efficiency. These fuel-switching demand reductions were not un-done when oil prices collapsed in the 1980s – strong evidence of asymmetric price-responsiveness – and thus cannot be re-done when oil prices increase again. However, the world still uses 10 mbd of residual oil (of 84 mbd total), making further reductions possible.

Now that Residual Oil's share of Total Oil has declined from 28% in 1973 to 12% today, future changes in Total Oil demand are dominated by what happens to Other Oil. In most of the developing world, demand for Other Oil has increased almost as rapidly as income since 1973, and half as fast as income in the OECD.

The price-responsiveness of demand for Other Oil has been much smaller than for Residual Oil, especially among the Income Growers, China, and the Oil Exporters. There has been some evidence of asymmetric price-responsiveness for Other Oil, but only within the OECD – the result of fuel-efficiency improvements that were not abandoned when oil prices fell. However, some OECD reductions in transport oil have been partially reversed by oil price declines, as consumers have chosen vehicles that are heavier and more powerful.

Our analysis suggests – at current real prices – weaker demand growth over the next decade in comparison with IEA and DOE, but much stronger growth beyond 2015. Over the period to 2030 we project that the ratio of world oil demand growth to income growth will be 0.52. In contrast, they project that – at current real prices – this ratio will be only 0.39 (IEA) or 0.34 (DOE). By 2030, this would be a difference of 20 mbd between our projections and theirs –

roughly the production of two Saudi Arabias. Since such rapid demand growth is unlikely to be supplied, real world oil prices would have to increase substantially by 2030 in order to slow demand growth, or income growth would have to slow substantially, or both.

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Appendix A

Data Sources

Oil Demand, 1965-2006: *BP Statistical Review (2007).*
Used only for world totals in Figures 1, 7, and 8

Oil Demand: Total Oil, Residual Oil, Other Oil:
OECD, 1971-2006: IEA, *Energy Statistics of OECD Countries*, Paris, 2007
Non-OECD, 1971-2005: IEA, *Energy Balances of Non-OECD Countries*, Paris, 2007

Real GDP (billion 2000 US$ using PPPs) and Population: SourceOECD dataset, for all countries

GDP growth rates for recent years, from IMF *World Economic Outlook* April 2007 database.

World crude oil prices (2006 $ per barrel),1965-2006: *BP Statistical Review (2007)*

Real end-user price indices (including taxes) for each of the G-7 countries:
IEA, *Energy Prices and Taxes*

1) Residual Oil. For 1978-2006 data we used the series "Indices of Energy End-Use Prices: Heavy Fuel Oil, Real Index for Industry". For 1971-1978, we used the (nominal) series "Industry Price per ton of High Sulfur Fuel Oil", deflated by the CPI; we then used the rate of change of these real prices to splice onto the 1978-2006 indices, creating the price index for 1977, then 1976, and back to 1971.
2) Other Oil. For 1978-2006, we created a weighted index of each country's real prices and consumption levels from the following products: Gasoline, Real Price Index for Households, weighted by Gasoline consumption; Automotive Diesel, simple average of Real Price Index for Households and for Industry, weighted by Road Transport use of Diesel; Light Fuel Oil (LFO), Real Price Index for Households, weighted by LFO consumption by Households; LFO, Real Price Index for Industry, weighted by LFO consumption by Industry. For 1971-1978, we created real price series based upon: Gasoline, nominal price for Households, deflated by CPI, weighted by Gasoline consumption; Automotive Diesel, simple average of nominal prices for Households and for Industry, deflated by CPI, weighted by Road Transport use of Diesel; LFO nominal price for Households, deflated by CPI, weighted by LFO consumption by Households; LFO nominal price for Industry, deflated by CPI, weighted by LFO consumption by Industry. We then the rate of change of these real prices to splice onto the 1978-2006 indices, creating the price index for 1977, then 1976, and back to 1971.
3) Total Oil Products. For 1978-2006, we used the series "Real Price Index for Oil Products for Households and for Industry". For 1971-78, we created a weighted average of the 1971-78 price indices for Residual Oil and Other Oil, weighted by their respective shares in Total Oil. We then used the 1971-78 growth rates to splice backward to 1971 the 1978-2006 series.

Appendix B

Description of Country Groups

OECD (19% of world population): Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, South Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

China (excluding Hong Kong and Chinese Taipei): 21% of world population

Former Soviet Union (5% of world population)

Oil Exporters (9% of world population): Algeria, Bahrain, Brunei Darussalam, Ecuador, Gabon, Indonesia, Iraq, Islamic Republic of Iran, Kuwait, Libya, Nigeria, Oman, Qatar, Saudi Arabia, United Arab Emirates, Venezuela.

Income Growers (17 countries: 27% of world population): Chile, Chinese Taipei, Cyprus, Dominican Republic, Egypt, Hong Kong, India, Malaysia, Malta, Myanmar, Pakistan, Singapore, Sri Lanka, Thailand, Tunisia, Vietnam, Yemen. The criteria for inclusion: increases of per-capita income in at least 27 years from 1972-2005 and an average annual growth rate of 3%.

Other Countries. (19% of world population) 49 other countries excluding only several small countries for which data is unavailable for the entire time period:
Albania, Angola, Argentina, Bangladesh, Benin, Bolivia, Brazil, Bulgaria, Cameroon, Colombia, Congo, Costa Rica, Côte d'Ivoire, Cuba, Dem. People's Republic of Korea, Democratic Republic of Congo, El Salvador, Ethiopia, Former Yugoslavia, Ghana, Gibraltar, Guatemala, Haiti, Honduras, Israel, Jamaica, Jordan, Kenya, Lebanon, Morocco, Mozambique, Namibia, Nepal, Nicaragua, Panama, Paraguay, Peru, Philippines, Romania, Senegal, South Africa, Sudan, Syria, Togo, Trinidad and Tobago, United Republic of Tanzania, Uruguay, Zambia, Zimbabwe.

Appendix C

Additional Econometric Results

Table C1.
Comparison of results for 30 OECD countries and G-7 countries only, using crude oil prices versus oil product prices.

			equation coefficients					long-run elasticities			
Product	Prices used	Countries	Income	Pmax	Pcut	Prec	lagged price adjustment	Income	Pmax	Pcut	Prec
Total Oil	Crude Oil	30 OECD	0.88 (t=19.1)	-0.040 (t=-12.)	-0.017 (t=-5.7)	-0.028 (t=-7.6)	0.93 (t=120.)	0.88	-0.55	-0.22	-0.38
				reject symmetry							
	Crude Oil	G-7 OECD	0.91 (t=8.19)	-0.058 (t=-9.7)	***-0.004*** (t=-0.5)	-0.027 (t=-4.6)	0.85 (t=28.3)	0.91	-0.39	***-0.02***	-0.18
				reject symmetry							
	Oil Products	G-7 OECD	1.02 (t=8.8)	-0.124 (t=-7.5)	***-0.003*** (t=-0.2)	-0.090 (t=-6.0)	0.85 (t=32.5)	1.02	-0.84	***-0.02***	-0.61
				reject symmetry (except Pmax=Prec)							
Residual Oil	Crude Oil	30 OECD	0.57 (t=3.0)	-0.072 (t=-4.4)	-0.027 (t=-2.2)	-0.047 (t=-3.1)	0.98 (t=88.6)	0.57	-3.05	-1.14	-1.99
				reject symmetry							
	Crude Oil	G-7 OECD	0.97 (t=2.59)	-0.121 (t=-5.8)	***-0.015*** (t=-0.6)	***-0.030*** (t=-1.5)	0.94 (t=33.6)	0.97	-1.99	***-0.26***	-0.49
				reject symmetry (except Pcut=Prec)							
	Residual Oil	G-7 OECD	1.09 (t=2.98)	-0.154 (t=-5.8)	***-0.032*** (t=-1.2)	-0.047 (t=-2.1)	0.94 (t=36.2)	1.09	-2.38	***-0.49***	-0.73
				reject symmetry (except Pcut=Prec)							
Other Oil	Crude Oil	30 OECD	0.94 (t=21.1)	-0.030 (t=-9.9)	-0.017 (t=-6.4)	-0.026 (t=-7.4)	0.94 (t=131.)	0.94	-0.48	-0.27	-0.42
				reject symmetry (except Pmax=Prec)							
	Crude Oil	G-7 OECD	0.92 (t=10.1)	-0.045 (t=-10.)	-0.010 (t=-2.1)	-0.029 (t=-5.8)	0.85 (t=33.7)	0.92	-0.29	-0.06	-0.19
				reject symmetry							
	Other Oil	G-7 OECD	0.87 (t=11.5)	-0.237 (t=-7.2)	***-0.014*** (t=-0.6)	-0.158 (t=-6.9)	0.35 (t=8.69)	0.87	-0.36	***-0.02***	-0.24
				reject symmetry (except Pmax=Prec)							

Notes:

i. The elasticity corresponding to a coefficient that was not statistically significant at the 5% level is boldfaced, italicized and underlined.

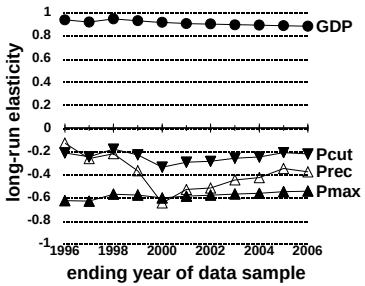
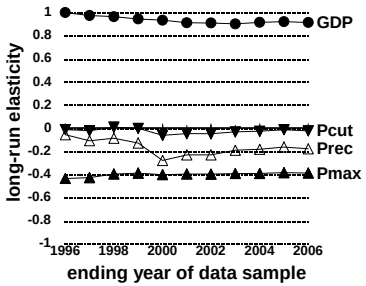
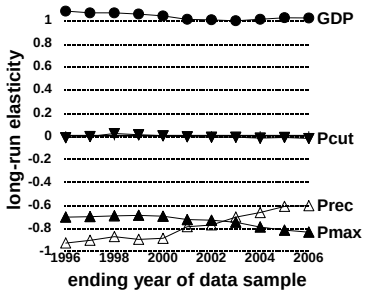
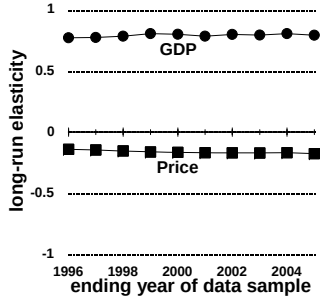
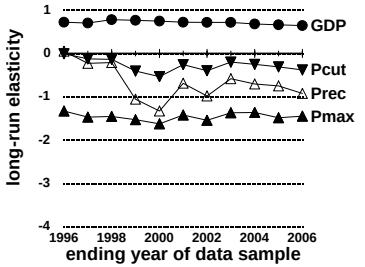
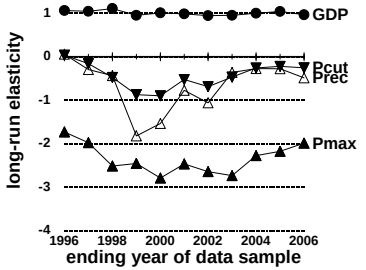
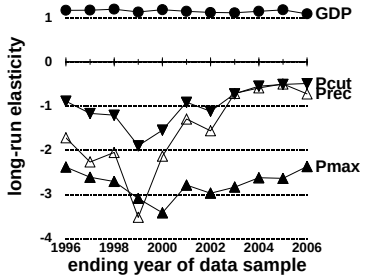
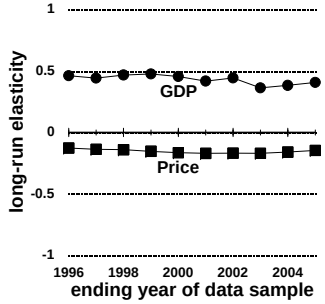
ii. For decomposed price coefficients, we performed a Wald test of the null hypothesis that the three coefficients are equal, using a 5% cutoff for the F-statistic probability. For all equations shown in this table, the Wald test allowed us to reject the null hypothesis that the decomposed-price coefficients were equal.

iii. Similar Wald tests were also done for price-increase symmetry between the coefficients for P_{max} and P_{rec}, and for symmetry between the coefficients for P_{cut} and P_{rec}. Those tests allowed us to reject those types of symmetry in all cases except as noted, in which case a specific type of symmetry could not be rejected.

iv. The Adjusted R^2 for almost all specifications were very high, usually above 0.99.

v. No autoregressive terms were found to be significant except for the following: AR1 for Residual Oil in G-7 countries using crude oil prices, and for Other Oil in 30 OECD countries using crude oil prices; AR1, AR2 & AR3 were used for Other Oil in G-7 countries using Other Oil product prices.

Table C2. Sensitivity of long-run elasticity estimates to ending year of the data sample, for various groups of countries and oil prices used

Countries	All 30 OECD members	OECD: G-7 countries	OECD: G-7 countries	17 Income Growers
Prices Used	**World Crude Oil Price**	**World Crude Oil Price**	**End-user Product Prices**	**World Crude Oil Price**
Total Oil Demand				
Residual Oil Demand				
Other Oil Demand