

Oil demand: Up the down staircase

prepared for Columbia University School of International and Public Affairs,
Center on Global Energy Policy by London Economics International LLC

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London Economics International LLC (“LEI”) was engaged by the Columbia University School of International and Public Affairs, Center on Global Energy Policy (“CGEP”) to prepare an econometric study of income and price elasticities of demand for crude oil and key refined products. This extensive study was provided to CGEP in the LEI report “Oil demand: Up the down staircase” November 19, 2018. This document provides highlights of the detailed study.

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1 Introduction

CGEP engaged London Economics International LLC to perform an in-depth analysis of the price and income elasticity of oil (crude oil, gasoline, and diesel) demand, in support of the CGEP study of peak oil demand.

To start from a solid foundation for the CGEP peak oil study, CGEP needed to explore fully the key drivers of oil demand, to comprehend the base outlook prior to any disruptive government policies or technology change. Understanding the drivers helps to envision how these drivers or relationships may change in the future.

CGEP also needed to understand the second order impacts, sometimes referred to as rebound effects, of what happens to gasoline or diesel demand when their prices fall as a result of disruptive technologies or policies which reduce demand. These effects are often left out of modeling of the impacts of disruptive technologies or policies. For example, if electric vehicle “EV” penetration lowers gasoline demand and prices, battery costs will need to be even lower to keep EVs competitive with the internal combustion engine. Therefore, it is important to understand the relationship gasoline demand and gasoline prices.

Specifically, CGEP asked:

- **What is the relationship between economic activity and oil demand?** Has the oil intensity of the global economy been declining since the 1980s and 1990s? Has the relationship between oil demand and economic activity broken down?
- **What is the relationship between oil prices and oil demand?** Was there an increase in the rate of oil demand growth during the long period of low oil prices? Is the relationship different for oil price shocks and are the effects lasting? Are there asymmetric impacts for oil price increases and declines? Was there an increase in the rate of oil demand growth during the long period of low oil prices? Are there asymmetric impacts for oil price increases and declines? How would a period of sustained low gasoline and diesel prices impact global oil demand growth?

1.1 Methodology

LEI examined historical trends and prepared an econometric study of income (GDP) and price elasticities of demand for crude oil and key refined products. Elasticities refer to the percentage change in oil consumption resulting from a percentage change in income or oil prices.

To examine the historical trends and to perform the econometric analysis, we used data for oil prices, oil consumption (crude oil, gasoline, and diesel fuel), and GDP for Organization for Economic Co-operation and Development (“OECD”) and non-OECD countries as a group, a group of Oil Producers, and the United States and China individually. The data covered a 40-year time period from 1977-2016; for the econometric analysis, we examined 1977-1996 and 1997-2016 separately, to discover whether the impacts of prices and income on oil demand have changed

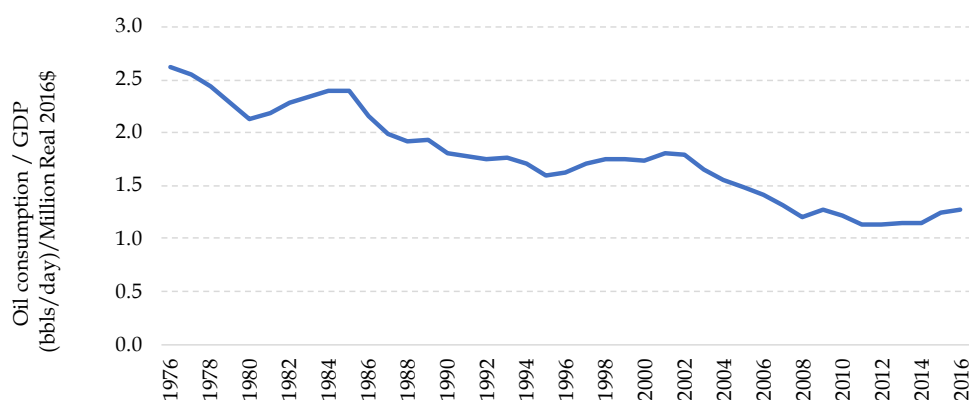
over time. We also performed a literature search to compare ranges of views on elasticities and examined how these have evolved over the decades.

1.2 Key findings and implications

Our analysis found that the oil intensity of the global economy has changed over time, and the impacts of price and income drivers has also changed. Key specific findings and their implications are:

- 1) **The decades-long upward movement in crude oil demand has been undermined by a “descending staircase” of declining oil-intensity of economic activity** (see Figure 1). The descending staircase refers to a repeated pattern of declining oil-intensity of GDP followed by a brief and incomplete recovery in which intensity did not return to its pre-decline levels. The descending staircase was evident in the trends in the data, as well as in the results of econometric analysis of the income and price drivers of global oil demand.

Figure 1. Oil intensity of the global economy – a descending staircase



Source: BP Statistical Review of World Energy 2017 and World Bank

- 2) **This finding implies that we should expect oil demand growth to continue to lag behind economic growth** as key developing countries population and economic growth rates slow and they transition away from an oil intensive economy to a service economy, and the world experiences periodic oil price spikes due to geopolitical events that destroy oil demand, which is not fully restored when prices recede.
- 3) **How consumers responded to falling oil prices has implications for how they might respond to policy or technological changes that lower gasoline or diesel prices.** Falling crude oil prices had a slightly larger long-term impact than recovering oil prices in the second (1997-2016) period. Gasoline and diesel had higher price elasticities of demand than crude oil, particularly in OECD region, and the price elasticities were higher in the second period. This implies that lower gasoline or diesel prices would stimulate demand. The impact was asymmetrical: lower gasoline and diesel prices in the OECD had a larger

positive impact on demand for those fuels than an upward price shock's negative impact on demand.

- 4) **The implication of the higher price elasticities of demand for gasoline and diesel is that we are likely to see rebound effects** if policies or new technologies like electric vehicles reduce gasoline and diesel demand. If this reduced demand results in lower prices, then the lower prices will re-stimulate demand, resulting in “rebound” of demand. The rebound could be the result of either or both more driving, and challenges to economic substitution between EVs and conventional gas or diesel vehicles. LEI's asymmetric models showed that lower crude oil prices generally had a larger impact on crude oil demand than higher crude oil prices (for 1997-2016), but not as large an impact as a price shock. In other words, an upward crude oil price shock did more damage to crude oil demand than the rebound effect for gasoline and diesel could repair. Of course, if government policies ban gasoline or diesel use outright, then the price elasticities no longer matter.

2 Trends in oil demand, prices, and economic growth

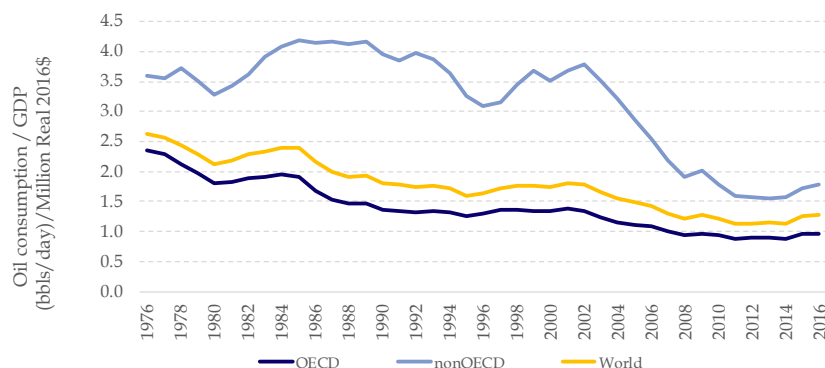
LEI's analysis of global-level data for GDP and oil consumption showed that the oil-intensity of the global economy resembled a descending staircase over the 40-year period from 1977-2016 (see Figure 1 above).

- Oil intensity declined in the late 1970s in response to the oil price shock; then, it recovered over a four- to five- year timeframe (fostered by the slowdown in the global economy which was deeper than the decline in oil demand);
- During the 1980s, energy efficiency policies such as the Corporate Average Fuel Economy (“CAFE”) standards in the United States which had been implemented during the period of high oil prices began to impact consumption; concurrently, many developed economies were transitioning to service-based economies in place of energy-intensive manufacturing activities. Oil intensity declined over about a decade, to 1995;
- A long period of low oil prices from about 1986 to 2000 eventually supported a somewhat more oil-intensive global economy, but oil intensity did not recover to anywhere near the levels of the early 1980s;
- Starting in 2001, the oil price up-cycle coincided with another decade of declining oil intensity. Global economic growth drove increases in demand for oil, but at a much lower rate than in the past, which led to declining oil intensity; and
- Beginning in about 2012, it appears that the decline in oil intensity has levelled off, and perhaps a new recovery is on the way for the near term.

2.1 OECD countries led the first decline in global oil-intensity of GDP, non-OECD led the second

During the years of high or rising oil prices of the 1970s and early 1980s, OECD countries reduced the oil-intensity of their economies (see Figure 2). In contrast, the non-OECD economies maintained their oil-intensity in the 1980s and into the early 1990s, reflecting the fast-growing production and manufacturing sectors and the increasing vehicle ownership in these countries.¹ But starting in 2002, oil consumption per unit of GDP declined rapidly in non-OECD countries. Structural change of the non-OECD economies was the main the driver of the closing gap between OECD and non-OECD's oil intensity. Studies have shown that during the 1990s to the 2010s, developing countries across Asia and Africa witnessed substantial declines in the share of the more energy-intensive manufacturing and production sectors and a notable increase in the share of the service sector in these economies.²

Figure 2. Global oil consumption per unit of GDP (1976-2016)



Note: The OECD and non-OECD groups in this chart are from the BP World Energy database (whereas the OECD and non-OECD countries included in LEI's econometric models are subsets of these two groups due to limited data availability)

Source: Oil consumption data: BP Statistical Review of World Energy June 2017

Population and GDP data: World Bank

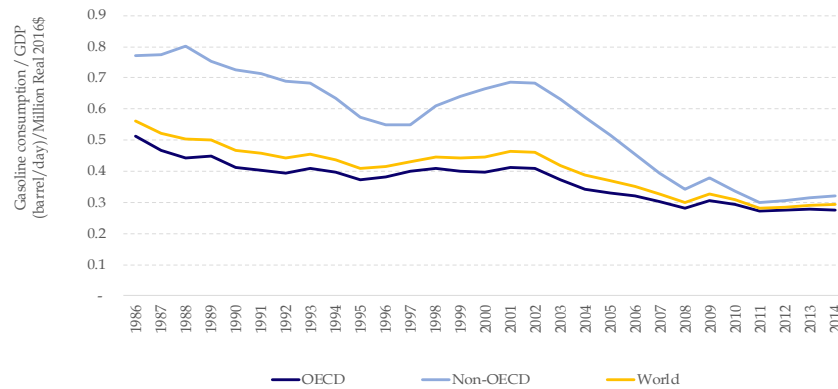
2.2 Gasoline consumption per unit of GDP declined dramatically in non-OECD countries

Gasoline intensity worldwide generally followed a pattern similar to crude oil intensity (see Figure 3), because gasoline is major driver of crude oil demand. Like crude oil, the gap between OECD and non-OECD countries' gasoline intensity started to converge from the early 2000s.

¹ OECD. *Oil Price Developments: Drivers, Economic Consequences and Policy Responses*. OECD Economic Outlook No. 76.

² United Nations Human Settlements Programme. *Structural Transformation in Developing Countries: Cross Regional Analysis*. 2016.

Figure 3. Global gasoline consumption per unit of GDP (1986-2016)

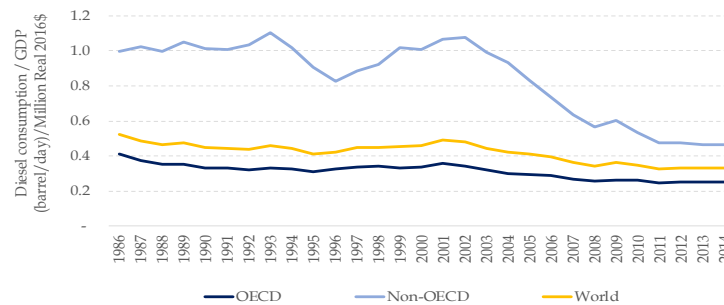


Source: Gasoline consumption data: US Energy Information Administration (“EIA”)
 GDP and population data: World Bank

2.3 Diesel consumption per unit of GDP declined dramatically in non-OECD countries

The diesel intensity of the world economy follows the same pattern as the crude oil intensity (see Figure 4). In 2002, the world diesel intensity was 0.5 bbl (barrel)/day per million dollars, yet by 2014 it was 0.3 bbl/day, a decline of almost 30% from the 2002 high. Gasoline intensity declined by 36% during the same time period. Non-OECD countries saw large declines starting in 2002 when economic growth surge ahead of diesel demand.

Figure 4. Global diesel consumption per unit of GDP (1986-2016)



Source: Gasoline consumption data: EIA
 GDP and population data: World Bank

The bottom line of this analysis of trends is that the economies of non-OECD countries have become much less oil intensive. The oil industry cannot simply rely on strong economic growth in non-OECD countries to continue to drive oil demand growth at levels seen in previous decades.

3 Econometric analysis

The trends examined in the previous section are informative, but on their own, they cannot isolate the individual impacts of the oil price and income (GDP) on oil demand. Econometric analysis does allow such isolation and measurement. CGEP was specifically interested in whether demand was more sensitive to price increases or price declines, which can be answered using an econometric model which allows for asymmetrical responses to changes in income and prices.

3.1 Methodology

Like the models in the econometric literature, our overall hypothesis was that oil demand is a function of two independent variables, or regressors: income (GDP) and oil prices. Like the models in the literature, we modeled the demand relationship as linear in logarithms. We tested an asymmetrical model (as well as a symmetrical model, for comparison). We estimated separate econometric models for crude oil, gasoline, and diesel fuel.

Although CGEP is ultimately interested in overall global impacts of prices and income, countries at different stages of economic development may have different responses to oil price changes and income (GDP) growth. For the purposes of the econometric analysis, therefore, we created several country groups and modeled them separately. We selected countries for each group based on their category (OECD, non-OECD, or oil exporting countries) as well as data availability. There was no overlap of countries in the groups.

To address how the elasticities have changed over time we estimated elasticities based on data from 1977-1996 (20 years) and separately for 1997-2016 (20 years). All the econometric models were based on a combination of time-series and cross-sectional data (referred to as panel data). The cross-sections are the various countries in the data set.

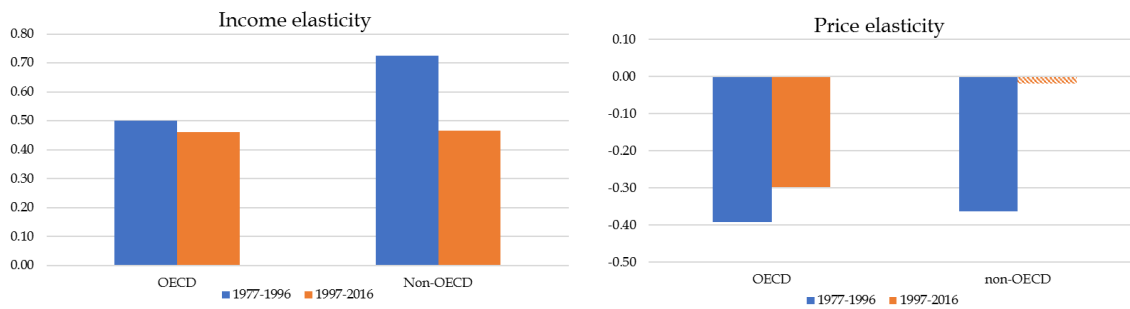
The cross-sectional aspect of the data captures persistent differences across countries. For example, countries with typically higher gasoline prices may drive less, given the same level of GDP. Countries with a smaller land mass or a smaller population may use less diesel and less gasoline (and/or less crude oil) for the same level of GDP. It also implies the elasticity estimated from such data will reflect long-term differences across countries.

3.2 Results for crude oil

3.2.1 Long-term relationship between economic growth and oil demand weakened

The econometric analysis showed that, indeed, income elasticities of crude oil demand were higher in the 1977-1996 period than the 1997-2016 period, for both a set of OECD and non-OECD countries (see Figure 5). For OECD countries the long-term income elasticity of demand was 0.50 based on 1977-1996 data (meaning a 1% change in GDP corresponded to 0.50% change in oil demand in the same direction). This elasticity declined to 0.46 in the 1997-2016 period. Non-OECD countries also showed a larger decline in the income elasticity of demand, from 0.72 to 0.47. Thus, the relationship between economic activity and oil consumption did not break down completely. It weakened but was still important.

Figure 5. Estimated long-term crude oil income and price elasticities



Note: The econometric models used to generate these results were dynamic, symmetric, fixed-effects models using panel data with total oil demand and total GDP.
 Shaded bars indicate not significant at 95 %
 Vertical axes are different scales

3.2.2 The long-term relationship between crude oil price and oil demand also weakened

OECD countries' price elasticity of demand declined from the first period to the second (see Figure 5 above). The group of non-OECD countries showed an even larger reduction in price elasticity, with a tiny and not statistically significant price elasticity in the later period.

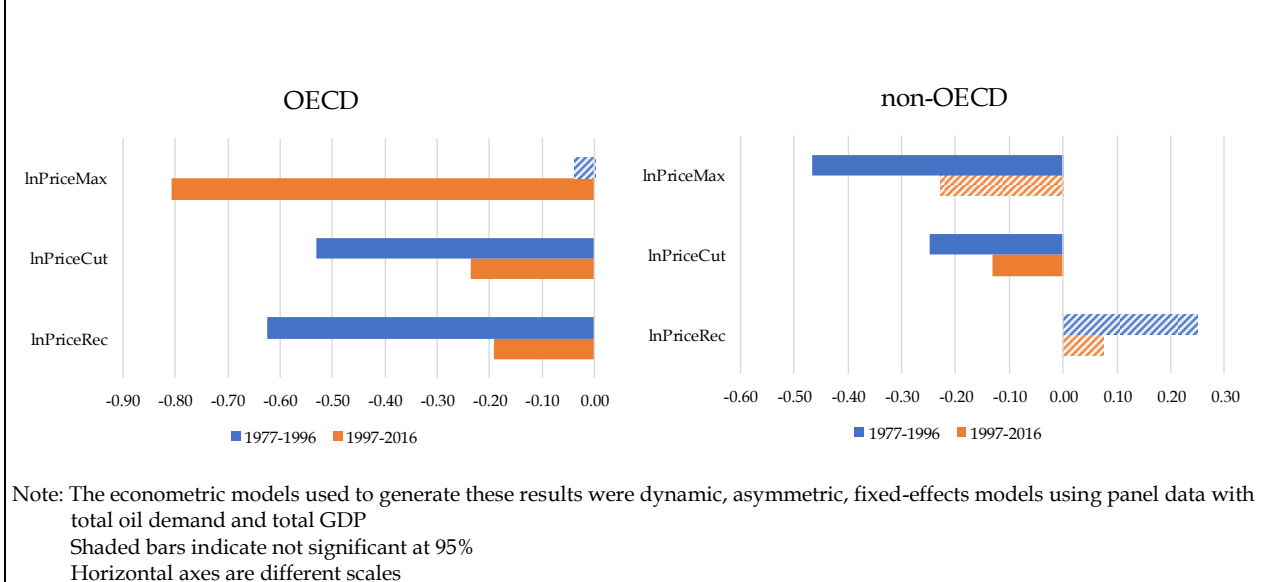
The decline in long-term price elasticity may reflect the response to an oil price spike driven by supply shocks (in the first period, which includes the 1970s) versus price surges owing to fast-growing demand (in the second periods, which includes 2001-2008). The price volatility in the earlier period was seen as a crisis – the “energy crisis,” and may have led consumers to expect a long period of high prices, or of physical shortages of oil. Also, opportunities to substitute other fuels for oil may have been more abundant in the 1970s and 1980s, as oil was more widely used for heating and electric power generation in many locations. Both these conditions would lead to higher (absolute) price elasticities of demand.

The oil price increases of 2001-2008 did not frighten consumers with visions of oil shortages; and did not ignite a global recession. There may have been fewer opportunities for efficiency gains or fuel-switching. Both these conditions would lead to lower absolute price elasticities of demand.

3.2.3 Falling oil prices had a slightly larger long-term impact than recovering oil prices, in the more recent period

The response to oil price changes was somewhat asymmetrical. OECD countries in the later period respond slightly more strongly to declines in oil prices than recoveries in oil prices (“recovering” oil prices refer to prices that are rising but do not exceed previous historical maximum levels) (see Figure 6). The non-OECD country group also responded more to falling oil prices than to recovering oil prices, but not as much as it had in the earlier period.

Figure 6. Estimated long-term asymmetric price elasticities, crude oil



3.2.4 Upward price shocks were a different matter

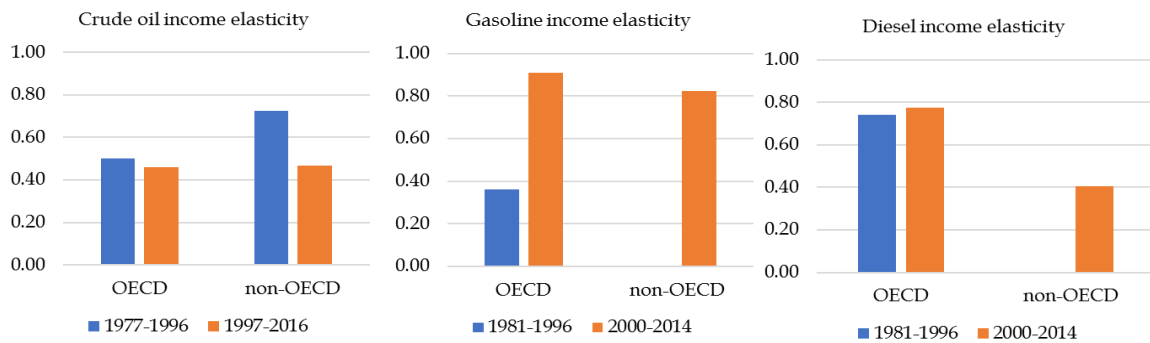
In response to a price shock, defined as a price which exceeds previous maximum levels and is tracked by the regressor “InPriceMax” referred to in Figure 6 above. the OECD group had a long-term price elasticity of demand of -0.81 in the 1997-2016 period. This response is larger than its response to either recovering or falling oil prices. This suggests that OECD consumers may perceive oil prices that exceed previous maximum levels as harbingers of a new long-term “playing field” of persistently high prices.

3.3 Gasoline had the highest income elasticities

Two refined products, gasoline and diesel fuel, provided the foundation for mobility in the 20th century, and continue to do so. Examination of these fuels was part of the CGEP assignment.

Income elasticities of demand for gasoline were higher than for crude oil (see Figure 7). As incomes increased, especially in developing countries, consumers were able to buy more cars and do more driving. Diesel, on the other hand, is more commonly used in the industrial sectors rather than by consumers. For diesel, income elasticities were higher than for crude oil in the OECD country group, but lower than for gasoline.

Figure 7. Long-term income elasticities of demand for gasoline and diesel compared to crude oil

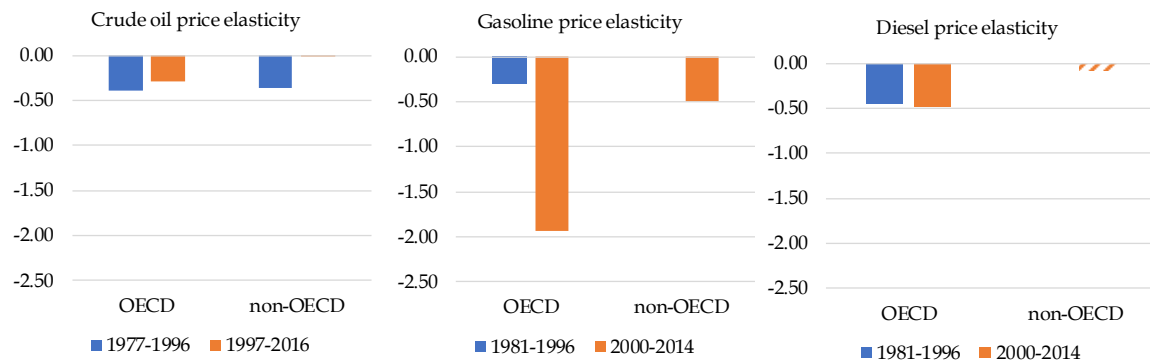


Note: The econometric models used to generate these results were dynamic, symmetric, fixed-effects models using panel data with total fuel demand and total GDP.

3.4 Gasoline and diesel had higher price elasticities than crude oil

Price elasticities of gasoline and diesel were larger than for crude oil (see Figure 8). This makes intuitive sense, because retail prices of gasoline and diesel are the prices that are actually experienced by consumers.

Figure 8. Long-term price elasticities of demand for gasoline and diesel compared to crude oil



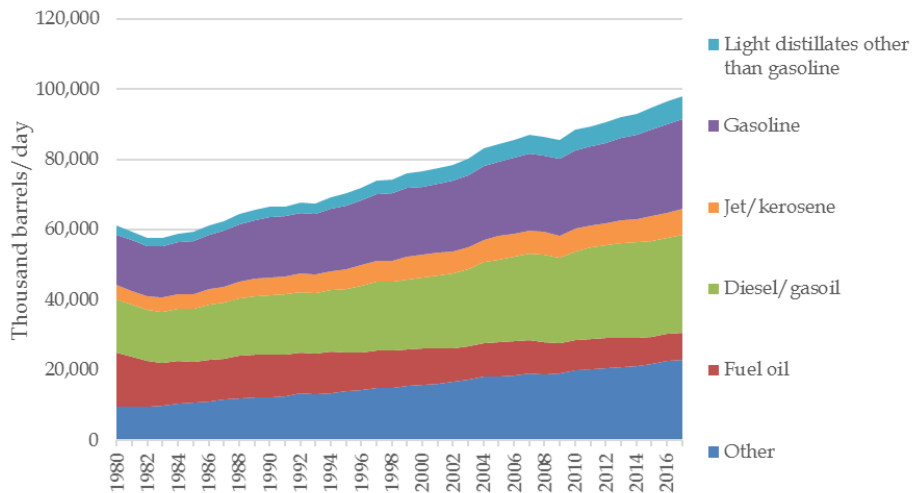
Note: The econometric models used to generate these results were dynamic, symmetric, fixed-effects models using panel data. Shaded bars indicate not significant at 95%

Price elasticities for gasoline were larger (in absolute value) than for diesel. This may be because gasoline prices impact households, who have little opportunity to pass the price increase along to others; while diesel is used more broadly in commercial transportation and in industry, and those sectors can pass all or some of the price increase to their customers, so have less incentive to respond to price changes.

As summarized above, although the price and income elasticities of gasoline and diesel increased from the first period to the second period, the price and income elasticities of crude oil declined. This seems unintuitive. However, gasoline and diesel are not the only products of crude oil. Fuel oil, a heavy product, has more substitutes than gasoline or diesel, and consumption of fuel oil

declined over the study period (see Figure 9). This would reduce the price elasticity of crude oil from the beginning of the period to the end, all else equal.

Figure 9. Global refined product consumption



Source: BP Statistical Review of World Energy

3.5 OECD gasoline demand was more sensitive to falling prices than rising prices

OECD group showed statistically significant long-term price elasticity results in the asymmetric gasoline models (see Figure 10). The long-term price elasticity for declining prices (lnPriceCut), at -3.04, was greater than for rising prices (lnPriceRec), at -0.28 in the 1997-2016 period. These are much larger elasticities than for crude oil. These results indicate that OECD consumers were sensitive to change in gasoline prices, especially to falling gasoline prices.

Figure 10. Gasoline asymmetric price elasticities

Time period	Price regressor	OECD Long-term	Non-OECD Long-term
1981-1996	lnPriceRec	-1.51	
2000-2014*	lnPriceRec	-2.05	<i>0.09</i>
1981-1996	lnPriceCut	-0.20	
2000-2014*	lnPriceCut	-3.04	<i>0.00</i>
1981-1996	lnPriceMax	0.63	
2000-2014*	lnPriceMax	2.08	<i>-0.82</i>

Italics indicate not significant at 95%.

*1997-2016 for OECD

3.6 Diesel demand was the opposite

In the 1997-2016 period, OECD demand for diesel responded more to price increases than to price declines: the coefficient for price recoveries, at -0.61 is larger in absolute value than the coefficient for price cuts, at -0.37. Diesel demand tends to reflect broader economic activity compared with gasoline demand, so that higher prices probably discourage consumption (i.e. encourage fuel efficiency efforts) more than lower prices incentivize more driving or less conservation.

Figure 11. Diesel asymmetric price elasticities

Time period	Price regressor	OECD Long-term	Non-OECD Long-term
1981-1996	lnPriceRec	-0.40	
2000-2014*	lnPriceRec	-0.61	<i>-0.20</i>
1981-1996	lnPriceCut	-0.88	
2000-2014*	lnPriceCut	-0.37	<i>0.10</i>
1981-1996	lnPriceMax	<i>0.18</i>	
2000-2014*	lnPriceMax	<i>0.01</i>	<i>-0.10</i>

Italics indicate not significant at 95%.

*1997-2016 for OECD

4 Literature review

The literature examining the price and income elasticity for crude oil and refined products dates back to the 1970s, and interest in the drivers of oil demand has not faded over the ensuing decades. One important question addressed in the literature is whether price and/or income elasticities may be asymmetric. Oil consumption—be it crude oil, gasoline, diesel, or other product—might decline more dramatically when prices increase than it rises when prices fall, for example, or they might do the opposite.

Our review of literature published within the last 15 years or so shows a variety of approaches to estimating demand, and a wide variety of resulting elasticity estimates (see Figure 12, Figure 13, and Figure 14). For example, for OECD countries as a group, short-term income elasticities of demand ranged from 0.027 to 0.80; and for non-OECD, they ranged from 0.031 to 0.905.

Even statistically significant results had a wide range of elasticity estimates. For example, estimates of (symmetric) income elasticities of 0.80 (Dargay & Gately, 2010), 0.65 (Fawcett & Price, 2012), and 0.27 (Javan & Zahran, 2015) were all reported to be statistically significant.

4.1 Results showed income elasticity lower in recent years

The data set used by Dargay & Gately began in 1971, and therefore captured the oil price volatility of the 1970s and 1980s. The Javan & Zahran data set began in 1992, well after that period of oil price volatility. Dargay & Gately used dynamic symmetric models for their OECD and “Income Grower” data sets³, as did Javan & Zahran, which makes comparison of the regression results straightforward. The Dargay & Gately results showed higher income elasticities of demand for both OECD and Income Growers (non-OECD) country groups than Javan & Zahran (see Figure 12). Results for price elasticities were consistent, in that both set of authors found higher (in absolute terms) OECD price elasticities of demand than non-OECD price elasticities of demand.

As a point of comparison, the International Energy Agency (“IEA”) projects global oil demand to increase from 97.8 mbd (million barrels per day) in 2017 to 104.7 mbd in 2023, an annual average rate of growth of 1.1%.⁴ It assumes world GDP growth of 3.8% per year over the same time, based on International Monetary Fund (“IMF”) projections. Thus, the implied income elasticity of demand in IEA’s outlook (if there were no projected changes to the price of oil from 2017 to 2023) is about 0.30.

³ Dargay & Gately’s “Income Grower” group is a subset of non-OECD countries which includes: Chile, Chinese Taipei, Cyprus, Dominican Republic, Egypt, Hong Kong, India, Malaysia, Malta, Myanmar, Pakistan, Singapore, Sri Lanka, Thailand, Tunisia, Vietnam, and Yemen.

⁴ IEA. *Market Series Report: Oil 2018*. March 2018.

Figure 12. Oil demand elasticity estimates from recent literature

Author (publication date), data, method	Period	Countries	Short-term Elasticity		Long-term elasticity	
			Income	Price	Income	Price
Cooper 2003	Individual country time series models, per capita data, dynamic model using lagged consumption; symmetric model; model incorporates income regressor but results for income elasticities are not reported					
	1979 - 2000	US	not reported	-0.061	not reported	-0.453
	1979 - 2000	China	not reported	0.001	not reported	0.005
Dargay & Gately 2010	Per-capita, panel data, fixed effects; dynamic, with lagged variables which included lagged consumption, lagged prices, and/or lagged income depending on the country group					
	1971 - 2008	OECD	0.80	-0.03	0.80	-0.29
	1971 - 2008	G7	0.89	-0.03	0.89	-0.21
	1971 - 2008	Income Growers	0.35	-0.03	0.87	-0.07
	1980 - 2007	China	0.16	not sig, dropped	0.74	not sig, dropped
	1971 - 2007	Oil Exporters	YMax = 0.141; YCut = 0.048; YRec = 0.099	not sig, dropped	YMax = 1.0; YCut = .34; YRec = 0.70	not sig, dropped
	1996 - 2007	Former Soviet Union	0.37	not sig, dropped	0.43	not sig, dropped
	1971-2007	Other Countries	YMax = 0.56; YCut = 0.58; YRec = 0.22	PMax = -0.06; PCut = -0.02; PRec = -0.01	YMax = 1.0; YCut = 1.03; YRec = 0.39	PMax = -0.12; PCut = -0.04; PRec = -0.01
	Fawcett & Price 2012	Per-capita, panel data, fixed effects; dynamic symmetric error-correction model with lagged values of all regressors				
1984-2009		G7	0.650	0.008	0.267	-0.068
1984-2009		Other OECD	0.610	-0.047	0.930	-0.075
1984-2009		Developing Asia	0.736	-0.017	0.681	-0.106
1984-2009		Latin America	0.905	-0.006	1.321	-0.154
Jobling & Jamasb 2014	Per-capita, panel data, fixed effects; dynamic asymmetric, with oil demand as lagged variable					
	1980-2012	11 OECD ("Developed")	YMax = 0.027; YCut = 0.085; YRec = 0.079	PMax = -0.057; PCut = -0.028; PRec = -0.031	0.213	-0.389
	1980-2012	5 non-OECD ("Developing")	YMax = 0.059; YCut = 0.164; YRec = 0.031	PMax = -0.047; PCut = -0.053; PRec = -0.017	0.435	-0.348
Javan & Zahran, 2015	Quarterly, per-capita, panel data with fixed and random effects; dynamic (using lagged value of consumption); three-year moving average of oil price used as price regressor, symmetric model					
	1992-2012	US	0.34	-0.09	0.94	-0.24
	1992-2012	China	0.34	-0.03	0.76	not sig, dropped
	1992-2012	OECD	0.27	-0.08	0.67	-0.2
	1992-2012	non-OECD	0.12	-0.02	0.69	-0.09
	1992-2012	BICS	0.10	0.00	0.61	not sig, dropped
	1992-2012	North America	0.23	-0.05	0.94	-0.19
	1992-2012	Europe	0.25	-0.07	0.95	-0.26
	1992-2012	Developed Asia	0.47	-0.18	0.57	-0.22
	1992-2012	Emerging Asia	0.14	-0.03	0.79	-0.17
	1992-2012	Latin America	0.11	0.01	0.44	not sig, dropped

Figure 13. Highlights of literature review: Range of short-term crude oil elasticities

Country or group	Range of short-term elasticity estimates	
	Income	Price
OECD	0.027 to 0.80	-0.057 to 0.008
non-OECD, or other group of developing countries	0.031 to 0.905	-0.006 to 0.05
US	0.34	-0.061 to -0.09
China	0.16 to 0.34	-0.03 to 0.001

Figure 14. Highlights of literature review: Long-term elasticities crude oil compared across symmetric dynamic models

Authors	Time period	Country group	Long-term elasticity estimates	
			Income	Price
Dargay & Gately	1971 - 2008	OECD	0.80	-0.29
	1971 - 2008	Income growers	0.87	-0.07
Javan & Zahran	1992 -2012	OECD	0.67	-0.20
	1992 -2012	non-OECD	0.69	-0.09

Although other researchers used somewhat different time periods, regressors, and country groups (for non-OECD), it can be useful to compare econometric results at a high level. LEI's long-term income elasticities were generally somewhat lower than those found by previous researchers (see Figure 15).

Figure 15. LEI's long-term elasticities compared to results in the literature (symmetric, dynamic models)

Authors	Time period	Country group	Long-term elasticity estimates	
			Income	Price
Dargay & Gately	1971 - 2008	OECD	0.80	-0.29
	1971 - 2008	Income growers	0.87	-0.07
Javan & Zahran	1992 -2012	OECD	0.67	-0.20
	1992 -2012	non-OECD	0.69	-0.09
LEI	1977 - 1996	OECD	0.50	-0.39
	1977 - 1996	non-OECD	0.72	-0.36
LEI	1997 - 2016	OECD	0.46	-0.30
	1997 - 2016	non-OECD	0.47	-0.02

5 Conclusions and implications

The trends of the past 40 years and the econometric analysis of the drivers of crude oil demand during that time indicate the following answers to CGEP's framing questions about oil prices, economic activity, and oil demand.

5.1 The relationship between economic activity and oil demand

Has the oil intensity of the global economy been declining since the 1980s and 1990s?

Yes, crude oil, gasoline, and diesel intensity have all been declining. As shown in Figure 1 through Figure 4 previously, this decline was driven mostly by non-OECD countries, though OECD countries also show this trend. However, beginning in about 2012, it appears that the decline in crude oil intensity has levelled off, and perhaps a new recovery is on the way for the near term. The decline in gasoline and diesel intensity is still under way, which implies that potential growth in oil intensity will probably come from demand for other types of petroleum products, such as petrochemicals.

Has the relationship between oil demand and economic activity broken down?

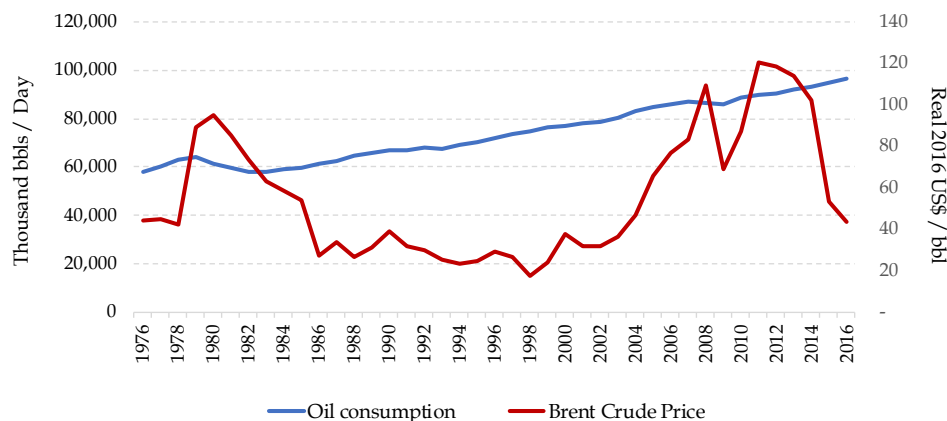
The relationship has not broken down, but it is much weaker. As shown in Figure 5 previously, the income elasticity of oil demand declined over the past 40 years and was lower for the 1997-2016 period than for the 1977-1996 period. However, the income elasticity of demand during 1997-2016 was still about 0.46, meaning a 1-percent increase in GDP growth corresponded to a 0.46 per cent increase in oil demand during that time. The overarching implication of this trend is that the oil industry cannot simply rely on strong economic growth in non-OECD countries to continue to drive oil demand growth at levels seen in previous decades.

5.2 The relationship between oil prices and oil demand

Was there an acceleration in the pace of oil demand growth during the long period of low oil prices?

Yes, there was a slight acceleration: During the long period of low oil prices (from about 1986-2002) global crude oil demand grew fairly steadily, at about 1.6 percent annually. Within that period, demand grew at 1.4 percent annually from 1986-1993; and then 1.6 annually from 1994-2002, indicting a slight acceleration. However, this rate of growth was far short of what would have been needed to allow oil demand to resume the trajectory it had established in the 1960s and 1970s (see Figure 16).

Figure 16. Global oil consumption and global oil prices



Source: BP Statistical Review of World Energy 2017

Is the relationship different for oil price shocks and are the effects lasting?

For upward shocks to crude oil prices (as compared to price recoveries in which prices do not exceed previous maximum levels), OECD and non-OECD countries had larger demand responses than to gradually increasing prices, or to falling prices in the 1996-2016 period (see Figure 6 previously). The oil demand trend data shown in Figure 16 above indicate that these effects were long-lasting, because oil demand never recovered the trajectory it had established going into the 1970s.

Are there asymmetric impacts for oil price increases and declines?

Yes, for crude oil falling oil prices had a slightly larger long-term impact than recovering oil prices, for 1997-2016 (see Figure 6 previously).

For gasoline, in the 1997-2016 period OECD demand responses to falling prices was greater than those for rising prices (see Figure 10 previously). Consumers are highly aware of gasoline prices and seem to adjust accordingly – witness the surge in sales of SUVs in the United States during the period of low oil and gasoline prices.

For diesel, the opposite occurred. In the 1997-2016 period, OECD demand for diesel responded more to price increases than to price declines (see Figure 11 previously).

How would a period of sustained low gasoline and diesel prices impact global oil demand growth?

The finding that gasoline consumers responded more to price cuts than to price recoveries in the recent period may provide oil producers with some comfort that persistently low oil prices would at least help support demand. This implies that second order impacts, or rebound effects, could help mitigate the demand-reducing effects of EVs, for example.

5.3 Final observations

The weakening income elasticity of oil demand over the past 40 years reflects deep and long-term changes in the way the world has used crude oil. It also implies that further changes, including moving away from using oil for transportation, will eventually also have profound and long-lasting effects on total global oil demand. Our results imply that income elasticities would have to decline substantially to flatten oil demand growth, assuming a smooth trajectory of global GDP growth. However, changes in the way in which economies use oil are on the horizon and could result in such a decline.

Alternatively, demand could follow a path which would result in periodic setbacks that would not be overcome in subsequent years. An upward price shock that triggered a decline in demand could, as in the past, reduce oil intensity to a level that would not recover fully, despite subsequent economic growth and a return to low oil prices.

The profile of oil demand is set to change, with demand for petrochemicals for plastics and fertilizers expected to be an increasingly important driver of oil demand. At the same time, other fundamental changes are potentially on the horizon (for example, the widespread adoption of electric vehicles) and they could result in a further decline in long-term income elasticities of oil demand. This could lead to the next downward step in global oil-intensity: though demand could continue to increase, it will struggle “up the down staircase.”

6 Appendix A: Works cited

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