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The demand for petroleum products: industrial sector in Thailand

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Atlanta University

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THE DEMAND FOR PETROLEUM PRODUCTS:
INDUSTRIAL SECTOR IN THAILAND

A THESIS
SUBMITTED TO THE FACULTY OF ATLANTA UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF ARTS

BY
JERARAK SAENGCHAN

DEPARTMENT OF ECONOMICS

ATLANTA, GEORGIA
DECEMBER 1987
ABSTRACT
ECONOMICS

SAENGCHAN, JERARAK B.A., Ramkamhaeng University, 1982

The Demand for Petroleum Products: Industrial Sector in Thailand

Adviser: Dr. Fred O. Boadu

Thesis dated December 1987

The demand for petroleum product has been increasing rapidly in the industrial and transportation sectors in Thailand. This is due to economic growth and the increasing population. There is a need for more information to address the problem created by the increased demand for petroleum resources.

The purpose of this thesis is to describe and examine the demand for petroleum product for the industrial and transportation sectors in Thailand. Demand is expressed as a function of price and the level of economic activities.

Time-series data for Thailand will be used to estimate the parameters of a specified demand function for the period 1971-1981. The empirical results are consistent with the predictions of economic theory. More specifically, a positive relationship was found between quantities of each petroleum product used and the level of economic growth. We also found negative relationship between price and quantities of each petroleum used. Estimates of elasticities showed -1-
that prices are inelastic with respect to quantities demanded of gasoline, diesel and fuel oil. This indicates that gasoline, diesel and fuel oil are critical inputs in the industrial and transportation sectors.
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</tr>
</tbody>
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ACKNOWLEDGEMENTS

I wish to thank Dr. Charlie Carter and the Department of Economics at Atlanta University for providing me the opportunity to carry out this thesis. Special acknowledgement goes to my thesis adviser, Dr. Fred O. Boadu, for his guidance and assistance. Lastly, I wish to thank my father and mother for their support.
CHAPTER I
INTRODUCTION

Growth of petroleum products consumption in Thailand was rapid in the 1960s and during much of the 1970s (Table 1). This was due to a rapid growth in the economy, and also because of the structural transformation of the economy. The latter included the extension of commercial agriculture with its reliance on a rapidly expanding road network and increasing farm mechanization; rapid growth in the industrial and service sectors; and higher personal incomes leading to higher private usage of energy for automobiles, air conditions, lighting, and home appliances. During the 1970s, the continued growth in energy consumption was also due to the fact that domestic energy prices were not adjusted in line with the 1973 increase in the international oil price. Since domestic energy resources remained of limited importance, most of the growth in the energy demand spilled over into rapidly expanding energy imports, which by 1978 accounted for twenty-one percent of the total imports and absorbed twenty-eight percent of export earnings.

After the second oil shock (1979-1980), the share of Thailand's energy imports increased to thirty-one percent and required forty-five

TABLE 1
DEMAND FOR PETROLEUM CONSUMPTION IN THAILAND, 1974-1981
(In Millions of Liters)

<table>
<thead>
<tr>
<th>Date</th>
<th>Gasoline</th>
<th>Diesel</th>
<th>Fuel Oil</th>
<th>Kerosine</th>
<th>LPG</th>
<th>Jet Fuel</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>1,606.0</td>
<td>2,954.5</td>
<td>2,536.1</td>
<td>240.7</td>
<td>161.2</td>
<td>713.5</td>
<td>8,112.0</td>
</tr>
<tr>
<td>1975</td>
<td>1,762.5</td>
<td>2,866.8</td>
<td>2,648.3</td>
<td>206.4</td>
<td>194.5</td>
<td>834.6</td>
<td>8,513.1</td>
</tr>
<tr>
<td>1976</td>
<td>1,963.0</td>
<td>3,356.5</td>
<td>2,924.1</td>
<td>294.5</td>
<td>223.2</td>
<td>854.7</td>
<td>9,616.0</td>
</tr>
<tr>
<td>1977</td>
<td>2,182.8</td>
<td>3,726.6</td>
<td>3,528.8</td>
<td>285.1</td>
<td>243.9</td>
<td>763.3</td>
<td>10,733.5</td>
</tr>
<tr>
<td>1978</td>
<td>2,307.3</td>
<td>3,926.0</td>
<td>3,977.2</td>
<td>265.8</td>
<td>277.1</td>
<td>785.4</td>
<td>12,244.9</td>
</tr>
<tr>
<td>1979</td>
<td>2,324.5</td>
<td>4,410.5</td>
<td>3,972.4</td>
<td>323.5</td>
<td>328.6</td>
<td>885.4</td>
<td>12,244.9</td>
</tr>
<tr>
<td>1980</td>
<td>2,298.4</td>
<td>4,374.3</td>
<td>4,004.6</td>
<td>300.1</td>
<td>366.7</td>
<td>958.8</td>
<td>12,294.1</td>
</tr>
<tr>
<td>1981</td>
<td>2,101.4</td>
<td>3,972.2</td>
<td>3,602.3</td>
<td>391.3</td>
<td>479.9</td>
<td>1,007.9</td>
<td>11,505.1</td>
</tr>
<tr>
<td>Average% Change Per Year</td>
<td>4.52</td>
<td>3.46</td>
<td>4.57</td>
<td>9.76</td>
<td>16.24</td>
<td>2.32</td>
<td>6.81</td>
</tr>
</tbody>
</table>

percent of the economy's total export earnings to finance these imports in 1982.²

The expectation of continued rapid increase in the real world price of energy and the need for continued rapid growth of the Thai economy, led to the preparation of the Fifth Five-Year Plan.³ The plan addressed three interrelated basic energy sector issues:

1) Appropriate energy prices set to reflect opportunity costs;

2) Reduction in the growth of energy consumption, and substitution of resources for imported energy through appropriate pricing, conservation measures, and domestic energy development; and

3) Improved energy sector management.

Substantial advances have been made in some important areas of energy policy, especially pricing. There is need for more information to enable policymakers develop appropriate measures to address specific problems in various energy sectors. Even though petroleum prices have fallen considerably in recent times, there is a consensus that the conditions that prevailed in the 1970s ought not surprise us again. This study is in support of this consensus.

Objectives

The objectives of this study are as follows:

1) To identify the factors that influence the demand for selected petroleum fuels in the industrial and transportation sectors of Thailand;


³Thailand has a five-year period of economic and social development, with the First Five-Year Plan beginning in 1961.
2) To quantitatively estimate the effect of the identified factors on the demand for selected petroleum products in the industrial and transportation sectors of Thailand; and

3) To estimate the changes in quantity in response to changes in the price of petroleum products in the industrial and transportation sectors of Thailand.

The World Petroleum Market

To address the stated objectives, we begin with an analysis of the world petroleum market and a brief history of the Organization of Petroleum Exporting Countries (OPEC). The dominating feature of world petroleum is the preeminence of the Middle East, accounting for over one-third of the world production and fifty-five percent of world reserves. If North Africa is added, the shares become forty-three and sixty-three percent respectively (production and reserves). If the other major oil producers outside the Middle East are included, these proportions go up to one-half and seven-tenths. The dominance of the Middle East in world oil production is quite recent. Before World War II, three countries (the United States, the U. S. S. R., and Venezuela) accounted for more than eighty percent of world output, compared to the Middle East's share of less than six percent. The U. S. still produces twenty percent of the world's oil and, although she processes a little

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more than five percent of proven reserves, her position would be very healthy, were it not for very high energy consumption and the relatively inelastic demand for gasoline.\(^6\)

Since the 1950s, a stream of new discoveries of very low-cost oil, combined with escalating demands from the developed countries, have steadily boosted the Middle Eastern share to its present levels. Demand has been doubling approximately every decade.\(^7\) This exponential growth cuts heavily into available reserves. Even today's world output equals about three percent of known reserves--thirty-five years of production at current rates, but demand will continue to grow. Extrapolating recent growth rates; consumption in the year 2000 could be equal to about twenty-three percent of current proved reserves. Obviously, world petroleum reserves will be exhausted before then, unless either new discoveries are made on a substantial scale or growth is moderate. The most likely outcome is a mixture of both, with the oil producers, themselves, controlling demand by fixing prices or output.\(^8\)

There are moderate grounds of optimism in regard to new discoveries. The sharp upward movement in prices will stimulate new exploration. Even before prices rose, however, there have been increases in the

\(^{6}\)Ibid.


stock of reserves. Major new producers such as Nigeria have entered the market. Although discoveries in the North Sea and Alaska have made only marginal additions to world reserves, the Alaskan fields have hardly been touched. Discoveries offshore in such areas as the Gulf of Mexico, the North Atlantic, the Pacific, and more recently, in the Persian Gulf, raise the hope of more offshore fields in these and other areas. Also, there have been recent small-scale discoveries in some Latin American countries (e.g., Bolivia) so that it is at least a possibility that other Latin American countries may join Venezuela and Mexico as major producers.9

Despite this optimism, there is little evidence in recent discovery experience that the Middle Eastern-North African hold on the oil market can be weakened, or that the long-run supply constraints can be avoided. Saudi Arabia holds thirty-eight percent of the Middle East's reserves, followed by Kuwait with eighteen percent and Iran with seventeen percent.10 Libya owns more than one-half of North African reserves and Algeria one-quarter. Apart from the U. S. S. R. (second only to Saudi Arabia) and the United States, the other leading oil nations (from a reserves point of view) outside the Middle East and North Africa are Nigeria, Venezuela, Indonesia, and Canada. OPEC's export capacity is


10Pindycky, The Structure of World Energy Demand, p. 33.
expected to increase from thirty MBD\(^{11}\) in 1973 to more than fifty-three MBD by 1985. Of this projected total, Saudi Arabia alone would account for thirty-six percent, with Libya and Iran accounting for less than fifteen percent each.\(^{12}\) Whether or not this capacity will be reached, depends on a myriad of unforeseeable factors: the success of demand restraint in the industrial world; the rate of economic development in developing countries; production decisions within the individual OPEC countries; and the unity and durability of OPEC itself. The survival of OPEC will depend, to a very large extent, on the policy pursued by Saudi Arabia.\(^{13}\)

**History of OPEC**

In the 1950s, the dominant pattern of concession agreements between the oil companies and the oil-producing countries was that the companies paid the host government a tax on profits realized from the sale of exported oil. The tax rate was fifty percent of the profits calculated on a public price—the posted price.\(^{14}\) The host governments had a strong interest in keeping these posted prices as high as possible because

\(^{11}\)MBD means millions of barrels per day.

\(^{12}\)Pindycky, *The Structure of World Energy Demand*, p. 34.

\(^{13}\)Ibid.

this boosted their tax receipts. However, rapid expansion in supply
associated with new discoveries from the mid 1950s placed downward
pressures on prevailing posted prices. A gap emerged between the
posted price and the market price; oil company tax payments were
related to the posted price, and as a result, the companies made several
reductions in the posted price between 1958 and 1960. The consequent
loss in tax receipts and the threat of further losses led to the
formation of OPEC in 1960. Its original members were Iran, Iraq,
Kuwait, Saudi Arabia, and Venezuela. However, a trickle of new
members over the years has brought its present strength up to thirteen.

The primary goal of OPEC in its early years was to keep the posted
price as high as possible. It was successful in doing this, and the
posted price's effect became a tax reference price that served as a
basis for tax payment rather than a true market price. Other minor
concessions were gained during 1960. In 1962 and 1963, an agreement
was reached under which royalties were treated as deductions from
income rather than as income tax. This change raised the government's
share of the take, even though—until they were phased out—the oil

15Ibid.
16Fried and Schultze, Higher Oil Price, pp. 227-228.
17Szulc, The Energy Crisis, p. 73
18Ibid., pp. 74-75.
19Ibid.
companies were allowed partial offsets from the posted price. In 1967, three OPEC members (Venezuela, Libya and Indonesia) changed over from the old system of taxing real profits to the tax reference price system. In 1968, OPEC issued a declaration calling for renegotiation of existing contracts and determination of posted prices by the host governments so that they would move in line with world prices of manufactured goods, and eventual OPEC country participation in concessions.

Up to 1970, however, the consensus was that though OPEC appeared to be winning the minor skirmishes, the oil companies were winning the war. As a cartel, OPEC was ineffective. The countries were suffering from overproduction in an era when demand was growing more modestly than in more recent years. They differed widely in their reserves, their fiscal needs, and their development potential. They lacked a tradition of cooperation, a mechanism for restricting output, and an identity of interest. The oil companies knew their interests better. They produced, transported, refined, and marketed the oil. They maintained their profits remarkably well and were very successful in their dealings with consumers so that they could easily afford minor concessions to the host countries.

20Schurr and Homan, Middle Eastern Oil, pp. 123-124.
21Ibid.
22Shwadran, The Middle East Oil, pp. 524-528.
23Ibid.
24Ibid.
In 1970 to 1971, everything changed. Quite suddenly, rapid demand growth ran ahead of capacity.\textsuperscript{25} There were output cutbacks in Libya, while the United States finally ran out of excess capacity. In September of 1970, posted prices made their first notable advance since the formation of OPEC.\textsuperscript{26} Crude oil from Libya, Nigeria, and the Mediterranean ports handling Iraqi and Saudi Arabian crude increased price by about thirty cents per barrel.\textsuperscript{27} In addition, the tax rate was raised from fifty to fifty-four thru fifty-eight percent. Iran and Kuwait followed a similar path in November of 1970, and so did Venezuela in December.\textsuperscript{28} These actions were facilitated by the closure of the Trans-Arabian pipeline in May of 1970 and the aftermath of the closing of the Suez Canal in the 1967 Arab-Israeli War.\textsuperscript{29} As a result of the Arab-Israeli War, there was a shortage of tanker capacity needed to ship Persian Gulf oil via a long route around Africa.

In February of 1971, the Tehran Agreement was signed between twenty-two international oil companies and six OPEC members.\textsuperscript{30} For the


\textsuperscript{26}Schurr and Homan, The Middle East Oil, pp. 124-125.

\textsuperscript{27}Ibid.

\textsuperscript{28}Ibid.

\textsuperscript{29}Ibid.

\textsuperscript{30}Szulc, The Energy Crisis, pp. 76-77.
first time, the oil companies bargained collectively with the producing countries rather than individually. In effect, there was collusion between the oil-producing countries and the multinational oil companies, despite window-dressing to convey the impression that they were bargain- ing hard with each other.31 Moreover, they were encouraged at this stage by the United States. The United States had two main motives: first, to use higher oil revenues for the Arab countries as a "sweetener" to induce them to be more willing to compromise in a political settle- ment with Israel. Second, to allow oil prices to drift upwards appeared to have advantages from the point of view of competition with Western Europe and Japan. Since these areas depended more on Middle Eastern supplies, but had benefited (despite high fuel taxes) from very cheap oil. The strategy backfired. Initially, because some of the oil producing countries quickly recognized that they did not need to cooperate with the oil companies; subsequently, because of the 1973 Arab-Israeli War and the decision to use the supply of oil as a political weapon.32

The balance of bargaining power had shifted perceptibly. The agreement included: an increase in posted prices of about thirty-three cents per barrel; upward adjustments in the prices of heavier crude; elimination of discounts; incremental increase in posted prices through

31 Ibid.
32 Ibid.
1975; and a minimum tax rate of fifty-five percent. A month later, a similar agreement was ratified at Tripoli. Prices were higher because of the closer proximity of Mediterranean ports to European markets. Other price supplements included a low-sulfur premium, a Suez Canal closure premium, and a freight rate component.

In the following year, the producing countries demanded a higher posted price to account for the declining purchasing power of the U. S. dollar. In January of 1972, under Geneva I, posted prices were raised by 8.5 percent. In the following year, the second Geneva agreement (Geneva II) provided for a June increase of almost twelve percent over the January level to compensate for the second U. S. dollar devaluation. Provision was made for a parity index to adjust prices according to changes in the value of the dollar, and minor price adjustments were made throughout 1973.

A new ingredient was introduced after October of 1972 with the signing of the General Agreement on Participation by several OPEC members. The governments would acquire (January 1973) a twenty-five

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34Ibid.
35Ibid.
37Ibid.
percent interest in all production facilities immediately, to be raised by fixed increments to fifty-one percent participation by 1982.\textsuperscript{39} Negotiations were also planned for the transportation and refinery facilities. To minimize market disruption, bridging arrangements were made for the first three years; however, oil purchased under these arrangements would be more costly. In April of 1973, Nigeria acquired a thirty-five percent interest in local shell-British Petroleum properties with the option to increase the share to fifty-one percent by 1982 or earlier.\textsuperscript{40}

The Petroleum Situation in Thailand

Petroleum Demand

The transportation sector accounts for forty percent of the petroleum product consumption; industry, twenty percent; power generation, twenty percent; household, ten percent; and other uses (especially agriculture), ten percent.\textsuperscript{41} Petroleum product consumption in the manufacturing sector increased at an average annual rate of about ten percent during the 1970s; but since 1979, it slightly declined in absolute terms as a result of a slowdown in industrial activities and

\textsuperscript{39}Ibid.

\textsuperscript{40}Ibid.

improvements in the sector's energy efficiency. The sector relies most heavily on fuel oil (see Table 2). Future growth in industry will, in part, draw on domestic gas resources to replace present fuel oil (e.g., in cement production) and to support expansion of industrial development into new areas, especially petrochemicals. Petroleum production consumption in the transport sector developed similar to that of manufacturing: increasing at a rate of eight percent annually during the 1970s, but then witnessing a slight decline since 1979, partly in response to the economic slowdown and partly due to gains in fuel efficiency brought about by increased fuel prices, progressive taxation of engine capacity, and fleet modification. The transport sector draws heavily on gasoline and diesel products and, in 1981 accounted for about ninety-one percent of the total consumption for the former, and fifty-two percent for the latter. The other major sector using diesel products extensively is agriculture (including fisheries) accounting for twenty-seven percent of the total diesel oil consumption in Thailand in 1981. Between 1979 and 1981, diesel fuel reduction in petroleum product consumption could be observed since 1979 in all the

43 Ibid.
44 Ibid., p. 41.
TABLE 2
PERCENTAGE DISTRIBUTION OF PETROLEUM PRODUCT CONSUMPTION BY SECTOR AND PRODUCT, 1981

<table>
<thead>
<tr>
<th>Type of Petroleum Product</th>
<th>Agriculture</th>
<th>Manufacturing</th>
<th>Electricity &amp; Water</th>
<th>Transportation &amp; Communication</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>0.0</td>
<td>2.4</td>
<td>0.0</td>
<td>91.6</td>
<td>6.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Diesel Oil</td>
<td>27.0</td>
<td>0.8</td>
<td>5.0</td>
<td>52.0</td>
<td>15.2</td>
<td>100.0</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>0.0</td>
<td>42.2</td>
<td>54.6</td>
<td>1.0</td>
<td>2.2</td>
<td>100.0</td>
</tr>
<tr>
<td>Kerosolene</td>
<td>0.0</td>
<td>20.9</td>
<td>0.0</td>
<td>0.9</td>
<td>78.2</td>
<td>100.0</td>
</tr>
<tr>
<td>Jet Fuel</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>100.0</td>
<td>--</td>
<td>100.0</td>
</tr>
<tr>
<td>LPG</td>
<td>--</td>
<td>24.2</td>
<td>--</td>
<td>6.7</td>
<td>69.1</td>
<td>100.0</td>
</tr>
</tbody>
</table>

major sector of Thai Economy.\textsuperscript{46} The scope for further reduction in petroleum product consumption across the sectors of the Thai Economy depends on each sector's capability to:

1) Substitute gas for oil, especially in industry and power generation (mainly oil); and

2) Reduce energy intensity in the major petroleum products used: for transportation about equally gasoline and diesel; mostly fuel oil in the manufacturing sector.\textsuperscript{47}

Petroleum Pricing\textsuperscript{48}

Through 1978, Thailand's domestic energy price increases were held substantially below the average import price of oil. The import price of oil increased more than sixfold between 1970 and 1978; however, the domestic price of electricity and gasoline only about doubled, roughly in line with domestic inflation (see Table 3). Since 1978, the government has substantially increased the domestic prices of energy in response to international price developments during the 1970s. Between 1978 and 1982, domestic energy prices to final users increased by about twenty-two percent. The domestic price level during the same period rose by only fifty-six percent.\textsuperscript{49} In September 1982, gasoline prices

\textsuperscript{46}Ibid.

\textsuperscript{47}Ibid.

\textsuperscript{48}Most of the discussion in this section is extracted from the National Energy Administration Study on Thailand.

<table>
<thead>
<tr>
<th>Date</th>
<th>Average Import of Oil (B/bbl)</th>
<th>Electricity (B/kwh)</th>
<th>Premium Gasoline a/ (B/l)</th>
<th>High Speed Diesel (B/l)a/</th>
<th>Fuel Oil a/ (B/l)</th>
<th>Consumer Price Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>43.1</td>
<td>100.0</td>
<td>2.10</td>
<td>0.98</td>
<td>100.0</td>
<td>/e 100.0</td>
</tr>
<tr>
<td>1971</td>
<td>49.0</td>
<td>113.7</td>
<td>2.10</td>
<td>0.98</td>
<td>100.0</td>
<td>/e 100.4</td>
</tr>
<tr>
<td>1972</td>
<td>50.8</td>
<td>117.9</td>
<td>2.10</td>
<td>0.98</td>
<td>100.0</td>
<td>/e 105.3</td>
</tr>
<tr>
<td>1973</td>
<td>64.2</td>
<td>149.0</td>
<td>2.30/b</td>
<td>1.05/b</td>
<td>107.1</td>
<td>/e 121.7</td>
</tr>
<tr>
<td>1974</td>
<td>209.2</td>
<td>485.4</td>
<td>3.62/c</td>
<td>2.33/c</td>
<td>237.8</td>
<td>1.44 151.3</td>
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<tr>
<td>1975</td>
<td>232.0</td>
<td>538.3</td>
<td>3.62</td>
<td>2.33</td>
<td>237.8</td>
<td>1.44 159.3</td>
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<td>1976</td>
<td>250.1</td>
<td>580.3</td>
<td>3.62</td>
<td>2.33</td>
<td>237.8</td>
<td>1.44 166.0</td>
</tr>
<tr>
<td>1977</td>
<td>269.1</td>
<td>624.4</td>
<td>4.22/d</td>
<td>2.64/e</td>
<td>269.4</td>
<td>1.61 177.9</td>
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<td>1978</td>
<td>286.3</td>
<td>664.3</td>
<td>4.85</td>
<td>2.64</td>
<td>269.4</td>
<td>1.61 192.8</td>
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<tr>
<td>1979</td>
<td>395.1</td>
<td>916.7</td>
<td>6.72</td>
<td>3.99</td>
<td>404.1</td>
<td>2.35 211.3</td>
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<tr>
<td>1980</td>
<td>668.5</td>
<td>1,551.1</td>
<td>9.80</td>
<td>6.54</td>
<td>667.4</td>
<td>3.61 252.8</td>
</tr>
<tr>
<td>1981</td>
<td>821.6</td>
<td>1,906.3</td>
<td>12.03</td>
<td>7.39</td>
<td>754.1</td>
<td>4.47 285.7</td>
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<td>1982</td>
<td>871.7</td>
<td>2,022.6</td>
<td>13.45</td>
<td>7.39</td>
<td>754.1</td>
<td>4.47 300.6</td>
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<td>1983</td>
<td>771.5</td>
<td>1,790.0</td>
<td>12.60</td>
<td>6.99</td>
<td>713.3</td>
<td>4.09 305.3</td>
</tr>
</tbody>
</table>

/a Retail in Bangkok
/b In July, gasoline raised to B50 3.01 and diesel raised to B 1.60 in December
/c Raised in February
/d Raised in March
/e Uncontrolled prior to October 1974
/f April 1983
/g March 1983


Thailand's currency unit is Baht.
were more than one hundred percent above CIF import price, and diesel and fuel oil prices were about fifteen percent and three percent, respectively. Kerosine was the only major petroleum product for which retail prices were below CIF price (see Table 4). In the wake of the international oil price reduction during 1982, and particularly following the reduction in official OPEC price in March 1983, domestic petroleum product prices were also reduced.\textsuperscript{51} However, the weighted average decrease in domestic petroleum product prices was only five percent, while imported crude oil prices declined by ten to twelve percent so that the ratio of domestic prices to import prices increased for all petroleum products, with the exception of LPG. As a result, all petroleum product prices in Thailand now exceed import prices, including that of kerosine.\textsuperscript{52}

The structure of petroleum product prices, however, has not reflected the structure of costs, since substantial taxes have been levied on gasoline products (about 105 percent for premium gasoline and 88 percent for regular gasoline in September 1982), while diesel products and fuel oil are hardly taxed at all (ten percent and one percent respectively), and kerosine and LPG are subsidized at moderate rates.


\textsuperscript{52}Ibid.
TABLE 4
DOMESTIC PRICES AND TAXES FOR PETROLEUM PRODUCTS, SEPTEMBER 1982

<table>
<thead>
<tr>
<th>Petroleum Product</th>
<th>Retail Price (June 1978 = 100)</th>
<th>Retail Price as % of Import/Price</th>
<th>Oil Fund Contribution (Subsidy) as % of Import Prices</th>
<th>Total Tax (Subsidy) as % of Cost</th>
<th>Total Tax (Subsidy) Rate as % of Tax Rate on Regular Gasoline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premium Gasoline</td>
<td>270</td>
<td>222 (236)</td>
<td>49</td>
<td>105 (116)</td>
<td>119 (107)</td>
</tr>
<tr>
<td>Regular Gasoline</td>
<td>243</td>
<td>204 (229)</td>
<td>28</td>
<td>88 (108)</td>
<td>100 (100)</td>
</tr>
<tr>
<td>Kerosine</td>
<td>228</td>
<td>93 (107)</td>
<td>(20)</td>
<td>117 (132)</td>
<td>11 (20)</td>
</tr>
<tr>
<td>High-speed Diesel</td>
<td>280</td>
<td>117 (132)</td>
<td>(5)</td>
<td>10 (22)</td>
<td>11 (20)</td>
</tr>
<tr>
<td>Low-speed Diesel</td>
<td>285</td>
<td>114 (128)</td>
<td>(6)</td>
<td>9 (22)</td>
<td>10 (20)</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>280</td>
<td>103 (107)</td>
<td>1</td>
<td>1 (4)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>LPG</td>
<td>185</td>
<td>116 (103)</td>
<td>(7)</td>
<td>(6)(14)</td>
<td>(7) ([13])</td>
</tr>
</tbody>
</table>

/a Figures in brackets are for June 1983.
/b Cost defined as import price plus market margin; total tax equals import or excise taxes plus oil fund contribution.
/c These columns demonstrate that (with the exception of LPG) the dispersion of tax rates as petroleum products has been reduced between September 1982 and June 1983.

Considering the high degree of substitutability among different types of petroleum products, significant price differentials in excess of cost differences can lead to inefficient consumption patterns. The relatively low prices of diesel fuel and kerosine in Thailand, as elsewhere, are the result of distributive and regional policy considerations. Diesel fuel is used mainly in agriculture (including fisheries) and in transport (in particular, trucking), while kerosine is used mainly by rural households. However, the benefits of such subsidization have to be measured against the efficiency losses inherent in substantial relative price distortions and the fiscal costs of the subsidies. In particular, a correction of the gasoline-diesel price discrepancy would result in a better balancing of the present refinery capacity in Thailand. Presently, the Thai refinery balance is characterized by a scarcity of diesel production capacity, which, in the absence of prices designed to balance demand, would require costly investment in new refinery capacity or by imports. The government has

53 In the wake of the international oil price changes in early 1983, domestic petroleum product prices were reduced; however, with the exception of LPG, tax rates on petroleum products effectively increased as shown by the figures in brackets in Table 4, but the differences among each other were narrowed.


56 Ibid.
recently initiated an energy pricing study in the context of its structural adjustment program.57

One way to address the issue confronting the Thai energy sector is to generate the necessary elasticity estimates to serve as informational input into the public policymaking process. This thesis focuses on estimating basic price and income elasticities in the energy sector in Thailand. Information about these responses should aid in prediction and policymaking.

CHAPTER II
LITERATURE REVIEW

Several studies have been undertaken on the demand for energy by the industrial sector. Murti and Sastry estimated a production function of the Cobb-Douglas type and applied it to Indian industry.¹ They used cross-section data relating to individual firms rather than industrial aggregates for the years 1951 and 1952. For the year 1951, they had data from 607 firms covering twenty-eight manufacturing industries, and for the year 1952, they used data covering 320 firms. The model used in their study may be expressed as:

\[ Y_i = a' * Y_1^{\alpha_1} * Y_2^{\alpha_2} \]

where,

\[ Y_i = \text{Revenue} \]
\[ Y_1 = \text{Labor} \]
\[ Y_2 = \text{Capital} \]
\[ \alpha_1, \alpha_2 = \text{Elasticities of output with respect to labor and capital, respectively.} \]

The result of their model:

1951: \[ Y_i = 1.03 * Y_1^{0.59} * Y_2^{0.40} \] ............................... (2)
1952: \[ Y_i = 0.68 * Y_1^{0.53} * Y_2^{0.50} \] ............................... (3)

Both equations (2) and (3) have high coefficients of multiple correlation .98 in 1951 and .95 in 1952 indicating that during both 1951 and 1952 more than ninety percent of the variation in net value of output was explained by the two factors of production (labor and capital). The exponents of labor and capital are significant for both years.

With respect to expenditure on labor, the elasticities of output are 0.59 and 0.53 for 1951 and 1952 respectively. The elasticities with respect to capital are 0.40 and 0.50 for 1951 and 1952, respectively.

In a recent study, John P. Nelson\(^2\) analyzed the demand for space heating energy (excluding electricity) using cross-sectional data for states in the U. S. for the year 1971. Space heating was estimated to account for seventy-seven percent of the gas, oil and coal consumption in the residential and commercial sectors. The model that was used to estimate the demand by states for these fuels in 1971 may be expressed as:

\[
Qi = f(Yi, Pi, PEi, DDi, Ui, D1, D2) \quad \text{............... (4)}
\]

where,

- \(Qi\) = Total oil, gas and coal consumed per capita in the residential and commercial sectors in the \(i\)th state in 1971;
- \(Yi\) = Mean personal income per capita in the \(i\)th state in 1971;
- \(Pi\) = Weighted average residential and commercial price of oil, gas, and coal in the \(i\)th state in 1971;

PEi = The average residential and commercial price of electricity in the ith state in 1971;

DDi = Weighted average heating degree days per year;

Ui = The percent of total population in the ith state living in the urban areas in 1970;

D1 = 1 if DDi < 3500, 0 otherwise; and

D2 = 1 if DDi > 6500, 0 otherwise.

The results of his study indicated that price increases for space heating fuels will have a rationing effect on energy use, especially in the long-run context. With current price far outside the range of past data, the quantity demanded has been reduced as a consequence of these price increases. Also, increases in per capita consumption is associated with increase in per capita income, residential and commercial price of electricity and average heating degree. The author also found that for equivalent degree of winter coldness, energy consumption rates will be higher in the south. Potential saving from increased insulation exist in southern as well as in northern states, particularly as a consequence of the substantial increase in heating oil price.

Ernst R. Berndt and David O. Wood studied the structure of technology in the United States' manufacturing, 1947-1971. The authors examined the possibilities for substitution between energy and nonenergy

inputs. They assumed a general form for the cost function \( G \) as:

\[
G = G(Y, P_K, P_L, P_E, P_M) \tag{5}
\]

where,

- \( G \) = Total cost;
- \( Y \) = Gross output; and
- \( P_K, P_L, P_E, P_M \) = Price of capital, labor, energy and all other intermediate materials, respectively.

The authors used a translog cost function in their study. First, they differentiated the translog cost function and then, using Shephard's Lemma, they obtained what they called the "KLEM" input demand equation. KLEM stands for capital, labor, energy and material. They argued that the previous production functions had not been explicit in identifying the elements that entered a production function. Since their study was during the height of the energy crisis, they were principally concerned with the interaction between energy and other inputs. Their equation may be expressed as followed:

\[
\begin{align*}
M_K &= P_KK/G = \alpha_K + \gamma_{KK}\ln P_K + \gamma_{KL}\ln P_L + \gamma_{KE}\ln P_E + \gamma_{KM}\ln P_M \\
M_L &= P_LL/G = \alpha_L + \gamma_{KL}\ln P_K + \gamma_{LL}\ln P_L + \gamma_{LE}\ln P_E + \gamma_{LM}\ln P_M \\
M_E &= P_EE/G = \alpha_E + \gamma_{KE}\ln P_K + \gamma_{LE}\ln P_L + \gamma_{EE}\ln P_E + \gamma_{EM}\ln P_M \\
M_M &= P_MM/G = \alpha_M + \gamma_{KM}\ln P_K + \gamma_{LM}\ln P_L + \gamma_{EM}\ln P_E + \gamma_{MM}\ln P_M
\end{align*}
\]

where the total cost \( G = P_KK + P_LL + P_EE + P_MM \). The \( M_i \)'s are the cost shares of the inputs in the total cost of producing \( Y \).
They also used the elasticities of substitution to analyze the relationships between the inputs. Thus, between two inputs, i and j, the elasticity of substitution ($\sigma$) was calculated as:

$$\sigma_{ij} = \frac{G_{ij}}{G_i G_j} \quad (6)$$

where,

$$G_i = \frac{\partial G}{\partial P_i}, \quad G_{ij} = \frac{\partial^2 G}{\partial P_i \partial P_j}$$

and price elasticities of demand for factors of production were calculated using the formula:

$$E_{ij} = \frac{M_i \sigma_{ij}}{m} \quad (7)$$

where,

$$M_i = \text{Cost share of input; and}$$

$$\sigma_{ij} = \text{The calculation in (6).}$$

Based on their estimates, they found that the $R^2$ of the cost share of input is 0.473, for the K equation means about 47 percent of the capital demand can be explained by the variables in the equation. And the $R^2$ of $M_L$, $M_E$ and $M_M$ equations are 0.820, 0.671 and 0.616, respectively. That means about 82, 67 and 62 percent of the labor demand, energy demand and all other material demands can be explained by the variables of the equation, respectively.

Some of the elasticities of substitution and price elasticities of demand derived from the author's work are as follows:

1) Energy demand is responsive to change in its own price, the own price elasticity $E_{EE}$ are about -.47.
2) Energy and labor are slightly substitutable; the estimated $\sigma_{LE}$ is about 0.65, while the cross-price elasticities $E_{LE}$ and $E_{EL}$ are about 0.03 and 0.18, respectively.

3) Energy and capital display substantial complementarity, the estimated $\sigma_{KE}$ is about -3.2, while the estimated cross-price elasticities $E_{KE}$ and $E_{EK}$ are about -.15 and -.18, respectively.

4) Capital and labor tend to be quite substitutable, the estimate is about 1.01, the estimated cross-price elasticities $E_{KL}$ and $E_{LK}$ are about 0.28 and 0.06, and the estimated own price elasticities $E_{KK}$ and $E_{LL}$ are approximately -.48 and -.45, respectively.

These production function approaches are the theoretically correct method of estimating the input demand function. However, in our study, data on price of output and labor productivity measures were unavailable so that our approach is not strictly analogous to Sastry and Murti or Berndt and Wood. We specify our demand functions based on the theoretical and empirical observation of the relationship between quantities of energy used, energy prices and economic growth represented by per capita incomes.
CHAPTER III
THE DEMAND FUNCTION FOR PETROLEUM PRODUCTS IN INDUSTRIAL AND TRANSPORTATION SECTORS

In this chapter, we will investigate representative demand functions for industrial and transportation sectors in Thailand. The demand function is a function of price and the level of economic activities. Then, we will discuss price and income elasticities for the models.

According to the law of demand, the quantity of a commodity purchased at a point in time is a function of the price of the commodity and income. This may be expressed in mathematical form as:¹

\[ Q_a = f(P_a, I) \] (1)

where,

\[ Q_a = \text{Quantity of commodity A}; \]
\[ P_a = \text{Price of commodity A}; \text{ and} \]
\[ I = \text{Income}. \]

This simple demand model is applied to the data on Thailand. As stated in equation (1), since there is no specific functional form, this provides an opportunity to experiment with alternative functional forms.

We can estimate the demand for petroleum products for the industrial and transportation sectors in Thailand as:

\[ Q_i = f(P_i, GDPIT) \]  \hspace{1cm} (2)

where,

- \( Q_i \) = Quantity of \( i \);
- \( P_i \) = Price of \( i \);
- \( i \) = Gasoline (G), diesel (D), fuel oil (F), kerosine (K) and LPG (LPG); and
- \( GDPIT \) = Gross domestic product of industrial sector (including transportation).

The simplest functional form for a single demand equation is the linear one. Such a linear demand equation can be written as:\(^2\)

\[ Q_i = a + bP_i + cGDPIT \]  \hspace{1cm} (3)

A second specification of a functional form is the semilogarithmic demand function which may be written as:

\[ Q_i = a + b\ln P_i + c\ln GDPIT \]  \hspace{1cm} (4)

A third functional form, and in fact the one that has been the most widely used, is the log-linear or constant-elasticity form. It specifies the demand function as:

\[ Q_i = A * P_i^b * GDPIT^c \]  \hspace{1cm} (5)

Taking logarithms leads to the log-linear representation:

\[ \ln Q_i = a + b \ln P_i + c \ln GDPIT \]  \hspace{1cm} (6)

\[ (a = \ln A) \]

From equation (3), (4), and (6) where:

\[ a = \text{Constant}; \text{ and} \]
\[ b \text{ and } c = \text{coefficients of } P_i \text{ and GDPIT respectively.} \]

**Price Elasticity of Demand**

In order to measure the effects of changes in the economic environment on demand, the concept of elasticity is relevant. The price elasticity of demand \( \varepsilon_{ij} \) is defined as the proportionate rate of change in quantity \( (Q_i) \) divided by the proportionate rate of change of its own price \(^3\) (other things constant):

\[ \varepsilon_{ij} = \frac{\partial \ln Q_i}{\partial \ln P_i} = \frac{P_i}{Q_i} \cdot \frac{\partial Q_i}{\partial P_i} \]  \hspace{1cm} (7)

A numerically large value for elasticity implies that quantity is proportionately very responsive to price change. Commodities which have numerically high elasticities \( (\varepsilon_{ij} < -1) \) are often called luxuries, whereas those with numerically small elasticity \( (\varepsilon_{ij} > -1) \) are called necessities. Price elasticities of demand are pure numbers independent

---

of the unit in which price and outputs are measured. The elasticity $\varepsilon_{ij}$ is negative if the corresponding demand curve slopes downward.

**Income Elasticity of Demand**

Another type of elasticity frequently encountered in demand analysis is the income elasticity of demand ($\eta_i$). This concept records the relationship between income changes and quantity changes, and is another application of the general definition given as:

$$\eta_i = \frac{\partial \ln Q_i}{\partial \ln GDPIT} = \frac{\partial Q_i}{\partial GDPIT \cdot GDPIT/Q_i} \ldots \ldots \ (8)$$

Equation (8) is defined as the proportionate change in the purchases of commodities relative to the proportionate change in income (with price and other things constant). $\eta_i$ denotes the income elasticity of demand for $Q_i$. Income elasticities can be positive, negative, or zero, but are normally assumed to be positive.

**Hypotheses**

The objective of the demand for petroleum product in industrial and transportation sectors in Thailand is to identify the factors that influence the demand for select petroleum fuels. Based on the review of literature and the theoretical framework discussed in this thesis,

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two major hypotheses are examined with respect to the five energy sources studied in this thesis:

1) There is negative relationship between the price and quantity demand of each petroleum product; and

2) There is positive relationship between the gross domestic product and the quantity demand of each petroleum product.

Data and Sources

Time-series data was used in this study. Data on petroleum quantities and prices were obtained from the "Report of Oil in Thailand," published by the Ministry of Science Technology and Energy. The data on gross domestic product was obtained from the Bank of Thailand and measured at market price. The total of the domestic capital was obtained from the "Statistics of Capital Stock of Thailand, 1970-1981" of the National Economic and Social Bureau.
CHAPTER IV

EMPIRICAL AND STATISTICAL RESULTS

Multiple linear regression methods were used to estimate the parameters of the demand function. There were five different kinds of petroleum products—gasoline, diesel, kerosine, fuel oil and LPG. For each oil product, three functional forms of the basic demand were estimated. The functional forms were: linear, semilogarithmic and log-linear. Comparisons between the $R^2$, $F$ and $t$ statistics from each equation were then compared against the background of the predictions of economic theory. Results are discussed below.

Demand for Petroleum Products

Gasoline

The log-linear form of the gasoline demand equation is given below (see Table 5, equation 4).

\[
\ln Q_G = 0.547 - 0.380 \ln P_G + 0.659 \ln GDPIT
\]

\[\begin{array}{c}
(-2.497) \quad (4.179)
\end{array}\]

\[F = 17.538 \quad R^2 = 0.854 \quad SE = 0.075\]

The above equation gives the results of the empirical test of the relationship between quantities used of gasoline ($Q_G$), price of gasoline ($P_G$) and gross domestic product ($GDPIT$). The results, with $t$-test in
TABLE 5
DEMAND FOR GASOLINE

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Endogenous Variable</th>
<th>Constant Value</th>
<th>PG</th>
<th>lnPG</th>
<th>GDPIT</th>
<th>lnGDPIT</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>F</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>QG</td>
<td>1331.52</td>
<td>-176.42b</td>
<td>(.2.284)</td>
<td>.014d</td>
<td>(3.060)</td>
<td>.738</td>
<td>.650</td>
<td>8.437</td>
<td>178.77</td>
</tr>
<tr>
<td>2</td>
<td>lnQG</td>
<td>7.216</td>
<td>-.103c</td>
<td>(-2.488)</td>
<td>.000008d</td>
<td>(3.302)</td>
<td>.761</td>
<td>.681</td>
<td>9.550</td>
<td>.096</td>
</tr>
<tr>
<td>3</td>
<td>QG</td>
<td>-10078.08</td>
<td>-629.822b</td>
<td>(-2.111)</td>
<td>1126.385d</td>
<td>(3.644)</td>
<td>.824</td>
<td>.765</td>
<td>14.051</td>
<td>146.416</td>
</tr>
<tr>
<td>4*</td>
<td>lnQG</td>
<td>.547</td>
<td>-.380c</td>
<td>(-2.497)</td>
<td>.659e</td>
<td>(4.179)</td>
<td>.854</td>
<td>.805</td>
<td>17.538</td>
<td>.075</td>
</tr>
</tbody>
</table>

Note: T values are in parentheses.

a The confidence interval of 90 percent  
b The confidence interval of 95 percent  
c The confidence interval of 97.5 percent  
d The confidence interval of 99 percent  
e The confidence interval of 99.5 percent
the parentheses, indicate a strong negative relationship between quantities of gasoline and price of gasoline with the coefficient of price for gasoline being significant at the five percent level. There is also a strong positive relationship with the gross domestic products, which the t-value is significant at a one percent level. About eighty-five percent ($R^2 = 0.854$) of the variation in the quantities of gasoline can be explained by the price of gasoline and gross domestic products.

Based on the estimated statistics, these variables are statistically significant at the one percent level ($F = 17.538$). The t-value for the coefficient of gasoline price and the gross domestic products is -2.497 and 4.179, given the confidence interval of ninety-five and ninety-nine percent, respectively. The standard error is 0.075, which means there is an error in this equation of about $\pm 0.075$. The results are consistent with the predictions of economic theory as shown by the negative coefficient of price and the positive coefficient of income.

**Diesel**

The log-linear form of diesel demand equation is given below (see Table 6, equation 8).

$$\ln Q_D = -0.451 - 0.351 \ln P_D + 0.733 \ln GDP_{IT}$$

$$\begin{align*}
(-1.701) & \quad (3.073) \\
F & = 12.177 \\
R^2 & = 0.802 \\
SE & = 0.104
\end{align*}$$

The quantities of diesel demanded in the industrial and transportation sectors ($Q_D$) depended on the price of diesel ($P_D$) and the gross
<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Endogenous Variable</th>
<th>Constant Value</th>
<th>PD</th>
<th>lnPD</th>
<th>GDPIT</th>
<th>lnGDPIT</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>F</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>QD</td>
<td>1280.496</td>
<td>-143.017 (-1.133)</td>
<td></td>
<td>.011b (2.339)</td>
<td></td>
<td>.754</td>
<td>.672</td>
<td>9.179</td>
<td>232.952</td>
</tr>
<tr>
<td>6</td>
<td>lnQD</td>
<td>-7.221</td>
<td>-0.0867 (-1.358)</td>
<td></td>
<td>.000006c (2.508)</td>
<td></td>
<td>.747</td>
<td>.663</td>
<td>8.852</td>
<td>.118</td>
</tr>
<tr>
<td>7</td>
<td>QD</td>
<td>-12620.668</td>
<td>-561.730 (-1.343)</td>
<td></td>
<td>1326.401c (2.746)</td>
<td>.798</td>
<td>.730</td>
<td>11.835</td>
<td>211.070</td>
<td></td>
</tr>
<tr>
<td>8*</td>
<td>lnQD</td>
<td>-.451</td>
<td>-.351a (-1.701)</td>
<td></td>
<td>.733d (3.073)</td>
<td>.802</td>
<td>.736</td>
<td>12.177</td>
<td>.104</td>
<td></td>
</tr>
</tbody>
</table>

Note: T values are in parentheses.

a The confidence interval of 90 percent
b The confidence interval of 95 percent
c The confidence interval of 97.5 percent
d The confidence interval of 99 percent
e The confidence interval of 99.5 percent
domestic products from both sectors (GDPIT). The above equation shows a negative relationship between the price of diesel and the quantities of diesel. The relationship is statistically significant at the five percent level with a confidence interval of ninety-five percent. There is a positive relationship between gross domestic product and the quantity of diesel fuel demanded. The relationship is significant at the one percent level.

From the statistical results, this regression is significant at the one percent level ($F = 12.177$). About eighty percent ($R^2 = 0.802$) of the variation in quantities of diesel in the industrial and transportation sectors is explained by the price of diesel and gross domestic products. The standard error is 0.104, which means there is ±0.104 of the error, in this equation. In this equation also, the relationships between the variables are as predicted by economic theory.

Fuel Oil

The demand equation of fuel oil is equation 9 in Table 7.

\[
Q_F = 1182.704 - 126.545 PF + 0.0043 GDPIT
\]

\[
\begin{array}{ccc}
(-1.137) & (1.903) \\
\end{array}
\]

\[
F = 3.407 \quad R^2 = 0.532 \quad SE = 128.024
\]

Based on the estimated statistics, these variables are statistically significant at the ten percent level. About fifty-three percent ($R^2 = 0.532$) of the variation in the quantities of fuel oil can be explained by the price of fuel oil and gross domestic products for industrial and transportation sectors.
### TABLE 7
DEMAND FOR FUEL OIL

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Endogenous Variable</th>
<th>Constant Value</th>
<th>PF</th>
<th>lnPF</th>
<th>GDPIT</th>
<th>lnGDPIT</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
<th>F</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>9*</td>
<td>QF</td>
<td>1182.704</td>
<td>-126.545 (-1.137)</td>
<td></td>
<td>.0043b (1.903)</td>
<td>.532</td>
<td>.376</td>
<td>3.407</td>
<td>128.02</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>lnQF</td>
<td>7.081</td>
<td>-.091 (-1.121)</td>
<td></td>
<td>.000003a (1.879)</td>
<td>.526</td>
<td>.368</td>
<td>3.332</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>QF</td>
<td>-1919.612</td>
<td>-84.892b (-.377)</td>
<td></td>
<td>292.481a (1.458)</td>
<td>.482</td>
<td>.309</td>
<td>2.792</td>
<td>134.66</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>lnQF</td>
<td>4.820</td>
<td>-.063 (-.382)</td>
<td></td>
<td>.213a (1.452)</td>
<td>.478</td>
<td>.304</td>
<td>2.746</td>
<td>.09</td>
<td></td>
</tr>
</tbody>
</table>

Note: T values are in parentheses.

- a The confidence interval of 90 percent
- b The confidence interval of 95 percent
- c The confidence interval of 97.5 percent
- d The confidence interval of 99 percent
- e The confidence interval of 99.5 percent
The above equation shows a negative correlation between the price of fuel oil (PF) and quantities of fuel oil for industrial and transportation sectors (QF). For the gross domestic products (GDPIT), it shows a positive correlation with the quantities of fuel oil demanded. The relationship is significant at the five percent level. The error in this equation is +128.02.

Kerosine

The demand equations for kerosine are in Table 8 and equation 16. The log-linear form is shown below.

\[
\ln Q_K = 23.261 - 2.206 \ln P_K + 1.892 \ln GDPIT \\
\quad (-3.751) \quad (3.456)
\]

\[F = 7.083 \quad R^2 = 0.702 \quad SE = 0.2412\]

The quantities of kerosine (QK) from the above equation will be effected by the change in kerosine price (PK) and the gross domestic products in industrial and transportation sectors (GDPIT). The t-values (in parentheses) indicate a strong negative relationship between the quantity of kerosine and the price of kerosine (t = -3.751). Gross domestic products is positively correlated with the quantity of kerosine demanded in the industrial and transportation sectors.

From the Table 8, the regression for kerosine is significant at the five percent level (F = 7.083) and seventy percent (R^2 = 0.702) of the variation in quantities for kerosine demand used can be explained by the price of kerosine and the gross domestic products for industrial


TABLE 8
DEMAND FOR KEROSINE

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Endogenous Variable</th>
<th>Constant Value</th>
<th>PK</th>
<th>InPK</th>
<th>GDPIT</th>
<th>InGDPIT</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>F</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>QK</td>
<td>36.827</td>
<td>23.061&lt;sup&gt;b&lt;/sup&gt; (-2.169)</td>
<td></td>
<td>-.0005&lt;sup&gt;a&lt;/sup&gt; (-1.704)</td>
<td></td>
<td>.502</td>
<td>.336</td>
<td>3.026</td>
<td>15.67</td>
</tr>
<tr>
<td>14</td>
<td>InQK</td>
<td>3.655</td>
<td></td>
<td>-.513&lt;sup&gt;c&lt;/sup&gt; (-2.540)</td>
<td></td>
<td>.000001&lt;sup&gt;b&lt;/sup&gt; (2.147)</td>
<td>.546</td>
<td>.394</td>
<td>3.603</td>
<td>.29</td>
</tr>
<tr>
<td>15</td>
<td>QK</td>
<td>915.495</td>
<td></td>
<td>103.459&lt;sup&gt;d&lt;/sup&gt; (3.164)</td>
<td></td>
<td>-84.807&lt;sup&gt;c&lt;/sup&gt; (-2.787)</td>
<td>.636</td>
<td>.514</td>
<td>5.233</td>
<td>13.41</td>
</tr>
<tr>
<td>16*</td>
<td>InQK</td>
<td>23.261</td>
<td></td>
<td>-2.206&lt;sup&gt;e&lt;/sup&gt; (-3.751)</td>
<td></td>
<td>1.892&lt;sup&gt;d&lt;/sup&gt; (3.456)</td>
<td>.702</td>
<td>.603</td>
<td>7.083</td>
<td>.24</td>
</tr>
</tbody>
</table>

Note: T values are in parentheses.

-<sup>a</sup> The confidence interval of 90 percent
-<sup>b</sup> The confidence interval of 95 percent
-<sup>c</sup> The confidence interval of 97.5 percent
-<sup>d</sup> The confidence interval of 99 percent
-<sup>e</sup> The confidence interval of 99.5 percent
and transportation sectors. The equation has a standard error of 0.2412, which means there is an error on this equation by ±0.2412.

The estimated demand for LPG is shown in equation 18 in Table 9, in the semilogarithmic form.

\[
\ln Q_{LPG} = 1.304 - 0.009 PLPG + .00002 GDPIT \\
\quad (-1.245) \quad (3.879)
\]

\[F = 25.963 \quad R^2 = 0.896 \quad SE = 0.449\]

The quantities of LPG for the industrial and transportation sectors (QLPG) depend on the price of LPG (PLPG) and the gross domestic products (GDPIT). Based on the estimated statistics, these variables are statistically significant at the one percent level (F = 25.963). About ninety percent (R^2 = 0.896) of the variation in the quantities of LPG can be explained by the price of LPG and the gross domestic products for industrial and transportation sectors.

The above equation shows a positive correlation between the gross domestic products and quantities of LPG for industrial and transportation sectors. The relationship is significant at the one percent level. For the price of LPG, it shows a negative correlation with the quantities of LPG demanded. The standard error of estimate is 0.449, which means there is an error on this estimation at about ±0.449.
### TABLE 9

DEMAND FOR LPG

<table>
<thead>
<tr>
<th>Equation Number</th>
<th>Endogenous Variable</th>
<th>Constant Value</th>
<th>PLPG</th>
<th>lnPLPG</th>
<th>GDPIT</th>
<th>lnGDPIT</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>F</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>QLPG</td>
<td>-61.307</td>
<td>0.079</td>
<td>(.163)</td>
<td>.0008</td>
<td>(1.597)</td>
<td>.775</td>
<td>.700</td>
<td>10.331</td>
<td>31.173</td>
</tr>
<tr>
<td>18</td>
<td>lnQLPG</td>
<td>1.304</td>
<td>-0.009</td>
<td>(-1.245)</td>
<td>.00002e</td>
<td>(3.879)</td>
<td>.896</td>
<td>.862</td>
<td>25.963</td>
<td>.449</td>
</tr>
<tr>
<td>19</td>
<td>QLPG</td>
<td>-862.345</td>
<td>95.712</td>
<td>(1.157)</td>
<td>36.905</td>
<td>(.677)</td>
<td>.703</td>
<td>.604</td>
<td>7.100</td>
<td>35.813</td>
</tr>
<tr>
<td>20</td>
<td>lnQLPG</td>
<td>-23.903</td>
<td>-0.198</td>
<td>(-.185)</td>
<td>2.433d</td>
<td>(3.442)</td>
<td>.889</td>
<td>.852</td>
<td>24.058</td>
<td>.464</td>
</tr>
</tbody>
</table>

Note: T values are in parentheses.

a The confidence interval of 90 percent
b The confidence interval of 95 percent
c The confidence interval of 97.5 percent
d The confidence interval of 99 percent
e The confidence interval of 99.5 percent
The Price and Income Elasticities

From the demand equations discussed in the last section, the implied price and income elasticities are in Table 10. The price elasticities for gasoline, diesel and fuel oil are inelastic. This means that the price increases proportionally more than quantity decreases. For example, fuel oil has the smallest price elasticity. The increase in the price of fuel oil by ten percent will lead to a decrease in quantities of fuel by 1.98 percent ($e_{FF} = -0.198$).

<table>
<thead>
<tr>
<th>Petroleum Products</th>
<th>Price Elasticity ($e_i$)</th>
<th>Income Elasticity ($\eta_i$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>-0.380</td>
<td>0.659</td>
</tr>
<tr>
<td>Diesel</td>
<td>-0.351</td>
<td>0.733</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>-0.198</td>
<td>0.353</td>
</tr>
<tr>
<td>Kerosine</td>
<td>-2.206</td>
<td>1.892</td>
</tr>
<tr>
<td>LPG</td>
<td>-1.445</td>
<td>2.294</td>
</tr>
</tbody>
</table>

SOURCE: From Appendix 2.

The price elasticities for gasoline is -0.380. This means if the price of gasoline increased by one percent, there will be a decrease in the quantities of gasoline by 0.38 percent. The price elasticity of
diesel is -0.351, indicating that the quantities of diesel will decrease by 35 percent if the price increases by 100 percent.

On the other hand, price changes will have the greatest effect on the quantities of kerosine and LPG because kerosine and LPG are price elastic. The price elasticity of kerosine is -2.206, meaning that increasing the price of kerosine by ten percent affect decreases in the quantities of kerosine by twenty-two percent.

The price elasticity of LPG is -1.445, indicating that the quantities will increase by 14.4 percent if the price decreased by ten percent. In fact, gasoline, diesel, and fuel oil are frequently used in the industrial and transportation sectors. The result of the price elasticities of gasoline, diesel, and fuel oil are inelastic, the price does, in fact, have as much of an effect on quantity demanded. On the other hand, kerosine and LPG are elastic. The price, therefore, affects quantities significantly because kerosine and LPG are not so important in the industrial and transportation sectors.

The numerical size of price elasticities are different for each fuel because of the role of each fuel in the production process and also on several factors. A few of these factors are described below.

1) The price elasticity of demand depend on the number of substitutes. If the commodity has many close substitutes, its demand is likely to be price elastic. For example, the price elasticity of LPG is -1.445. This means that the price increases proportionally less than quantity decrease. On the other hand, it will be affected on another sector which uses coal for material because coal will be used instead of LPG when the price of LPG increases.
2) The price elasticity of demand depends on the importance of commodity. If the commodity is very important, the price elasticity will be inelastic. For example, gasoline, diesel and fuel oil are inelastic because they are mainly used in industrial and transportation sectors.

3) The price elastic of demand depends on the length of the period of time. Demand is likely to be more elastic or less inelastic over a long period of time than over a short period. The price elasticity of LPG is 2.294. In the longer period of time, there will be a smaller number of price elasticity because it can be utilized most economically on LPG.

The income elasticities of petroleum products, such as, gasoline, diesel and fuel oil, are small. For example, the income elasticity of gasoline is 0.659, indicating that an increase in income by ten percent results in an increase in the quantities of gasoline by 6.59 percent. The income elasticities for diesel and fuel oil are 0.733 and 0.353 respectively. Decreasing the income by 100 percent will decrease the quantities of diesel and fuel oil by 73.3 and 35.3 percent, respectively.

Kerosine and LPG have large income elasticities (1.892 for income elasticity of kerosine and 2.294 for LPG). These numbers indicate that increasing income by ten percent results in increasing quantities of kerosine and LPG by 18.92 and 22.94 percent, respectively. LPG and kerosine will be more frequently used when income increases; for example, the increase in quantities of LPG for cooking instead of coal, and more frequently on LPG is used for water heaters. These lend further support to our theoretical observation that there is an important relationship between the quantities of energy used and incomes. As incomes go up, there will be a tendency to substitute the more efficient burning fuels like LPG in production than less efficient fuels like coal.
Before we finish this chapter, we will discuss the possible influence of technical improvement on the demand for energy in the industrial and transportation sectors of Thailand. Changes in the energy efficiency of equipment and machines can alter the demand for energy products. One way of addressing the issue of technical change on energy demand is by reviewing the total production, i.e., gross domestic product (inflation adjusted) for industrial and transportation sectors divided by the total quantity of energy sources utilized in production. This is shown in Table 11.

According to the results in Table 11, energy efficiency of the industrial and transportation sectors improved over the period 1971 to 1981. For example, markedly in 1971 a liter of energy produced 8.96 baht on the gross domestic product. By 1981 a liter of energy produced of 32.09 baht of gross domestic product. The annual averages percent change over the 1971-1981 period was 14.9 percent. This means that the productivity of energy resources improved by 14.9 percent per year. The improvement in the efficiency on energy may have been caused by use of new techniques or substitution of energy for another input; for example, less machine and more manpower. The improved efficiency of energy helped to reduce Thailand's dependency on energy.
TABLE 11
RATIO BETWEEN GDP (INFLATION ADJUSTED) AND TOTAL QUANTITIES USED ON ENERGY SOURCES IN INDUSTRIAL AND TRANSPORTATION SECTORS, 1971-1981

<table>
<thead>
<tr>
<th>Year</th>
<th>GDPIT*</th>
<th>GDPIT (i)* GDPIT - Inflation Adjusted</th>
<th>Total (ΞE)** Energy Consumption</th>
<th>GDPIT(i)/ΞE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>33,863</td>
<td>33,338.1</td>
<td>3717.3</td>
<td>8.96</td>
</tr>
<tr>
<td>1972</td>
<td>38,378</td>
<td>35,065.9</td>
<td>4087.9</td>
<td>8.58</td>
</tr>
<tr>
<td>1973</td>
<td>48,851</td>
<td>38,983.1</td>
<td>4618.5</td>
<td>8.44</td>
</tr>
<tr>
<td>1974</td>
<td>65,325</td>
<td>55,438.9</td>
<td>4166.0</td>
<td>13.31</td>
</tr>
<tr>
<td>1975</td>
<td>72,674</td>
<td>70,653.7</td>
<td>4579.1</td>
<td>15.43</td>
</tr>
<tr>
<td>1976</td>
<td>84,853</td>
<td>81,509.8</td>
<td>5230.5</td>
<td>15.58</td>
</tr>
<tr>
<td>1977</td>
<td>99,382</td>
<td>90,855.0</td>
<td>5732.9</td>
<td>15.84</td>
</tr>
<tr>
<td>1978</td>
<td>118,695</td>
<td>108,475.4</td>
<td>5843.7</td>
<td>18.56</td>
</tr>
<tr>
<td>1979</td>
<td>147,584</td>
<td>130,464.3</td>
<td>6432.8</td>
<td>20.28</td>
</tr>
<tr>
<td>1980</td>
<td>179,776</td>
<td>150,238.3</td>
<td>6342.2</td>
<td>23.69</td>
</tr>
<tr>
<td>1981</td>
<td>215,553</td>
<td>198,330.3</td>
<td>6180.9</td>
<td>32.09</td>
</tr>
<tr>
<td>Average % Change Per Year</td>
<td>20.5</td>
<td>19.9</td>
<td>5.5</td>
<td>14.9</td>
</tr>
</tbody>
</table>

*Millions of Baht
**Millions of Liter
SOURCE: Calculated from Appendix 1.
CHAPTER V
SUMMARY

Conclusion and Recommendations

The demand for energy has been increasing rapidly due mainly to economic growth and increasing population. About eighty percent of energy uses is petroleum products. Almost all of them have to be imported. The increasing world oil price has affected the standard of living of consumers and the stability of the Thai economy. To the extent that petroleum products are very essential for the Thai economy, they are generally considered to be basic requisites for industrial development and economic activities of Thailand.

In this paper, we have presented models of demand functions which represented demand for five kinds of petroleum products. To estimate the demand equations, we have used the demand theory which describes demand as a function of price and level of economic activities.

Based on the results of the demand function analysis for each petroleum product for the industrial and transportation sectors, it is found that the increase in oil price has led to the decrease in fuel oil use, and the increase in oil use would be indicated by the growth of economic activity.

The estimates for the price elasticities range from -0.380 to -2.206, and kerosine (-2.206) has a larger elasticity than others.
the rest are LPG (-1.445), diesel (-0.351), gasoline (-0.380) and fuel oil (-0.198). The low price elasticity of demand shows that oils are necessary goods which the demand response of price change is small. To allow for the demand for energy in the future, while the oil price is increasing rapidly, the government should adjust the structure of energy use from oil to other energy uses that are available in Thailand.

As the estimated price elasticities of demand for various petroleum products show, it will be very difficult to use energy price policy as a rationing device to reduce oil use, but it will be effective for some fuels. It is recommended that such policies be used so that oil can be utilized most economically. At the same time, efforts should be made to find new sources of petroleum products within Thailand to replace the imports. Most important, result of our analysis is the danger in across the board energy price policies without regard to the specific fuel in question. Our results indicate that such a policy could actually produce a "wash," that is, with negative and positive responses cancelling out.

Income elasticities range from 0.353 to 2.294 and LPG has the largest income elasticity (2.294), others are kerosine (1.892), diesel (0.733), gasoline (0.659) and fuel oil (0.353). The income elasticities are rather low (except LPG and kerosine), thus, if petroleum product prices remain constant relative to other prices, as output increases, there will be an increase in the demand for petroleum products.
If the government can maintain growth rates according to its economic development plan, it will be possible to forecast the demand for each petroleum product and adopt the energy supply planning model to this trend. Our study also points to the future needs of the Thai economy. For all the fuels used in this study, we find a strong relationship between income growth and fuel use. The Government of Thailand must initiate efforts at energy conservation and "reserves" buildup in order to assure the healthy growth path that the economy is on in the face of turmoil and conflict in major supply sources.
APPENDIX 1

DATA USED IN THIS STUDY

<table>
<thead>
<tr>
<th>Year</th>
<th>PG</th>
<th>PK</th>
<th>PD</th>
<th>PF</th>
<th>PLPG</th>
<th>GDPI*</th>
<th>GDPT*</th>
<th>GDPIT*</th>
<th>QG**</th>
<th>QD**</th>
<th>QF**</th>
<th>QK**</th>
<th>QLPG**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>24,908</td>
<td>8,955</td>
<td>33,863</td>
<td>1175.1</td>
<td>1405.9</td>
<td>1083.3</td>
<td>53.0</td>
<td>--</td>
</tr>
<tr>
<td>1972</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>27,864</td>
<td>10,514</td>
<td>38,378</td>
<td>1177.7</td>
<td>1623.3</td>
<td>1212.3</td>
<td>74.6</td>
<td>--</td>
</tr>
<tr>
<td>1973</td>
<td>3.24</td>
<td>1.59</td>
<td>1.24</td>
<td>1.48</td>
<td>120.88</td>
<td>35,614</td>
<td>13,237</td>
<td>48,851</td>
<td>1385.2</td>
<td>1842.8</td>
<td>1327.3</td>
<td>58.1</td>
<td>5.10</td>
</tr>
<tr>
<td>1974</td>
<td>3.53</td>
<td>2.41</td>
<td>2.30</td>
<td>1.48</td>
<td>120.88</td>
<td>49,359</td>
<td>15,966</td>
<td>65,325</td>
<td>1514.0</td>
<td>1459.9</td>
<td>1117.5</td>
<td>66.9</td>
<td>7.70</td>
</tr>
<tr>
<td>1975</td>
<td>3.53</td>
<td>2.41</td>
<td>2.30</td>
<td>1.48</td>
<td>122.43</td>
<td>53,910</td>
<td>18,764</td>
<td>72,674</td>
<td>1660.3</td>
<td>1600.3</td>
<td>1255.7</td>
<td>57.4</td>
<td>5.40</td>
</tr>
<tr>
<td>1976</td>
<td>3.53</td>
<td>2.41</td>
<td>2.30</td>
<td>1.48</td>
<td>122.43</td>
<td>63,025</td>
<td>21,828</td>
<td>84,853</td>
<td>1856.2</td>
<td>1915.6</td>
<td>1387.1</td>
<td>40.9</td>
<td>30.70</td>
</tr>
<tr>
<td>1977</td>
<td>4.08</td>
<td>2.68</td>
<td>2.57</td>
<td>1.57</td>
<td>130.26</td>
<td>74,676</td>
<td>24,706</td>
<td>99,382</td>
<td>2064.0</td>
<td>2085.1</td>
<td>1526.3</td>
<td>31.0</td>
<td>26.50</td>
</tr>
<tr>
<td>1978</td>
<td>4.84</td>
<td>2.68</td>
<td>2.57</td>
<td>1.60</td>
<td>136</td>
<td>89,089</td>
<td>29,606</td>
<td>118,695</td>
<td>2176.4</td>
<td>2244.9</td>
<td>1360.1</td>
<td>28.9</td>
<td>33.43</td>
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<tr>
<td>1979</td>
<td>8.67</td>
<td>3.86</td>
<td>3.89</td>
<td>2.39</td>
<td>167.53</td>
<td>109,740</td>
<td>37,844</td>
<td>147,584</td>
<td>2192.6</td>
<td>2517.3</td>
<td>1648.1</td>
<td>35.2</td>
<td>39.63</td>
</tr>
<tr>
<td>1980</td>
<td>9.53</td>
<td>6.21</td>
<td>6.85</td>
<td>3.68</td>
<td>265.83</td>
<td>134,515</td>
<td>45,261</td>
<td>179,776</td>
<td>2153.9</td>
<td>2644.7</td>
<td>1409.1</td>
<td>65.6</td>
<td>68.9</td>
</tr>
<tr>
<td>1981</td>
<td>12.04</td>
<td>6.12</td>
<td>7.26</td>
<td>4.50</td>
<td>258.5</td>
<td>158,272</td>
<td>57,281</td>
<td>215,553</td>
<td>1977.0</td>
<td>2374.4</td>
<td>1557.5</td>
<td>85.3</td>
<td>186.7</td>
</tr>
</tbody>
</table>

* Millions of Baht
** Millions of Liter
where,

\begin{align*}
\text{PG} & \quad \text{Price of gasoline;} \\
\text{PK} & \quad \text{Price of kerosine} \\
\text{PD} & \quad \text{Price of diesel;} \\
\text{PF} & \quad \text{Price of fuel oil;} \\
\text{PLPG} & \quad \text{Price of LPG;} \\
\text{GDPI} & \quad \text{Gross domestic product for industrial sector;} \\
\text{GDPT} & \quad \text{Gross domestic product for transportation sector;} \\
\text{GDPIT} & \quad \text{Gross domestic product for industrial and transportation sectors (GDPIT = GDPI + GDPT)} \\
\text{QG} & \quad \text{Quantities of gasoline used in industrial and transportation sectors;} \\
\text{QD} & \quad \text{Quantities of diesel used in industrial and transportation sectors;} \\
\text{QF} & \quad \text{Quantities of fuel oil used in industrial and transportation sectors;} \\
\text{QK} & \quad \text{Quantities of kerosine used in industrial and transportation sectors; and} \\
\text{QLPG} & \quad \text{Quantities of LPG used in industrial and transportation sectors.}
\end{align*}
APPENDIX 2

ESTIMATION FOR ELASTICITIES OF DEMAND

1) Gasoline

The equation being represented is:

\[ \ln Q_G = 0.547 - 0.380 \ln P_G + 0.659 \ln G \]

A) The price elasticity of gasoline \((e_G)\) takes a partial derivation of \(\ln Q_G\) with respect to \(\ln P_G\).

\[ \frac{\partial \ln Q_G}{\partial \ln P_G} = \frac{\partial Q_G}{\partial P_G} \cdot \frac{P_G}{Q_G} = -0.380 \]

\[ e_G^2 = -0.380 \]

B) The income elasticity of gasoline \((n_G)\) takes a partial derivation of \(\ln Q_G\) with respect to \(\ln GDPIT\).

\[ \frac{\partial \ln Q_G}{\partial \ln GDPIT} = \frac{\partial Q_G}{\partial GDPIT} \cdot \frac{GDPIT}{Q_G} = 0.659 \]

\[ n_G^3 = 0.659 \]

2) Diesel

The equation being used in this model is:

\[ \ln Q_D = -0.451 - 0.351 \ln P_D + 0.733 \ln GDPIT \]

A) The price elasticity of diesel \((e_D)\) takes a partial derivative of \(\ln Q_D\) with respect to \(\ln P_D\).

\[ \frac{\partial \ln Q_D}{\partial \ln P_D} = \frac{\partial Q_D}{\partial P_D} \cdot \frac{P_D}{Q_D} = -0.351 \]

\[ e_D^2 = -0.351 \]

\[ \frac{1}{Q_G} \cdot \frac{\partial Q_G}{\partial QG} = 0.547 \]

\[ \frac{\partial e_G}{\partial P_G} = \frac{\partial Q_G}{\partial P_G} \cdot \frac{P_G}{Q_G} \]

\[ n_G = \frac{\partial Q_G}{\partial GDPIT} \cdot \frac{GDPIT}{Q_G} \]
B) The income elasticity of diesel ($\eta_D$) takes a partial derivation of $\ln QD$ with respect to $\ln GDPIT$.

$$\frac{\partial \ln QD}{\partial \ln GDPIT} = \frac{\partial QD}{\partial GDPIT} \cdot \frac{GDPIT/QD}{} = 0.733$$

$\eta_D = 0.733$

3) Fuel Oil

The equation that represents this model is:

$$QF = 1182.704 - 126.545 PF + .0043 \cdot QDPIT$$

A) The price elasticity for fuel oil ($\epsilon_FF$) takes a partial derivation of $QF$ with respect to $PF$.

$$\frac{\partial QF}{\partial PF} = -126.545$$

$$\epsilon_FF = \frac{\partial QF}{\partial PF} \cdot \frac{PF/QF}{} = -126.545 \cdot \frac{2.184/1398.744}{}$$

$$\epsilon_FF = -0.198$$

B) The income elasticity of fuel oil ($\eta_F$) takes a partial derivation of $QF$ with respect to $GDPIT$.

$$\frac{\partial QF}{\partial GDPIT} = 0.0043$$

$$\eta_F = \frac{\partial QF}{\partial GDPIT} \cdot \frac{GDPIT/QF}{} = 0.0043 \cdot \frac{114743.667/1398.744}{}$$

$$\eta_F = 0.353$$

4. Kerosine

The equation being used in this model is:

$$\ln QK = 23.261 - 2.206 \ln PK + 1.892 \ln GDPIT$$

A) The price elasticity of kerosine ($\epsilon_KK$) takes a partial derivation of $\ln QK$ with respect to $\ln PK$.

$$\frac{\partial \ln QK}{\partial \ln PK} = \frac{\partial QK}{\partial PK} \cdot \frac{PK/QK}{} = -2.206$$

$$\epsilon_KK = -2.206$$
B) The income elasticity of kerosine ($\eta_K$) takes a partial
derivation of $\ln Q_k$ with respect to $\ln GDPIT$.

$$\frac{\partial \ln Q_k}{\partial \ln GDPIT} = \frac{\partial Q_k}{\partial GDPIT} \cdot \frac{GDPIT}{Q_k} = 1.892$$

$$\eta_K = 1.892$$

5. LPG

The equation that represents this model is:

$$\ln Q_{LPG} = 1.304 - 0.009 \cdot PLPG + 0.00002 \cdot GDPIT$$

A) The price elasticity of LPG ($e_{LPG, LPG}$) takes a partial
derivation of $\ln Q_{LPG}$ with respect to

$$\frac{\partial \ln Q_{LPG}}{\partial PLPG} = \frac{\partial Q_{LPG}}{\partial PLPG} \cdot \frac{1}{Q_{LPG}} = -0.009$$

$$e_{LPG, LPG} = \frac{\partial Q_{LPG}}{\partial PLPG} \cdot \frac{PLPG}{Q_{LPG}} = -0.009 \times 160.527$$

$$= -1.445$$

B) The income elasticity of LPG ($\eta_{LPG}$) takes a partial derivation
of $\ln Q_{LPG}$ with respect to GDPIT.

$$\frac{\partial \ln Q_{LPG}}{\partial GDPIT} = \frac{\partial Q_{LPG}}{\partial GDPIT} \cdot \frac{1}{Q_{LPG}} = 0.00002$$

$$\eta_{LPG} = \frac{\partial Q_{LPG}}{\partial GDPIT} \cdot \frac{GDPIT}{Q_{LPG}} = 0.00002 \times 114743.667$$

$$\eta_{LPG} = 2.29$$

6. The means of the variables used in this study are:

A) Gasoline: $\bar{PG} = 5.888$, $\bar{QG} = 1886.662$

B) Diesel: $\bar{PD} = 3.476$, $\bar{QD} = 2076.111$

C) Fuel Oil: $\bar{PF} = 2.184$, $\bar{QF} = 1398.744$

D) Kerosine: $\bar{PK} = 3.374$, $\bar{QK} = 52.144$

E) LPG: $\bar{PLPG} = 160.527$, $\bar{QLPG} = 44.900$

F) GDPIT: $\bar{GDPIT} = 11473.667$
BIBLIOGRAPHY


