# Modeling and Forecasting the demand for Crude Oil in Asian Countries

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# ABSTRACT

This study examines the growth in oil demand in selected Asian countries over the 1982-2002 period. In particular, it analyses GDP and price in relation to oil demand. The demand for crude oil imports for the Asian countries. Which will be divided into four groups: first, Newly Industrializing Economics (NIEs) e.g. Hong Kong, Taiwan, Korea, Singapore, Indonesia, Malaysia, the Philippines and Thailand, as one group; second, OECD countries (Japan, and South Korea); Third is China fourth, South Asia (India and Pakistan). These groups are divide according to geographical location and similitary of economic status.

The demand function will be estimated using cointegration analysis and an Error Correction Model (ECM). There are however, three approaches for estimating the ECM: the Engle-Granger's two-step procedure; General to specific Hendry's type of testing; and the Autoregressive Distributed Lag (ARDL) approach of Pesaran et al. (1999, 2001). First the stationarity for all the variables will be tested followed by the use of the Autoregressive Distributed Lag (ARDL). This test has the advantage of its applicability irrespective of the different integration level. The ARDL procedures involve two stages. The first stage, is testing the existence of the long-run relation between the variables using "the Bound testing approach" (Pesaran, et al 2001). The second stage of the analysis is to estimate the coefficients of the long run relations and to make inferences about their values using the ARDL approach. Finally, the ARDL model is used to forecastle the crude oil consumption for the years 2006-2010. The paper concludes that GDP and Price are significant variables in demand for oil. However, elasticities of demand were low indicating the importance of Asia's crude oil to the economies of the Asian countries.

When the estimated model was used to forecast crude oil demand, it was found that GDP growth is an essential factor in the increase or decrease of crude oil demand by Asian countries. China has the largest demand for crude oil followed by Japan; South Korea; NIEs; India and with Pakistan being last. Recently, China, India and Pakistan show a high growth rate of oil demand.

**1. Introduction:**

Oil and energy markets have experienced dramatic changes over the past three decades. Steep price increases in the 1970s and 1980s were followed by a decrease in 1986 and then stable prices during the period 1992-1996. In 1998 there was a sharp decline. However, in 1999, the oil prices started to increase and have continued doing so until now. Despite considerable uncertainty about future developments in the world oil market, the demand for oil has been increasing on average by 1.38 percent per year for the period 1971-2002, particularly from Asian and OECD Pacific countries. This demand was fueled by increasing incomes, population, industrialization, investment and trade.

Table 1: World Crude Oil consumption Average Rate of growth (1980-2003)

| Region | Average Rate of growth |
|---|---|
| North America | 0.82% |
| Central and South America | 1.67% |
| Western Europe | 0.22% |
| Eastern Europe & Former U.S.S (1992-2002) | -2.78% |
| Middle East | 4.21% |
| Africa | 2.68% |
| Asia and OECD Pacific | 3.26% |
| World Total | 1.05% |

Source: OPEC Secretariat (Unpublished data).

The Asian and OECD Pacific Region countries have witnessed a 3.62% rate of growth of crude oil consumption for the period 1980-2003, compared to the world average of 1.05 percent per year, and to North America's average of 0.82 percent per year. This, in turn led to an increase in that region's share of total oil consumption from 17 percent in 1980 to 27 percent in 2003 as shown in Table 2. This indicates the importance of Asian countries as one of the leading regions in the demand for oil.

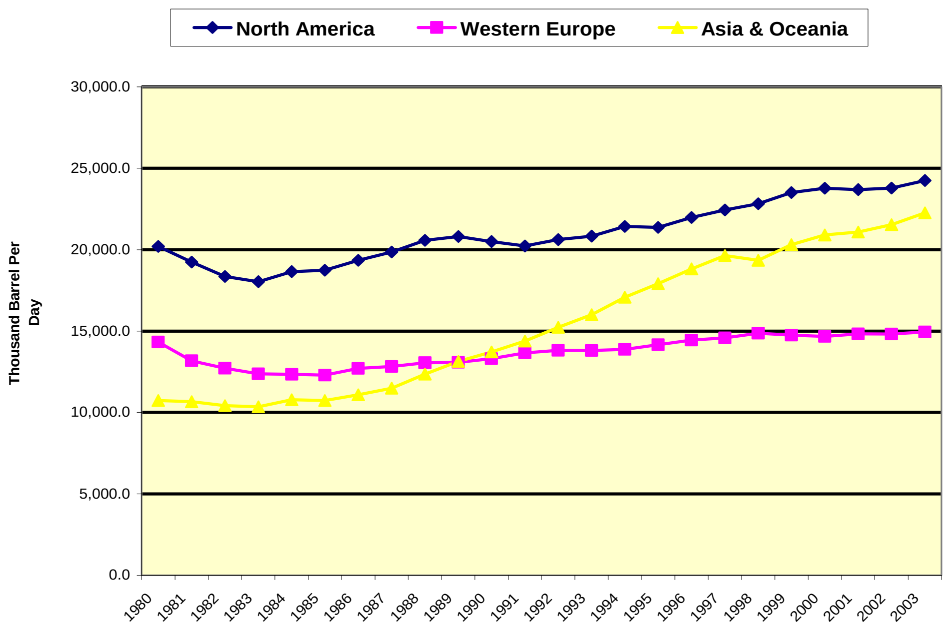
Table 2: The Share of world Regions Oil consumption.

| Countries / Year | **1980** | **1985** | **1990** | **1995** | **2000** | **2003** |
|---|---|---|---|---|---|---|
| **North America** | 32.01% | 31.17% | 30.78% | 30.52% | 30.89% | 30.28% |
| **Central & South America** | 5.73% | 5.37% | 5.65% | 6.37% | 6.80% | 6.55% |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Western Europe** | 22.69% | 20.46% | 19.99% | 20.22% | 19.06% | 18.67% |
| **Eastern Europe & Former U.S.S.R.** | 16.97% | 17.35% | 14.62% | 8.15% | 6.62% | 6.75% |
| **Middle East** | 3.26% | 4.75% | 5.25% | 5.94% | 6.21% | 6.60% |
| **Africa** | 2.34% | 3.04% | 3.11% | 3.22% | 3.26% | 3.37% |
| **Asia & Oceania** | 17.00% | 17.86% | 20.61% | 25.58% | 27.16% | 27.79% |

As illustrated on  Figure 1, while Asia and Pacific consume less than 10.00 Mb/d in early seventies, coming third after North America and Western Europe, Asia and Specific countries consumption has continued to increase dramatically reaching a level of more that 20 Mb/d in 1999 and has continued to increase to become second following North American.

**Figure 1: World demand for Crude Oil by Major Consumer (1980-2003)**




## 2. The Objective of the study:

This study examines the growth in oil demand in selected Asian countries for the period 1982-2002.  In particular, it analyses GDP and price, in relations to the  demand for oil.  An Econometric model of the regions' demand for oil will be driven from a cost minimization problem in which demand depends on the price of oil and the GDP. The model includes estimation of short and long-term elasticities of demand. The study starts with a historical overview of the growth in crude oil consumption. This is followed by a

review of the main economic indicators that effect crude oil demand, such as energy efficiency and economic growth for each country that included in the study. Variables of the study include Consumption of Crude oil, Real GDP in USA Dollar, and Crude oil Price. The sources for data are OPEC secretariat and Energy Information Administration (EIA). The data will cover the period 1980-2003 for the following countries: Japan, South Korea, China, and NIEs countries as one group, In edition to South Asian Countries India and Pakistan as the last group.

## 3-Historical Overview of the growth in crude oil consumption:

The Asia and Pacific countries are divided in this study into four major regions. The first region is OECD Pacific which includes Japan, and South Korea. It accounts for 10.5 percent of the total world oil consumption in 2003. The second region is China, which accounts for 6.5 percent of the total world consumption. The third region is "NIEs" Newly Industrializing economics which accounts for 10.2 percent the total world consumption of oil. The fourth region is South Asia which includes India, Pakistan, 3.3 percent of the total world oil consumption. In 2003 the total oil consumption of Asian countries amounted to 22,255.5 thousand b/d out of the total world oil consumption of 80,098.8 thousand b/d. As illustrated in Table 3.

Table 3: Oil Demand for Asia and Pacific

| | Oil Consumption thousand b/d | | |
|---|---|---|---|
| | **1983** | **1993** | **2003** |
| Japan | 4,395.0 | 5,380.0 | 5,578.4 |
| Korea, South | 561.0 | 1,684.1 | 2,168.1 |
| Australia | 594.0 | 759.9 | 875.6 |
| New Zealand | 82.0 | 108.1 | 151.9 |
| **OECD Pacific** | 5,632.0 | 7,932.1 | 8,774.0 |
| **% of world Total** | 9.41% | 11.52% | 10.95% |
| **China** | 1,730.0 | 2,959.5 | 5,550.0 |
| **% of world Total** | 2.89% | 4.30% | 6.93% |
| Indonesia | 470.0 | 764.9 | 1,155.0 |
| Taiwan | 337.0 | 616.4 | 915.0 |
| Thailand | 214.0 | 544.5 | 810.0 |
| Singapore | 220.0 | 469.2 | 705.0 |
| Malaysia | 192.0 | 335.9 | 510.0 |

| | | | |
|---|---|---|---|
| Philippines | 195.0 | 284.5 | 335.0 |
| Hong Kong | 119.0 | 157.5 | 260.0 |
| Vietnam | 26.6 | 77.4 | 216.0 |
| Other Asia, Other | 41.0 | 1,426.3 | 3,270.5 |
| **NIEs** | **1,814.6** | **4,676.7** | **8,176.5** |
| **% of world Total** | 3.0% | 6.8% | 10.2% |
| India | 824.0 | 1,413.3 | 2,320.0 |
| Pakistan | 140.0 | 282.2 | 338.0 |
| **South Asia** | **964.0** | **1,695.4** | **2,658.0** |
| **% of world Total** | 1.6% | 2.5% | 3.3% |
| **Total Asian Countries** | **10,350.0** | **16,006.4** | **22,255.5** |
| **% of World Total Oil Consumption** | 17.3% | 23.2% | 27.8% |
| **World Total** | **59,829.6** | **68,845.7** | **80,098.8** |
| | | | |

Source: eia.doe.gov.

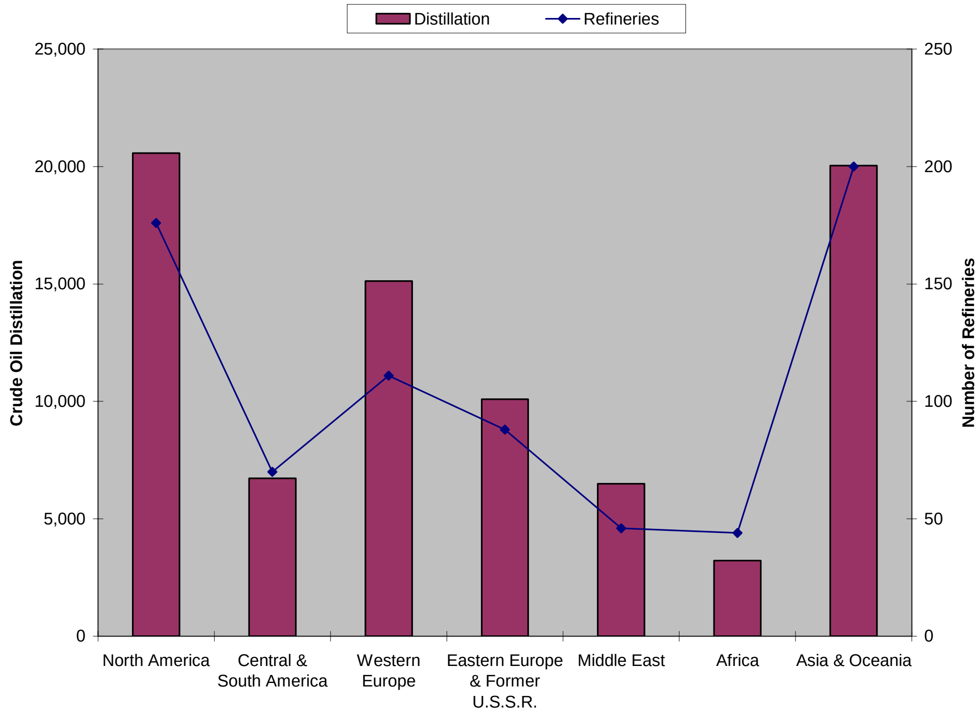
By the year 2002 the refineries in Asia & Oceania are performed those of North America and West Europe. Asian countries are also major refining centers with a total crude oil refining capacity of nearly, 20.235 MB/d. and 200 refineries out from a world total of 735 in 2004. Most of these refineries are located in Japan, China, and South Korea. These countries has a refining capacity of 4.703 MB/d in Japan; 4.528 Thousand B/d in China and 2.544 MB/d in South Korea. Singapore, also, is a major refining center for Southeast Asia, with total crude oil refining capacity of nearly 1.393 MB/d.

Table 2: World Crude Oil Refining Capacity, January 1, 2004

| | Number of Refineries | Crude Oil Distillation |
|---|---|---|
| Australia | 8 | 755 |
| China | 95 | 4,528 |
| India | 17 | 2,135 |
| Indonesia | 8 | 993 |
| Japan | 33 | 4,703 |
| Korea, South | 6 | 2,544 |
| Malaysia | 6 | 516 |
| New Zealand | 1 | 104 |
| Pakistan | 5 | 269 |
| Philippines | 3 | 333 |
| Singapore | 3 | 1,319 |
| Sri Lanka | 1 | 48 |
| Taiwan | 4 | 920 |
| Thailand | 4 | 703 |
| Asia & Oceania | 200 | 20,038 |
| World Total | 735 | 82,258 |

Source: eia.doe.gov.

Figure 2: World Crude Oil Refining Capacity, January 1,2004




## 3.4 Energy efficiency:

Energy is used in an economy to supply a service or perform a certain activity. Thus, energy efficiency improvement means decreasing the use of energy per unit of activity. During the last two decades, the OECD countries have witnessed an increase in energy efficiency where energy intensity has declined from 16.32 Btu/ dollar of GDP in 1980 to a level of 10.73 Btu/ dollar for the USA and less for other European countries. The OECD energy intensity used an average of 7.691 Btu/ dollar of GDP in 2001. In comparison to North America and Western Europe, Asian countries are trying to increase energy efficiency. In China, there also has been a substantial decline of energy intensity. In 1980, China instituted a loan program and committed 7-8% of total energy investment to efficiency improvements, (Sinton and Levine, 1994). This program contributed to a remarkable decline in the energy intensity of China's economy decreased from a level of 105.632 in 1980 to 35.619 Btu per 1000 of GDP in 2001. However, in NIEs countries, energy intensity has been increasing from an average of 13.8 in 1980 to 17.5 Btu per 1000 of GDP in 2001. Energy intensity for India and Pakistan has been constant for the total period with some decline in India's energy intensity. As shown in Table 4.

| Table 3 : World Primary Energy Consumption Per Dollar of Gross Domestic Product, 1980-2001 | | | | | | | |
|---|---|---|---|---|---|---|---|
| ( Btu per 1995 U.S. Dollars Using Market Exchange Rates) | | | | | | | |
| **OECD Pacific** | | | | **China** | | | |
| | **1983** | **1993** | **2003** | | **1983** | **1993** | **2003** |
| Australia | 14,724 | 13,770 | 12,383 | China | 89,733 | 53,678 | 33,175 |
| Korea, South | 12,377 | 15,631 | 14,739 | **NIS Asia countries** | | | |
| Japan | 4,728 | 4,507 | 4,605 | Indonesia | 19,838 | 23,352 | 28,041 |
| New Zealand | 12,377 | 15,631 | 14,739 | Taiwan | 13,213 | 11,843 | 12,924 |
| **Mean** | 11,052 | 12,385 | 11,616 | Thailand | 12,944 | 16,651 | 22,158 |
| **SD** | 4358.433 | 5324.71 | 4804.491 | Singapore | 17,274 | 19,204 | 18,727 |
| | | | | Malaysia | 16,556 | 21,366 | 23,267 |
| | **South Asia** | 30,449 | 25,460 | Philippines | 10,687 | 14,426 | 14,407 |
| India | 27,245 | 25,002 | 24,403 | Hong Kong | 5,054 | 4,667 | 4,995 |
| Pakistan | 24,699 | 27,725 | 24,932 | Vietnam | 18,021 | 20,389 | 25,715 |
| **Mean** | 25,972 | 3851.886 | 747.4419 | **Mean** | 14,198 | 16,487 | 18,779 |
| **SD** | 1800.294 | | | **SD** | 5551.303 | 6878.237 | 8187.61 |
| | | | | | | | |

Source: Energy Information Administration www. eia.doe.gov

## 4. Economic Growth

For the past two decades, Asia has witnessed a remarkable economic growth. Asia grew by an average of 5.30 percent with China growing by an average rate of 9.55 percent for the period of 1980-2002. The average economic growth of these countries has outperformed these of Western Europe.

For the period 1980-1995, the OECD countries in Asia (mainly Japan) were the dominating economy in the region, with the main contributor to economic growth. The "NIEs" start showing a high growth rate starting from 1986. This was followed by other countries including Indonesia, Malaysia, the Philippines and Thailand.

**Table 5: Asian and specific countries'average real Economic Growth (1980-2003).**

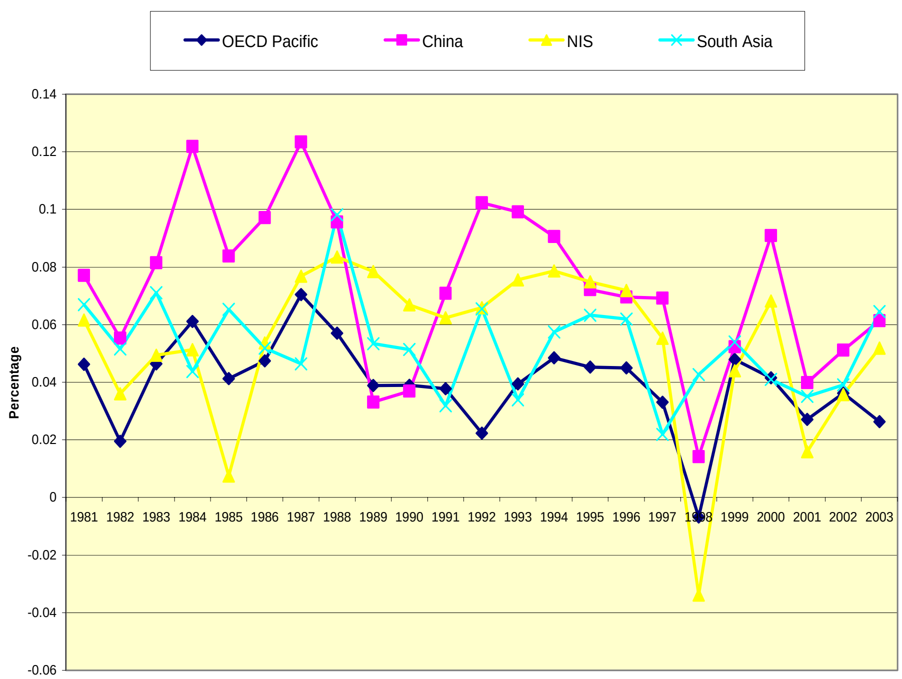
| | 1980-2003 |
|---|---|
| Australia | 3.53% |
| China | 9.56% |
| Hong Kong | 5.13% |
| India | 5.68% |
| Indonesia | 4.67% |
| Japan | 2.51% |
| Korea, South | 6.98% |

| | |
|---|---|
| Malaysia | 6.14% |
| New Zealand | 2.82% |
| Pakistan | 4.85% |
| Philippines | 2.64% |
| Singapore | 6.53% |
| Taiwan | 6.45% |
| Thailand | 6.07% |
| Vietnam | 5.18% |
| Total Asia/Pacific | 5.25% |

Source: International Monetary Statistics IMS

China became the fastest growing economy in the region and maintained this position in the 1990s as well as NIEs countries. However, in 1997, these countries were faced with a major financial crisis[1] causing a slow down in their economies. Nevertheless, most of these countries economies recovered by 1999.

**Figure 3: Average Real Economic growth for Four regions of Asian Countries (1981-2003)**




Oil demand in Asia has increased concomitantly with the high economic growth rate in the region. Oil consumption has increased from 10.729 MB/d in 1980 (17.0 % of world total) to reach a level of 22.255 Mb/d (27.8% of world total) in 2003. The growth comes

[1] At the end of 1997 the Asian countries faced a financial crisis…..

mainly from NIEs, where it grew from 1.747 Mb/d (2.7%) in 1980 to 4.906 Mb/d (6.12 %) in 2004. China's consumption increased from less than two millions in 1980(2.8%) to reach 5.55(6.12%) MB/d in 2003. Each region's economic growth will be explained in the following section:

### 4.1. OECD Pacific:

Of the OECD Pacific region, the most important country is Japan, which are the world's third largest energy consumer and second largest energy importer (after the United States). Japan has been experiencing a period of slow economic growth, and has taken important steps towards economic deregulation and restructuring which has resulted in 2003 leading to a positive increase in economic growth of 3% from 0% in the previous three years. As a result of slow economic growth, the Japanese demand for energy has been stagnant in recent years. The oil consumption has stabilized reaching 5.57 Mb/d in 2003. Most of Japan's oil imports (75%-80%) came from the Middle East. most prominently from Saudi Arabia, the United Arab Emirates, Kuwait, and Iran.

The second most important country among the OECD pacific countries in terms of oil imports is South Korea. It is the seventh largest importer of crude oil, and the second largest importer of Liquefied Natural Gas (LNG). Oil makes up the largest share of South Korea's total energy consumption, though its share has been declining in recent years. By 2003. South Korea consumed 23.00 Mb/d which had decreased from its previous high of 2.373 MB/d in 1997, all of which was imported.

Table 3: Consumption of Crude oil (Million Barrel Per Day)

| | 2000 | 2001 | 2002 | 2003 | **2004** |
|---|---|---|---|---|---|
| Japan | 5606.96 | 5530.03 | 5464.56 | 5578.39 | 5280.00 |
| Korea, South | 2135.29 | 2132.04 | 2149.15 | 2168.13 | 2280.00 |
| Australia | 871.89 | 877.85 | 875.84 | 875.62 | 858.00 |
| New Zealand | 131.63 | 131.79 | 145.25 | 151.88 | 151.00 |
| China | 4795.71 | 4917.88 | 5160.71 | 5550.00 | 6684.00 |
| Indonesia | 1036.70 | 1077.00 | 1125.65 | 1155.00 | 1150.00 |
| Taiwan | 865.30 | 881.72 | 893.74 | 915.00 | 877.00 |
| Thailand | 724.94 | 701.61 | 763.27 | 810.00 | 909.00 |
| Singapore | 660.30 | 686.56 | 698.04 | 705.00 | 748.00 |
| Malaysia | 465.02 | 475.10 | 492.75 | 510.00 | 504.00 |
| Philippines | 352.77 | 346.85 | 337.75 | 335.00 | 336.00 |

| | | | | | |
|---|---|---|---|---|---|
| Hong Kong | 244.92 | 245.38 | 252.00 | 260.00 | 314.00 |
| Vietnam | 175.71 | 178.57 | 192.90 | 216.00 | 2555.00 |
| India | 2127.44 | 2183.73 | 2263.44 | 2320.00 | 296.00 |
| Pakistan | 365.01 | 367.12 | 355.89 | 338.00 | 411.00 |
| **Asia & Oceania** | 20897.80 | 21078.17 | 21535.20 | 22255.53 | 23446.00 |
| **World Total** | 76945.89 | 77701.30 | 78457.74 | 80098.82 | 80757.00 |

Source: Bp Statistical Review of World Energy June 2005

**4.2-China:**

China is the world's most populous country and the second largest energy consumer Production and consumption of coal, its dominant fuel is the highest in the world. Rising oil demand and imports have made China a significant factor in world oil markets. China surpassed Japan as the world's second-largest petroleum consumer in 2004. As a net oil importer since 1993, China's petroleum industry is focused on meeting domestic demand, with modest exports to Japan. With China's expectation of growing dependence on oil imports, China has been acquiring interest in exploration and production abroad, in countries such as Kazakhstan, Venezuela, Sudan, Iran and Peru. For major exports, Russia is seen as a potential source of China's crude oil import depending on the feasibility of the export pipelines downstream infrastructure development in China centers primarily on upgrading existing refineries rather than building new ones to handle heavier and more sour grades of crude oil. With China's domestic reserve of natural gas standing at 53.3 trillion cubic feet (Tcf) at the beginning of 2003, China has embarked on a major expansion of its gas infrastructure. The major fuel for consumption in China is Coal, it makes up 64% of China's primary consumption, and China is both the largest consumer and producer of coal in the world. China's consumption in 2003 was 1.38 billion short tons, (over 26% of the world total).

China experienced high economic growth in recent years which has led to raise in demand for oil and oil consumption reached a high level of 6.684 million barrel per day in 2004 ( 8.27% of world total) causing a surge of oil prices during 2004.

**4.3 Newly Industrlized Economy (NIEs):**

The NIEs countries considered important with regard to oil import are as follows: Taiwan, Thailand, Singapore, and the Philippines. The other countries in the group, Indonesia and Malaysia are still net exporters of oil at 403 thousand b/d for Indonesia and 258 thousand b/d. for Malaysia.

4.3.1 Taiwan: Taiwan is a leading economic and trading center. For Taiwan, oil is by far the dominant fuel contribution, representing 51% of its total energy consumption. Coal also plays an important role (32% of total energy consumption) followed by nuclear power (8%) and natural gas (6%) Taiwan has very limited domestic energy resources and relies on imports for most of its energy requirements.

4.3.2 Thailand: Thailand is a important energy consumer, and its energy consumption is expected to resume strong growth as the country recovers from the global slow down of 2001-2002. In 2001, Thailand produced about 175,027 barrels per day of oil. It's oil consumption peaked in 1996 at 749,000 b/d. It fell to 706,000 in 1998 during the Asian crisis, by 2001 it had increased to 715,000 b/d. Part of the reason consumption has not recovered fully is that the Thai government has been raising taxes on petroleum products, which is intended to promote conservation and reduce oil imports. However, by 2003 the demand of oil increased to a level of 836000 b/d.

4.3.3. Singapore: Singapore is a major refining center for Southeast Asia, with total crude oil refining capacity of nearly 1.3 Mb/d has nearly doubled its rate of petroleum products consumption. It is also strategically located near the Strait of Malacca, a major route for oil tankers. Singapore's strategic location has helped it to become one of the most important shipping centers in Asia. The Asian economic crisis of 1997-98 had a negative impact on Singapore's refining industry and Singapore's refining companies lost significant business due to the declining demand for oil products in the region. While the region staged a recovery from the financial crisis in 1999 and 2000, the construction of new refineries in Singapore's traditional export markets has had a more enduring negative effect.

4.3.4. The Philippine: The Philippines are a growing consumer of energy, particularly electric power, and a major potential market for foreign energy firms. It's also produce a modest amount of less than 9 thousand Barrel/d while it consumes 356 thousand B/d resulting in net imports of 347 thousand. On the other hand, the Philippines have 3.693 trillion cubic feet of gas proven reserves but no significant production at the present time.

4.3.5 Indonesia: Indonesia is important to world energy markets since it is the only NIEs member of OPEC and it is the worlds largest liquefied natural gas (LNG) exporter.

Indonesia currently holds proven reserves of 5 billion barrels. In 2003, Indonesian crude oil production averaged 1.24 million barrels per day B/d, having decreased from its pick at 1.638 Mb/d in 1995. The recent declines in production are due mainly to a natural decline of aging oil fields, which recent oil discoveries have been too small to offset. Besides crude oil, Indonesia also produces approximately 230,000 b/d of natural gas liquids and lease condensate (which are not part of OPEC quota) bringing the country's total oil production to around 1.3 Mb/d. Despite the significant proven natural gas reserve of 92.5 trillion cubic feet (Tef) and its position as the world's largest exporter of LNG, Indonesia still relies on oil to supply about half of its energy needs. About 70% of Indonesia's LNG exports are to Japan, 20% to South Korea, and the remainder to Taiwan. As Indonesia's oil production has leveled off in recent years, the country has tried to shift towards using its natural gas resources for power generation. However, the domestic natural gas distribution infrastructure is still not extensive.

4.3.6 Malaysia: Malaysia holds 75.0 trillion cubic feet (tcf) of natural gas reserves and 3 billion barrel of oil reserves. Its oil exports average 260,000 barrels per day and its LNG exports 0.74 tcf. Despite its declining oil reserves (due to a lack of major new discoveries in recent years), Malaysia's crude oil production has been stable in recent years, between 650-730 thousand b/d. Its domestic product consumption is growing again. Moreover, the country is expected to become a net oil importer before the end of the current decades. Malaysia has six refineries with a total processing capacity of 516 B/d. Natural gas production has been raising steadily in recent years, reaching 1.7 tcf in 2000, up from 1.42 tcf in 1999.

## **4.4 South Asia:**

South Asia countries consist of India, Pakistan, Afghanistan, Pangldish, Sri Lanka Nepal and Kashmir among others. However, India and Pakistan are the two most important economies in the region. Moreover both are the major consumers of oil in the region of South Asia.

4.4.1 India: India is the world's sixth largest energy consumer and is planning major energy infrastructure investments to keep up with increasing demand-particularly for electric power. India is also the world's third largest producer of coal which satisfies

more than half of its total energy needs. Oil accounts for about 30% of India's total energy consumption. India has implemented a series of policy changes since the mid-1990s to encourage foreign investment which is expected to grow rapidly, beyond the level of 1.5 in 2001. India is attempting to limit its dependence on oil import somewhat by expanding domestic exploration and production.

4.4.2 Pakistan: Pakistan produced 61 thousand B/d of oil in 2003, and consumed 338 Thousand b/d. This means they had a net total of oil imports of 276 thousand b/d. Pakistan's net imports are projected to rise substantially in the coming years as demand outpaces the increase in production. The demand for refined petroleum products also greatly exceeds domestic oil refining capacity, so nearly half of Pakistan imports are refined products.

Section 4, indicates the importance of Asian Countries as a major consumer of oil. Even though, several countries produce oil they become by the 1995 net importer. Only Indonesia and Vietnam still produce more than it consume. Japan followed by China (in the year 2001) is the major consumer of oil in the Asian countries. However, China is the second oil consumer now with its high economic growth causing oil prices to surge in 2004. Moreover, there growing economies are indicating the major role that they are playing in the world oil marker. This role will have more significant on the coming years.

Table 7: Total Consumption, Production and Imports of Asian and Pacific countries (2003)Thousands Barrel a Day.

| | Consumption | Production | Import |
|---|---|---|---|
| Japan | 5578.39 | 120.7 | 5457.7 |
| Korea, South | 2168.13 | 2.8 | 2165.3 |
| Australia | 875.62 | 630.8 | 244.9 |
| New Zealand | 151.88 | 31.7 | 120.1 |
| China | 5550.00 | 3,549.0 | 2001.0 |
| Indonesia | 1155.00 | 1,240.0 | *(-85.0) |
| Taiwan | 915.00 | 8.4 | 906.6 |
| Thailand | 810.00 | 255.5 | 554.5 |
| Singapore | 705.00 | 8.3 | 696.7 |
| Malaysia | 510.00 | 840.3 | *(-330.3) |
| Philippines | 335.00 | 14.4 | 320.6 |
| Hong Kong | 260.00 | 0 | 260.0 |
| India | 2320.00 | 814.9 | 1505.1 |
| Pakistan | 2320.00 | 61.9 | 2258.1 |
| Vietnam | 338.00 | 352.5 | *(-14.5) |

| | | | |
|---|---|---|---|
| Other Asia | 386.00 | 268.9 | |
| Total Asia | **22255.53** | **8,199.9** | **14055.6** |

* Exports. Source: Energy Information Administration   www. eia.doe.gov

With total consumption of energy in Asian countries of 403.92 Btu oil consist of 156.48 consisting of almost 40% of energy consumption. According to that, oil is the dominant source of energy

Table 8: Asian Countries Consumption of different energy sources. (Btu) 2001

| | Petroleum | Dry Gas | Coal | Other | Total Energy |
|---|---|---|---|---|---|
| Australia | 1.71 | 0.88 | 2.19 | 1.90 | 4.97 |
| China | 10.22 | 1.24 | 25.37 | 13.05 | 39.67 |
| India | 4.40 | 0.83 | 6.51 | 5.46 | 12.80 |
| Indonesia | 2.17 | 1.39 | 0.91 | 2.33 | 4.63 |
| Japan | 10.97 | 2.97 | 3.69 | 15.27 | 21.92 |
| Korea, South | 4.44 | 0.83 | 1.70 | 5.54 | 8.06 |
| Malaysia | 0.96 | 1.16 | 0.08 | 1.03 | 2.27 |
| Pakistan | 0.79 | 0.77 | 0.09 | 1.01 | 1.87 |
| Philippines | 0.71 | 0.00 | 0.20 | 1.05 | 1.25 |
| Singapore | 1.56 | 0.09 | 0.00 | 1.56 | 1.65 |
| Taiwan | 2.09 | 0.23 | 1.31 | 2.52 | 4.07 |
| Thailand | 1.62 | 0.83 | 0.37 | 1.71 | 2.90 |
| Vietnam | 0.38 | 0.05 | 0.15 | 0.56 | 0.76 |
| **Asia and Oceania** | **43.71** | **12.03** | **45.32** | **55.41** | **112.76** |
| **(% share of world total )** | **27.9%** | **12.9%** | **47.2%** | **25.7%** | **29.9%** |
| **World Total (Btu)** | **156.48** | **93.11** | **95.94** | **214.87** | **403.92** |

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This is an indication of the importance of conducting studies regarding the demand of oil in Asian countries. However, there are few studies that analyze the significance of Asia countries in whole. Some studies assume the stationarity of the variables included on the studies. Several of these studies will be reviewed on the following section.

## 5. Review of the Literature:

.Most studies of oil demand for Asian countries focus on demand for petroleum products and use individual countries. McRae (1994) presented estimates of motor gasoline demand in eleven developing countries of Asia, and provided estimates of elasticities for Asian countries and compared then to those of the OECD countries. Banaszak, et al (1999) examined the demand for gasoline and diesel in ground transportation in South Korea and Taiwan, comparing the effects of their different pricing policies and stages of

economic growth. Han, X. and Lakshmanan, T., (1994) analyzed the effects of the pervasive changes in the Japanese economy on its energy intensity during the period 1975-85. Fatai. K et al (2003) modeled and forecasted the demand for electricity in New Zealand and compared alternative approaches.

Other studies used demand for energy not specific energy source, Lee and Hing (1997) used Co integration and vector error-correction model to analyze the energy consumption behavior in China. They found that not only convention variables such as energy price and income are important. Galli, R (1998) studied the relationship between energy intensity and income levels and forecasted long-term energy demand in Asian emerging countries for the period 1973-1990 using a quadric function of log income. Kenneth, et al (2001) examines the relationship between economic development and energy demand and analyzed the effect of sector-specific energy demand growth rates on the composition of fuel energy demand, for selected Developing countries.

In another paper comparing the dependence on the Gulf oil regarding the importance of Asian-Pacific, region oil vs. the US Salameh (2003) analyzed the impact of growing dependence of Asian Pacific region on the Gulf oil.

In the literature, number of studies have used Granger Causality to analyze the relationship between consumption GDP and oil price, Masih et al (1996) used System equations to test the relationship between consumptions and real income for six Asian countries While Cheng et al (1997) applied Granger causality between energy consumption and GDP using techniques of co integration to Taiwanese data for the 1955-1993 period. Asafu-Adjaye (2000) estimates the causal relationships between energy consumption and income for India, Indonesia, Philippines and Thailand. Using cointegration and error-correction modeling techniques. The results indicate that in the short run Granger causality is unidirectional, running from energy to GDP for India and Indonesia. Masih, A. et al (1997) tested for cointegration between total energy consumption, real income, and price level of two highly energy dependent East-Asian NIEs: Korea and Taiwan. The Granger causality was tested using a dynamic vector correction model. Masih, A et al (1997) concluded that it is the rate of price change that leads to the change in energy consumption, which leads on to the change in economic growth.

In this paper crude oil demand will be estimated for the Asian countries which include NIEs Countries (Singapore, Thailand, Taiwan Philippine and Other East Asian countries) as one group , OECD countries (Japan, South Korea), China, India and Pakistan., using co integration analysis and an ECM. There are however three approaches to estimating the ECM: the Engle-Granger's two-step procedure and Hendry's type of testing down., and the Autoregressive Distributed Lag (ARDL) approach of Pesaran et al.. (1999, 2001). To avoid "spurious result" stationarity all variables will be tested and if the variables are non-stationary, cointegration analysis and Error Correction Model will be applied.

## 6. Method of Analysis:

The data commonly used in demand analysis is normally non-stationary; Plosser (1964) Hendery 1982) among others indicated that econometric studies that overlook this particular characteristic may get a "spurious result" i.e. giving parameters that is far from the true one, also is leading to a very high $R^2$ although there is nor relationship existing between the variables included in the study. This problem occurs because both the dependent and independent variables exhibit strong trends; the high $R^2$ observed is due to the presence of the trends, not to a true relationship between them.

To overcome the 'spurious' problem Engel and Granger (1986) show that one of the best solutions is to apply co integration and error correction models (ECM). The advantages of employing ECMs are numerous (see Bentzen and Engsted, 1993).

### 6.1 Cointegration and Error Correction Model

To illustrate the ECM model we use the following equilibrium equation:

$$y_t = \alpha + \beta x_t \qquad 1$$

$y_t$ is a dependent variable and $x_t$ is a vector of independent variables. If yt and $x_t$ are in equilibrium, then the balance $y_t - \alpha + \beta x_t$ will equal zero. However, $y_t - \alpha + \beta x_t$ will be non-zero when disequilibrium occurs. More precisely, this quantity measures the extent of disequilibrium between $y_t$ and $x_t$ and hence is be assumed to be related to the value of xt and the lagged values of $y_t$ and $x_t$ of which one typical form of which is

$$y_t = \gamma + \delta_0 x_t + \delta_1 x_{t-1} + \delta_2 y_{t-1} + u_t \qquad 2$$

Where ut is the disturbance term, subtracting yt-1 from both sides of Eq. (2) and regrouping the resulting equation yields

$$\Delta y_t = \delta_0 \Delta x_t - \mu(y_{t-1} - \alpha - \beta x_{t-1}) + u_t \qquad 3$$

Where μ, α and β assume the values 1-$\delta_2$, γ/ (1- $\delta_2$) and ($\delta_0$+ $\delta_1$)/ (1- $\delta_2$) respectively. Δ represents the first difference of the variables. Eq.(3) shows that the change in $y_t$ depends on the change in $x_t$ and the lagged value of the disequilibrium error, which implies that when $y_{t-1}$ is greater than its equilibrium value, the value of $y_t$ will be decreased for the disequilibrium error and hence is called the ECM. From Eq. (3), it is clear that δ0 and β measures the short-run and long run parameters, while μ measures the speed of adjustment towards the long-run equilibrium. Assuming a simple relationship in Eq. 2, in practice Eq (2) is added with higher lag orders as explanatory variables, so as to make ut white noise. When higher order lagged variables are introduced, Eq. (3) is required to be modified into the form

$$\Delta y_t = \sum_{i=1}^{k-1} \Psi \Delta y_{t-1} + \sum_{i=0}^{k-1} \delta_t \Delta x_t - \mu(y_{t-k} - \alpha - \beta x_{t-k}) + u_t \qquad (4)$$

The popularity of the ECM is due to the works of Granger (1983, 1988), Engle, and Granger (1987) on cointegration. The importance of cointegration comes from the fact that statistical inference from conventional regression is only valid when the variables in a model are stationary. Most economic regression is only valid when variables in a model are stationary. Most economic time series which are not stationary leads to misspecification. To confront this problem, Engle and Granger develop the concept of co integration. They argued that although the variables are individually non-stationary a linear combination of the variables may be stationary. If this is the case, the variables are said to be co integrated.

The relationship of the ECM to co integration analysis derives from a representation theorem proved by Engle and Granger (1987). The theorem states that if variables are cointegrated, then the short-run or disequilibrium can always be represented by an ECM. Further, under the co integration assumptions, simple regressions will provide a consistent estimates of the long-run coefficients, regardless of the variables are correlated with the disturbances (thus causing ' simultaneous equation bias' in finite samples' After 1988, however, a maximum-likelihood procedure developed by Johansen

and Juselius (1990) and Johansen (1991) began to replace the simple regression approach to estimate the long-run coefficients. Due to Engle and Granger's findings, both the long-and short-run effects can be captured with the help of the ECM and counteraction analysis.

6.2 Unit Root Tests

Before conducting the Engle-Granger ECM analysis, it is necessary to examine time series properties of the variables to be estimated. This is important because if the variables are non-stationary as well as non-co integrated; an ordinary least squares (OLS) regression of Eq. (5) will be miss-specified, resulting in misleading values of $R^2$, F and t statistics. To investigate this, we conduct Augmented Dickey-Fuller (ADF) (1981) unit root tests on the stationary of levels and the first differences of the variables included in the study. In essence, testing whether a particular series, say $z_t$, is integrated is equivalent to testing for the significance of $\theta_2$, *I.e.* $H_0:\theta_2=0$, in the regression below where T is a linear trend.

$$\Delta z_t = \theta_0 + \theta_1 T + \theta_2 z_{t-1} + \sum_{i=1}^{k} \lambda z_{t-i} + v_t \qquad (5)$$

Table 9 : Augmented Dickey-Fuller test for years 1980-2002.

| Series | Level (lag(1) | | First Difference (no lag) | | Second Difference (no lag) | | |
|---|---|---|---|---|---|---|---|
| | No trend | With trend | No trend | With trend | No trend | With trend | |
| Critical Value | -3.0115 | -3.6454 | -3.0199 | -3.6592 | 3.0294 | -3.6746 | |
| $Q_{NIS}$ | -1.4334 | -0.9817 | -2.7452 | -4.2446 | | | I(1) |
| $q_{CH}$ | -2.3380 | -0.7139 | -4.9860 | -5.0665 | | | I(1) |
| $q_{JAP}$ | -1.0696 | -1.5767 | -3.7472 | -3.7350 | | | I(1) |
| $q_{SK}$ | -1.0494 | -1.3677 | -2.5610 | -2.6548 | 6.7688 | -6.7084 | I(2) |
| $q_{IN}$ | -0.7675 | -2.3408 | -2.7187 | -2.7452 | -3.8919 | -4.3958 | I(2) |
| $q_{PK}$ | -2.4577 | -0.9425 | -4.8591 | -5.2974 | | | I(1) |
| $Y_{NIS}$ | -1.2252 | -0.7932 | -3.7662 | -2.7187 | | | I(1) |
| $Y_{CH}$ | -1.5318 | -3.4553 | -3.4339 | -3.2610 | | | I(1) |
| $Y_{JAP}$ | -2.1683 | -.78635 | -1.7091 | -2.6518 | -4.0925 | -7.8898 | I(2) |
| $Y_{SK}$ | -1.9780 | -1.0184 | -4.1746 | -4.9176 | | | I(1) |
| $Y_{IN}$ | -0.4389 | -2.7602 | -2.4115 | -2.7218 | -3.7457 | -4.9860 | I(2) |
| $Y_{PK}$ | -0.8179 | -1.1940 | -4.2446 | -4.2747 | | | I(1) |
| Pt | -2.4849 | -2.7238 | -5.2591 | -5.3285 | | | I(1) |

The results in Table 9 indicate that the variables under examination are integrated of order one except those for South Korea, India and the GDP for Japan and China) which indicate they are of order two I(2).

The result of the ADF test show that the time series included in the study has a different order of integration therefore, we cannot use the Johansen Procedures which require the equality of the level of integration. Hence, Autoregressive Distributed Lag (ARDL) approach of Pesaran et al. (1999, 2001) will be used. It has the advantage of its applicability irrespective of the different integration level. The ARDL procedures involve two stages, First, testing the existence of the long run relation between the variables using "the Bound testing approach" Pesaran, et al (2001). The second stage of the analysis is to estimate the coefficients of the long run relations and make inference about their values using the ARDL approach and testing the performance of the model in forecasting. Finally, the ARDL model will be used in forecasting for the crude oil consumption for the years 2003-2006.

Variables of the study include Consumption of Crude oil, Real GDP in USA Dollar, and Crude oil Price. The data will cover the period 1980-2002. The source for the data is OPEC secretariats.

## 6.3 Demand Model: Specification and Identification

The energy demand equation to be estimated in this study is

$$q_{it} = \beta_0 + \beta_1 y_{it} + \beta_2 p_t + u_t \qquad (6)$$

where $q_{it}$ is the crude oil consumption for country i in year t, $y_{it}$ is the Gross Domestic Product (GDP) for the country I in year t, p is the real retail price of crude oil, which is the price of crude price indicator such as Brent, Dubai or Oman, Brent is the one will which be used because it is used as an oil price indicator and its available for the whole period. And $u_t$ is the disturbance, which is assumed to have conventional properties. The model used for estimating demand for oil in Asian countries is the logarithm of the actual data,

Lowercase letters denote the natural logarithm of variables and each coefficient estimated as an elasticity. The data set contains annual observation over the period 1980-2002. The source of the data is OPEC secretariats in Vienna and the Energy Information Administration (EIA) in Washington, and it's provided in Appendix I. In order to evaluate the forcastability of the model, it is run between the years 1980-1998, leaving the last four observation period 1999-2002 for carrying out the post-sample forecast error comparison. The estimation will be for different region: Japan; South Korea; China; NIEs countries (which include Singapore, Thailand, Vietnam, and Taiwan, Philippine), and south Asia including India and Pakistan. The function of each country is shown below where the quantity consumed is in left side GDP and Price on the right side.

$$q_{jap} = f(y_{Jap}, P_{Dub},)$$
$$q_{SK} = f(y_{SK}, P_{Dub},)$$
$$q_{CH} = f(y_{CH}, P_{Dub})$$
$$q_{NIC} = f(y_{NIC}, P_{Dub})$$
$$q_{Ind} = f(y_{IND}, P_{Dub})$$
$$q_{PK} = f(y_{PK}, P_{Dub})$$

The ARDL method of integration analysis has the advantage against other method that it does not generally require knowledge of the order of integration of variables, which is necessary in the Johansen procedures. The ARDL method also estimate the long run and short run components of the model simultaneously, removing problems of omitted variables and autocorrelation. Thus, estimates obtained from the ARDL method of Co integration analysis are unbiased and efficient, since they avoid the problems that may arise in the presence of serial correlation and endogenous. The augmented ARDL (model) can be written as follows (Pesaran and Pesaran, 1997) pp.393-5, Pesaran and Shin, 1999) Harvey (1991), (Pesaran, Shin and Smith (2001).

$$\alpha(L,P)y_t = \alpha_0 + \sum_{i=1}^{k} \beta_i(L,q_i)x_{it} + u_t$$

Where α is a constant; y is the dependent variable; L is a lag operator such that $L^j y_t = y_{t-j}$

$$\alpha(L,p) = 1 - \alpha\delta_1 L^1 - ...\alpha_p L^p,$$
$$\beta_i(L,q_i) = \beta_{i0} + \beta_{i1}L + \beta_{i2}L^2 + .. + \beta_{iqi}L_i^q$$

and $x_{it}$ is the $i^{th}$ independent variable where I=1,2,..k. In long run we have yt=yt-1=…yt-p; $x_{it}=x_{i,t-1}=\ldots x_{i,t-q}$ where $xi_{,t-q}$ denotes the qth lag of the $i^{th}$ variable. The long run equation can be written as follows:

$$y = \alpha + \sum_{i=1}^{k} \beta_i x_i + v \qquad \alpha = \frac{\alpha}{\alpha(1,p)}$$
$$\beta_i = \frac{\beta_i(1,q)}{\alpha(1,p)}, \quad v_i = \frac{u_i}{\alpha(1,p)} \qquad (7)$$

The error correction (EC) representation of the ARDL model can be written as follows:

$$\Delta y_t = \Delta\hat{\alpha}_0 - \sum_{i=2}^{p} \hat{\alpha}_j \Delta y_{i-j} + \sum_{i-j}^{k} \beta_i \Delta x_{it} - \sum_{i=1}^{k} \sum_{j=2}^{q} \hat{\beta}_{i,i-j} \Delta x_{,i-j} - \alpha(1,p) ECM_{i-j} + u_t$$
$$ECM_i = y_i - \hat{\alpha} - \sum_{i=j}^{k} \hat{\beta}_i x_{it} \qquad (8)$$

Where Δ is the first difference operator; $\alpha_{,\ t-j\ j}$ and $\beta_{ij,\ t-j}$ are the coefficients estimated from equation 2 and α(1,p) measures the speed of adjustment.

A two-step procedure is used in estimating the long-run relationship. In the first step. We investigate the existence of a long run relationship predicted by theory among the variables in equation (see equation 5). The short and long run parameters are estimated in the second stage by using Equations 2 and 3, respectively, if the long-run relationship is established in the first step.

Suppose that at the first stage, theory predicts that there is a long-run relationship among y, x and z. without having any prior information about the direction of the long-run

relationship among variables, the following three unrestricted error correction (EC) regressions are estimated considering each variables in turn as a dependent variables:

$$\Delta y_t = \alpha_{0y} + \sum_{t=1}^{n} b_{ty}\Delta y_{t-j} + \sum_{i=1}^{n} c_{iy}\Delta x_{t-j} + \sum_{i=1}^{n} d_{iy}\Delta z_{t-j} + \gamma_{1,y} y_{t-j} + \gamma_{2,y} x_{t-j} + \gamma_{3,y} z_{t-j} + \nu_{1t} \quad (8a)$$

$$\Delta x_t = \alpha_{0x} + \sum_{t=1}^{n} b_{tx}\Delta y_{t-j} + \sum_{i=1}^{n} c_{ix}\Delta x_{t-j} + \sum_{i=1}^{n} d_{ix}\Delta z_{t-j} + \gamma_{1,x} y_{t-j} + \gamma_{2,x} x_{t-j} + \gamma_{3,x} z_{t-j} + \nu_{2t} \quad (8b)$$

$$\Delta z_t = \alpha_{0z} + \sum_{t=1}^{n} b_{tz}\Delta y_{t-j} + \sum_{i=1}^{n} c_{iz}\Delta x_{t-j} + \sum_{i=1}^{n} d_{iz}\Delta z_{t-j} + \gamma_{1,z} y_{t-j} + \gamma_{2,z} x_{t-j} + \gamma_{3,z} z_{t-j} + \nu_{3it} \quad (8c)$$

The F tests are used for testing the existence of long-run relationships. When such relationships are seen to exist, the F tests dictates which variable should be normalized. The null hypothesis for testing the 'nonexistence' of the first 'long-run relationship' as follows:

$$H_0 : \gamma_{1y} = \gamma_{2y} = \gamma_{3y} = 0 \qquad \textit{the test} \quad F_y(y/x,z). \quad \textit{for} \quad (8a)$$

$$H_0 : \gamma_{1x} = \gamma_{2x} = \gamma_{3x} = 0 \qquad \textit{the test} \quad F_x(x/y,z). \quad \textit{for} \quad (8b)$$

$$H_0 : \gamma_{1z} = \gamma_{2z} = \gamma_{3z} = 0 \qquad \textit{the test} \quad F_z(z/y,x). \quad \textit{for} \quad (8c)$$

The test has a nonstandard distribution, which depends upon whether the ARDL model is to be I(0) or I(1), the number of regressors, and whether the regressors contain an intercept and a trend.

Two tests of critical values (CVs) are reported in Pesaran and Peasaran (1997): and (Pesaran, Shin and Smith (2001). One set is calculated assuming that all variables included in the ARDL model are I(1) the other is estimated considering the variables are I(0). If the computed F values fall outside the inclusive band, a conclusive decision can be drawn without knowing the order of integration of the variables. More precisely, if

the empirical analysis shows that the estimated $F_y(.)$ is higher than the upper bound of the CV while $F_x(.)$ and $F_z(.)$ are lower than the lower bound of the CV, there exists a 'unique and stable long run' relationship. In this relationship, y is a dependent variable and x and z are long run forcing' or exogenous variables. Conversely, if the computed F statistics fall within the band, prior information on the order of integration of the variables is necessary to make a decision on the long-run relationship.

## 7. Results

Since the observations are annually, the maximum order of the lags used in the ARDL model will be (2) and the estimation will be carried for the period 1980-1998, retaining the remaining four years, 1999-2002 for predication.

The error correction version of the ARDL model in the variables $lq_{it}$,$ly_{it}$, and $lp_t$ is given by:.

$$\Delta lq_{it} = \alpha + \sum_{i=1}^{k=4} \Psi \Delta lq_{it-k} + \sum_{i=0}^{k=4} \varphi_t \Delta ly_{it-k} + \sum_{i=0}^{k=k} \delta_t \Delta lp_{t-1} \qquad 9$$
$$+ \gamma_1 lq_{t-k} + \gamma_2 ly_{t-1} + \gamma_3 y_{t-k} + \nu_t$$

The Null hypothesis that will be tested is "non-existence of the long-run relationship" defined by

$$H_0 : \gamma_1 = \gamma_2 = \gamma_3 = 0 \qquad 10$$
$$H_A : \gamma_1 \neq \gamma_2 \neq \gamma_3 \neq 0$$

| | Intercept and no trend, k=2 | | |
|---|---|---|---|
| Long Run Relationship<br>Critical values bounds 95%<br>(3.79-4.85) | F-statistic ($lq_{it}/ly_{it},lp_t$) | F-statistic ($ly_{it}/lq_{it},lp_t$) | F-statistic ($lp_t/ly_{it}lq_{it}$) |
| NIEs Countries | 9.3863 | 3.4297 | 2.5323 |
| Japan | 1.5718 | 16.0350 | 3.4661 |
| South Korea | 2.0010 | 4.0273 | 1.7141 |
| China | 3.0492 | 3.0544 | 4.3643 |
| India | 0.71155 | 2.1906 | 1.7519 |
| Pakistan | 1.3560 | 1.3934 | 0.9872 |

K= number of regressors

The above test results suggest that there exists a long run relationship between $lq_{it}$ $ly_{it}$, and $lp_t$, and that the variables $ly_{it}$, and $lp_t$ can be treated as "long-run forcing" variables

for the explanation of $lq_{it}$ for all of the six region. This is because the F-statistic ($lq_{it}/ly_{it},lp_t$) for all the six region either exceeds the upper bound of the critical value band or less than the lower bound of the critical value band. Hence, we can reject the null of no long run relationship between $lq_{it}$ $ly_{it}$, and $lp_t$ . This, indicate the existence of equilibrium relation between the three variables. The GDP and oil prices are significant factors on the decision of consumption of oil on the long run and any changes in any of the two variables will have emphasis on demand of oil.

For F-statistic ($ly_{it}/lq_{it},lp_t$)all the statistics fall well below the lower bound except for this of South Korea, These result suggest that there exists a long run relationship between $lq_{it}$ $ly_{it}$, and $lp_t$ .

For F-statistic ($lp_t/ly_{it}lq_{it}$) all the statistics fall well below the lower bound except for China, These result suggest that there exists a long run relationship between $lq_{it}$ $ly_{it}$, and $lp_t$ . and the Variables $ly_{it}$, and $lp_t$ can be treated as "the long Run forcing variables for the explanation of $lq_{it.}$

Table 10-15 : Error Correction model for NIEs, China, Japan, South Korea, India, Pakistan

| Table 10: Error Correction model for NIEs ARDL(1,1,0) | | | |
|---|---|---|---|
| Dependent Variable $\Delta q_{est}$ | | | |
| Regressors | Coefficient | Standard Error | T-ratio{Prop] |
| Intercept | -2.60 | 0.22 | -1.67[0.120] |
| $\Delta ly_{NIEs}$ | 1.035 | 0.031 | 4.07[0.002] |
| $\Delta lp$ | -0.02 | 1.55 | -0.54[0.596] |
| ECM(-1) | -0.35 | 0.22 | -1.57[0.142] |
| ECM(-1)= $lq_{est}-1.15ly_{NIEs}+0.048\ lp\ +7.49$ | | | |
| $\overline{R}^2 = 0.79$ | DW=2.7 | $F_{(3,12)}$=19.86[0.000] | |

Diagnostic tests for NIEs Error Correction Mode countries show significant results $R^2$=0.79, DW shows no autocorrelation and high significant F. For the variables included in the model the signs are follow the economic theory where it is positive for the GDP and negative for the price. GDP is highly significant while an oil price has no significance. Thus, on the short run the changes in GDP will affect the demand for oil.

However, the price of oil will not have a significant effect on the demand for oil in NIEs countries.

| Table 11: Error Correction model for China ARDL(2,2,1) | | | |
|---|---|---|---|
| Dependent Variable $\Delta lq_{ch}$ | | | |
| Regressors | Coefficient | Standard Error | T-ratio{Prop] |
| Intercept | -0.80 | 0.27 | -2.95[0.015] |
| $\Delta lq_{ch(t-1)}$ | -0.67 | 0.24 | -1.78[0.019] |
| $\Delta ly_{ch}$ | 0.17 | 0.19 | 0.83[0.423] |
| $\Delta ly_{ch(t-1)}$ | 0.66 | 0.21 | 3.05[0.012] |
| $\Delta lp$ | -0.03 | 0.03 | -0.96[0.358] |
| ECM(-1) | -0.48 | 0.17 | -2.90[0.016] |
| ECM(-1)= $lq_{cht}$-0.72$lly_{est}$-0.054lp +1.67 | | | |
| $\bar{R}^2 = 0.70$ | DW=1.84 | $F_{(5,10)}$=8.42[0.002] | |

Diagnostic tests for China's Error Correction Mode countries show significant results $R^2$=0.70, DW shows no autocorrelation and high significant F. For the variables included in the model the signs are follow the economic theory where it is positive for the GDP and negative for the price. GDP is highly significant while an oil price has no significance. Thus, on the short run the changes in GDP will affect the demand for oil. However, the price of oil will not have a significant effect on the demand for oil in China.

| Table 12: Error Correction model for Japan ARDL(1,0,0) | | | |
|---|---|---|---|
| Dependent Variable $\Delta q_{est}$ | | | |
| Regressors | Coefficient | Standard Error | T-ratio{Prop] |
| Intercept | -0.64 | 1.11 | -0.57[0.575] |
| $\Delta ly_{JAp}$ | 0.32 | 0.14 | 2.27[0.042] |
| $\Delta lp$ | -0.02 | 0.04 | -0.65[0.526] |
| ECM(-1) | -0.49 | 0.16 | -2.91[0.013] |
| ECM(-1)= $lq_{jap}$-0.65$lly_{jap}$+0.047 lp +1.32 | | | |
| $\bar{R}^2 = 0.40$ | DW=1.9 | $F_{(3,12)}$=4.35[0.027] | |

Diagnostic tests for Japan's Error Correction Mode countries show significant results DW shows no autocorrelation and high significant F. However the $R^2$ is low, and this is usual on Error Correction mode. For the variables included in the model the signs are follow the economic theory where it is positive for the GDP and negative for the price. GDP is highly significant while an oil price has no significance. Thus, on the short run

the changes in GDP will affect the demand for oil. However, the price of oil will not have a significant effect on the demand for oil in Japan.

| Table 13: Error Correction model for South Korea ARDL(2,1,0) | | | |
|---|---|---|---|
| Dependent Variable $\Delta q_{est}$ | | | |
| Regressors | Coefficient | Standard Error | T-ratio{Prop] |
| Intercept | -2.18 | 1.42 | -1.53[0.153] |
| $\Delta lq_{SK(t-1)}$ | 0.75 | 0.21 | +3.55[0.004] |
| $\Delta ly_{SK}$ | 1.39 | 0.35 | 3.97[0.002] |
| $\Delta p_t$ | 0.024 | 0.06 | 0.41[0.526] |
| ECM(-1) | -0.15 | 0.09 | -1.68[0.120] |
| ECM(-1)= $lq_{SK}$-1.57$lly_{SK}$+0.154 lp +13.90 | | | |
| $\bar{R}^2 = 0.74$ | DW=2.6 | $F_{(4,11)}$=12.42[0.027] | |

Diagnostic tests for South Korea's Error Correction Mode countries show significant results $R^2$=0.74, DW shows no autocorrelation and high significant F. For the variables included in the model the signs are follow the economic theory where it is positive for the GDP and negative for the price. GDP is highly significant while an oil price has no significance. Thus, on the short run the changes in GDP will affect the demand for oil. However, the price of oil will not have a significant effect on the demand for oil in South Korea.

| Table 14: Error Correction model for India ARDL(1,0,0) | | | |
|---|---|---|---|
| Dependent Variable $\Delta q_{est}$ | | | |
| Regressors | Coefficient | Standard Error | T-ratio{Prop] |
| Intercept | -0.55 | 0.77 | -0.72 [0.484] |
| $\Delta ly_{IN}$ | 0.14 | 0.10 | 1.32[0.209] |
| $\Delta lp$ | -0.03 | 0.03 | -1.24[0.240] |
| ECM(-1) | -0.15 | 0.10 | -1.57[0.141] |
| ECM(-1)= $lq_{IN}$-0.92$lly_{IN}$+0.24 lp +3.56 | | | |
| $\bar{R}^2 = 0.05$ | DW=1.7 | $F_{(3,12)}$=1.24[0.336] | |

Diagnostic tests for India's Error Correction Mode countries show significant results DW shows no autocorrelation and high significant F. However the $R^2$ is low, and this is usual on Error Correction mode. For the variables included in the model the signs are follow the economic theory where it is positive for the GDP and negative for the price. GDP is highly significant while an oil price has no significance. Thus, on the short run the

changes in GDP will affect the demand for oil. However, the price of oil will not have a significant effect on the demand for oil in India.

| Table 15: Error Correction model for Pakistan ARDL(1,1,1) | | | |
|---|---|---|---|
| Dependent Variable $\Delta q_{est}$ | | | |
| Regressors | Coefficient | Standard Error | T-ratio{Prop] |
| Intercept | -0.85 | 1.00 | -0.85 [0.411] |
| $\Delta ly_{PK}$ | -0.20 | 0.16 | -1.22[0.246] |
| $\Delta lp$ | -0.07 | 0.03 | -2.12[0.055] |
| ECM(-1) | -0.37 | 0.14 | -2.57[0.024] |
| ECM(-1)= $lq_{PK}$-0.85$lly_{PK}$+0.37 lp +2.30 | | | |
| $\bar{R}^2 = 0.49$ | DW=2.11 | $F_{(3,12)}$=6.64[0.007] | |

Diagnostic tests for Pakistan's Error Correction Mode countries show significant results DW shows no autocorrelation and high significant F. However, the $R^2$ is low, and this is usual on Error Correction mode. For the variables included in the model the signs are follow the economic theory where it is positive for the GDP and negative for the price. prices are significant on the level of 0.10 while GDP has no significance. Thus, on the short run the changes in oil prices will affect the demand for oil. However, the GDP of Pakistan will not have a significant effect on the demand for oil.

In general, the underlying Error Correction model that was based on the ARDL equations for all the countries passes all the diagnostic test , Only India shows a low $R^2$ and no significance for F-test, $F_{IN(3,12)}$ = 1.24[0334] . The error correction coefficient, estimated has the correct signs, and suggests a moderate speed of convergence to equilibrium. The larger the error correction coefficient (in absolute value) the faster is the economy's return to its equilibrium, when the country's economy is disturbed by external variables.

Table 16: Estimated Error Correction Coefficients based on ARDL models.

| | ECM Coefficient | T-ratio{Prop] |
|---|---|---|
| East Asian Countries | -0.35 | -1.57[0.142] |
| China | -0.48 | -2.90[0.016] |
| Japan | -0.49 | -2.91[0.013] |
| South Korea | -0.15 | -1.68[0.120] |

| | | |
|---|---|---|
| India | -0.15 | -1.57[0.141] |
| Pakistan | -0.37 | -2.57[0.024] |

The long run and short run elasticities were calculated from the ARDL models for all different countries. It shows that the long-run elasticities were greater more than the short-run

Table 17 : The long run and Short-run elasticities for GDP and Price.

| | Income Elasticities | | Price Elasticities | |
|---|---|---|---|---|
| | Long -Run | Short-run | Long -Run | Short-run |
| East Asian Countries | 1.15 | 1.03 | -0.48 | -0.02 |
| China | 0.72 | 0.17 | -0.05 | -0.03 |
| Japan | 0.65 | 0.32 | -0.04 | -0.02 |
| South Korea | 1.57 | 1.39 | | |
| India | 0.92 | 0.14 | -0.24 | -0.03 |
| Pakistan | 0.85 | | -0.37 | -0.07 |

For South Korea the price, elasticity was not statistically significant and it did not have the right sign. This is also, the short run income elasticity for Pakistan. For the rest of the variables the elasticities were very low especially the price elasticities, in the short run they were all almost zero. For income elasticities only Korea and East Asian countries have more than one elasticity. Other countries have also less than one elasticities. These result shows that the demand for crude oil is highly sensitive for GDP.

## 8.Forecast of Crude oil demand:

The error correction model is used in forecasting the rate of change of consumption conditional on current and past changes in real income and price. The root mean squares of forecast errors compare favorably with the value of the same criterion compared over the estimation period. The results are shown on the following table:

Table 18 : Statistics for residuals and forecast errors for the ARDL estimated Models.

| | Forecast Period 1999 to 2002 | Estimation period 1980 to 1998 |
|---|---|---|
| East Asian Countries | 0.049 | 0.040 |
| China | 0.080 | 0.012 |
| Japan | 0.023 | 0.022 |
| South Korea | 0.089 | 0.035 |
| India | 0.037 | 0.022 |
| Pakistan | 0.050 | 0.021 |

The objective of the final part of the paper is to forecast the crude oil demand of all the six countries. In doing this, assumptions regarding the real GDP are obtained from OPEC secretariat 2003 for all the six countries. We will use the ARDL Model for the period 1980-2002.

Table 19 : Real GDP assumed growth rate and Brent using the value for 2003 and the assumed values used for prediction the consumption of Crude oil.

| Assumed real GDP growth rates* | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|
| East Asia | 3.92 | 5.34 | 5.02 | 4.82 |
| CHINA | 8 | 8.2 | 7.9 | 7.6 |
| JAPAN | 0.6 | 0.6 | 0.7 | 0.6 |
| SOUTH KOREA | 2.4 | 4.4 | 4.6 | 4.6 |
| INDIA | 6 | 6.6 | 7.5 | 6.8 |
| PAKISTAN | 5.8 | 5.4 | 5.2 | 5.1 |
| Brent | 30 | 32 | 28 | 26 |

- the GDP forecasts are from OPEC secretariat.

Table 20 : Predicted Crude oil consumptions (thousands MB/D) using ARDL for the period 1980-2002 and the assumed value for GDP and oil prices.

| | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|
| NIEs | **2678** | 2636.8 | 2581.3 | 2550.3 | 2491.4 |
| CHINA | **4270** | 5621.9 | 6011.0 | 6396.5 | 6803.7 |
| JAPAN | **5300** | 5152.0 | 4995.2 | 4927.0 | 4894.9 |
| SOUTH KOREA | **2179** | 2109.6 | 2116.9 | 2169.2 | 2263.7 |
| INDIA | **2086** | 2062.5 | 2067.3 | 2129.9 | 2242.3 |
| PAKISTAN | **363** | 368.86 | 379.65 | 395.71 | 414.68 |

The results, show that demand for crude oil will increase in Asia except for Japan as a result of the low rate of economic growth and oil prices will increase simultaneously. China shows the highest increase in crude oil demand followed by India, South Korea, and Pakistan. The highest consumption of crude oil comes from Japan, However China is expected to exceed it in the year 2003-2006, East Asian countries consume more than 2.5 Mb/d followed by South Korea, India and last is Pakistan.

## 9. Conclusions:

In this paper, the demand of crude oil in Asian countries has been analyzed. Using cointegration and the extension of this, ARDL methods. Since the ARDL is a more sensitive approach, more information is derived. It is found that GDP and price are important in affecting the demand for crude oil in Asia. However, elasticities of demand

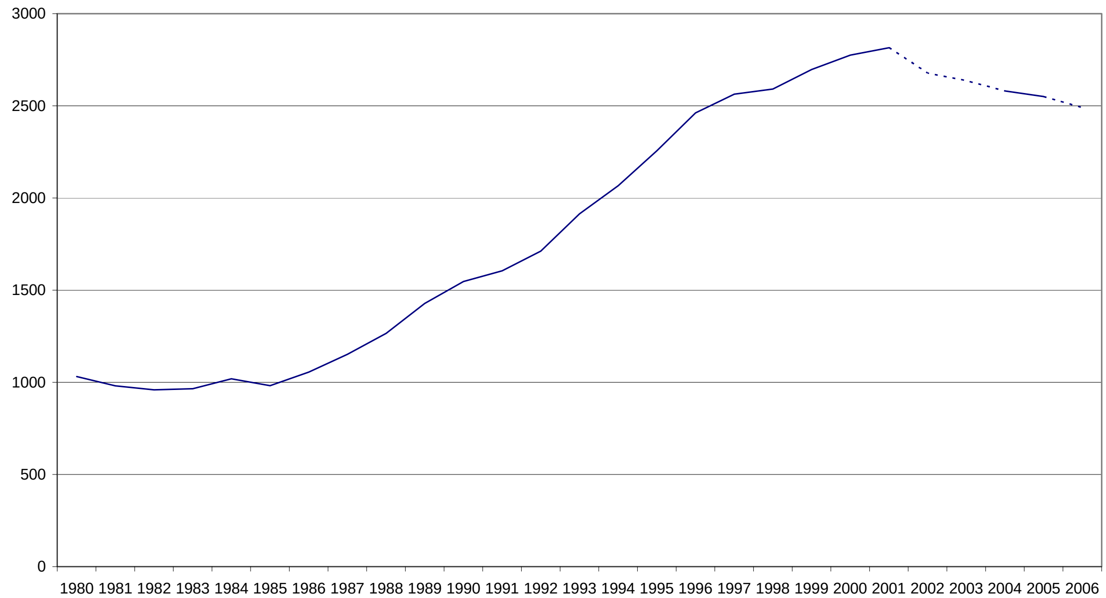
were low, indicating the importance of Asian countries as a major consumer in the market for crude oil.

This indicates the importance of Asia countries as a major consuming region especially for the Gulf region, where more that 2/3 of Gulf oil exported to that region. ½ of Saudi Arabia' crude oil exports is for the Asian countries. Moreover, the economic growth in these countries shows a significant effect on their demand for oil. Consequently, the world oil market will see a highly significant role of Asian countries especially Chine.

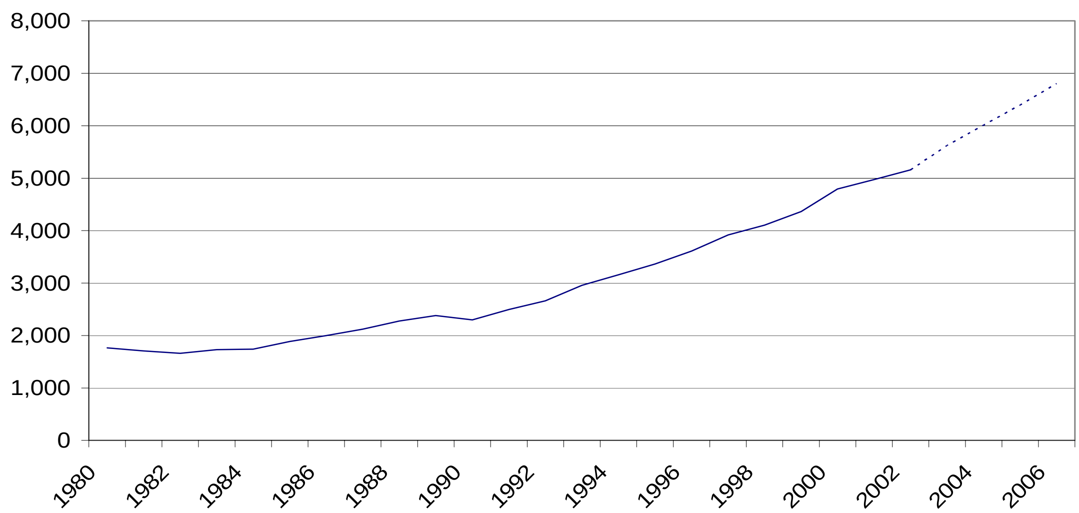
Therefore, Saudi Arabia and other Gulf oil producer have to develop pipe-line output and open their markets for Asian's Investment on oil Companies to have a strong effective relationship.

When the estimated model is used to forecast crude oil demand, it is found that GDP growth is an essential factor in the increase or decrease of crude oil demand by Asian countries. China has the largest demand for crude oil followed by Japan, East Asian countries, South Korea, India and last is Pakistan. China, India and Pakistan show a high growth rate of demand.

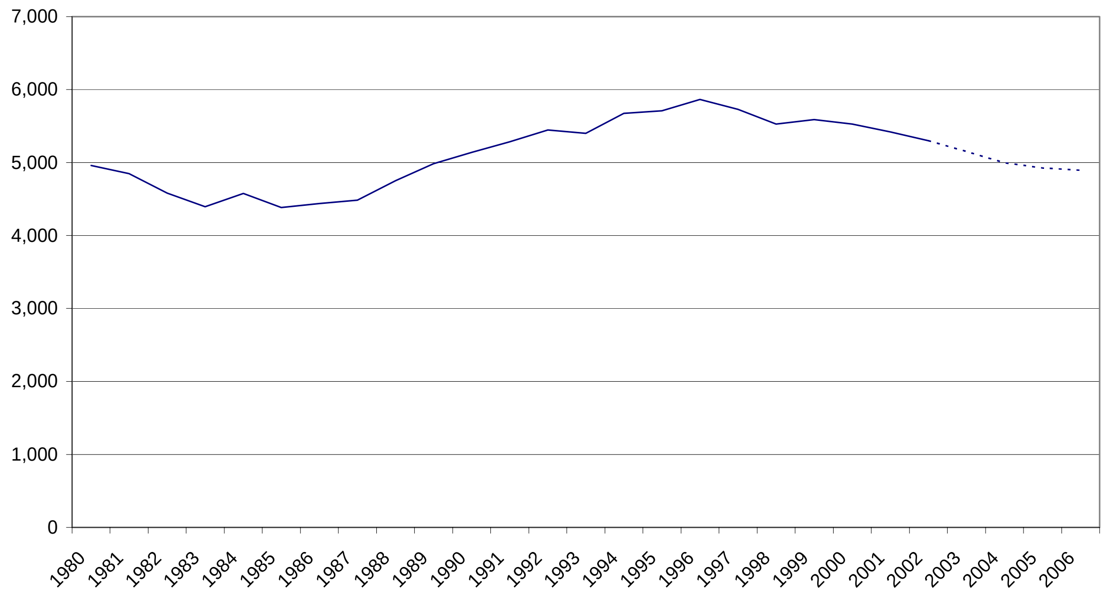
East Asian Coutries Crude Oil consumption  and



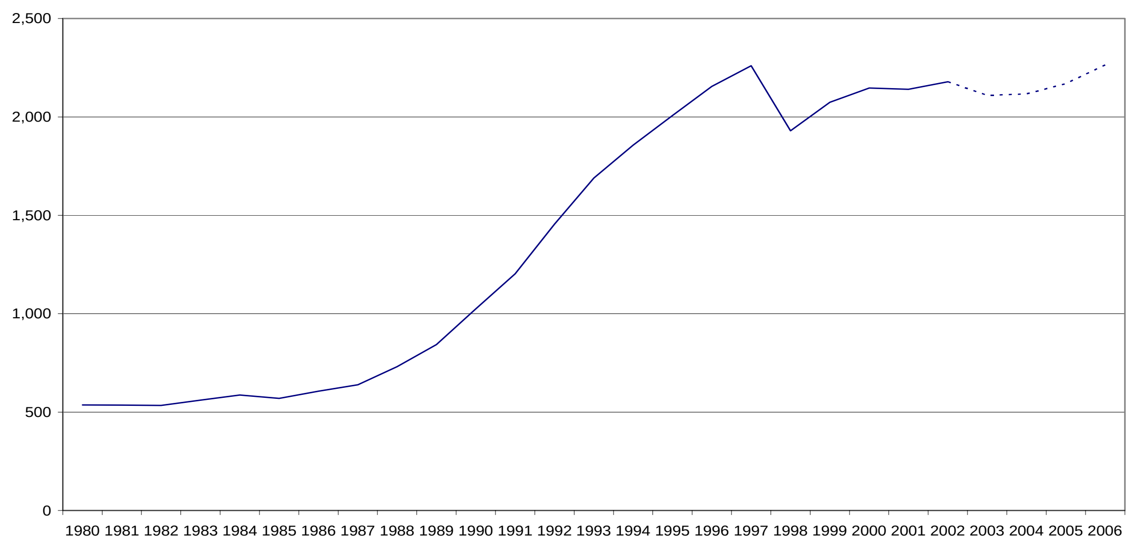

CHINA Crude Oil consumption



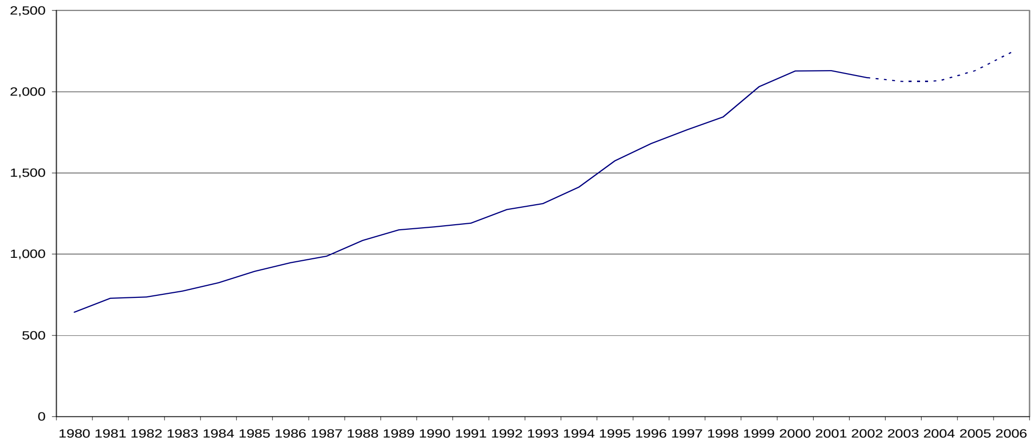
JAPAN Crude Oil consumption



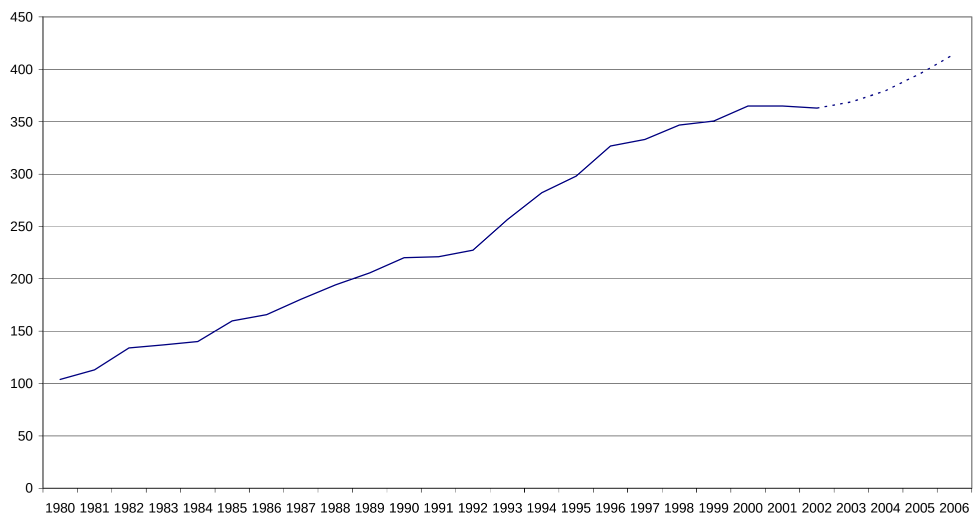

South Korea Crude Oil Consumption



India Crude Oil Consumption




Pakistan Crude Oil Consumption



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