CHAPTER 3
REVIEW OF LITERATURE

Literature has been reviewed on following topics:

a) Emerging oil scenario in India

D.R. Pendse (1985) in his paper has discussed that there have been various developments in the India's oil sector after 2nd world oil shock. The financial performance of the oil sector is no doubt satisfactory, but interestingly in the surpluses of oil sector, represented by ‘cess’ amounts, government found an unexpected method of concealing its otherwise budget deficit. The surpluses of the oil sector to a large extent reflect the sacrifices by the consumers of petroleum products because the benefits of the falling world oil prices according to the author’s view are not passed on to the Indian consumers of petroleum products. It is a pity that instead of investing these surpluses in intensifying further exploration and refining programmes they are being used as a general budget prop. The author has concluded that with the continued success in the oil sector, India may lose grip about the imperatives of gradual transition of coal, electricity & the renewables in the medium & long term, and the time India’s and perhaps the world resources of oil do run out, would also be the time when having been much more addicted to the oil intensive life styles than at present, India finds itself unnecessarily landed in a terrible oil mess. By that time industrial world would surely have moved on to ‘higher’ technologies and got itself out of the oil mess.

b) India’s oil resource balance

K.V. Raju (1990) in his paper has revealed that India is not self sufficient in petroleum products and about 30 percent to 40 percent of our requirements is being met by imports. This causes great strain on our foreign
exchange reserves and balance of payments (BOP) position. Though domestic production of oil has increased considerably in the last two decades, but now it appears that the dynamism in domestic crude output has of late given way to some kind of stagnation. There is increasing fear among oil experts that the over-utilization of the existing wells may seriously jeopardize the oil fields in the future. According to the author what is especially distressing is the galloping rate of consumption of petroleum products with no noticeable trend towards efficiency in the utilization of alternative sources of energy anywhere possible. Therefore in spite of considerable increase in domestic crude output and high priority accorded to exploration of oil there has been a high supply demand gap, made good by imports of both petroleum crude and refined products. The author looks at the emerging oil scenario in India in the context of the developments in the gulf region. India imports about 93 percent of the oil requirement from the gulf region, thus any problem in the gulf countries is particularly alarming for India. Thus he asserts that the time has come to give up our over dependence on imports and the lasting answer to solve the problem of energy is that the developed and developing countries should join together and conduct research for the invention of alternative sources of energy.

c) Changing oil consumption pattern

Jos’e Goldemberg (1990) makes a comparison between developing country like India with that of industrialized nations or developed countries of the world on the energy consumption pattern. He says that developing countries like India have adopted the energy consumption pattern of industrialized economies and are more threatened by their dependency on foreign oil. Developing countries consist of a dual society with rich elite and poor masses. A dual society is therefore a fundamental reality that shapes the developing country like India. It is crucial to explore the impact of a dual society on a developing country’s energy system to keep in mind that the
energy policy like other policies is biased towards the desire of elites whose wants of goods and services are similar to those available in industrialized countries. Initially these desires can be satisfied by imports from industrialized world but such imports can rarely be sustained for long because they result in Balance of Payments problems. It has been analyzed that oil crisis rapidly worsened the Balance of Payments for oil importing countries with a larger fraction of export earnings of developing countries like India going to pay for oil imports. As a result the economies of most oil importing developing countries are suffering. Ultimately this is all due to the tendency of dual societies to bias economic growth towards the wants of the elite and ignore the needs of the poor. This bias leads to norms of energy use, which may have been economical in heavily industrialized countries during an era of cheap energy but are uneconomical today in both developing and industrialized countries. The analysis of his study is that the developed countries of the world are now in a web and too much dependent on this sector but India still has an option to satisfy its basic energy needs by using modern; efficient methods and technology to promote efficient and economic use of this energy source.

**Tata Energy Research Institute (TERI) (1992)** has presented a paper on “The Crisis in Excessive Energy Consumption: 1985-2010 AD and Criticality in Payments: 1992-2010 AD”. TERI has compared the consumption of petroleum products by different sectors in 1972-73 with the pattern in 1990-91. From the comparison it can be seen that transport sector which had 33percent of 22.16 million tonnes in 1972-73, and rose to 46percent of a major larger total of 55.46 million tonnes surpassing industrial sector consumption of 35percent in 1990-91 which was 48percent in 1972-73. TERI have examined that the critical factor in the future energy consumption arises from the pattern of increasing consumption of the growing areas of petroleum products particularly High Speed Diesel (HSD) and Kerosene. The domestic refineries are not producing the needed volume
of these middle distillates which are currently in increasing demand because of the marked shift since 1972-73 towards road based freight transportation. It has been analyzed in the paper that since 1975-76 the import share of middle distillates has become very substantial. With current rates of growth and unless refineries changes their patterns of production substantially, this can only become more pronounced. Therefore sufficient for the day is the emphasis on huge imbalance between demand and supply and its massive adverse consequence on India’s Balance of Payments.

Institute for Defense Studies & Analyses (IDSA), (Shebonti Ray Dadwal) (1999) focuses a paper on Hydrocarbons, as the world is running, albeit decreasingly on oil. In this paper India’s GDP rate and oil consumption is specified. It is examined that currently, India’s oil consumption is around 80 million tonnes (Mt) per year. If the GDP rate grows at a rate of 6percent, by 2020 India will need around 275 million tonnes of oil (crude + petroleum products) and if the GDP rate is 7percent, the requirement will be 350-400 million tonnes. The author has examined data on total oil demand, production and imports and has analyzed that, even if domestic production picks up, India will continue to remain and become increasingly dependent for imports of oil in foreseeable future. The share of POL imports against total imports and exports from the year 1970-95 have been specified. The conclusion of the paper is that with globalization taking place, supply destruction from one region would affect all other regions at least in the short term or till the market has time to adjust. For instance a sudden increase or decrease in the price of oil can have serious consequences for both consumers and producers. In the case of supply disruptions, finding a substitute for petroleum products would be difficult in short term, as demand would be relatively inelastic. By the first half of next century, India will be one of the top five consumers of petroleum products in the world. The author thus recommends that policies for dealing with possible oil shortage and consequent price hike are formulated and put to place in advance. At the
same time, it is necessary to reduce the country's dependence on hydrocarbons.

d) Oil intensity of transport and other sectors

Literature Survey

Intensity based works have been done by Skolka (1984), Howrath, Schipper, Anderson (1993), for Austria, Wu and Chen (1989) for Taiwan and Gowdy (1992) for Australia. Wu and Chen (1989) have presented an application of hybrid-unit formulations of energy input-output analysis for energy intensity variations in Taiwan for the period 1971-84. The analytical results indicate that about 85% of the economic sectors show remarkable downward trends in total primary energy intensity implying the effectiveness of energy conservation measures. Gowdy (1992) has explained labour productivity and energy intensity in Australia during 1974-87. Results indicate a decline in productivity growth rates during 1972-82 for both energy and labour. Howrath, Schipper, Anderson (1993) have examined the trends in the structure and intensity of final energy demand in five OECD countries between 1973 to 1988 (i.e. Japan, U.S.A, Denmark, West Germany and Norway). They conclude that the changes in the structure of a nation's economy may lead to substantial changes in its Energy/GDP ratio that are unrelated to changes in the technical efficiency of energy utilization. An application to aggregate energy intensity for manufacturing in ten OECD countries is conducted by Grenning et al. (1997). They have applied six decomposition methods in their analysis. Industrial energy intensities have been examined by Freeman, Niefer, Roop (1997). They identify and discuss several issues and problems that arise in the construction of commonly used industrial energy intensity indicators. In particular they focus on issues that arise due to the use of alternative measures of output as intensity indicators.

Another intensity-based work has been done by Battjes, Noorman, Bicsiot (1998) by using an Input-output mode for OECD- Europe (Germany, The Netherlands, and Ireland). The authors estimate the energy intensities of
imports by means of the average energy intensities of the region in which the country is situated. Gardner and Elkhafif (1998) attempt to provide insight into the changes in industrial structure and energy intensity that occurred in Ontario between 1962 and 1992. Rose and Casler (1996) define Structural Decomposition Analysis (SDA) as “the analysis of economic change by means of a set of comparative static changes in key parameters in an input-output table”. The basic idea in SDA is to express an identity in various components, which should fulfil the properties of being (1) completely exhaustive, which is guaranteed by the decomposition of the identity, and (2) mutually exclusive, which requires a certain degree of care in the mathematical derivation in order to avoid an interaction effect of difficult interpretation. Applications of the structural decomposition analysis are numerous, many of them in relation to energy studies. Casler and Afrasiabi (1993) applied a mixed methodology to determine direct and indirect changes in the energy-output ratio. The methodology is used in Alcántara and Roca (1995) to analyse the CO2 emissions in the period 1980-90 in Spain. Energy intensity and the relationship between CO2 emission and primary energy GDP was studied again by Roca and Alcantara (2001) for Spain. In the critical review by Rose and Casler (1996), the relations of SDA to other methodologies, such as decomposition indexes, are commented on, and details are given of its application to the case of the energy, such as the hybrid units method, in which energy rows are substituted by their physical equivalent in the structural matrix. Ang and Zhang (2000) carry out a complete review of index decomposition analysis applications in energy and environmental studies, in which they include 15 references to the SDA methodology, quoted as ‘a more sophisticated and elaborated version' of the decomposition analysis based on Laspeyres indexes. Some methodological issue regarding energy intensity has been raised by Arrous (2002). Hes shows that integrating energetic resources into input-output analysis does not need any a priori reformulation of this analysis. Miller and Blair consider that such
integration needs using hybrid units in order to satisfy some energy conservation conditions. He shows that these conditions are specifically defined and founded on a particular case, inspired by empirical data of the U.S economy. Bernard et al. (2004) applied principal components analysis to assess the information derived from six energy intensity indicators for Quebec, Ontario, Alberta, and British Columbia from 1976 to 1996. They use two measures of total energy use (thermal and economic) and three measures of industry output (value added, value of production, and value of shipments). They have shown that the variation of the six energy intensity indicators that is accounted for by the first principal component is quite large.

As energy intensity and efficiency are quite dependent factor on each other so many studies also try to compose some literature on energy efficiency. Bosseboueuf and Richard (1997), Eyre (1998), Geller et al. (1998) have worked on the issue of energy efficiency. The evaluation of environmental and energy efficiency is outlined by Bosseboeuf and Richard (1997) for France during 1973 to 1993. Using over 200 explanatory energy efficiency indicators they have evaluated and characterized the sectoral trends in energy efficiency over 20 years. Eyre (1998) focuses on the effects of liberalisation on those characteristics of energy markets, which underpin the long-term energy inefficiency in U.K. The efficiency of use of electricity in Brazil is examined by Howard Geller et al. (1998). They review the efforts made for electricity conservation and DSM programmes in Brazil during 1970 - 96. They discuss in detail the status of electricity conservation measures in each sector of the economy. Finally, they try to show the main barriers inhibiting energy efficiency improvements and suggest strategies to overcome them.

Haas and Schipper (1998) in their work consider irreversible efficiency improvements as a major reason for the moderate growth in energy demand after the plummeting of the oil price in 1985. They test different econometric models to take into account efficiency indicators. Sinton et al. (1998) provide
a comprehensive overview of the policy measures and implementation approaches in China and identify some major challenges that need to be dealt with to maintain the extraordinary efforts to reduce energy intensity. Energy efficiency leads to consumption was derived by Greening et al (2000). The gains in the efficiency of energy consumption will result in an effective reduction in the per unit price of energy services. They concluded that the range of estimates for the size of the rebound effect is very low to moderate.

Energy intensity base literature in Indian context is very rare considering IO approach. Various authors have the studied energy intensity problem. One of the elaborate and earliest individual efforts in this regard is of Henderson (1975). Along with the wide-ranging review of the energy sources he discusses the policy prospects for Fifth Five Year Plan. His findings of increasing energy intensity in the decade of the sixties and its relation to output change and change in energy coefficient provide certain basic information on the nature of country's energy scene. The change of energy intensity in India has been explained by Bhattacharya (1998) in his recent study. He has shown two factors (a) structural change in GDP, and (b) non-structural changes such as improvement inefficiency, energy conservation etc. His study tries to show the energy conservation and its demand management of coal crude oil and electricity. His study is based on the challenges and opportunities during the Eighth Plan. He concludes that a directional change towards a less energy intensive pattern of growth is in any case necessary.

Some of these studies were in relation to individual sub-sectors of energy whereas a few others we will discuss are in the nature of analyzing the energy sector scenario in an integrated framework.

B. Sudhakara Reddy (1995) has done a case study of Bangalore. His article is based on econometric analysis of annual data (1980-90),
disaggregates passenger transport by vehicle type (2-wheelers, cars, buses, etc) and studies its impact on passenger kilometers and energy intensity. The study then investigates the relation between transportation, energy consumption particularly petroleum products and its environmental impacts. As the effect of different categories of vehicles on the total consumption of petrol/diesel is important, the paper has used ‘Multiple Regression’ in order to estimate the vehicle wise consumption. This method can be referred to as vehicle census approach. Using this approach, the fuel consumed by different vehicles has been estimated by regressing the average monthly fuel consumption on the number of vehicles in different categories. The results indicate that the regression coefficients are not zero and there exists a relationship between the number of vehicles of different categories and the consumption of petroleum products. The conclusion of this study is that transport sector is the maximum consumer of petroleum products and there has been growth in personal transport, which has very high-energy intensity. The energy intensities of each mode of travel have a significant impact on energy use and the impact on environment is also significant. Thus, with increasing use of transport services the level of petroleum product consumption particularly petrol and diesel have increased thereby increasing atmospheric pollution posing a threat to people’s health and is a major environment dilemma. The introductions of point-to-point travel by transport; education or conservation of fuel etc are therefore important factors to be considered. According to the author a developing country like India cannot afford to neglect the development of an efficient transportation system.

Piyush Tiwari (1999) has used an Input-Output framework to calculate energy intensities for different sectors in Indian economy. The overall energy intensity has declined during 1983-1990. A decomposition model analyses the causes for this change. The energy demand has been projected for the year 2002 and the impact of output changes and energy price changes have also been analyzed. The results show that the direct and
total energy intensity in case of oil is the highest for fertilizer, 34.92 kg oe/thousand rupee of output, which moves to 53.7 kgoe/thousand rupees of final demand. Fertilizer is followed by other transport services with direct oil intensity of 26.36-kgoe/per thousand rupee and total intensity of 35.13 kgoe/thousand rupees. Iron ore, non-metallic mineral products & non-ferrous metals follow fertilizers with direct oil intensities of 18.94, 15.53 and 14.17 kgoe/thousand rupees of output. Under the decomposition of oil consumption, the output effect, oil intensity effect and structural effect on the petroleum product consumption have been discussed. The result show that the overall output effect on consumption of petroleum is positive in which fertilizer has the highest share of 27 percent in total output effect. In case of oil intensity effect some sectors have positive impact while others have negative impact but the oil intensity has an overall negative impact on oil consumption. The impact of structure in case of oil consumption is positive and chemical industry has the highest positive share of 97 percent in total structural effect. The author has concluded that one adverse consequence of the pattern of energy consumption in India is the dependence on import for crude oil and petroleum products, causing heavy drain on foreign exchange reserves of the country.

Joaquen A. Millan and Jose S. Millan (2001) has examined the changes in energy costs and energy intensities in the Spanish economy in terms of direct energy requirement effect, energy inputs, substitution effect and indirect non-energy input effect, through decomposition of the change in the inverse of input-output matrix. Data is based on a 24 sector aggregation (4 energy sources and 20 non energy sectors) from available input output tables since 1980. From a technical point of view, the focus is on two issues of the decomposition analysis. First, by means of a perfect decomposition scheme, in which changes in energy intensity are evaluated using the arithmetic mean for two adjacent periods, interaction terms do not exist. Second, the use of the hybrid unit’s approach, in which the monetary units of
the energy rows of the structural matrix are replaced by their physical unit equivalent (TOE) is compared with the direct monetary based energy rows. The results with both approaches are different, mainly in 1980’s. The author have concluded that the direct effects of energy on input only explain part of the relations between energy use and output production, since the indirect effects also contribute to changes in total energy use. In some case, it is shown that indirect effects are more important and counteract direct changes. The structural decomposition analysis allows the identification of those sectors in which input requirements are more responsible, directly or indirectly and for changes in the relation between energy and output. The major changes are directly caused in the utilization of energetic factors. The indirect effects of non-energy factors that extend or reduce the direct effects are significant. In the study of energy use in Spain between 1980 to 1994, it is observed that, in general both direct and indirect effects work in the same direction. Consequently, the improvement in energy intensity that has been observed in sectoral studies is reinforced when considering the indirect effects. The comparison between the mixed units approach and monetary approach has led to the conclusion that some positive effects obtained when energy intensity is measured become negative effects when monetary values are used. Thus the use of mixed units can mask ‘cost saving’ efficiency improvements.

Joydeep Roy and Ranjana Mukhopadhyay has made an attempt to estimate output multipliers and energy multiplier. In this paper the input output technique has been used as a method of analysis. Input output analysis can interrelate industry inputs and outputs with the intermediate and final demand for energy. So the direct energy intensity for different sources can be obtained using the input-output table. Once this direct intensity is known, the (I-A) increase matrix is used to compute the desired direct and indirect effects, which is then used in the computation of primary energy. Analysis of sectoral multipliers shows that India’s primary energy needs
would rise the most for one unit rise in direct primary energy use in the mining sector, (99 units) followed by agriculture sector (39 units), equipment sector (14 units) and other service sector (7 units respectively). Rise in India's primary need would be negligible for one unit rise in direct use of it for the basic metal industries. Considering the direct coefficients of the primary energy, the results depicts that the agricultural sector and the mining sector has a low value of direct primary energy coefficient though its value of multiplier is high. It is the energy products sector which has the highest value of direct primary energy coefficient for the year 1989-90 and 1983-84 followed by the basic metal industry, infrastructure sector and manufacturing sector.

Kakali Mukhopadhyay & Debesh Chakraborty (2005) discussed that India annually consumes about three percent of the world’s total energy. The country is the world’s sixth largest energy consumer. Indian domestic energy resources are highly utilized and the economy is a net energy importer particularly of petroleum products. The energy requirement of an economy is sensitive to the rate of economic growth and energy intensity of producing sectors. The energy intensity is the function of technological progress and it varies from sectors to sectors. Continued economic development and population growth are driving energy demand faster than India can produce it. India’s electricity sector currently faces capacity problems, poor reliability, and frequent blackouts. Moreover, industry cites power supply as one of the biggest limitations on progress. The shortfall means the country will increasingly have to look to foreign sources of energy supplies, transported mostly via ship and pipeline. Oil and natural gas have been downplayed somewhat because of uncertainty in global supply and price, and because heavier reliance on these two sources would require even greater imports. Thus it is not easy to increase the supply of energy. In this context it is important to analyze sectoral energy intensity in the Indian economy.
The present paper uses a static input output framework to estimate the intensity of energy of different sectors in Indian economy during 80's and 90's. The paper uses four consecutive input output tables (1983-84, 1989-90, 1993-94 and 1998-99) to calculate direct and total (direct + indirect) energy intensities. The basic purpose is to capture the pre reform as well as reform period performance in energy sector as Govt. of India has initiated few stalwart strategies for energy sectors in the year 1991-92 (on the eve of the reforms). The paper reports the findings and finally suggests proper policies.

The energy intensity, defined in this is energy consumption per unit of GDP, and has increased in India since the early 1970s and it is one of the highest in comparison to other developed and developing countries. This is in sharp contrast to the developments in China and in OECD countries. For example, it is 3.7 times that of Japan, 1.55 times that of the United States, 1.47 times that of Asia and 1.5 times that of the world average. Thus, there is a huge scope for energy conservation in the country. During the pre-reform period, the commercial energy sector was totally regulated by the government. The economic reform and liberalization, in the post 90s, has gradually welcomed private sector participation in the coal, oil, gas and electricity sectors in India. The paper places emphasis on the energy intensity in India during pre-reforms and reforms covering a period of 15 years (1983-84 to 1998-99) with proper policy suggestions. The basic purpose is to capture the pre reform as well as reform period performance in energy sector as Govt. of India has initiated few stalwart strategies for energy sectors in the year 1991-92 (on the eve of the reforms). The authors started their model formulation from a static monetary input-output model. Mathematically, the structure of the input-output model has been expressed as:

\[ X = Ax + Y \quad \text{(1)} \]
The solution of (1) gives

$$X = (I - A)^{-1} Y$$ ........ (2)

Where $(I - A)^{-1}$ is the matrix of total input requirements. For an energy input-output model, the monetary flows in the energy rows in equation (2) are replaced with the physical flows of energy to construct the energy flows accounting identity, which conforms to the energy balance condition (Miller & Blair 1985). We apply a “hybrid method” based on Miller & Blair (1985), and it always conforms to energy conservation conditions.

Therefore, in equation (2), $X$ is a hybrid unit total output vector $(nx1)$ in which the outputs of energy sectors are measured in million tonnes of coal replacement (MTOE), while the outputs of other sectors are measured in million rupees (M.RS). $Y$ is a hybrid unit final demand vector $(nx1)$, in which the final demands for different types of energy are measured in MTOE, while the final demands for the outputs of other sectors are measured in M.RS. $A$ is a hybrid unit technical coefficient matrix $(nxn)$, in which the unit of the input coefficients of energy sectors from energy sectors is mtoe /mtoe; the unit of the input coefficients of energy sector from non energy sectors is M.RS/ mtoe, the unit of the input coefficients of non energy sectors from energy sectors is mtoe /M.RS; and the unit of the input coefficients of non-energy sectors from non-energy sectors is M.RS/M.RS. $I$ is an identity matrix $(nxn)$.

The basis of the data of this study are the four Input-Output tables of the Indian economy for the years 1983-84, 1989-90, 1993-94 and 1998-99 prepared by CSO (1985, 1995, 2000, 2004 unpublished). Input-Output tables are Commodity-by-Commodity tables consisting of 60 x 60 sectors. These have been aggregated to 47 sectors on the basis of the nature of commodities. Here we have considered three energy sectors coal, crude oil & natural gas and electricity separately and other 57 non-energy sectors have been aggregated to 44 non-energy sectors. The fuel rows are converted into physical units using the methodology discussed above. We convert the monetary units of energy sectors into physical unit from the energy data.
published by CMIE report. Three energy sectors like coal as million tonnes, crude petroleum in million tonnes, natural gas in million cubic meters and electricity in T.W.H have been converted into one common unit, which is million tonnes oil equivalent or mtoe. For better presentation of results this mtoe unit has been transformed to thousand tons of oil equivalent (thoutoe).

The total and direct energy intensities for different fuels for the 47 sectors as indicated by fuel rows of 1983-84, 1989-90, 1993-94 and 1998-99 R are given in the paper. The top ten sectors performance in case of three energy sectors is explained. Direct crude oil intensity in Petroleum product sector is always top in ranking, though its share declined gradually from 1983-84 to 1998-99. Another important sector in this respect is fertilizer, which fluctuates throughout the study period. Rank of Inorganic heavy chemicals is also declined to 15th. Iron and steel sector was crude oil intensive during 80s but its share gradually reduced after 90s. Other most important sectors dominate during 90s are plastic and rubber products, paints and varnishes, other chemicals. The oil intensity has worsened in coal tar products; jute, hemp, mesta; wool, silk, synthetic textiles; non-metallic mineral products; leather and leather products etc. sector was crude oil intensive during 80s but its share gradually reduced after 90s. Other most important sectors dominant during 90s are plastic and rubber products, paints and varnishes, other chemicals. But the total intensity figures for crude-oil sector also reveals almost same. The petroleum products ranked first throughout but its share declines. Similarly coal tar products performance also had fallen after 93-94. Fertilizer though kept its performance but little bit reduced. Other transport services increased its share gradually. Railway transport services, other machinery and miscellaneous manufacturing also deserved mentionable during 1998-99. In this paper therefore the authors have looked at the sectoral energy intensity of the Indian economy since 1983-84. The most important point to reveal that energy intensity really reduced for some traditional energy intensive sectors
but on the other hand some new sectors also entered in the economy. On an average the direct intensity of coal has been reduced during 1983-98 but the total intensity for the same increased. Tendency of oil intensity is on the whole fluctuating but if we estimate the 15 years performance then the rise and decline is very marginal in case of direct and total respectively. Though the direct intensity of the electricity sector has increased a little bit but the abnormal increment has been observed in case of total intensity. This analysis stresses that indirect energy consumption is very important and should be seen as a fundamental part of the activity.

This analysis would help us to get a clear picture of energy consumption pattern in Indian economy and enables to derive proper policies for further improvements in this sector. The authors have mentioned some relevant policies in this respect.

e) **Determinants and elasticities of oil demand**

Many OECD countries experienced considerable increases in energy demand during the two decades leading up to the first oil crisis in 1973/74. Since then, energy consumption has been growing much more moderately, likely caused by a slowdown in economic growth rates and an increase in real energy prices. Probably as a consequence of the dramatic events in energy markets and the increasing importance of this sector in national economies, great effort has been devoted to the study of energy demand. Econometric studies include Beenstock and Willocks [2], Kouris [11,12], Nguyen [14], Bopp [3], Prosser [16], Ramain [17], Welsch [19], Brennand and Walker [4] and Paga and Brennand [15]. In most of these papers the purpose has been to measure the impact of economic activity and energy prices on energy demand, i.e. estimating income and own price elasticities. The evidence shows long run income elasticities about unity, or slightly above, and the price elasticity is typically found to be rather small. Early papers look into this behavioural relationship such as Kouris (1976) were
based on time series data pooled for various countries. However the results of these investigations raise questions since the sample period usually involved only five to fifteen year’s worth of data for just a handful of countries. For the purpose of planning and forecasting energy demand, long run elasticity’s are of particular interest. However, estimating such long run relationships is likely to pose some problems. The result of the investigations raise questions since the sample period usually involved only five to fifteen years worth of data for just a handful of countries. Moreover because apart from the need for not always easily available time series data- the variables used in the analyses typically exhibit multicollinearity and non-stationarity. These problems are often dealt with by taking first differences of all the variables before any estimation are done. A major drawback with this procedure, however is that by taking first differences, the low frequency (long run) variation of the data is removes, thereby making the model able to explain only pure short-run effects. Bishwanath Goldar and Hiranya Mukhopadhyya (1990) have made an econometric analysis of India’s petroleum imports and their impact on economic growth of the country. For this purpose, demand functions have been estimated for various petroleum products and an import function has been estimated for petroleum. As the domestic demand is not observed, it has been replaced by domestic consumption to estimate the demand function. The demand function is estimated by using a regression equation. Then a log – linear time trend is fitted to the series on total consumption of petroleum products. Thus all equations are estimated in log – linear specification, applying the ordinary least squares (OLS) techniques. The import function has been estimated in this paper by the OLS method, using a log – linear specification. To allow for lags in response of import demand to changes in explanatory variables, a regression equation is estimated, in which the previous year’s imports of petroleum is taken as an additional explanatory variable. The results of the analysis indicate that the gap between domestic demand for petroleum

68
products and domestic production of crude oil is the main determinant of petroleum imports. International price of petroleum and the foreign exchange availability also exert some influence on government’s decision to import petroleum. An important finding of the study is that domestic demand for petroleum products is not much responsive to price changes. For some of the petroleum products such as kerosene, the low price elasticities seems to be attributable to the fact that the product is consumed in small quantities by large number of consumers as the product is a necessity, so its consumption cannot be curtailed unless effective substitutes are provided. For other products, the observed price inelasticities probably reflect the ratchet effect prevalent in the economic system, developed on a petroleum base. The estimates of the import demand function for petroleum indicate very low elasticities of import demand for petroleum with respect to petroleum prices in international markets. It may be possible to reduce demand of some petroleum products if the prices are raised to very high level, but this saving in foreign exchange outflow on account of petroleum imports is likely to involve high cost to the country in terms of reduced economic growth. The main conclusion that may be drawn from the analysis presented in the paper is that one cannot hope to reduce petroleum imports much by simply raising the domestic administered prices of petroleum products; one has to think of other measures. Jan Bentzen and Tom Engsted in 1992 argued that since energy consumption, real energy prices and real income are most naturally regarded as being non-stationary unit root processes, econometric modeling of energy demand should be based on methods which explicitly take this feature of the data into account, namely cointegration techniques and error correction models (ECM). The main advantages in using an ECM are first that since both first differences and levels of the variables enter the model; it is possible to distinguish clearly between short and long run effects. Second, the speed of adjustment towards the long-run relationship can be directly estimated. Finally, ECM’s have a sound statistical foundation in the theory of
cointegration developed by Engle and Granger. In their paper they used cointegration and ECM methodology to estimate short-and long-run energy demand elasticities on Danish data for the post war period 1948-90. The next section contains a brief description of these methods in the context of energy demand modeling, and empirical results for Denmark are reported. The estimated short-and long-run income elasticities are 0.666 and 1.213, respectively, and the corresponding own-price elasticities are −0.135 and −0.465. In addition, we find these estimates to be fairly stable; there are no signs of a structural break in energy demand following the first oil crisis. We use these estimates to evaluate the further energy consumption scenario for Denmark on the basis of the assumptions for future growth in real income and energy prices made in the official report Energy 2000 from the Danish Ministry of Energy. Summing up, the proper way to estimate energy demand schedules on time-series data is as follows. First, the time series properties in terms of integration and cointegration of all the variables should be investigated. Then, if the variables are found to be non-stationary but cointegrated, the long-run elasticities may be estimated using cointegration methods (we describe these methods below). Finally, the short-run elasticities and the speed of adjustment were estimated from an ECM. The time-series properties of the individual variables were investigated using the Dickey and Fuller [5] unit root test. Consider a variable $Z_t$. Testing whether this variable is integrated, $I(1)$, or stationary, $I(0)$, was done by running the following regression

$$\Delta Z_t = \phi_0 + \phi_1 t + \phi_2 Z_{t-1} + \text{lags of } \Delta Z_t \text{ } + \text{ut}$$  \hspace{1cm} (3)

where $t$ is a time-trend, and testing whether $\phi_2$ is significantly smaller than zero. Augmentation lags of $\Delta Z_t$ are often included in order to whiten the errors. If $\phi_2$ is not found to be significantly negative, $Z_t$ cannot be rejected to be an $I(1)$ variable. If (some of) the variables are found to be $I(1)$ processes by this test, the next step is to conduct a cointegration analysis. The most widely used technique in testing for cointegration and estimation of long-run
parameters is simply to regress the levels of the variables under consideration on one another in a static OLS-regression like Equation, and then test for stationarity of the residual, $e_t$, using Dickey-Fuller test. If the residuals are found to be stationary it means that the variables cointegrate, thereby implying a long-run stationary relationship between them. This makes standard inference invalid. It will therefore not be possible to test interesting hypotheses, e.g., a unit income-elasticity in energy demand using conventional ‘t-tests’ and ‘F-tests’. The authors have therefore not estimated the long-run demand elasticities by use of the simple OLS regression. Instead, they have applied the multivariate maximum likelihood approach to cointegration developed by Johansen [8, 9] and Johansen and Juselius [10], which does not suffer from any of the above-mentioned problems. The approach is based on the following k-lag vector autoregressive (VAR) mode.

$$X_t = \delta + \Pi_1 X_{t-1} + \ldots + \Pi_k X_{t-k} + e_t$$

Where $X_t$ is a $(p \times 1)$–vector of non-stationary I (1) variables, $\delta$ is a $(p \times 1)$–vector of constant terms, $\Pi_1, \ldots, \Pi_k$ are $(p \times p)$-coefficient matrices and $e_t$ is a $(p \times 1)$–vector of Gaussian error terms. This method was used to test for cointegration and to estimate long-run income and price elasticities in Danish energy demand. The final step in the analysis was to estimate an ECM where the ECM term is given as the estimated long-run stationary relationship from the cointegration analysis. Having estimated a model with both short- and long-run elasticities in total energy demand, they were able to evaluate the future energy consumption scenarios for Denmark. Like Danish energy demand both the authors also estimated the short-run and long-run elasticities in US petroleum consumption in 1996. Like Jones [13] they presented a model which applied general to simple strategy and a specification was estimated in which all the variables were first differenced. It was started by including three lags of all variables and then sequentially the significance of the individual parameter using standard t-tests, until a parsimonious model was obtained. This model did not contain a long-run
relationship between these variables. Instead it contained long-run relationship between the growth rates of the variables. This model was stated with a well specified and structurally stable model containing only four parameters. The implied short-run and long-run income elasticities, in terms of growth rates, were respectively 0.55 and 1.000. The equivalent short and long run oil price elasticities calculated were respectively −0.084 and −0.341.

In 1996 Ahmed Al-Azzam and David Hawdon estimated the demand for energy in Jordan over the period 1968-1997. The purpose of their study is to use the most recent advances in modeling long-run or cointegrated relationships, in order to take into account the problems of demand modeling. Jordan was chosen because of its developing country status, its almost total dependence on imported oil as a source of energy. Like Bentzen and Engsted, here also the authors have pointed out that the OLS approach, while simple to implement is not without problems and have mentioned the same difficulties associated with this approach. They have announced that these difficulties associated with the OLS approach have led to the development of alternative procedures and have regarded that Johansen maximum likelihood procedure improves OLS in various ways. Firstly, the existence of at most one cointegrating vector is not assumes a priori, but is tested for in this procedure. Next, the Johansen procedure takes the regressor to be endogenous and appropriate methods. Finally, a more powerful set of tests are provided which enable the number of cointegrating vector to be identified and the effect of various restrictions to be evaluated. Finally, Ahmed Al-Azzam and Davis Hawdon have estimated the demand for energy in Jordan using the dynamic OLS (DOLS) method developed by Stock and Watson, 1993 and have pointed out that this alternative approach has certain advantages over both the OLS and the maximum likelihood procedures. This method improves on OLS by coping with small samples and dynamic source of bias. The Johansen method, being a full information technique, is exposed to the problem that parameter estimates in one
equation are affected by any misspecification in other equations. The Stock-Watson method is, by contrast, a robust single equation approach which corrects by regressor endogeneity by the inclusion of leads and lags of first differences of the regressors, and for serially correlated errors by a GLS procedure. In addition, it has the same asymptotic optimality properties as the Johansen distribution. The method has been applied to the estimation of Chinese coal demand by (Masih and Masih, 1996) and the authors adapted and extended the approach here and have given the model of demand for energy in Jordan. The authors examined that the Johansen results are sufficiently close to the DOLS results and have compared the DOLS and Johansen results with those that would have been obtained from the popular error correction model (ECM). Since the ECM here use the lagged residuals from the long-run OLS model as one of regressors, the authors see from the OLS results reported the extent of long-run bias, which would result from using this method. The results were found to be robust to various departures from standard regression assumptions and to be stable in spite of the rapid structural changes in the Jordanian economy over the period of the study. Similar to the results obtained by Bentzen and Engsted and Jones, the author here also found that income, construction activity and political instability are found to impact significantly on consumption, while real price has only a neutral or weak effect.

Jan Bentzen’s again in (1999) gave a paper “Elasticities in oil demand in developing countries” in which he gave a short geographical description of the developments in both aggregate energy consumption and oil consumption in the developing countries. After investigating the statistical properties of the data- the variables turn out to be non-stationery. The next step in the paper tested the hypothesis of co-integration between oil consumption, real income and coal consumption in the developing countries, where both the Engle-Granger OLS (ordinary least square) method and the multivariate Johansen procedure was been applied to the time series data.
Then the model was re-estimated for three sub-groups of developing countries using more recent data (1970-1997), which include GDP (Gross Domestic Product) calculated in PPP (purchasing price parity) terms, and the question of oil price influence on oil demand was addressed. The study has analyzed that the development in oil consumption in the developing countries has been heavily increasing from the 1950’s until today, with only some stagnation in oil consumption during the oil price shocks in the 1970’s. The relationship between oil consumption, real income (GDP), coal consumption and real oil prices was analyzed in the framework of co-integration techniques applied to the linear and log-linear models of oil demand with only small differences in elasticity estimates between the two modeling alternatives. The results from the cointegration tests were not overwhelmingly in favor of long run relationships (cointegration) between oil consumption and real income. Applying the error-correction techniques to developing countries, oil demand reveals that oil prices only for developing countries with highest income level seem to matter in the long run, but in all cases the short-run influence from real oil prices are generally estimated to be very modest. Contrary to these results, the long-run income elasticity is found to be close to unity and with somewhat smaller values in the short run. According to the author these results are likely to change if a better data set including all fuel prices become available, and hence allows a better-specified oil demand model to be estimated. Finally, the author concludes that the analysis presented here rests on highly aggregated data for a considerable number of countries and as revealed by the differences in the results for the three developing countries sub groups, it might be better to confine empirical testing to the national level. J.Tyler Hodge in 1999 also examined some of the problems that arise in classical regression estimation of an energy demand function. He also used the technique of cointegration analysis and finally an error correction model which details the long-run and short-run dynamics of a group of integrated variables to estimate the US
long-run and short-run price and income elasticity's of energy demand for the sample period of 1950 to 1996. He also used Johansen's procedure as a means to investigate the cointegrating relationship between integrated series and concluded that this cointegrating relationship represent the foundation of a complete dynamic error correction model and allows to compare the immediate and overall elasticity's of demand and this model also shows how fast adjustment occur. The author also concludes that this cointegration and ECM analysis has provided some insights into the behavior of aggregate energy markets; the adequacy of this model could also be tested by its potential forecasting ability. Fortunately, the estimated coefficients are very plausible. A 1% increase in per-capita income results in an almost equal percentage increase in energy demand. If the level of technology, as measured by miles per gallon, goes up 1% energy consumption falls by a little less than one half of a percentage point. For price, the result is a 0.169% decrease in demand. Given that energy is such an important part of daily life, and very few substitutes exist, we would expect the price elasticity to be rather low. Although the coefficient is significantly different from zero, the magnitude implies very inelastic demand. Result of papers from other countries and regions provide similar results even though many are based on different estimation methods. The results presented in this paper correspond to previous studies by indicating the energy demand is very price inelastic, but quite responsive to income changes both in the short and long run. Given that substitutes for energy do not exist, it is now very obvious how the good is unresponsive to price movements. However, future analysis of individual energy sources may reveal a much stronger substitution effect among them. In terms of the direct positive relationship between energy consumption and per-capita income, it would seem reasonable that higher incomes lead to the purchases of items that require more energy consumption such as luxury cars, larger homes, travel etc. However, we can also view energy consumption as a type "investment effort" that results in more production and
income. An examination of exogeneity or causality among these two variables could provide some answers. This cointegration and ECM analysis has provided some insights into the behavior of aggregate energy markets; the adequacy of this model could be tested by its potential forecasting ability. In 1999 Bentzen and Engsted again discussed that the findings in the recent energy economics literature that energy economic variables are non-stationary, have led to an implicit or explicit dismissal of the standard autoregressive distributed lag model (ARDL) in estimating energy demand relationships. The authors depict that recent research however; shows that ARDL model remains valid when the underlying variables are non-stationary, provided the variables are cointegrated and in 2001 both the authors again gave a paper in which they used the ARDL approach to estimate a demand relationship for Danish residential energy consumption, and the ARDL estimates are compared to the estimates obtained using cointegration techniques and error correction models (ECM’s). Both authors have said that it is very interesting to compare the long-run elasticity estimates obtained from the ARDL model with estimates obtained using standard cointegration methods (the static OLS, DOLS, the non linear least squares (NLLS) procedure and the VAR procedure. The static OLS procedure as usual according to the authors does not provide consistent standard errors and where standard hypothesis testing is in general invalid. The latter three procedures are asymptotically equivalent but differ in the way the short-run dynamics are modelled and, hence, may give different results in finite samples. All three methods provide consistent estimates of standard errors of the long-run parameters and they allow standard statistical inference based on asymptotic normality. Thus the three asymptotically equivalent methods (DOLS, NLLS and Johansen) give almost identical estimates. The ARDL estimates are slightly larger than the estimates obtained from the four-cointegration methods. Finally the authors estimate an error correction model (ECM) where the error correction term is given as the
lagged cointegrating relationship from the Johansen analysis in order to compare the results obtained from the ARDL approach. Comparing the ARDL estimates and the estimates obtained using cointegration techniques and error correction model (ECM's), they found out that quantitatively and qualitatively, the ARDL approach and the cointegration/ECM approach give very similar results with the long-run income elasticity and the long-run price elasticity estimated to be approximately 1 and -1 respectively. In line with this Sreekanth Venkataraman (1998) in his paper examines the growth in oil product demand over the period 1981-96 for India. He says that India represents a high proportion of oil demand, being the second most populous country in the world. The basis objectives of his paper are- examining the relationship of oil demand with respect to population and energy, the paper then focuses on demand for major petroleum products in India, factors affecting demand for oil products and projection of oil demand up to the year 2007 based on price and income elasticities calculated for each of the petroleum product. He has taken data on the following variables: Population, oil demand, real income (GDP) and real international price of crude oil and has applied Koyck-lag specification model. He has then analyzed in his study the long run elasticities of different petroleum products. Based on the long run elasticities he has projected the demand for oil up to 2007. The author has also done a case study of Asian countries. He has taken a large-cross section of the countries in Asia to establish a statistical relationship between per capita energy consumption and real GDP per capita. The long-run income elasticities and price elasticities for energy and oil for these countries is estimated. The estimated elasticities are used to forecast the level of energy consumption and oil consumption. The author has given a simple linear functional relationship between energy per capita and real GDP per capita. For estimation of elasticities for energy (and oil), he has used the relatively simple regression of the logarithm of total demand on the logarithm of world crude oil price, the logarithm of total income and the logarithm of the
lagged demand, which is Koyck-lag, perfectly price reversible specification of demand. The demand for energy (and oil) is calculated using the estimated long-run price and income-elasticities derived. The results of his study strongly support the hypothesis that energy (and oil) consumption per capita will increase with real GDP per capita, a proxy for economic growth. The incremental growth in energy and oil consumption for some countries is expected to be less than others, and this is because there are some middle-income countries, which have, been taken into account. The long run price elasticities for energy is expected to be demand elastic, but less as compared to the price elasticities for oil. The same goes for energy, but the result will vary for the countries depending on the fact whether they are low-income or middle-income countries. In 1997 Dermont Gately and Shane S. Streifel analyzed the growth in oil product demand since 1971 in developing countries defined as those countries outside the organization for economic cooperation and development (OECD), The former Soviet Union and Eastern Europe (FSU AND EE). The analysis focus on 37 largest oil consuming countries, which represent 90% of oil demand for this group, and nearly 70% of the world's population. The authors have analyzed the relationships and changes over time for income, population energy and oil demand. They have then focused on 8 major petroleum products and analyzed some important phenomena that explain many of the changes in demand for these products. Income and price elasticities are calculated for each of the eight major oil products in all 37 countries. The paper has used four general types of Koyck or polynomial distributed lag model. The authors then gave some generalizations about the econometric results. For most of oil products, the most important variable in explaining the change in product demand was the change in income. For about half of the countries, income was the only explanatory variable; changes in crude oil price were not useful in explaining changes in demand. Dermot Gately again with Hillard G. Huntington presented a paper in 2001 and analyzed the determinants of
commercial energy and oil demand for 96 of the world’s largest countries, using 1971-97 data on a per capita basis. Their primary interest was estimating the long-run response of demand to income changes as this parameter has important implications for future energy and oil demand. They examined various specifications of the demand equation for various groups of countries. Specifically, the authors tested whether allowing for asymmetries in the demand response to price and income at the country level can improve our understanding of world energy consumption trends. The paper was motivated by estimates of the income elasticity of energy and oil demand in the recent literature that seemed too low, both the developing countries and for high income countries. For example, demand projections reported by the US department of Energy’s Energy Information Administration (EIA)\(^1\), whose outlooks were used extensively by number of organizations, used an income elasticity of about 0.65 for energy and oil in Asian Developing Countries. In contrast, econometric estimates reporting by Pesaran et al. (1998) were 1.0 or higher for those countries. For higher-income countries, several articles in the literature on world energy and carbon dioxide emissions have reported income elasticities that are close to zero and sometimes negative-for examples, Schmalensee, Stoker, and Judson (SSJ, 1998), Judson, Schmalensee, and Stoker (JSS, 1999) and Holtz-Eakin and Selden (1995). For the highest income OECD countries, SSJ (1998) estimated income elasticities that are quite low; in fact, their estimates were not even positive for the richest set of countries. The paper used Koyck-lag model for energy and oil demand. Using correctly specified equation for energy and oil demand, the long-run response in demand for income growth was about 1.0 for NON-OECD countries oil exporters, income growers and perhaps all Non-OECD countries, and about 0.55 for OECD countries. These estimates for developing countries were significantly higher than estimates used by the US department of energy and those estimated by Schmalensee-Stoker-Judson (1988) and Holtz-Eakin And Selden (1995). All
the authors discussed used more or less the same techniques of cointegration or distributed lag model and had more or less the same results. Now we will present certain other studies on energy demand with different models.

Ramesh Bhatia in 1984 discussed in his paper about energy demand analysis (EDA) to have a good understanding of the factors affecting the growth and pattern of energy demand before making demand projections. For understanding the changes in energy consumption and demand, the author has first discussed energy demand analysis at the macro level. He said that such analysis should be done separately for commercial energy and total energy as well as for different sources of commercial energy. He discussed various convenient methods of macro level energy demand analysis like to compute energy GDP ratios and regression analysis. The author points out that a thorough analysis of various factors affecting energy consumption and economic growth in a simultaneous system would require use of macro econometric and CGE models and said that a number of studies have analysed energy demand with the help of CGE models. He emphasized on the energy economy interactions where two-way feedbacks between energy demand, aggregate growth, the sectoral patterns of growth, the BOP situation and external shocks etc. are explicitly considered with such models. The author highlighted the study of energy demand analysis at the sectoral level, saying that it is necessary to quantify determinants of demand at the sectoral level e.g. for agriculture, industry, transport and household etc. The author has concluded that it is positive to use different models for these sectors. However, if independent sectoral models are developed, the estimates he proves are unlikely to be consistent and a further mechanism for ensuring consistency would have to be introduced. Further an attempt should be made to quantify relationship between the level and pattern of energy consumption and economic activity variables such as
the price of energy and other output changes in demographic variables, taste and technology etc.

Jean-Thomas Bernard in his paper presented an integrated total energy demand model and its application to be Province of Quebec. The Key determinants were the relative price of energy sources (coal, electricity, natural gas and oil), the level of economic activity, the number of households and weather. The energy demand, due to dynamic effects, adjusts over time. This econometric model is applied of three economic sectors of the Quebec economy: residential, commercial and industrial. The sample consists of annual time series from 1970 to 1997. The results highlight the roles played by short-run and long run price and income elasticities. The model is easily used for simulation and forecasting purposes. Based on this information, they attempted to obtain the most reliable estimates of price and income elasticities or any other factor that may seem relevant. According to the author the total energy demand, either with respect to the whole economy or to a specific sector, has garnered widespread attention in the last twenty years as a result of the international oil crises of 1973 and 1979. Some studies present a synthesis of previous works, on total energy demand namely Ziemba et al. (1980), Bohi and Zimmerman (1984), Donnelly (1987), and Hawdon (1992). In this paper total energy demand with energy source substitution is modeled through two integrated levels at the first level (aggregate), total energy demand, measured in joules, is made a function of its lagged value, aggregate real energy price, real income and heating degree days. At the second level (disaggregated), market shares held by each energy source (coal, electricity, natural gas and oil) are made functions of the corresponding lagged share and of relative prices of energy sources. Lagged variables at the aggregate and disaggregated levels are introduced to account for dynamic effects over time. Indeed, the use of energy requires complementary equipment, and consumer response to price or income variations may spread out over several periods due to adjustment costs.
More formally, the integrated total energy demand model by sector has been written in the following terms

\[
\begin{align*}
MS_{t,1} &= (MS_{t-1}, PC_t, PEL_t, PNG_t, PO_t) \\
PEN_t &= \sum MS_{\phi_t} x P_{\phi_t} \\
En_t &= h(En_{t-1}, PEN_t / Pit, Y_t, DD_t) \\
Q_{\phi_t} &= MS_{\phi_t} x EN_t
\end{align*}
\]

This two-level integrated model provides a tool, which can be easily used for policy simulation or for forecasting. The substitution effects among energy sources (set of equations (1)) and between total energy and the other goods (equation (3)) are incorporated explicitly. Furthermore, real income also has an impact on energy consumption. The exogenous variables that determine energy consumption is the relative prices of energy sources and real income. At each period, lagged variables are also known variables, which determine the current demand level. The ordinary least squares (OLS) estimation method is applied to equation (3) representing total energy consumption by sector, and the results are presented. With few exceptions, the results are satisfactory when they are assessed in terms of some commonly used statistical criteria. All price and income coefficients display signs that are expected on a priori grounds. Zellner’s seemingly unrelated regression (SUR) procedure is applied to the set of market share equations. The coefficients of the lagged dependent variables are all very high, thus indicating a very slow adjustment process of market shares. The coefficients of relative prices variables for energy sources are generally significant and indicate the presence of substitution among energy sources. From the estimation results, author has calculated the short-run and the long-run total energy demand price and income elasticities directly by sector. The estimates of price elasticities, which are all less than one in absolute value for the short run and the long run; this fact is particularly significant in the industrial sector, thus indicating that energy consumption responds weakly to price changes. Income elasticities are relatively high in the commercial and
industrial sectors and are found to be close to one over the long run. This implies that for both these sectors, energy consumption follows the level of economic activity in the long run. The paper has concluded that the integrated total energy demand model presented above may easily be used for simulation or forecasting purposes. We only need to insert into the model the exogenous variables, which, in this case, are the prices of the energy sources, the level of economic activity and the number of households. These variables are considered to be the basic determinants of the growth of total energy demand.

Long-term energy demand forecasting and planning certainly aid in terms of enabling policymakers to calculate strategic energy reserves and to form / adjust energy policies and regulations. The recent deregulation of Taiwan’s energy markets makes this sort of research even more compelling. In sum, the aim of efforts undertaken by government agencies and by academia is to maximize the utilization efficiency of costly imported energy. According to Yu chang Jeffrey Bor Shi- Miin Liu, Hung-Kang Jan and Feng-Ying Chou, in general there are three basic methods of forecasting energy demand: (I) statistical, (ii) econometric, and (iii) engineering. Each method has its own pros and cons. For long term energy forecasting in Taiwan the authors have used the observation period of yearly data is from 1961 to 1995, a total of 35 years. They have discussed that there are two levels of secondary energy forecasting model. First is specific energy forecasting (non divided by sectors). This includes one total energy series and two subtotal energy series (coal products and oil products), and ten subenergy series (steam coal, coke, coke oven gas, liquefied petroleum gas, gasoline, diesel, fuel oil, other petroleum products, natural gas, and electricity). The time series method is used to create a high level of forecast accuracy for these energy demand series. Second is the forecast of energy demand by sector. Altogether, there are twelve sectors considered in the paper. There are six non-industrial sectors: energy transportation,
agriculture, residential, commercial, and other services, and six industrial sectors textiles, paper and printing, chemical material, steel and iron, cement and other industrial sectors. Although the energy items in each sector are the same as for specific energy series forecasting, the purpose of doing sector forecasting is to focus on the substitution relationship and technological change of energy consumption in each sector. The econometric model and end use model are the major methods in this level of forecasting. After following the standard procedures for testing time series data such as the unit root test (Dickey and Fuller 1979, 1981), the exponential smoothing model has been found to be the best model for forecasting and detecting the long-term trend in most energy demand series. The stepwise autoregressive method has been used to handle the forecast of exogenous variables, such as population industrial production, and GDP. The stepwise autoregressive method combines time-trend regression and the autoregressive model into one model. The final step of the secondary energy-forecasting model is to adjust the discrepancy between the result of specific energy demand forecast and the forecast result of energy demand by sectors. A top-down adjustment principle is used in this paper. The results depict that the average annual growth rate of Taiwan's total energy demand will be 4.4% for the next 15 years, and the average annual growth rate of GDP will be 4.8%. Oil products and coal products together account for about 76% of the total energy demand forecast in the economy.

Lester C. Hunt, Guy Judge, Yasushi Ninomiya in 2002 demonstrated the importance for energy demand modeling of allowing for trends and seasonal effects that are stochastic in form, it is shown that unless energy demand models are formulated so as to allow for stochastic trends and seasonals, estimate of price and income elasticities could be seriously biased. The UEDT may be non-linear and reflect not only technical progress, which usually produces greater energy efficiency, but also other factors such as changes in consumer tastes and the economic structure that
may be working in the opposite direction. Given the need to model the UEDT in a general and flexible way, the structural time series approach is an ideal vehicle for estimation in these circumstances. Therefore, The authors have combined it with an Autoregressive Distributed Lag (ARDL) to estimate UK aggregate energy demand function for various sectors of the UK. This framework allows for both a stochastic trend and stochastic seasonality when estimating the price and income elasticities of aggregate energy demand. The structural time series approach allows for an unobservable trend and seasonal components that are permitted to vary stochastically over time consider the following quarterly model. For UK aggregate energy for the whole economy, the residential sector, the manufacturing sector, and the transportation sector. The data for all sectors consisted of quarterly unadjusted data from 1971q1 to 1997q4. The estimated long-run income and price elasticities for the whole economy are 0.56 and –0.23 respectively. The preferred model for the residential sector requires a couple of lagged variables implying the demand cannot adjust instantaneously to the long-run position. Unlike the whole economy and the other sectors analysed in this paper, energy demand in the residential sector does not have a trend component at all – either stochastic or deterministic. The result that there is no significant UEDT for the residential sector implies that the demand for energy is driven solely by income, price, and temperature. This result is consistent with Barker (1995) who also found no role for a linear time trend. However, the absence of a UEDT in energy demand could indicate that an improvement in the energy efficiency of residential energy usage is cancelled out by changes in consumer’s taste; that is consumers choosing large and more comfortable energy appliances such as central heating system, freezers, tumble dryers, etc. This result is also consistent to the findings of Schipper et al. (1992), pp. 175-176. The estimated long-run income and price elasticities are 0.30 and – 0.22 respectively. It is also worth noting that the long-run income elasticity of 0.3 is somewhat smaller than those
estimated in this paper for the whole economy, manufacturing, and transportation sectors. This is consistent with the view that the energy services for the residential sector is approaching saturation (Haas and Schipper, 1998), p. 438. The preferred model for the manufacturing sector does not include any lagged variables implying immediate adjustment to the long-run position. Almost all diagnostic tests are passed satisfactorily, although there is some problem with the post-sample prediction tests. The estimated long-run output and price elasticities are 0.72 and −0.20 respectively. It is worth noting that the output elasticity is somewhat larger than the other sub-sectors analysed in this paper. This is not surprising, reflecting the close link between output and energy demand in the manufacturing sector. The diagnostics of the model are very satisfactory for the transport sector with no indication of serial correlation, non-normality, etc. In addition the post-sample predictive failure tests are all passed. The number of lagged variables required is small with just a one-quarter lag on income required, but the residuals are still clearly white noise. This suggests almost instantaneous adjustment of transportation energy demand to the price change. The UEDT is generally upward sloping is the transportation sector. Therefore, after controlling for the normal income and price effect, the use of transportation energy has been increasing. This illustrates that over the past 25 years (other than the last few years of the estimation period) the sector has become more energy intensive. This increase in energy intensity shown by the upward UEDT reflects a shift in the energy demand curve to the right, ceteris paribus. The hyperparameter of the seasonal components are relatively small compared with that of the level indicating that the stochastic movement in the seasonal component is not as large as the stochastic fluctuation of the trend. However, the changes in the seasonal pattern are still found to be stochastic and are clearly preferred to conventional deterministic seasonal dummies. The estimated long-run income and price elasticities are 0.77 and −0.13 respectively.
Robert McRae quantified how energy consumption per capita will shift with economic development. Development is usually associated with structural changes such as people moving from rural to urban areas and an increase in industrial activity, which are hypothesized to lead to a shift in energy consumption per capita. The estimated relationship between consumption per capita and economic development is used to predict future consumption of energy. To estimate the function relationship, the model requires data on energy consumption, oil consumption, population and real GDP per capita for each country. For simplicity, a linear functional relationship between energy per capita and real GDP per capita is assumed, as shown in the following equation:

\[
\frac{\text{energy}}{\text{rGDP}} = \beta_1 + \beta_2 \frac{\text{Npop}}{\text{Npop}}
\]

The model is estimated separately for Asian countries and for Latin American countries. All of the countries in each region are pooled together when the parameters are estimated. The estimated relationship between energy (and oil) consumption per capita and real GDP per capita can be used to forecast energy (and oil) consumption. For convenience, the countries are separated into low, middle and high income. It is assumed that real GDP per capita and population in the Asian countries will continue to grow at their historical rates and it is assumed that population in the Latin American countries will continue to grow at historical rates. Since the historical growth rates for real GDP per capita in Latin American countries have been quite low, and not indicative of future prospects, it is assumed that real GDP per capita will grow at 2 percent in the future. This sort of model is not as useful for explaining energy consumption for individual countries as it is for regional totals. Alternatively, one might estimate more sophisticated individual country models with time series data. However, this approach would not likely capture the shift in energy consumption arising from
economic development. So the main contribution of this paper is to show that energy and oil consumption per capita depends upon the stage of economic development. It is concluded that the relationship between energy consumption per capita and economic development has important implications for predicting future world demand for energy. If real GDP per capita in the developing countries of Asia continues to grow at something similar to historical rates and the real GDP per capita in Latin American countries grows at a relatively modest 2 percent per annum then energy consumption in these developing countries will increase more rapidly than in the developed world, and will consume an increasing share of world energy production.

B Sudhakara Reddy and P Balachandra (2002) presented a paper which looks at various parameters that influence the energy demand in India and visualizes the energy and environment outlook in the year 2010 AD. The authors have presented a mathematical model that estimates the ratio of likely future energy demand with the influence of a given factor to the likely future demand without this effect. The model takes into consideration factors such as population growth, economic growth, energy prices, urbanization, appliance stock, availability of indigenous energy resources (which produces substantial potential) etc. The impact of any given factor is estimated in terms of quantum change it causes on the growth rate of a given energy type. Finally, the impacts of all factors have been combined to obtain overall impact on the energy demand growth rate. Two scenarios, business as usual (BAU) as well as sustainable energy planning (SEP) are discussed in the paper. The SEP scenario includes the implementation of energy efficiency measures, fuel switching etc. The implementation of these measures reduces energy consumption levels thereby decreasing carbon emissions significantly. In this scenario, the energy consumption levels in 2010 are projected to decrease by about 27 per cent (related to baseline scenario). There will be a rapid decline in carbon emissions also. The cost of these
options is significantly less than the cost of energy generation. For the successful implementation of various measures suggested in SEP scenario, there are various barriers to be tackled such as technical, financial, institutional, pricing policies and environmental laws. If India can overcome these barriers then there will be significant reduction in energy consumption and air pollution levels. The author concludes that the analysis presented in this paper is based upon forecasts and other data that contain some uncertainties. The major purpose of this study is to inform the consumers as well as utilities and decision-makers in India about the importance of energy consumption patterns and their impact on environmental pollution.

FICCI (Federation of Indian Chambers of Commerce and Industry) (2005) indicted that long run demand elasticity is generally higher than short run elasticity and the long run elasticity of demand are very wide and vary between OECD countries and developing countries. They estimated developing countries have lower price elasticity and higher income elasticity, particularly the fast growing countries. According to FICCI study, there is also evidence that oil demand may become less sensitive to income levels as income elasticity in the post 1986 period has been lower than those for a longer period. Their estimated long run price elasticity of non-OPEC supply varies from a low 0.1 to a high of 0.6 depending upon the permanency of the price change assumed.

f) The Effects of Oil Shocks on the Economy:

A Review of the Empirical Evidence

Due to the central role energy plays in the functioning of our economy, changes in energy prices are not the same as changes in the price of most other goods. Energy "shocks" can have macroeconomic consequences, in terms of higher inflation, higher unemployment, and lower output.

Economic theory suggests that economies suffer from recessions due to the presence of "sticky prices." If markets adjusted instantly, then
recessions could be avoided: whenever economic conditions changes, price and wage changes would automatically bring the economy back to full employment. In actuality, however, there are menu costs, information costs, uncertainty and contracts in our economy that make prices sticky. As a result, adjustment takes time and unemployment and economic contraction can result in the interim.

Historically, energy price shocks have proven particularly troublesome for the U.S. economy. Sharp spikes in the price of oil have preceded nine of the 10 post-war recessions, including the current one. When oil prices rise suddenly, the overall inflation rate is temporarily pushed up because other prices do not instantly adjust and fall. At the same time, because energy is an important input in the production process, the price shock raises the cost of production. Because other prices do not instantly fall the overall cost of production rises and producers must cut back production, which causes the contractions in output and employment, all else equal. There may also be adjustment costs to shifting toward less energy intensive methods of production, and these could temporarily have a negative effect on output. Typically, the effect on output occurs over a few quarters. The recent energy price spike followed this pattern, with oil prices rising in the second half of 1999 through the first half of 2000, and output growth slowing in the third quarter of 2000.

Early Studies

Darby (1982) had one of the earliest econometric studies that attempted to estimate the economic effects of oil shocks. His study aimed to determine what had caused the 1973-1975 recessions. He hypothesized that it could have been due to four causes: the removal of the Nixon price control regime (because GDP was overstated during the regime), the breakdown in the Bretton Woods exchange rate regime, the slowdown in money growth (contractionary monetary policy), or the oil shock. He
estimated that the 1973 oil shock caused a total cumulative decrease in GNP of 2.5%. While the oil shock’s effect on the economy was statistically significant, statistical tests could not rule out the possibility that it was the removal of price control, rather than the oil shock, that caused the recession.

The next year, Hamilton published what many would consider to be the seminal study on oil shocks. He drew attention to the fact that all but one of the post-war recessions had been preceded by a sharp rise in the price of oil, and set out to demonstrate statistically that, contrary to conventional wisdom, it was these oil price rises that caused the recessions. He demonstrated that oil prices, to use a term from economics, Granger caused GNP. To prove that price and GNP were not both being determined by some third variable, he demonstrated that no other macroeconomic variable Granger-caused oil prices. He estimated that a 10% increase in the price of oil in this quarter would increase GNP growth by 0.04 percentage points in the next quarter, then decrease it by 0.07 percentage points after two quarters, another 0.5 percentage points after three quarters and 0.6 percentage points after a year. Considering that during the major oil shocks prices rose by 20% in some quarters and rose for several quarters in a row, these estimates suggest the effect of oil shocks on the economy are quite large. However, statistical tests suggest that his equation was mis-specified or the relationship changed over time, and should be split in two at 1973. Surprisingly, although oil still Granger-caused GNP after 1973, he estimated that it had a much smaller effect on GNP from 1973-1980, when the first two major oil shocks occurred. He was one of the first to note that oil affected GNP with a lag — the effect on GNP was nearly ten times larger after four quarters than it was after two quarters.

Extensions

Over the late 1980s, standard regression specifications no longer showed oil shocks to have substantial effect on economic growth. Several
papers were written attempting to explain why, using more sophisticated and complex mathematical relationships and statistical techniques.

Knut Mork (1989) was one of the first authors to find that in a standard regression, when extended through 1988 and controlling for other macroeconomic factors, the effect of oil price changes on the growth rate of gross national product (GNP) was now small and statistically insignificant. In the mid-1980s, there had been a series of oil price declines, and Mork hypothesized that, unlike oil price increases, price declines had little effect on the economy. His regressions confirmed his hypothesis when the distinction between prices increases and decreases was made, the effect of price increases on GNP growth doubled, whereas price declines had a small and statistically insignificant effect. He estimated that a 10% temporary increase in the price of oil in this quarter would lower the growth rate of GNP by 0.31 percentage points after one quarter, another 0.15 percentage points after two quarters, 0.49 percentage points after three quarters, and 0.49 percentage points after four quarters.

Lee Ni and Ratti (1995) re-confirmed that when newer data is added the effect of oil price increases on economic growth using the standard linear relationship between oil price changes and economic growth becomes statistically insignificant. They claimed that the real oil price had not lost predictive power for growth in real GNP if appropriate account is taken of oil shocks and the variability of real oil price movement. The basic idea is that an oil shock is likely to have greater impact in an environment where oil prices have been stable than in an environment where oil price movement has been frequent and erratic (p.42). When they include an “oil price shock” variable that can be thought of as being a measure of how different a given oil price movement is from the prior pattern, (p.42) in the regression along with an oil price change variable, their results become statistically significant. Lee, Ni, and Ratti (1995) use a generalized autoregressive conditional heteroscedasticity (GARCH) model to get conditional variance of real oil
price changes. For Lee, Ni, and Ratti (1996) define oil price shock as a "normalized" oil price change given by unexpected oil price shocks divided by conditional standard deviation of real oil price change from a GARCH model. They show that normalized positive oil price shocks are significantly negatively correlated with real GNP growth but normalized negative oil price shocks are not.

Similarly, Ferderer(1996) believed that oil price volatility was the missing factor that could explain oil's macroeconomic effects and added a variable to capture volatility to his regressions that previous studies lacked. He argued that volatility could be costly in terms of shifting resources across sectors and causing investment uncertainty. He measured volatility as the standard deviation of daily prices. Using industrial production growth as a proxy for economic growth (in order to study the date over monthly intervals), he found that monthly oil price changes could statistically "explain" 5.7-18.5% of the fluctuations. By contrast, monetary policy could explain only 11.6-12% of the fluctuations in industrial production. He confirmed Mork's findings that oil price increases had a greater effect on the economy than price decreases.

Hooker (1996) found that oil prices no longer Granger-cause economic growth or unemployment after 1973, even though all three oil shocks occurred during this period. His results held for a variety of structural specifications. In reply to Hooker's work, Hamilton suggested that the relationship was not statistically significant after 1973 because many of the price increases since 1986 came on the heels of even larger decreases. Hamilton (1996) doubted that these types of prices increases would affect the economy. He devised a net oil price increase variable to control for this phenomenon, but still found smaller economic effects since 1973 and still did not find that his new variable, "the net oil price increase," Granger-caused economic growth.
Hamilton (2000) has posited that the reason standard regressions do not find that oil has a strong effect on economic growth is due to misspecification. If the effect of oil on the economy is best represented by a non-linear mathematical relationship, and then standard linear regression may pick up very weak and misleading effects. In a later paper, Hamilton demonstrated that non-linear specifications suggest that oil has stronger effects than linear specification. Unfortunately, since there are an infinite number of non-linear specifications to choose from, there is no easy way to identify the correct one. Hamilton also noted regression results may be hampered because the oil price can no longer be treated as exogenous, that is, it can now be driven by demand or supply. Using the net oil price increase measure proposed in his earlier work (1996), he found that a 10% increase in the price of oil (when it is not following a prior price decrease) in the current quarter will lower GDP growth in the next quarter by 0.13 percentage points, 0.13 percentage point two quarters later, 0.22 percentage points three quarters later, and 0.45 percentage points four quarters later. The sum of these effects is 0.2 percentage points smaller than in Hamilton (1983).

A recent paper by Jimenez-Rodriguez and Sanchez (2004) updates Mork's, Hamilton's, and Lee et al.'s respective work. Using standard vector autoregression method, the authors find that a 10% increase in the oil price reduces GDP growth in the U.S. by a cumulative 0.39 percentage points after eight quarters. Using Mork's variation, they find that a 10% oil price increase reduces growth by 0.46 percentage points after eight quarters, but a 10% decrease increases growth by only 0.11 percentage points. Using Hamilton's net oil price measure increases the effect of a 10% price increase to 0.54 percentage points after eight quarters. Using Lee's method, which focuses on price volatility, yields the largest results: the 10% price increase now reduces growth by 0.62 percentage points after eight quarters. These results are somewhat smaller than the earlier studies had yielded.
Kapetanios and Tzavalis (2004) present a new model in which structural breaks are caused by large economic shocks that exceed some threshold value. The timing and size of breaks are stochastic. Kapetanios and Tzavalis (2004) apply the model to the impact of oil price shocks on the relationship with real GDP. They find that large oil price-shocks (above 2.2% in absolute value) explain instability in the oil/macroeconomy links. Kapetanios and Tzavalis (2004) find that the increases in the price of oil reduce industrial production, but that decreases in the price of oil do not increase industrial production. They think oil price increases cause firms to adjust to the negative impact of oil price increases on production, but oil prices decreases do not cause firms to react.

In contrast to the above papers, a recent work by Barsky and Kilian (2004) questions the correctness of the whole literature on oil price shocks. Barsky and Kilian (2004) argue that oil prices are not exogenous (political events in the Middle East are only one factor influencing oil price), and that there may be reverse causality in that economic events cause world oil prices to change. They also argue that stagflation-rising inflation in the GDP deflator with high unemployment-usually given as support for importance of oil price shocks is not a feature found that strongly in data for the U.S.

In a recent paper in 2002, Hooker attempted to estimate how oil shocks affect inflation when controlling for other macroeconomic variables such as unemployment and price controls. He found that the effects of oil price increases were much greater before 1981 than after that date. After 1981, he found that oil price increases had only a small effect on the core inflation rate (excluding food and energy) as measured by the personal consumption expenditures deflator. He estimated that a 10% increase in the price of oil in the current quarter would lower core inflation by 1 percentage point in the next quarter and raise it by 0.5 percentage points two quarters after increase. Thus, he finds no positive net effect on inflation.
Oil Shocks or Monetary Policy

Despite the remarkable historical coincidence between oil shocks and recessions, a strain of research has suggested that there might nonetheless be some third force responsible for the recessions. In particular, the research has tried to separate the effect of the oil shock on the economy from the effects of simultaneous changes in monetary policy. Some of the research has concluded that had it not been for the changes in monetary policy, the oil shocks would have had little effect on economic growth.

In an early paper, Gisser and Goodwin (1986) tried to capture the effects of monetary policy, fiscal policy, and oil price changes on economic growth, inflation, and unemployment.” They measure Monetary Policy by growth rate of the money supply and fiscal policy by the full employment measure of federal expenditures. They estimated that a 10% increase in the price of oil in the current quarter would reduce GNP growth by 0.2 percentage points in this quarter, 0.01 percentage points in the next quarter, 0.02 percentage points after two quarters, 0.3 percentage points after three quarters, and 0.5 percentage points after four quarters. Similarly, a 10% increase in the price of oil is estimated to increase the inflation rate (as Measured by the GDP deflator) by 0.1 percentage points This quarter, 0.2 percentage points the next quarter, and an additional 0.2 percentage points after two, three, and four quarters. A 10% increase in the price of oil is estimated to increase the unemployment rate by 1.6 percentage points this quarter decrease unemployment 0.4 percentage points after one quarter, increase unemployment by 0.2 percentage points after two quarters, 2.4 percentage points after three quarters, and 3.2 percentage points after four quarters. The unemployment estimates seem questionably large, given the much milder estimated effect on growth. Monetary policy is estimated to have a much larger effect than the oil shocks: the effect of a 10% change in the money supply is estimated to be about twice as large as a 10% change in the oil price for GNP and about six times as large for the price level and
unemployment. The effects of fiscal policy on GNP and unemployment are
smaller than the effects of oil price changes, although larger than the effect
on the price level. The authors also demonstrated that oil Granger-caused
GNP, the price level, and unemployment. Contrary to other studies, they
also found that after controlling for monetary and fiscal policy, there was no
structural break in the oil GNP relationship after 1973. However, they do
confirm that there was a break in the oil –GNP price level and oil-
unemployment relationship.

Dotsey and Reid (1992) attempted to synthesize the work of Romer
and Romer, which claimed that contractionary monetary policy was the
cause of post-war recessions, with the work of Hamilton, surveyed above,
which claimed that the recessions were caused by oil shocks. They
estimated that a 10% increase in the price of oil lowered GNP growth by a
total of 0.7 percentage points over the next four quarters. (Similar to Mork,
they estimated the effects of price increases and decreases separately, and
found that price decreases had a smaller and statistically insignificant effect
on growth). By contrast, a 1-percentage point increase in the federal funds
rate was estimated to reduce GDP growth by 0.1 percentage points over the
next four quarters. They also estimated the effect of oil price increases on
unemployment and found that a 10% increase in oil prices would increase
the unemployment rate by a total of 0.4 percentage points over the next 24
months.

Bernanke, et al. (1997) were interested in finding out what effects
monetary policy changes had when they were unanticipated. They chose to
study oil shocks because these are one of the only macroeconomic
phenomena that most economists would agree are both unanticipated and
exogenous. First, they estimated the effect of a 10% increase in the price of
oil when monetary policy response as it has historically. They estimated that
our 24 months, GDP would fall by 3.8% and prices would rise by 0.09%. To
separate the effects of the oil shock from the effects of the change in
monetary policy, they then estimated a counter-factual example where monetary policy does not respond to the oil price increase, which they represented with a constant federal funds rate. In this case, GDP was estimated to rise by 1.33% and prices by 0.13%. They therefore concluded that oil price shocks have very little negative effect on the economy; rather it is the monetary response to oil shocks that leads to the historical coincidence between oil shocks and recessions.

The work of Bernake, et al. raises an interesting conceptional question; while the effects of oil shocks and monetary policy can be statistically separated, can they be separated in reality? Bernake, et al. Attribute the tightening of monetary policy following oil shocks as the Fed’s response to the increase in inflationary pressures that oil shocks are commonly believed to cause. Commenting on the Bernake paper, Sims (1997) points out that the assumption that monetary policy could remain unchanged in response to an increase in inflationary pressures is not a sustainable policy, and thus falls prey to the Lucas critiques. It is unlikely that private individuals would have no reaction to the implementation of an unsustainable policy, making the statistical separation of oil price effects from monetary effects problematic. This would suggest that one could reasonably question whether there is a practical distinction between attributing a recession to an oil shock or attributing it to the monetary response to an oil shock.

Hamilton and Herrera pursues this line of reasoning in a critique of the Bernake paper. While Bernake’ regressions can mechanically be interpreted to imply that monetary policy could prevent a recession, Hamilton and Herrera point out that these regressions would imply that the federal funds rate would have to have been an improbable 9 percentage points lower in 1973 to prevent a recession. Using the Lucas critique, it is unlikely that private individuals' expectations would have remained unchanged in light of such a significant policy change. Hamilton and Herrera also argue
that Bernake et al. Underestimate the effects of oil shocks because they use too short a lag length of at least 12 months would be more appropriate since many works find the largest economic effects of oil price changes to come after three and four quarters. In particular, by using a longer lag than Bernake, they find that countering oil shocks with expansionary monetary policy has much larger effects on inflation since monetary policy affects inflation with a significant lag.

The Effect of Oil Shocks on Employment

A related strand of research studied the effect of oil shocks on employment. Since economic growth has a strong effect on unemployment in the short run, one would expect oil shocks to affect unemployment if they affect economic growth.

Loungani (1986) presents oil price shocks as a major influence on the dispersion of employment growth across industries. He shows that once this dispersion effect of oil price is taken out, the dispersion of employment growth across industries has no relationship to unemployment. Loungani (1986) argues that major oil price shocks result in large reallocation of labor across industry. Work by Bohara (1988) supports the argument that resources are reallocated with a rise in oil price. Bohara (1988) considers oil price shocks in regional economies. He finds that oil and gas sector producing regions in U.S. (the states of Alaska, Louisiana, Oklahoma, Texas, and Wyoming) react differently from rest of the economy to an oil price rise since they benefit directly in terms of employment and income from a rise in energy price.

Carruth, Hooker, and Oswald (1998) estimated that oil shocks had a larger effect on unemployment than economic growth. They showed that oil shocks Granger-caused unemployment (unlike GDP) upto (1995) and estimated that a 10% increase in the price of oil would increase the unemployment rate by 0.1 percentage points. Although this is a relatively
small effect, they found that the effect of oil price changes on unemployment before 1978 was more than three times larger. They found that their model, based on oil prices and interest rates, forecasts unemployment more accurately than commercial forecasts.

Davis and Haltiwanger (1999) focused on oil’s effect on employment in the manufacturing sector, broken down by industry. They hypothesize that oil price changes have distinct “allocative” effects on manufacturing employment. The aggregate effects on employment are caused by the slowdown in GDP growth that oil price increases cause. The allocative effects on employment come from the fact that some industries are harmed more than others—and some are actually helped by a price increase. Thus, some jobs are shifted from one industry to another so that the net allowance effect of an oil price change on employment is zero. They found that a unit standard deviation positive oil shock triggers the destruction of an extra 290,000 production worker jobs and the creation of an extra 30,000 jobs in the first two years after the shock. After four years, the net employment response to a unit positive oil shock is only 60,000 fewer jobs, but the gross reallocation response amounts to 410,000 jobs or more than 3 percent of employment.

By comparison, they estimated that a unit standard deviation tightening in monetary policy leads to a net loss of 140,000 manufacturing jobs after two years. Looking at the data on an industry level, they estimated that the effects differ greatly by industry depending on the characteristics of that industry. For example, categorized by the energy intensity of production, the decline in employment was almost twice as large for industries in the 90th percentile than industries in the 10th percentile. Because their study excluded the service sector, which accounts for most employment, their results cannot be meaningfully extrapolated to judge the effects of oil price changes on overall unemployment.
Davis and Haltiwanger (2001) use sectoral VARs to consider effects of oil price shocks on job creation and destruction in U.S. manufacturing. They measure oil price by a weighted average of real oil prices over the last 20 quarters. The weights sum to one and decline linearly to zero. Nominal price of crude oil is deflated by the producer price index. This measure is interesting in it captures a huge real price decline in the late 1980s. Davis and Haltiwanger (2001) find oil price shocks explain 25 percent of the cyclical variability in employment growth from 1972 to 1988. They also find an asymmetric response to oil price changes. Oil price increases cause employment growth to decline more than oil price decreases cause employment growth to increase.

Oil price shocks and the stock market

A number of papers attempt to measure the effect of oil price shocks on the stock market. Kyung-Hwan Yoon (2004) argue that if oil prices affect the economy in the ways documented by studies of the macroeconomic and sector effects of oil price shocks then stock prices should be influenced by oil price shocks. Compared to work on oil price shocks and growth not very much work has been written on the effect of oil prices on stock prices.

Kaneko and Lee (1995) estimate a VAR system that includes U.S. and Japanese stock prices, industrial production growth, inflation, change in oil price, and exchange rates, for 1975 to 1993 period. They find that the U.S. stock returns are not affected by oil price shocks, but that Japanese stock prices are influenced by oil price shocks. Huang, Masulis and Stoll (1996) argue that oil price shocks may have an effect on the cash flow of firms and in this way have an influence on stock prices. They find that there is almost no connection between oil futures returns and stock returns except for oil companies.

An important work on stock prices and oil price shocks is by Jones and Kaul (1996). They test whether the effect of oil prices is on current and
expected future real cash flows using a decomposition of stock returns due to Campbell (1991). Campbell (1991) decomposes stock returns into expected and unexpected components. He shows by an approximation that forecasts of stock returns that give unexpected stock returns can be divided into two pieces. The first depends on forecasts of cash flows or “news about dividends” (Campbell; p.157) and the second depends on forecasts of future stock returns or “news about future returns” (Campbell; p.158).

Jones and Kaul (1996) argue that if the market reacts rationally to oil prices, oil price is not statistically significant since the effect of oil price should already be reflected in future real cash flow or expected returns. They look at stock prices in the Canada, Japan, the United Kingdom, and the United States, over 1947 to 1991. Jones and Kaul (1996) find that oil price shocks affect stock prices in these countries. The reaction in the U.S. and Canada is rational in that the effect of oil price on stock prices is completely through effects on real cash flows. The reaction in Japan and the United Kingdom is not rational in that the effect of oil price on stock price too large to be captured through effects on real cash flows or changes in expected returns. Jones and Kaul (1996) cannot explain the difference in results on the effect of oil price shocks on stock returns in these countries.

Sakellaris (1997) considers a panel of U.S. firms in four manufacturing industries over 1959 to 1985. Sakellaris (1997) checks for the effect market value of a firm of factor prices including the price of energy. He finds that the first oil price shock (in 1973-1974) significantly reduced excess returns (returns above those on a risk free asset) for a firm, but the second oil price shock (in 1979-1980) did not have as big an impact on excess returns as the first oil price shock. Sakellaris (1997) makes a good argument that physical capital used by firms before 1973 was technologically highly inflexible to adjust to oil price shocks. After the first oil price shock, physical capital installed by firms had more flexible technology to deal with oil price shocks.
Sadorsky (1999) considers the relationship between oil price shocks and stock returns using a four-variable VAR. Real oil price is given by the producer price index for fuels divided by the CPI. Real stock return is measured by the nominal return on the S & P 500 minus CPI inflation. The other variables are log of industrial production and the 3-month T-bill rate. Data are monthly time for 1947:1 – 1996:4. In the VAR the 3-month T-bill rate is placed first and oil price second. Thus, Sadorsky (1999) assumes monetary policy shocks have contemporaneous influence on oil prices. An oil price shock is found to have a negative and statistically significant impact on stock returns. He finds that oil price shocks explain about 8% of the stock return forecast error variance over 1950:1- 1985:12 and about 17% of the stock return forecast error variance over 1986:1-1996:4. This result is surprising in that oil price has bigger influence on stock returns in the period after the two big oil price shocks. The reason may be that the last period is one of greater volatility in oil prices.

Sadorsky (1999) finds an asymmetric oil price shock effect. Increases in the price of oil have statistically significant effects on reducing stock prices and oil price declines do not raise stock prices. He also considers oil price volatility by using a GARCH model of real oil price movement to construct conditional standard deviation of real oil price movement's normalized unexpected movements in oil prices. He finds oil price shocks and oil price volatility affect real stock returns. Volatility in the real price of oil is thought to have an effect on investment by firms. This argument is related to effect of uncertainty on irreversibility of investment by Pindyck (1991).

In a second paper Sadorsky (2003) considers the effect of oil prices on technology stock price volatility. This is considered important since technology share prices have shown very great volatility compared to other share prices. Using daily and monthly data he finds that the conditional volatility of oil prices have a strong influence on the volatility of technology stock prices. Sadorsky (2003) thinks that the link he finds is due to oil price
shocks increasing economic uncertainty with regard to recession and general business conditions, and not though affects on earnings due to use of oil as a factor input.


Mark J. Holmes and Ping Wang (2001) in their paper examined the role played by oil in influencing the growth in UK GDP. Their particular interest was the possibility that asymmetries might exist in such a relationship. Using Hamilton’s regime-switching estimation, they considered whether oil influences both the deepness and duration of the business cycle. According to the authors there is debate as to whether two successive oil price shocks in 1973-4 and 1979-80 can be blamed for the severe recessions experienced in the world economy during the mid-1970s and early 1980s. On the other hand, they say that Rasche and Tatom (1981), Darby (1982) and Ahmed et al. (1988) argue that it was in fact the tight macroeconomic policies pursued by governments in the aftermath of the oil price shocks that worsened the recession. Bjonland (2000), however, found that the importance of oil price shocks has varied over the UK recessions. Finally, it can be argued that a large increase in the relative price of oil causes aggregate unemployment to rise because it is costly for unemployed workers to shift between industrial sectors. Hamilton (1989) proposed a regime-switching model in which output growth switches between two different states according to a first order Markov process. Applying this model to the U.S., he found that shifts between positive and negative output
growth accord well with the National Bureau of Economic Research (NBER) chronology of business cycle perks and troughs. In the wake of this paper, a large number of researches have explored various aspects of the US business cycle using the Markov regime-switching framework [inter alia, Lam (1990), Sichel (1993), Durland and McCurdy (1994), Kim (1994), Filardo (1994)]. Much less work, however, has addressed the UK business cycle [exceptions include Acemoglu and Scott (1994), Krolzig and Sensier (2000) and Simpson et al. (2001)]. Raymond and Rich (1997) provide an interesting application of the Markov-switching approach where they analyze the relationship between oil price shocks and post war US business cycle fluctuations. Their novel approach was to investigate whether the oil price shocks affect the inference about the unobserved state through their influence on the estimates of the trend growth rates or through their influence on the estimates of the transition probabilities associated with switching from one regime to another. They found that the main effect is on the mean of growth phases rather than the transition probabilities. The purpose of this paper by Mark j. Holmes and Ping Wang was to utilize Markov regime-switching methodology to look at the relationship between real oil price and GDP growth in the UK. They employed quarterly data for the period 1960Q1-2001Q1. On the basis of the above discussion, there were several reasons of interest attached to their study. They contributed to the debate over the role of oil prices offering the first study that employs the Markov regime-switching framework on UK data. Are asymmetries present and if so, does oil exert an influence through the transition probabilities. Much of the existing literature on asymmetries in macroeconomics has focused on demand-side disturbances. Their contribution was to examine asymmetries against the background of supply-side shocks. Oil is the most identifiable supply side shock and they are able to address further important questions. The authors found that oil price shocks have exerted mean-dependant effects associated with expansionary and recessionary states. However, they also found that
asymmetries are present because oil price shocks adversely affect the duration of the expansionary phase of the business cycle. This latter can be contrasted with the US study by Raymond and Rich (1997) who attach less significance to transition probability effects. Their work augments the growing literature on asymmetries in macroeconomics in the sense that they considered the role of played by a key supply side variable. Finally they concluded that avenues for future research in this area might include a more formal investigation of the relative importance played by government policy, irreversible investment and sectoral shocks in underpinning oil-related asymmetries.

Stephen P.A. Brown and Mine K. Yucel in their paper said that considerable research finds that oil price shocks have affected the U.S. output and inflation. Gisser and Goodwin (1986), Hickman et al (1987) confirmed the relationship between oil price and aggregate economic activity for United States. Darby (1982), Burbidge and Harrison (1984), Bruno and Sachs (1982,1985) documented similar oil price- economy relationships for other countries other than U.S. In this article, a vector autoregressive (VAR) model have been constructed of the U.S. economy. Research supports the view that these shocks have been an important source of economic fluctuation in the U.S. over the past decades. Nevertheless other studies argue it was not the oil price shocks themselves but monetary policy’s response to them that caused the fluctuations in aggregate economic activity. To examine whether the definition of monetary neutrality affects the conclusion that monetary policy’s response to oil price shocks accounts for the fluctuation in aggregate economic activity, the model consist of seven variables and equations. The model can be used to represent money demand as well as the relationship between oil prices, aggregate economic activity; financial variables and inflation. This version of the model has two price wars: the net oil price proposed by Hamilton (1996) which was constructed by calculating the difference between the current price and the
maximum price seen to the past twelve months (in logs) and the price of oil. The authors have used both variance decomposition and impulse responses to assess the relationship between oil price shocks and aggregate economic activity. Using the model and procedures the authors examined the sources of variation in each variable and the estimated responses of aggregate economic activity to an oil price shock with the federal fund rate free to respond and with the rate constant. The authors have examined that innovation in the oil price itself except possibly through a manifestation in commodity prices- have little effect on monetary policy during the estimation period. They also found that holding the federal funds rate constant prevents a decline in real GDP, but at the cost of higher inflation. The authors have concluded using impulse responses from a VAR model, interactions between seven variables, real GDP, commodity price, the GDP deflator, oil price in the federal funds, and short and long term interest rates. The impulse responses to an oil price shock show that the model responds to a temporary oil price shock with a decline in real GDP, increases in the federal funds rate and other interest rates, and an increase in the price level. The decline in real GDP deflator is similar in magnitude and consequently nominal GDP remains constant. Under Godon's definition of monetary neutrality when the federal funds rate is held constant, impulse responses are obtained contrary to assertion that a constant federal funds rate represent a neutral monetary policy. When the rate is held constant in the face of an oil price shock, nominal GDP is higher, as are real GDP, commodity prices and the price level, all of which are consistent with accommodative

Some other authors have also worked on this topic like Carlos De Miguel, Baltasar Manzano and Jose M Martin-Moreno, (2002) analyzed the effects of oil price shocks on the characteristics of the business cycle and on welfare in a small open economy, such as in the case of the Spanish economy. The paper discusses that one of the identifiable sources of shocks that has claimed the attention of many economists is oil price shocks. The
effects of these shocks on the economies of industrialized countries have been widely recognized in the literature. The study reviews that authors such as Pindyck (1979), Hamilton (1983) and Olson (1998) suggest that these shocks affect growth as well as the business cycle, thereby becoming an additional source of economic fluctuation. There is extensive empirical literature that offers evidence of an asymmetric relationship between oil price and aggregate economic activity (see Mork 1989 and 1994). Such asymmetry has been attributed to a wide range of explanation: adjustment costs, financial stress, monetary policy (Balke et al. 2002). Another kind of literature, has analyzed the effects of energy price shocks on economic variables using real business cycles models in closed economics. In this framework, authors such as Kim and Loungani (1992) and Finn (1995) find that such shocks offer very little help in explaining the US business cycle. The model used in this paper is a standard dynamic general equilibrium model for a small open economy in which oil is included as an imported productive input. The oil price as well as the interest rate is assumed to be set by the international markets so the authors consider a small economy in the sense of taking those prices as given. Oil price shocks are considered the only source of fluctuation. Therefore, although the economy has been hit by many shocks, their analysis is conditional on a single shock. This analysis would allow verifying the extent to which oil price shocks can account for the Spanish business cycle. The parameters of the model are chosen by taking data from the Spanish economy for the period 1970:1 – 1998:4. This period includes two significant oil crises. The results show the ability of the model to reproduce the cyclical path of the Spanish economy, especially in those periods when oil price shocks were most dramatic. This kind of shocks accounts for more than half the size of the aggregate fluctuations of the economy. In addition, the model reproduces other regularities of the business cycle. Finally, the paper concludes that the increases in the relative price of oil had a negative and significant effect on welfare.
International Energy Association (IEA) 2004 in their paper discussed the impact of high oil prices on the global economy. Tomas Nordstrom and Bengt-Christer Ysander traced the direct impact of an oil price hike on the ‘Swedish economy disregarding the repercussions on the world market and analyzed that the immediate impact of a large oil price rise in the model economy is to boost inflation, as measured by the consumer price index. However the oil price hike and its inflation impact will set forces in motion which will affect the real development of the economy and feed back on prices with various lags.

Now we would review some studies done in the context oil shocks and their impact on India. Some authors applied input-output analysis to estimate the long-run cost-push effect of a hike in the administered price of oil and constrained supply of oil [C. Rangarajan, Raaj Kumar Sahand, K.S. Reddy 1981; Sastry 1982, A.K. Sen Gupta and Parimal Pariya 1990-91].

RangaRajan, Raaj Kumar Sahand and K.S. Reddy (1981) in their paper have used input-output technique for observing the impact of hike in price of coal and petroleum products on other sectors of the economy. They have attempted to present a methodology by which the impact of the increase in the price of one commodity on others can be calculated under a situation where the prices of specific commodities are not allowed to rise even though input prices go up. Certain assumptions have been clearly laid down in the model. The results of the study indicate that with the initial increase in the prices of coal and petroleum products by 45.4percent & 17.72percent, when no restriction is imposed on the increase in the price of any sector, the most affected sector is miscellaneous coal and miscellaneous petroleum products. Next in order of impact are cement and electricity where the price increase would be close to 2 percent. In the absence of miscellaneous coal and miscellaneous petroleum products its prices go up by approximately 5.8percent. Next in the order of impact is the cement industry, the price of which would have to go up by 2percent in order to any
direct restriction, the price of railway services would have increased by 0.94\% percent. The restriction that the railway price should remain the same, in spite of the increase in the prices of coal and petroleum products would benefit most of the sector (miscellaneous coal and miscellaneous petroleum products), followed by cement, fertilizer, iron and steel and paper and paper products. This is due to the fact that transport is an important element in the cost of production of these commodities. With the additional restrictions that even the price of electricity should not increase the industry that gains most is fertilizers. With the restriction on the prices of coal, railway services and electricity, the industry most affected by the price increases announced is compensating for the increase in the price of inputs. Taking into account the impact of all commodities and weighing them properly, the authors find that the wholesale price index would go up by 1.3\% percent approximately. The authors have concluded; it is possible, that either because of government controls or because of demand factors, the prices of some of the commodities may not increase in spite of the increase in the price of inputs. Under these conditions, it becomes necessary to evolve a new computational procedure to estimate the impact on the prices of various commodities. This paper has outlined such a procedure and has applied to Indian situation, when coal and petroleum product prices are increased without increasing the prices of railway services and electricity.

A.K Sen Gupta and Parimal Pariya (1990-91) in their paper for assessing the economic impact of constrained supply of oil on Indian economy have used Input – Output framework that has been suggested by Ghosh in 1960 and Augustinovics in 1963. Under this framework, two alternative Input–Output approaches have been used (a) partitioned production Input–Output model and (b) partitioned allocation model. Set of assumptions under these two approaches has clearly been distinguished. The authors have tried in this paper to compute the consequences of oil shortages in India by using the two alternative partitioned Input–Output
frameworks. The result of their study indicates that the impact of oil shortage assessed through the partitioned production model is most severe on the sectors like ‘Transport’ (66.29 percent reduction), ‘Trade’ and ‘Service’ (64.03 percent reduction) and ‘coal and lignite’ (37.4 percent reduction). Again the impact of oil shortage assessed through the partitioned allocation model is severe for the sectors like transport (13.62 per cent reduction in output) and comparatively mild only for all the rest of the sectors. In general the authors have concluded that partitioned allocation model may be more efficient in assessing the impact of shortage in supply of any primary input, provided the proportion of intermediate cost to the output of the concerned (for which the impact is being assessed) sectors is significant.

Anushree Sinha and Shashanka Bhide (1997) in their paper have said that the domestic prices of petroleum products are adjusted in response to changes in the exchange rate as well as the world market price of oil. Using a macro computable general equilibrium (CGE) model for India, they have attempted to answer the question as to how do changes in domestic prices of petroleum products influence the overall price level and hence the whole range of economic performance. To facilitate discussions of the results, they have briefly discussed the pattern of use of petroleum products in the economy. They have concluded that India is a growing economy and like most developing nations will consume more and more of energy, and more specifically petroleum oil products (POL) to sustain its growth. In case production of POL does not improve India will continue to depend on imports to fulfill its demand. Under these conditions the world oil price would continue to exert pressure on the Indian economy. The results presented in this paper using a macro model indicate that the increase in international prices by 10 percent leads to as much as a 2 percent increase in the overall price level, as domestic POL prices increase and the exchange rate depreciates to cut back the rising oil pool account deficit and trade deficit. This also leads to fall in Gross Domestic Product (GDP). It is therefore obvious that POL
production needs to improve. This would naturally involve major policy changes to enhance exploration efforts and also to make oil companies internationally competitive.

**Kaushik Bhattacharya & Indranil Bhattacharya (1998)** has attempted to study the transmission mechanism of an increase in petroleum prices on the prices of other commodities and output in India. They have also tried to examine the nature and the extent of ‘feedback’ in such a transmission mechanism and obtain evidence of bidirectional causality between oil and non-oil inflation in India. Econometrically, the nature and extent of the feedback in transmission of price from one sector to other has been examined by using a four equation vector auto regressive model (VAR) on oil and non oil inflation, and growth in broad money and output. Therefore the model has attempted to identify the lag structure in which a rise in prices of mineral oil begins to affect the prices of other commodities and output. The results indicate that bi-directional causality was pertinent because policymakers had typically increased the administered prices of petroleum products when the overall inflationary environment had been favorable. The impulse response functions from VAR model revealed that a 20 percentage point shock in oil prices lead to a 1.3 percentage point increase in inflation in other commodities at its peak, which typically occur after five to seven months after the shock. The impact on prices persists for about two years, though during the later period it lessens considerably in magnitude. In response to a shock of similar magnitude, growth in output decelerates by about 2.1 percentage point and recovery starts to take place approximately after a year. The results are useful in understanding the dynamics of core inflation and inflation targeting and imply that a rise in exclusion based core inflation could also be attributed to the excluded commodities like oil products in this study. Therefore the authors have concluded that oil price shocks lead to an indirect impact on the prices of those commodities, which
use them as inputs and can lead to wage price spiral as evidenced during the oil shock of the substantial increase in wages and prices and decrease in real output. Any hike in oil prices, apart from a direct impact, has 1970’s. The analysis also reveals that developing countries may be affected more by oil shocks than the developed countries due to lack of oil conservation techniques and absence of appropriate oil- substituting technology in the production process.

B.B. Bhattacharya and Sabyasachikar made a distinction between the impact of shocks on the short and long run growth rates as a characteristic of the neoclassical theories of growth. This distinction has been challenged by a number of alternative paradigms. One important school of thought that attempts this is the “Read business Cycle (RBC)” approach that starts with the view that growth and fluctuations are not distinct phenomena to be studied with separate data and analytical tools. This approach views economic fluctuations as being predominantly caused by persistent real (supply-side) shocks caused by large random fluctuations in the rate of technological progress that result in fluctuations in relative prices to which rational economic agents optimally respond by altering their consumption pattern and supply of labour. According to RBC theory, fluctuations in output and employment are Pareto efficient responses to real technology shocks to the aggregate production function of the economy. This implies that observed fluctuations in output are fluctuations in the natural rate of output rather than deviations of output from a smooth deterministic trend. Therefore, government intervention to smoothen fluctuations through stabilization policy is not only undesirable because attempts are unlikely to meet its desired objective, but also because reducing instability results in welfare losses. Hence, in contrast to Keynesian theory which views departure from full employment as a distortion in terms of societal welfare calling for proactive government intervention, the ‘bold conjecture’ of RBC
theory is that call phase of the business cycle boom and slump, is a Pareto efficient equilibrium. Clearly, any study that tries to analyze the effect of such shocks on the growth process needs an alternative framework that explicitly incorporates the sectors of the economy where these shocks originate and the intersectoral channels through which these shocks spread and affect the aggregate economy. This realization has given rise to a sizeable literature that analyses the impact of various kinds of shocks within the framework of a detailed model of the economy. The main approaches used for this purpose are structural macro models, general equilibrium models and VAR models. Each of these approaches has its strengths and weaknesses and there is a lot of ongoing research on which of these is the most useful approach. The authors view that it maybe worthwhile to note at this juncture, that the Indian economy has not experienced the extreme volatility in economic behavior that has been witnessed in other emerging economics, especially in Latin America, Africa and the formerly Soviet bloc of countries. Even after a decade of liberalization, India is one of the least globalized economies of the world. With the advent of freer markets and globalization, the economy has now become more sensitive to internal and external shocks. In this paper the authors try to identify the incidence and origin of the five types of shocks that are analyzed in this study. Moreover, they have also tried to identify the impact of these shocks on various intermediate and equilibrating variables in the economy. Given the objectives of this study, they say the most appropriate tool that can be used for an analysis of these issues is a structural macro-modeling framework. Macro modeling is based primarily on the ‘structural modeling’ methodology associated with the Cowles Commission. They have used annual data collected from various sources to estimate a model for the Indian economy. A simultaneous estimation of all the equations will not feasible as the number of observations is usually not sufficiently large and hence the equations has been estimated separately using OLS method. In a number of cases where found suitable, the
equations have been estimated using the logarithms of the variables. In order to keep the model tractable, few explanatory variables are chosen for each behavioral equation. This sometimes results in omitted variable bias leading to serial correlation and poor Durbin Watson statistic. In such cases they have estimated the functions with AR (1) errors. In order to incorporate both short run and long run effects of the shocks, they have incorporated a dynamic impact in a number of equations by using lagged dependent variables as regressors. In such cases, the Durbin Watson statistics becomes irrelevant and study has calculated the Durbin’s h statistics. Using OLS for the estimation of the behavioral equations gives rise to simultaneous equation bias. Note that in this case, even through the estimation procedure does not take care of the simultaneity, the Gauss – Seidel technique that is used to generate complete model solution, solves the endogenous variables simultaneously. In the case of oil price shocks we assume that the price index of oil imports rises by 100% over actual values in 1997 and 1998. Thus, the price index goes up in 1997 from 540 to 1080 and in 1998 from 440 to 880 respectively. The average price during this period jumps by about 50% over 1996. This may be compared to the oil shock in 1979-80 when the corresponding jump was about 125%. Thus it is a plausible shock though not of the extreme nature as the first and second international oil price shocks.

The authors have defined and studied the effect of five shocks that we believe might have affected the growth of the Indian economy. These include two domestic shocks (rain fall shortfall and fiscal profligacy) and three external shocks (oil price hike, world trade shock and capital flow shock). Next, they have constructed realistic shock scenarios and estimated the effect of these shocks on the growth process. The primary focus in this study is the effect of shocks on the aggregate growth rates. In this context, it is fair to say that realistic rainfall and fiscal profligacy shocks have a strong growth retarding effect compared to realistic scenarios of the other three shocks, both in the short as well as the long run. Thus the two domestic shocks are
the comparatively big shocks both in the short and long run. The second issue of interest is the pervasiveness of the shocks, i.e. their long run persistence. Here it was found that the oil price hike, the capital flow shock and fiscal profligacy show strong pervasiveness, while the economy is much more resilient to the rainfall shock and the world trade shock in the long run.

The third issue that is of interest from the policy point of view is whether the shock leads to a stagflationary situation or not. This is because demand management policies can be used in non-stagflationary situations while stagflationary situations sometimes worsen with the use of such policies. The study found that the rainfall shock and fiscal profligacy is stagflationary in the long run, while the oil price hike, capital flow shock and world trade shocks are not stagflationary in the long run. The forth and final point of interest was to study whether the shock leads to some instability in the growth process by enlarging the disequilibrium in the fiscal or the external sectors. As it was mentioned in this paper, a large increase in the deficits in these sectors has the potential to destabilize future growth rates by affecting investor confidence in the economy. It was found from the study that the oil shock, world trade shock and the capital flow shocks (i.e. the external shocks) give rise to some instability in the external sector in the short run. Similarly, the fiscal profligacy shock and the world trade shock give rise to some short run instability in the fiscal sector. However in the long run the authors found that none of the shocks have any significant negative impact on either the fiscal deficit or the external reserves.

A R Sihag, Siddhartha Chatterji, and Anurag Khetan in their paper "Vulnerability of the Indian economy to tensions in the Middle East: impacts and responses" develops four possible scenarios of the occurrence or non-occurrence of a military intervention in Iraq and corresponding oil supply and price scenarios. The impacts of these upon the Indian economy in macroeconomic and intra-sectoral terms are assessed and quantified. The
paper reviews that the impact of the oil supply shock induced by the 1973/74 OPEC embargo was studied by Rasche and Tatom (1977) in terms of its effect on the 'potential GDP' of the US over 1977-81. They came to the conclusion that a seven per cent reduction in this aggregate was possible, assuming a one-time permanent price shock originating in 1973/74. A post-Gulf War study (Mory 1993) concluded that a 5.5% decrease in the potential GDP of OECD (Organization for Economic Co-operation and Development) countries was likely due to Operation Desert Storm and its aftermath. Both these studies employed a simple elasticity approach. Oil imports account for approximately 74% of India's current domestic crude oil availability (Gol 2001a). A majority of these imports come from the Middle East, underscoring vulnerability to any disruptions in the region. The last situation of military conflict in the Gulf in 1991 coincided with a poor macroeconomic profile of the Indian economy. Growth slumped from approximately 5.5% (over 1980-90) to 1.3% (in 1991/92), a balance of payments crisis led to import curtailment and a slump in industrial production, inflation soared to 14%. The vulnerability of the Indian economy to oil price shocks has, however, remained a reality post-liberalization, as may be gauged from the following explanation. After a period of low prices and continuous decline during 1996/97 through 1998/99, oil prices rebounded upwards in mid-1999 and continued to rise, hitting 30 dollars per barrel in late 2000; India’s oil import bill rose from 6.4 billion dollars in 1998 to 16 billion dollars in 2001/01- the economy was effectively paying 800 million dollars per month extra in 2001/01 for its oil imports vis-à-vis 1998/99. Almost 0.6% of potential growth per annum may have been lost in these years. This paper attempts to quantify some possible macroeconomic impacts of the four oil price shocks scenarios. The impact of the oil shock on inflation does not seem to be threatening with the maximum average impact likely to be 0.69%). The impact of the price shock scenarios on the loss of potential GDP within a year has been calculated via a multiplier estimated through the oil price
elasticity of GDP for importing developing countries as in an IMF study of the Asia Pacific region (Mussa 2000). The direct impact on the external account has also been estimated. At the actual import level for crude for 2001, the absolute and percentage increase in the import bill under the four scenarios has been given. However, given the comfortable foreign exchange position, the economy could be expected to weather this burden smoothly unlike in the previous Gulf War. This paper provides a framework under which the impact of an oil price spike on the Indian economy can be measured and response strategies designed. After reviewing the current tensions in the Middle East and the impact they may have on the Indian economy, it is clear that costs can be substantial enough to warrant an early response. The outlining of both the fiscal and quantitative measures shows that political choice can be anywhere on the continuum. Four schematic approaches have been advocated through which the government could pursue the goals of burden sharing and impact smoothening. Around this matrix, the choices before the government are multifarious. However, for risk-averse consumers, a completely revenue-neutral role of the government to smoothen the impact would enhance welfare.

The FICCI Survey on ‘Emerging Oil Price Scenario and the Indian Industry’ was conducted during the month of October-November 2004 with oil prices skyrocketing towards the USD 50 per barrel mark. The effect of increasing oil prices was being felt country wide in terms of higher inflation. On the business front, costs of production were increasing, margins were being eroded and profits were on the decline. Against this background, FICCI decided to undertake an industry-wide survey to gauge the extent to which the increase in oil prices were crippling the industry in terms of its increased production cost, lower profitability, lower aggregate demand in the economy, higher inflation and the measures that Indian companies were taking to deal with the situation. A comprehensive questionnaire was prepared which
included questions on the impact of the oil price rise on the Indian economy as a whole and on a few important economic parameters. The respondents were also asked to categorize the extent of the impact as high, medium and low. There were firm level questions pertaining to the impact on the cost of production, total energy bill and how the respective companies were dealing with the increased costs. Finally the respondents were asked to specify the measures which they would like the government to undertake to reduce the impact of future oil price shocks. A database of 'high to medium' oil intensive companies were prepared. These companies represented a wide sectoral and geographical spread. The FICCI Survey on 'Emerging Oil price scenario and the Indian Industry' elicited response from 147 companies with a wide geographical and sectoral spread. FICCI also discussed the measures to reduce the impact of oil price shock on the Indian Industry. The study concluded that the ripple effect of increasing oil prices is felt throughout the economy, especially in case of high oil intensive economies like India. The immediate result of escalating oil prices is felt in the form of increasing consumer prices. It also reduces consumer expenditures on non-energy goods and services. On the business front, higher oil prices translate into higher costs of production for goods and services using oil as an input. The firms may also have to bear with pressure on margins and declining profits as they might find themselves unable to transfer the whole burden of higher oil prices to the consumer. The consequences of declining profits are felt in the form of lower capital spending. Eventually persistent and accelerating gains in oil prices result in higher nominal wages to maintain real wages. Finally trade deficit of oil importing countries widen exerting pressure on the currency. The magnitude of these effects depends to a large extent on the size of the net oil imports and the intensity of oil usage in an economy. The larger the consumption of oil per unit of GDP the bigger the negative impact on economic growth. According to IEA computations India is one of the high oil intensive economies. So, the need of the hour is to promote energy
efficiency and develop alternate energy sources like nuclear power, hydel power and wind power along with progressive substitution of fuels like petrol and diesel in automobiles with natural gas. Some other authors namely Donald W. Jones, Paul N. Leiby, Inja K. Paik, W.M. Corden, Alasdair Mac Bean, Rahul Nayar, Chetan Ahya, Asha Ram Sihag have also worked on this topic.

g) Possibility of export led growth in oil products

Kanan Srinivasan (1997) has studied India’s demand for petroleum products, which is rising sharply, even as domestic production has declined. He has observed that the opportunity cost involved in importing these depends on the availability of sufficient refining capacity. India’s exports which have lagged behind imports to produce a trade deficit of $4.54 billion in 1995-96, cannot pay for these imports. According to him this could precipitate the next Balance of Payment (BOP) crisis or a sharp decline in the rate of growth of our economy.

S. Majumder (2001) in his paper has pointed out that the only bright side of the Indian petroleum sector is the increase in the refining capacity. It is a paradoxical situation. With India’s crude production not growing, India has been importing. But with huge refining capacities, it has also been looking at markets abroad. The author points out that for the first time, petroleum products emerged as a major export item accounting for over 4 per cent of the total exports in 2000-01 (April-December) against 0.1 per cent in the corresponding previous period. But he concludes that this was hardly enough to cover the oil import bill, which zoomed with the sudden spiral in crude prices.

h) Alternate fuels

Daniel Sperling (1990) in his paper on new transportation fuels written under the premise of eventual exhaustion of petroleum has discussed
various non-petroleum based transportation fuel options. He has concluded that there are many historical examples that provide useful models for studying the transition to alternative fuels including a variety of experiences in the United States, Brazil's experiences with ethanol, Canada forays into Compressed Natural Gas (CNG), coal liquid in South Africa, Compressed Natural Gas and synthetic gasoline in New Zealand