Integrated Model of Computable General Equilibrium and Social Cost Benefit Analysis of an Indian Oil Refinery: Future Projections and Macroeconomic Effects

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Abstract

Social Cost Benefit Analysis has long been used as a useful tool to appraise and evaluate the value to a society of a range of investment projects. Various important aspects of this method have been subject to scrutiny over the decades, such as the appropriate discount rate, whether the Ramsey Rule of 'pure time preference' should be applied as impatience with a positive rate or zero-rated with concern for future generations; these are important concerns since the choice of discount rates deeply affect the valuations of future income streams. Other aspects concerning financial flows and appropriate 'shadow prices' have also undergone considerable attention. However, when a mega-project with the character of a 'universal intermediate' is considered, its multiplier effects may be wide-ranging and permeate several economic and social layers, and may be captured only in the aggregates. This study, a sequel to a paper that ignores such macro-aggregative benefits, examines the costs and benefits of Vadinar refinery in Gujarat with a focus on this welfare dimension on society for the project. The study allows for this large scale benefit accrual and examines the net economic benefit of refining at Vadinar by Essar Oil to the region, the state and the country by Social Cost Benefit Analysis. The framework thus explores a methodological breakthrough in SCBA studies. In constituting the macroeconomic effects of expansion of the mega oil refinery, the economic impact is estimated using the Computable General Equilibrium (CGE) model and incorporated into the cost benefit analysis. This assimilation of CBA with macroeconomic externality obtained from the CGE model framework is perhaps only one of its kind in economic analysis of major infrastructure projects of any country. SCBA when combined with CGE as an analytical tool can be gainfully employed to appraise or evaluate large scale projects like oil refineries, especially when they make a splash with their mega-sizes as the Essar Oil refinery is.

Keywords: Social Cost Benefit Analysis, Economic Impact, Computable General Equilibrium (CGE) Model, Oil Refinery

JEL Code: B41, C51, C52, C53, C54, C55, D50, D58, D60, D61, D62, H23, H43, L71, O22, Q43

1. Introduction

Petroleum, Oil and Lubricants (POL) commands a strategic and critical role in growth and development. These constitute a major part of energy used in India's economy, second only to coal as source of primary energy, and can spur growth in most sectors. India has been traditionally a net importer of POL products. The country is being forced to spend valuable foreign exchange to procure additional energy resources. In the recent past, there has been a growing concern to boost production of petroleum and natural gas from domestic sources as well as hydrocarbons equity abroad. At present India imports about three-fourths of its crude requirements. Investing in domestic oil and natural gas exploration is a long-term solution that will help quench India's growing energy demands. Since oil and natural gas also play a critical role in deciding the inflation rate, the prices for these energy commodities have long been a point of contention in Indian politics. After Government of India allowed private participation in petroleum refining in India, Essar Oil set up a 9 MMTPA oil refinery at Vadinar in Gujarat, which started commercial production on May 1, 2008. The current capacity of the refinery now stands at 20 MMTPA. With state-of-the-art technology, it has the capability to produce petrol and diesel that meets the latest Euro IV and Euro V emission standards. The refinery produces LPG, Naphtha, light diesel oil, Aviation Turbine Fuel (ATF) and kerosene. It has been designed to handle a diverse range of crude — from sweet to sour and light to heavy. It is supported by an end-to-end infrastructure setup, including SBM (Single Buoy Mooring), crude oil tanker facility, water intake facilities, a captive power plant, product jetty and dispatch facilities by both rail and road. To date, Essar Oil's Vadinar refinery has successfully processed more than 75 varieties of crude from across the world, including some of the "toughest crudes". This comes with an increase in its complexity from 6.1 to 11.8 on the Nelson index, making it India's second largest single-location refinery and amongst the most complex globally.

In this study, the researchers propose to conduct a study on social cost-benefit analysis (SCBA) for the Vadinar refinery using up-to-date information to estimate the costs and benefits associated with the project. The purpose of the study is to briefly examine whether the commercial refinery project at Vadinar is socially beneficial overall for the refinery business. The economics of a refinery are complex and depend on many factors. Profits or losses result primarily from the difference between the cost of inputs and the price of outputs. In the oil refining business, the cost of inputs (crude oil) and the price of outputs (refined products) are both highly volatile, influenced by global, regional, and local supply and demand changes. The question of whether the business of refining in aggregate is socially desirable and economically beneficial is adequate to justify the aggregate cost of running the refinery. The analysis is done in stages as the effects of a mega-refinery, in fact any refinery, are wide-ranging as they spill over not just in their local area of activity but much beyond, extending to the national economy and polity. It is intended that this complex process is captured in some meaningful way with very high degree of professional norms. There are however certain effects which may not be amenable to these standards, but we wish to give pointers to these directions in what follows.

In continuation of Phase I of the study, some important issues were added as fresh references for Phase II constituting this study. These issues are in two parts. In Phase I the evaluation was done with data for the period for which output, sales and costs of investment and operations have been realised/ incurred till date, i.e., 2014-15. This has its clear merit of basing the evaluation entirely on realised values of the refinery operations. However, the evaluation of a large and on-going business can be properly made taking into account the projected useful life of the project, even though there are elements of risks, both anticipated and unanticipated, going several years into the future. This will constitute one part of the second phase, further elaborated below. The second part of phase II will incorporate a completely new element into the evaluation of social benefit costs analysis (SCBA). Since the Essar Oil Refinery is a large greenfield project which has made a huge impact in the shortage syndrome that has been the experience of the Indian economy, its macroeconomic consequences are large - unlike those in many economies such as USA, where a refinery of similar magnitude would make a lesser impact on the economy in general. In principle it is like the presence of a large player taking up position rather than a continuum of small players adding to capacity in the market. This is sought to be captured in the second part of this phase II under the rubric of the CGE model, which has been developed to capture various macroeconomic issues at the economy and sectoral levels. These two parts are further elaborated below.

Projections based Benefit Cost Ratio: Cost-benefit analysis (CBA) is a method of quantitative economic analysis that is widely used to evaluate existing and proposed projects, programmes and policies, and which can inform decision-making. CBA is a quantitative analytical tool to aid decision-makers in the efficient allocation of resources. CBA is also often used to evaluate the social returns of the use of privately owned resources. In Phase I of the study, the CBA of EOL's Vadinar refinery was examined using data available till the current year of operations. Subsequently, input parameters are extended beyond their existing temporal values. The Economic Net Present Value and Benefit Cost Ratio (BCR) would be estimated by projecting the Investment Cost, Operating Costs and Revenues, Consumer Surplus, Producer Surplus, Government Surplus and the Project Externalities using data received from Essar Oil Limited. This would help in further refinement of the project deliverables of Phase I of the study and aid in building scenarios for the project CBA.

Assessing macroeconomic impacts using CGE model of Indian economy: CGE models are useful tools for analysing economy-wide impacts of various economic policies and issues that have ramifications beyond a particular sector or particular economic agent. Examples include tax reforms, trade reforms, income distribution policies, energy and environmental issues, etc.

They are economy-wide models in the sense that they include all sectors of the economy, and incorporate the behaviour of all economic agents (households, producing sectors, government, and rest-of-the world). These features make them particularly suited for analysing issues where the inter-sectoral and inter-agent linkages are very important.

These models are capable of tracking the impacts on prices, output, demand and trade flows at the individual sector level for all sectors of the economy, as well as impacts on the income, expenditure and savings of all economic agents in the economy. Since all sectors and all economic agents are included in the model, they also provide the impacts on several macroeconomic variables and on the income distribution.

As mentioned earlier, petroleum products being ‘universal’ inputs, any change in the oil sector will have economy-wide ramifications. Hence, this part of the study will use an existing CGE model for the Indian economy to assess the impact of an expansion of the output of refinery sector on the following:

Key macro variables: GDP, exports, imports, exchange rate, consumption, savings, government fiscal position, investment.

Sectoral impacts: The impacts on sectoral output, prices, demand, export, and import for both upstream and downstream industries would be covered here. The CGE model includes all sectors of the economy, viz., agriculture, industry and services, which are categorized into 18 sectors that produce 24 commodity groups. Refinery is one of these 18 sectors, which produces 6 commodity aggregates (LPG, Kerosene, HSD, Motor Spirit, Naphtha, Substitute fuels such as LDO, Lubes & Tar).

Income distributional impacts: Per capital income of rural and urban households separately for bottom 30%, middle 40% and top 30%.

Once the second part, constituting the macroeconomic effects of the expansion of oil refinery, is estimated using the CGE model and interpreted these may be incorporated into the cost benefit analysis. That part is a novel feature of this exercise. This may be done by identifying the channels through which they accrue, constituting the macroeconomic externalities of the refinery project. This exercise will thus provide an added scenario to the assessment made in phase I of the study which did not have this feature.

2. The Macro externalities of petroleum refineries

These issues of externalities were presented in phase I paper; however in view of their relevance in the context of the CGE model framework introduced in this study for estimation of macro benefits and their treatment as macro externalities, this section is included here. The estimation based on the CGE model framework are monetized and then incorporated in a later section. Those who may like to get a short summary of what is discussed below may skip to the recapitulation of these macro externalities later in this section.

The hydrocarbons sector of Indian economy has seen considerable growth for several decades alongside increased income of its citizens and growth in the national economy. The nature of this growth has many aspects, and it is useful to highlight them at the outset. Hydrocarbons form a major part of the total energy sector in India, and with growth in the economy it is a natural process that energy demand increases, and at a rate determined by the character and parameters of the energy intensity of growth. If economic growth is energy-intensive it follows that all subsectors of energy would feel the pressure of demand growth. However, some subsectors may outpace others, at rates determined by the economic structure. We see that the Indian economy has not only experienced high energy demand, but also a considerable shift in demand for hydrocarbons in general and specific petroleum products (such as diesel and other middle distillates) in particular.

There are two dimensions to this growth profile of energy demand. Oil and natural gas have not only direct use in specific sectors like transport (motor spirits, diesel, CNG, in households, industry, etc.) they are also used, very significantly, as ‘universal intermediates’. Thus petroleum products are not only used in transporting vehicles and firing gas stoves in households, the products of this industry are used as inputs in a variety of activities in a manner that can be best described as 'universal intermediates'. Thus natural gas can be used in power plants as much as coal as inputs, which in turn power several activities in the economy. Similarly, gas, naphtha and other products of this sector can be used for fertilizers, along with other multiple uses, and fertilizers are used as inputs in agriculture. Naphtha and other products can be cracked to derive ethylene, propylene and others, and these in turn can be used as inputs for producing mono- and poly-products such as polypropylene, with multiple uses in garments, packaging, plastics, food and several other uses. It is not just that the products of this industry (oil) are used in specific sectors like transport, but also assume a more pervading character. Its ramifications are huge and thus its security and stability to the economy is enormous. With growth in the Indian economy in the sustained manner that has been recorded for several decades now, it is natural that there is almost an insatiable demand for the hydrocarbons sector and its various derived products. This has been perceived in policy circles for some time and has helped in its development in recent decades.

Speaking about the character of the growth process underway, some specific issues such as the character and speed of urbanization are also important to underline, since this has been considerable in India. This growth in urban economy is true of all emerging economies in the world, and included those of the newly industrialized world in Asia and other continents. With urbanization comes not only considerable growth in urban transport that is frequently noted, but also other demands made by urban dwellers in procuring supplies from elsewhere in the country. Thus a variety of industrial products arrive from other cities and industrial centres, but also agricultural products ranging from common cereals, to fruits and vegetables and dairy products, grown in the countryside. Hence there is enormous demand on transportation to move products to urban centres; there is also in turn the increasing demand arising from agriculture on fertilizers, pesticides and other products of industry to produce increasing supplies to these centres; and these increase non-linearly in view of increasing incomes of the urban middle classes. It is these issues that must be kept abreast in appreciating the enormous pressures on the petroleum sector to fuel the growth in the economy. What happened in the course of the decades would be easier to comprehend then.

An important point generally missed in the context of inflationary process can be captured in this context. A balanced and stable production of petroleum products is paramount in this process of controlled target of inflation. When we measure inflation impacts through metrics like the wholesale and retail price indices (WPI and CPI) in the economy, it is not simply the weights of crude and petroleum products in the weighting diagrams of the indices being considered. Through their universal character, these products enter into consumption and production of most other sectors and add to inflationary pressures through secondary and tertiary effects. Prices of agriculture could rise, for instance, as a result of its impact, and so could their transportations to centres of consumption, and also through fertilizer prices reflected on producer prices. If these prices are not contained, then the subsidy burden to the exchequer of the large weight of food and fertilizer subsidies spiral, as we have seen in recent decades; these in turn add to the fiscal deficit burden and hence on the inflationary pressures. Inflation management is a huge social responsibility of any incumbent government and this in no small measure is better served by a responsible growth and stability of the hydrocarbons sector.

India's food security through rapid strides in the agriculture sector in the last few decades is well documented. It started in the late 1960s and gathered pace in the 1970s and 1980s, and sustained with some attendant costs since then. However, it had some distinct characters as it spread its wings. It was orchestrated through the Green Revolution, which had several features: it was mainly through increase in yields per acre; it was confined to the principals cereals, rice and wheat, and later extended to certain crops like maize and sugarcane and others in select areas; it was confined first to the Indo-Gangetic plains of India and then spread to coastal peninsular India. For increasing crop yields, common features were the new technology and seeds that depended on controlled water supply (irrigation), fertilizers and power, all of which were copiously supplied with heavy subsidy elements built into them. Petroleum products have made an important contribution in achieving and sustaining that. India's much debated green revolution leading to food security would have been a pale shadow of its success without generous dozes of subsidized inputs, in all of which hydrocarbons have played important roles, be they irrigation (diesel generated pump sets), fertilizers and pesticides, tractors, power tillers, harvesters, etc. Food security apart the income generated in the regions and prosperity of farmers was enormous.

A few other macroeconomic and social effects of the enormous importance of the oil sector may be quickly listed. India has been deficient in crude petroleum and products in relation to its net demand for several decades. As a result, there have been large deficits in the external trade account for imports of crude oil for refining and products for direct consumption to meet this burgeoning demand. Consequently, the deficit on the foreign exchange account was ballooning and the external value of the rupee was traditionally under pressure in a controlled exchange regime. As a result the rupee was considered to be overvalued. This was to a large extent contributed by the ballooning deficit in the demand supply gap of this sector, and this was considered serious till such time that the economy was liberalised in the early years of 1990s. In fact the critical phase leading to the crisis in the economy in the 1990s and opening up of the economy soon after and two successive devaluations of the rupee (in 1991) was in no small measure the reflection of this scenario. With liberalisation and globalisation of the Indian economy many changes have been wrought, including the controlled regime in the petroleum sector, the new exploration licensing policy for oil sector (NELP) and the administered pricing mechanism (APM) that was to be replaced. It is important to note here that the management of the exchange rate in a controlled regime gives rise to a shadow exchange rate that may be different from the actual prevailing rate, and thus management of the oil sector is a task of considerable policy significance. Increased production of crude oil and refinery products thus add considerably to the benefits accrued to the economy at the national scale.

There is also pricing and supply chains for petrochemicals as downstream products of refineries. These influence the growth and locations of downstream products around the country. For instance, economies around the world with large refining sectors, whether they are located in the Middle East, Southeast Asia (Singapore), or the United States, petrochemicals industries have grown in tandem with the growth of refineries, and these add considerable value chains in the economy with their boosts to output, employment and taxes in the economy. This has happened in India too with the development of the refining sector located in different parts of the country. Today the supply of petrochemicals products is so plentiful that even in rural India with masses of low income households, they have made pervasive inroads. Even in poor villages and hamlets, a visitor is offered a plastic chairs which they can afford rather than natural woven materials where they were made to squat. Several decades back, natural cotton was the apparel of the masses as they could not afford the synthetics. Today the synthetics fabrics are the apparel of the masses even in rural areas as they have replaced the natural fibres like cotton, which have become items of luxury at home, and for exports to markets abroad.

A parallel example may be drawn from automobiles and its linkages with auto-ancillaries, both growing in lockstep. There are strong case histories of these linkages from around the world where production takes place; these case histories may be cited from the United States, Britain, Germany, Japan, and recently from China, South Korea and India. Going a step backward, the Steel industry has very strong downstream linkages, including the just cited examples of automobiles and ancillaries. In fact Japan built its giant steel industry even without the local availability of iron ore; and China’s huge steel capacity is sustained largely by imported ore from India, Australia and several other locations; a similar example is South Korea, and all these three East Asian economies were dependent on imported ores in varying proportions. All these industries form a chain of metals-based sector. The story is similar for refineries and their products, which are petrochemicals. The first is Ferrous-metal-based value chain, and the refinery chain, whether built on local or imported crude, provide the petrochemicals value chain. Both these groups, when established provide enormous potential for value addition, employment and income generation, and direct and indirect tax collections. This underlines the independent standing of refineries as an engine of growth even when domestic sourcing of crude oil is limited; when domestic prospecting and production is added, the chain gets even stronger.

The pricing of petroleum products in the market is another instrument of social policy, quite apart from the downstream products and pricing of petrochemicals industries discussed above. It has been noted earlier that these products as universal intermediates, unless properly managed, have inflationary consequences. There is also social policy of direct subsidy to consumers in various forms such as kerosene (SKO) subsidy, LPG subsidy and till recently administered pricing mechanism of motor spirits and diesel. Increase in these prices (or even their full-cost pricing) can make significant holes in budgets of the poor and the middle classes, and hence they are sensitive to social and political order in India. It is not just that income levels matter (through transfers policy of product pricing), which they do, but inequality among social classes may have consequences on social order. While attempts have been made for several decades to contain the scale and target beneficiaries of petroleum subsidies, mainly in the household and agricultural sectors, the magnitudes continue to be large in scale and inefficient in terms of leakages. These are sensitive issues and government policies are always alert on them in a democratic set-up.

While in a study of the social costs and benefits of a large refinery it would be important to capture the ‘shadow price’ of good social order and its stability consequences on the investment climate for business prosperity, it may be an elusive animal to chase. Nevertheless, it is worth keeping in mind the importance of social order. It is after all what makes a lot of difference to the intangible elements that define business confidence. A volatile climate may not be conducive to the ‘animal spirits’ of entrepreneurs. Hence, even if this study is unable to measure this element of enormous benefits to the economy and society, the ‘peace dividend’ may be considered significant.

Recapitulation of macro benefits:

It is useful to recapitulate the principal benefits that expansion of the oil sector would bring to economic welfare and social and political conditions prevalent in India. Stability and continued growth of this sector is essential to an expanding economy like India where energy demand has been escalating with economic growth and diversification, intensifying with global reach and changed lifestyles. It is no longer business-as-usual for the energy sector. Population growth and rapid urbanization have added fuel to this engine of growth as this sector is one of the principal contributors to the national energy use. Oil and natural gas (hydrocarbons) have both direct and intermediate uses for various sectors of the economy, both as fuel and inputs to these processes. Its universal intermediate character adds weight to its impact on the national economy. India is sitting on a huge shortage compared with its burgeoning demand in the face of limited capacity thus far.

Lack of investment over decades in both hydrocarbons prospecting and refining capacity in the country has resulted in this outcome; both these lines of activity (crude exploration & production as well as refining capacity) have large gestation lags and risk profiles, especially in oil and gas prospecting. This has resulted in the economy receiving nightmarish jolts when caught napping in the face of ballooning demand for products, especially in middle distillates and overall demand measured in crude throughput. It had several manifestations. Its inflation consequences and effects on family budgets are significant and these cause social discontents and disorders which no political system can withstand, let alone a vibrant democracy like India. Inflation effects of oil price hikes may be measured, but it may be elusive to put numbers to the 'multiplier effects' of an orderly society that provides adequate supply lines and infrastructure to reach consumers. It is, however, surmised that the effect would be huge if a metric were to be devised. Analysts believe that a society with discontents may suffer from business confidence, as being not sanguine to investments and high risk capital; and these are matters of great consequence as India prospers as a giant world economic power.

The exchange rate effect of oil shortage is a little more subtle conceptually, though quite large in its result if that could be estimated. The domestic shortage syndrome has two parts, crude and natural gas availability and the products of refinery. Both shortages would be reflected in large trade and current account deficits, and have been large and continues to be so for India. Other than POL, significant contributors to India's trade deficit are gold and diamonds & precious stones, though the last group is re-exported largely; gold is not due to its insatiable demand in India. Refinery products' shortage increases the net value addition loss in the imports account, and these add up considerably. Additionally, refineries bring in their downstream products which are also lost in terms of their value additions and multiplier effects. Imagine a situation where India imported not gold ingots but also all the jewellery from abroad if there were no jewellers at home. Some powerful examples from steel and automobiles industries were cited above to drive home the point. The effect of refineries are similar and additionally all the downstream industries they spawn in different layers. The current account deficits that translate into BOP deficits put pressure on the exchange rate, and these could be harmful to domestic consumers, especially for imported goods which become costlier. A direct consequence, among others, is that imported crude and products in turn become costlier as they are always denominated in international currencies like the US dollars. They in turn have inflationary effects discussed above.

It was also emphasized that hydrocarbons are universal intermediates permeating all other economic activities. Hence, much beyond its inflation, exchange rate and social order outreach, this source of energy is critical to growth of agriculture, petrochemicals, fertilizers, power generation and to several others. These downstream industries which develop alongside refineries support the location and growth of these new activities. To give specific examples, the proliferation of industries producing plastics, packaging, apparel, among many other petrochemical products, are now prominent and pervasive even in rural India; it is not just the frequently cited transport industry that is the beneficiary of this sector. Its growth, though strenuous over the decades, has fuelled all round development of India. It was pointed out that refineries spawn other industries which form a chain for petrochemicals This underlines the independent standing of refineries as an engine of growth even when domestic sourcing of crude oil is limited; when domestic prospecting and production is added, the chain gets even stronger.

Furthermore, India’s food security through the much recorded green revolution in the Indo-Gangetic plains and coastal peninsula would have been a pale shadow of its achievements without generous dozes of subsidized inputs in all of which hydrocarbons have played important roles, be they irrigation (diesel generated pump sets), fertilizers, tractors, power tillers, harvesters, etc. Food security apart, the income generated in the regions and prosperity of farmers were enormous. Crude oil and natural gas as much as refineries are important cogs in that wheel of India’s growth. Thus to perceive the economic multiplier effects of this sector legitimately, we need to consider the total economy for externalities, and not just their neighbourhoods of activity for ripple effects. These are aggregative and macroeconomic effects of the sector, which make considerable splash.

3. Estimation

3a. Part I: Social Cost Benefit Analysis with Projected Values

Methodology

The noted economists Frank and Bernanke laid CBA as one of the seven core principles of Economic Sciences. CBA as a tool can be used either to appraise or to evaluate a given project. Appraisal is done before the commencement of the project and evaluation is done after the completion of the project. This study focuses on Essar Oil's already operational Vadinar Refinery Project. Therefore, technically, this work should be an evaluation of the project. However, the process of analysis is both retrospective as well as prospective. It is retrospective in the sense that the project is already completed and it has become fully operational. It is prospective in the way that by evaluation of the relative merits of the project in terms of the accrued benefits and costs, it serves as a template for deciding a fresh course of equity investment in refinery infrastructure augmentation. The study has been informed by EOL of its new and forthcoming investments and this analysis will aid in appreciation of the strategic direction of the project as well as its overall fit in the broader socio – economic rubric.

Formally, the analysis entails solving the following equation:

$$NSB = \sum_{t=0}^{n} .(Rt - Ct)/\,(1 + r)t$$

Where NSB is net social benefit, R is revenues generated from sales of the products, C is the cost of refining, r is the discount rate, t is the year, and n is the number of years in the project. The CBA analysis is conducted following generic steps of CBA as described below.

In accordance with the European Commission Guidelines for CBA (2014), the framework of SCBA is construed for EOL's Vadinar Refinery. The analysis is based on the following stages. First, the financial cost and revenue data are converted from financial prices to accounting or shadow prices by applying explicit conversion factors. Secondly all non-market impacts have been monetized by the notion of Willingness to Pay (WTP) or Willingness to Accept (WTA), which are grounded on the concepts of Consumer Surplus (CS) or Producer Surplus (PS). This, in turn, is expressed quantitatively by the Rule of Half. The process of determination of CS and PS involves identifying and quantifying the non-monetized costs and benefit streams associated with the project to generate the specific values of CS and PS. In the next stage, the externalities of the project are duly incorporated in the analysis. This is followed by the determination of the Social Discounting Rate for India using the Social Time Preference Rate (STPR) approach. The final stage involves calculation of economic performance indicators like ENPV, ERR and the most critical performance criteria for project evaluation, namely the BCR for the project.

In a separate part of this study discussed below, the macroeconomic effects of this large infrastructure project are estimated using a computable general equilibrium (CGE) model to capture their effects as part of the larger set of externalities. Those are then integrated in a separate exercise to arrive at the final picture. That part is a complete innovation of this study, and as such similar methods are not usually seen in its peer studies.

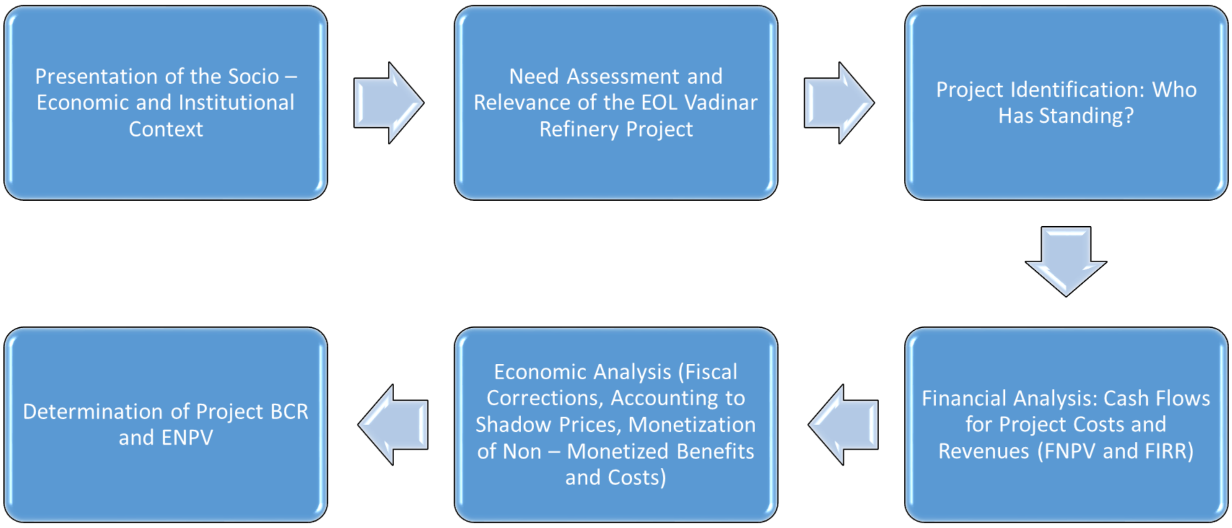

Figure 1: The Methodology for SCBA

Presentation of the Socio–Economic and Institutional Context

The socio-economic and institutional context has been elaborately discussed in phase I of this paper, and attention is drawn to the relevant document for the interested readers. The historical, political and economic settings were discussed in the context of international oil market and the need for huge investments by the private sector and foreign equity in the face of burgeoning demand for these products in India. The Vadinar Oil Refinery project and its social and environmental issues were covered in some detail in that document. There is thus no further scope for discussing these issues.

Need Assessment and Relevance of the EOL Vadinar Refinery Project

The Essar Oil Ltd grass roots refinery in Gujarat, India (started in 1996) was completed and commissioned in 2006 (commissioned in third quarter). The refinery is the second largest in India after the Reliance Jamnagar refinery on an adjacent site. According to information on the company's website, EOL has about 700,000 bpsd (barrels per stream day) of global crude-refining capacity (Vadinar + Stanlow). In downstream supply chain and distribution, the company operates a network of over 1,400 retail outlets across India, with another 600 under various stages of commissioning. Broader social objectives are therefore highly pertinent for the CBA of Vadinar Refinery, which should reveal to what extent they are met for all stakeholders in the system.

Who has standing?

The boundaries of the analysis should be defined here. The territorial area affected by the oil refinery project effects is defined as the impact area. This can be of local, as in the Vadinar region; state or regional as in Gujarat or National in context. A good description of the impact area requires the identification of the project's final beneficiaries, i.e. the population that benefits directly from the petroleum refinery project. These may include, for example, those identified in the Essar Foundation CSR Paper, papering the benefits of the project that are accrued by the inhabitants of the larger areas surrounding Vadinar region. The identification of 'who has standing' should account for all the stakeholders who are significantly affected by the costs and benefits of the project, in accordance to the CBA Guidelines (2014) under section 2.9.11. This aspect has been adequately reflected in the Micro Externalities analyzed later in the paper.

Financial Analysis

The financial analysis methodology used in this paper is the Discounted Cash Flow (DCF) method, in compliance with section III (Method for calculating the discounted net revenue of operations generating net revenue) of European Commission Delegated Regulation (EU) No 480/2014. The following rules are adopted:

1. Only cash inflows and outflows are considered in the analysis, i.e. depreciation, reserves, price and technical contingencies and other accounting items which do not correspond to actual flows are disregarded.
2. An appropriate Financial Discount Rate (FDR) is adopted in order to calculate the present value of the future cash flows. The financial discount rate reflects the opportunity cost of capital. In our case, a discount rate of 7.8% is adopted, based on the long–term annualized interest rate that India's central bank charges from commercial, depository banks for loans to meet temporary shortages of funds.
3. Project cash-flow forecasts should ideally be covered for a period appropriate to the project's economically useful life and its likely long term impacts. The number of years for which opex, capex and revenue forecasts are provided should also correspond to the project's time horizon (or reference period). The choice of time horizon affects the appraisal results. In practice, it is therefore helpful to refer to a standard benchmark, differentiated by sector and based on internationally accepted practice. The European Commission proposed reference period for the Energy Sector for 15 years (2015 – 2030) has been considered in this case (ANNEX I to Commission Delegated Regulation (EU) No 480/2014).

Investment Costs

Investment Cost includes the capital costs of all the fixed assets (e.g. land, constructions buildings, plant and machinery, equipment, etc.) and non-fixed assets (e.g. start up and technical costs such as design/planning, project management and technical assistance, construction supervision, publicity, etc.). In the construction phase, changes in net working capital (variations in working capital) are also included.

The investment cost figures are obtained from the Balance Sheet of EOL, sourced from the Annual Papers of the company. The costs are shown with a negative sign as they are considered to be outflows on the part of the operator of the refinery project. The projections for investment cost are obtained from the company's internal source and are assumed to be incremental in nature.

The variations of working capital indicate an investment outlay for the project and are included as a part of the Total Investment Cost. The Total Investment Cost for the project works out to be the sum of the total fixed cost, total startup cost and variation in working capital.

Total Investment Costs (IN INR CRORES)	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Land	-59	-80	-3	-4	-6	-4																
Buildings	-356	-42	-8	-330	-16	-14																
Plant & Machinery	-12677	-266	-139	-10003	-1208	-653																
Office Equipments	-35	-9	-6	-6	-1	-3																
Furnitures and Fixtures	-8	-8	0	-2	-1	-1																
Vehicles	-8	-1	-1	-2	-1	0																
Aircraft	0	-10	0	0	0	0																
Total fixed assets (A)	-13143	-416	-157	-10347	-1233	-675																
Softwares & Licenses	-30	-2	-3	-13	-7	-10																
Patents	0	0	0	0	0	0																
Other pre-production expenses	0	0	0	0	0	0																
Consulting Services (for the period, not cumu	-12	-4	-27	-32	-10	-13																
Training expenses	0	0	0	0	0	0																
R&D expenses	0	0	0	0	0	0																
Total start-up costs (B)	-42	-6	-30	-45	-17	-23																
Train 1 and Train 2 Projected Costs (C)							-250	-250	-250	-8912	-41517	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250
Current Assets (receivables, stocks, cash)																						
Current Liabilities																						
Net Working Capital																						
Variations in Working Capital (D)*	-1701	-2288	-3852	-774	-865	-1315																
*CWIP including EDC and Adv on Cap A/c																						
Total investment costs (A) + (B) + (C) +(D)	-14886	-2710	-4039	-11166	-2115	-2013	-250	-250	-250	-8912	-41517	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250

Chart 1: Total Investment Costs

Operating Costs and Revenues

The second step in financial analysis is the calculation of the total operating costs and revenues. Operating costs include all the costs to operate and maintain (O&M) the plant operations. Cost forecasts are based on Opex data provided by the company. Although the actual composition is project-specific, typical O&M costs in the current analyses includes: cost of raw materials; purchase of traded goods/petroleum products; employee benefits/expenses/salary costs; operating maintenance; exceptional items; repairs and maintenance and rent.

The project revenues are defined as the 'cash inflows directly paid by users for the goods or services provided by the operation, such as charges borne directly by users for the use of infrastructure, sale or rent of land or buildings, or payments for services' (Article 61 (Operations generating net revenue after completion) of (EU) Regulation 1303/2013). The project revenues till 2014 are obtained from the Annual Papers of EOL and projections from 2015 – 2016 till 2030 are obtained from company's internal database as provided to the researchers.

Operating Costs and Revenues																						
(IN INR CRORES)																						
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cost of raw materials consumed	-32560	-32856	-42129	-52895	-81334	-88824	-72691	-39352	-54152	-65889	-72258	-143632	-209784	-219964	-232210	-253517	-258055	-271022	-287613	-282029	-286502	-298302
Purchase of traded goods / petroleum products	-651	-1706	-1964	-1957	-867	-1276																
Employee benefits expense / Salary Cost	-97	-98	-120	-135	-186	-225																
Other expenses / Operating Expenses	-2198	-1090	-1507	-2662	-3387	-4297	-2336	-2442	-2243	-2277	-2552	-4521	-5851	-6180	-6403	-6277	-6625	-6865	-6728	-7098	-7346	-7198
Finance costs	-1091	-1181	-1220	-1387	-3424	-3218																
Exceptional items	-1139	-961	-1083	-1237	-111	0	-2161	-2161	-950	-950	-2400	-2400	-2400	-2400	-2400	-2400	-2400	-2400	-2400	-2400	-2400	-2400
Repairs & Maintenance	-32	-58	-47	-119	-121	-127	-280			-280			-316			-316			-316			-316
Rent	-15	-10	-11	-17	-20	-23																
Total operating costs	-37736	-37892	-48023	-60273	-89309	-97840	-77468	-43955.00	-57345.00	-69396.00	-77210.00	-150553.00	-218351.00	-228544.00	-241013.00	-262510.00	-267080.00	-280287.00	-297057.00	-291527.00	-296248.00	-308216.00
Total Operating Revenue	37,700.15	37,376.54	47,342.21	58,761.39	89,186.90	99,472.56	81,337.00	47,491	65,465	78,769	87,516	173,620	248,021	253,652	269,826	293,623	298,464	313,954	333,133	326,830	333,255	347,146
Net operating revenue	-35.85	-515.46	-680.79	-1,511.61	-122.10	1,632.56	3,869.00	3,536.00	8,120.00	9,373.00	10,306.00	23,067.00	29,670.00	25,108.00	28,813.00	31,113.00	31,384.00	33,667.00	36,076.00	35,303.00	37,007.00	38,930.00

Chart 2: Operating Costs and Revenues

Financial Return on Investment

After completion of the tables on Total Investment Costs and Operating Costs and Revenues, the next step in the financial analysis is to arrive at the Financial Return on Investment. In order to evaluate the Financial Return, there are two major indicators to be determined:

(a) Financial Net Present Value (FNPV)
(b) Financial Rate of Return (FRR)

The European Guide to CBA (2014) defines Financial Net Present Value as the sum that results when the expected investment and operating costs of the project (suitably discounted) are deducted from the discounted value of the expected revenues.

In mathematical notation, FNPV can be expressed as

$$\text{FNPV} = \sum_{t=0}^{n} a_t S_t = \frac{S_0}{(1+i)^0} + \frac{S_1}{(1+i)^1} + \ldots + \frac{S_n}{(1+i)^n}$$

… (1)

Where St is the balance of cash flow in time t, and at is the financial discount factor chosen for discounting at time t.

The FNPV is calculated as follows:

$$FNPV = \sum [S_t / (1+FRR)^t] = 0$$

… (4)

The calculation of the Financial Return on Investment measures the capacity of the Net Revenues to remunerate the Net Investment Costs.

Evaluation of the Financial Return on Investment	(IN INR CRORES)																					
			YEARS																			
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total operating revenues	37,700.15	37,376.54	47,342.21	58,761.39	89,186.90	99,472.56	81337	47491	65465	78769	87516	173620	248021	253652	269826	293623	298464	313954	333133	326830	333255	347146
Total inflows	37700.15	37376.54	47342.21	58761.39	89186.9	99472.56	81337	47491	65465	78769	87516	173620	248021	253652	269826	293623	298464	313954	333133	326830	333255	347146
Total operating costs	-37736	-37892	-48023	-60273	-89309	-97840	-77468	-43955	-57345	-69396	-77210	-150553	-218351	-228544	-241013	-262510	-267080	-280287	-297057	-291527	-296248	-308216
Total investment costs	-14886	-2710	-4039	-11166	-2115	-2013	-250	-250	-250	-8912	-41517	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250	-250
Total outflows	-52622.00	-40602	-52062	-71439	-91424	-99853	-77718	-44205	-57595	-78308	-118727	-150803	-218601	-228794	-241263	-262760	-267330	-280537	-297307	-291777	-296498	-308466
Net Cash Flow	-14921.85	-3225.46	-4719.79	-12677.61	-2237.1	-380.44	3619	3286	7870	461	-31211	22817	29420	24858	28563	30863	31134	33417	35826	35053	36757	38680

	IRR	16%	(2009-2030)		-20%		
Discount Rate	**IRR**	**83%**	**(2020-2030)**	Projection Phase			
Note: A discount rate of 8.4% has been applied to calculate the value						Sensitivity Analysis	
Financial Net Present Value of the Investment - FNPV (C)	₹ -31,126.65		2009 - 2014			Time Period	IRR
Financial Net Present Value of the Investment - FNPV (C)	₹ 3,014.65		(2020 - 2030)	Train 2		2009 - 2015	#NUM!
						2009 - 2020	-20%
	₹ -1,746.40		(2009-2030) @7.8%			2015 -2020	-26%
						2015- 2030	85%
	₹ -1,631.27		(2009-2030)@8.4			2009 - 2014	#NUM!
						2009 - 2030	16%
	Rs. 431.34		2015-2030)@8.4%				
	Rs. 464.77		(2015-2030@7.8%				

Chart 3: Financial Net Present Value of Investment

In our calculation FNPV (C) is -1746.40 INR Crores, by applying a discount factor of 7.8% for the period 2009 – 2030. It is observed that though the FNPV (C) is negative, the project breaks even in 2014. The FNPV is negative in the project phase 2009 - 2030 (- INR 1746.40) as expected, owing to lumpy investments in the Construction Phase. The FNPV (C) turns positive to INR 3014.65 Crores in the Train – II Phase in 2020 – 2030. The FIRR is 16% for the project phase 2009 – 2030 and 85% for the projected period 2015 – 2030. A Sensitivity Analysis is also developed by varying the discount rate and the time horizon for the discounted cash flows. The FIRR stands at 85% for the projection phase 2015 – 2030. The PAT , standing at -1180 INR Crores, which was negative in 2013, stood at 126 INR Crores in 2014, in a whopping positive turnaround. The Gross Revenue changed by 10.27% between 2013 and 2014, so did the CP GRM by 0.4% and EBIDTA by 28.8% between 2013 and 2014. It is interesting to observe that Financing Cost has decreased by 6.0%, signaling the increased efficiency and economies of scale for the refinery.

Economic Analysis

As set out in Article 101 (Information necessary for the approval of a major project) of Regulation (EU) No 1303/2013, an economic analysis must be carried out to appraise the project’s contribution to welfare. The economic analysis is distinctly different from the financial analysis with respect to benefits accrued as a result of the project. Whereas the latter is merely concerned with the owners or promoters of the project, economic analysis attempts to identify the project’s impact on the society at large. The key concept is the use of shadow prices to reflect the social opportunity cost of goods and services, instead of prices observed in the market, which may be distorted. Sources of market distortions are manifold, like non-efficient markets, administered tariffs for utilities may fail to reflect the opportunity cost of inputs due to affordability and equity reasons; and some effects such as no markets (and prices) are available. The standard approach followed in this paper, consistent with international practice, is to move from financial to economic analysis. After market price adjustments and non-market impacts’ estimation, costs and benefits occurring at different times must be discounted. When market prices do not reflect the opportunity cost of inputs and outputs, the usual approach is to convert them into shadow prices to be applied to the items of the financial analysis. The discount rate in the economic analysis of investment projects, the Social Discount Rate (SDR), reflects the social view on how future benefits and costs should be valued against present ones. After the use of the appropriate SDR, it is possible to calculate the project economic performance measured by the following indicators: Economic Net Present Value (ENPV), and benefit/cost ratio (B/C ratio or BCR).

In economic analysis, for the project inputs, if they are tradable goods, border prices are used. If they are non-tradable goods, the Standard Conversion Factor (SCF) is used. SCF measures the average difference between world and domestic prices of a given economy. A set of conversion factors to the project investment costs and operating costs are applied to convert the financial costs to economic costs.

Consumer’s Surplus

According to Alfred Marshall (1925), the consumer’s surplus is the maximum sum of money the consumer would be willing to pay for a given amount of the good, less the amount he actually pays. The consumers of a refinery project are the oil marketing companies and other agencies who buy the finished products. According to the Annual Paper of EOL for FY 2013 – 14 (page 22), Essar Oil has product off take and infrastructure sharing agreements with all oil PSUs (the state-owned public sector units). These include Bharat Petroleum Corporation Ltd. (BPCL), Hindustan Petroleum Corporation Ltd. (HPCL) and the Indian Oil Corporation Ltd. (IOCL). Essar Oil also offers a wide range of products to bulk customers in the industrial (cement, power, chemicals, construction, fertilizers, etc.) and transport sectors. Besides, EOL has also received approvals to supply ATF to the Indian Armed Forces. Essar Oil has an extensive network of about 1,400 operational retail fuel outlets across the country. EOL also stands to gain by lowering the cost of fuel supplied to their retail network, by entering into agreements with various public sector OMCs enabling to source products from their refineries and depots. This would also result in Opex savings for the company.

Consumer Surplus	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
HSD											
Domestic	5.42	5.1	5.34	4.69	7.82	7.818	6.134	8.6	9.5	8.3	9
Export	0.07	0.34	0.24	0.11	1.1	0.46908	0.36804	1.7	1.6	2.9	1.6
Total (MMT)	5.49	5.44	5.58	4.8	8.92	8.28708	6.50204	10.3	11.1	11.2	10.6
Total (litre)	6544080000	6484480000	6651360000	5721600000	10632640000	9878199360	7750431680	12277600000	13231200000	13350400000	12635200000
BAU (INR 49.86/l)	3.26288E+11	3.23316E+11	3.31637E+11	2.85279E+11	5.30143E+11	4.92527E+11	3.86437E+11	6.12161E+11	6.59708E+11	6.65651E+11	6.29991E+11
Premium	358916611680	355647790080	364800490560	313806873600	583157773440	541779722099	425080175921	673377249600	725678395200	732216038400	692990179200
EOL (@INR 47.4)	3.10189E+11	3.07364E+11	3.15274E+11	2.71204E+11	5.03987E+11	4.68227E+11	3.6737E+11	5.81958E+11	6.27159E+11	6.32809E+11	5.98908E+11
CS (ROH) FOR HSD	24363609840	24141719040	24763013280	21301516800	39585318720	36776536217	28854857145	45709504800	49259757600	49703539200	47040849600
CS TOTAL	**4060.60164**	**4023.61984**	**4127.16888**	**3550.2528**	**6597.55312**	**6129.422703**	**4809.142857**	**7618.2508**	**8209.9596**	**8283.9232**	**7840.1416**

Consumer Surplus	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
HSD											
Domestic	10.2	10.4	9.7	10.4	10.4	10	11	11.4	11	12	12.3
Export	7.6	14	13.9	13.2	14	13.6	12.5	13.1	12.7	11.6	12.1
Total (MMT)	17.8	24.4	23.6	23.6	24.4	23.6	23.5	24.5	23.7	23.6	24.4
Total (litre)	21217600000	29084800000	28131200000	28131200000	29084800000	28131200000	28012000000	29204000000	28250400000	28131200000	29084800000
BAU (INR 49.86/l)	1.05791E+12	1.45017E+12	1.40262E+12	1.40262E+12	1.45017E+12	1.40262E+12	1.39668E+12	1.45611E+12	1.40856E+12	1.40262E+12	1.45017E+12
Premium	1163700489600	1595184940800	1542883795200	1542883795200	1595184940800	1542883795200	1536346152000	1601722584000	1549421438400	1542883795200	1595184940800
EOL (@INR 47.4)	1.00571E+12	1.37862E+12	1.33342E+12	1.33342E+12	1.37862E+12	1.33342E+12	1.32777E+12	1.38427E+12	1.33907E+12	1.33342E+12	1.37862E+12
CS (ROH) FOR HSD	78993124800	1.08283E+11	1.04732E+11	1.04732E+11	1.08283E+11	1.04732E+11	1.04289E+11	1.08726E+11	1.05176E+11	1.04732E+11	1.08283E+11
CS TOTAL	**13165.5208**	**18047.1184**	**17455.4096**	**17455.4096**	**18047.1184**	**17455.4096**	**17381.446**	**18121.082**	**17529.3732**	**17455.4096**	**18047.1184**

Chart 4: Consumer Surplus

Producer Surplus

Estimating the producer surplus, the revenue above the long-run average cost, is an important part of social cost-benefit analyses of changes in petroleum use. In case of EOL, Producer Surplus is obtained by learning curve effect, economies of scale and efficient management practices.

PRODUCER SURPLUS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Operating Costs (OC)	-28526.46	-29339.86	-37260.8	-46465.7	-68810.88	-75543.7	-60086	-33322.8	-44598.8	-54136.4	-59787.2	-117674	-171279	-179403	-189289	-206436	-210054	-220524	-233893	-229422	-233100	-242632	-308216
Total OR (TOR)	37700.15	37376.54	47342.21	58761.39	89186.9	99472.56	81337	47491	65465	78769	87516	173620	248021	253652	269826	293623	298464	313954	333133	326830	333255	347146	347146
Net Revenue (TOR - OC)	9173.69	8036.68	10081.41	12295.69	20376.02	23928.86	21251	14168.2	20866.2	24632.6	27728.8	55946	76741.72	74248.8	80536.8	87186.92	88410	93430.4	99239.72	97407.6	100155	104513.5	38930
Producers' Surplus	**4586.845**	**4018.34**	**5040.705**	**6147.845**	**10188.01**	**11964.43**	**10625.5**	**7084.1**	**10433.1**	**12316.3**	**13864.4**	**27973**	**38370.86**	**37124.4**	**40268.4**	**43593.46**	**44205**	**46715.2**	**49619.86**	**48703.8**	**50077.5**	**52256.76**	**19465**

Chart 5: Producer Surplus

Government Surplus

Government has a direct interest in oil consumption because it generates tax revenues. These revenues can then be used to cut other taxes. However, we first consider these revenues as accruing to the Government, even though they are likely to be retroceded to consumers over time. The variation of tax revenues for the government can be calculated with the following formula. In algebraic form:

$$\Delta\Phi = T_2 Q_2 - T_1 Q_1$$

Where $\Delta\Phi$ is the variation in tax revenue. In the case of EOL, we have seen that there is progressive and substantial increase in tax revenue from 2009 – 2010 onwards.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GS as usual till 2016, VAT+CST+Excise from 2016 till 2030	1597.937	6126.371	6975.305	8605.318	6813.153	8359.911	9469.558	10098.8	8770.401	7442	9137	10694	11923	13218	14560	15809	17114	18530	20081	21730	23510	25015	26278
Direct Taxes for the Additional Labour (Indirect); Taxes for Direct and Indirect Labour from 2016		94.21713	97.13106	100.1351	103.2321	106.4248	109.7163	113.1096	174.653	189.7781	600.0649	646.5372	1590.617	1774.993	1992.231	2248.785	2552.392	2912.337	3339.754	3848.003	4453.111	5174.306	6034.657
Sub Total	1597.937	6220.588	7072.436	8705.453	6916.385	8466.336	9579.274	10211.91	8945.054	7631.778	9737.065	11340.54	13513.62	14992.99	16552.23	18057.78	19666.39	21442.34	23420.75	25578	27963.11	30189.31	32312.66
Miscellaneous Taxes*									196.7912	167.8991	214.2154	249.4918	297.2996	329.8458	364.1491	397.2713	432.6606	471.7314	515.2566	562.7161	615.1884	664.1647	710.8785
Total Government Surplus	**1597.937**	**6220.588**	**7072.436**	**8705.453**	**6916.385**	**8466.336**	**9579.274**	**10211.91**	**9141.845**	**7799.677**	**9951.28**	**11590.03**	**13810.92**	**15322.84**	**16916.38**	**18455.06**	**20099.05**	**21914.07**	**23936.01**	**26140.72**	**28578.3**	**30853.47**	**33023.54**

*Service Tax, RTO, Road Tax, Municipal Taxes, Mega Insurance Payment

Chart 6: Government Surplus

Externalities for EOL

For a good Economic Analysis, it is equally important to consider the externalities that are not accounted for in the converted financial inputs and outputs. While arriving at externalities, only immediate micro impact of the Essar Oil's Vadinar Refinery are taken account of at this stage, namely, indirect employment, mother and child care, education and livelihood, supply of safe drinking water to the nearby geographies, preventive universal healthcare, awareness and avoidance of communicable diseases are taken into consideration. Subsequently, macro externalities accruing to the economy at large are considered as discussed below.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Indirect Employment	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	35000	35000
Average Compensation	456953	471085.7	485655.3	500675.6	516160.4	532124.1	548581.6	565548	582514.4	599989.9	617989.6	636529.3
Impact in Employment	456.95	471.09	485.6553	500.6756	516.1604	532.1241	548.5816	565.548	582.5144	599.9899	2162.963	2227.852
People Benefitted in Education & Livelihood	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
EOL Contribution	12768	12768	12768	12768	12768	12768	12768	12768	12768	12768	12768	12768
Impact in Education and Livelihood	19.152	19.152	19.152	19.152	19.152	19.152	19.152	19.152	19.152	19.152	19.152	19.152
People benefitted from mother and child healthcare*	260000	260000	260000	260000	260000	260000	260000	260000	260000	260000	260000	260000
EOL Contribution	3897.6927	3897.6927	3897.693	3897.693	3897.693	3897.693	3897.693	3897.693	3897.693	3897.693	3897.693	3897.693
Impact on healthcare	101.3400102	101.3400102	101.34	101.34	101.34	101.34	101.34	101.34	101.34	101.34	101.34	101.34
People benefitted as a result of supply of potable drinking water	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00
EOL Contribution	21.25	21.25	21.25	21.25	21.25	21.25	21.25	21.25	21.25	21.25	21.25	21.25
Impact on drinking water provision	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125
People benefitted as a result of preventive healthcare	260000	260000	260000	260000	260000	260000	260000	260000	260000	260000	260000	260000
EOL Contribution	1713	1713	1713	1713	1713	1713	1713	1713	1713	1713	1713	1713
Impact on preventive healthcare	44.538	44.538	44.538	44.538	44.538	44.538	44.538	44.538	44.538	44.538	44.538	44.538
Total Impact	622.00	636.14	650.71	665.73	681.21	697.18	713.63	730.60	747.57	765.04	2328.01	2392.90

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Indirect Employment	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
Average Compensation	655625.1	675293.9	695552.7	716419.3	737911.9	760049.2	782850.7	806336.2	830526.3	855442.1	881105.4
Impact in Employment	3933.751	4051.763	4173.316	4298.516	4427.471	4560.295	4697.104	4838.017	4983.158	5132.653	5286.632
People Benefitted in Education & Livelihood	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
EOL Contribution	12768	12768	12768	12768	12768	12768	12768	12768	12768	12768	12768
Impact in Education and Livelihood	19.152	19.152	19.152	19.152	19.152	19.152	19.152	19.152	19.152	19.152	19.152
People benefitted from mother and child healthcare*	260000	260000	260000	260000	260000	260000	260000	260000	260000	260000	260000
EOL Contribution	3897.693	3897.693	3897.693	3897.693	3897.693	3897.693	3897.693	3897.693	3897.693	3897.693	3897.693
Impact on healthcare	101.34	101.34	101.34	101.34	101.34	101.34	101.34	101.34	101.34	101.34	101.34
People benefitted as a result of supply of potable drinking water	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00	10000.00
EOL Contribution	21.25	21.25	21.25	21.25	21.25	21.25	21.25	21.25	21.25	21.25	21.25
Impact on drinking water provision	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125	0.02125
People benefitted as a result of preventive healthcare	260000	260000	260000	260000	260000	260000	260000	260000	260000	260000	260000
EOL Contribution	1713	1713	1713	1713	1713	1713	1713	1713	1713	1713	1713
Impact on preventive healthcare	44.538	44.538	44.538	44.538	44.538	44.538	44.538	44.538	44.538	44.538	44.538
Total Impact	4098.80	4216.81	4338.37	4463.57	4592.52	4725.35	4862.16	5003.07	5148.21	5297.70	5451.68

Reference: http://www.payscale.com/research/IN/Industry=Oil_%26_Gas/Salary for average salary in oil and gas industry in India
http://www.who.int/countries/ind/en/ for per capita health spend in India
http://www.accountabilityindia.in/accountabilityblog/2798-how-much-does-india-spend-elementary-education
http://www.tradingeconomics.com/india/health-expenditure-per-capita-us-dollar-wb-data.html for 61.41 USD per capita spending on health care
*Only Indirect Employment Considered
INR 1105 Billion spent on safe drinking water for 1.3 Billion till 10th Five Year Plan people amounting to INR 850
Prinja S, Bahuguna P, Pinto AD, Sharma A, Bharaj G, et al. (2012) The Cost of Universal Health Care in India: A Model Based Estimate. PLoS ONE 7(1): e30362. doi:10.1371/journal.pone.0030362

Chart 7: Externalities for EOL's Vadinar Refinery

Choice of Social Discount Rate

The Asian Development Bank defines the social discount rate "as a reflection of a society's relative valuation on today's well-being versus well-being in the future." There is wide diversity in social discount rates, with developed nations typically applying a lower rate (3–7%) than developing nations (8–15%).

In our estimate, we have used the Social Time Preference Rate (STPR) Approach to arrive at the social discount rate for India.

The algebraic expression for the same as expressed by Ramsey formula is as follows:

$$r = \varepsilon g + p$$

Where r = Social Discount Rate

ε = Elasticity of Marginal Utility with respect to Consumption

g = Growth Rate of Public Expenditure

p = Rate of Pure Time Preference

Applying the values for the variables as above, we have,

$r = ((1.64) * (5.3)) + (1.3)$

$= 9.99\% \sim 10\%$

ADB have also recommended SDR for India in the range of 10-12% depending on the project. A high SDR is usually taken for small projects with immediate benefits. For megaprojects like oil refineries, a low SDR is preferred, since the benefits are accrued over a period of time. Thus, our estimate of SDR for India as 10% seems to be reasonably appropriate.

Once all project cost and benefits have been quantified and valued in money terms, it is possible to measure the economic performance of the project by calculating the following indicators.

Economic Net Present Value (ENPV): the difference between the discounted total social benefits and costs;

B/C Ratio, i.e. the ratio between discounted economic benefits and costs.

The difference between ENPV and FNPV is that the former uses accounting prices or the opportunity cost of goods and services instead of imperfect market prices, and it includes as far as possible any social and environmental externalities. This is because the analysis is done from the point of view of society, not just the project owner. Because externalities and shadow prices are considered, in our financial analysis, the project though had a negative FNPV(C), a positive ENPV is recorded in the economic analysis.

The abridged economic analysis is shown below.

ECONOMIC ANALYSIS OF ESSAR OIL

BENEFITS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total Consumers Surplus		4060.60164	4023.61984	4127.16888	3550.2528	6597.55312	6129.422703	4809.14286	7618.2508	8209.9596	8283.9232	7840.1416
Total Producers Surplus	4586.845	4018.34	5040.705	6147.845	10188.01	11964.43	10625.5	7084.1	10433.1	12316.3	13864.4	27973
Total Government Surplus	1597.937392	6220.587969	7072.435691	8705.45297	6916.384885	8466.336111	9579.274252	10211.9115	9141.8451	7799.677188	9951.280357	11590.02897
Externalities	622.0043421	636.1369116	650.706571	665.7268383	681.21165	697.1753734	713.6328202	730.59926	747.5657002	765.0411334	2328.014753	2392.903658
Total Benefits	6806.786734	14935.66652	16787.4671	19646.19369	21335.85934	27725.4946	27047.82977	22835.7536	27940.7616	29090.9779	34427.6183	49796.07423
Total Investment Costs		-11908.8	-14067.2	-17295.2	-19933.6	-20980.8	-21883.2	-7329.6	-7329.6	-7329.6	-7329.6	-33213.6
Total Cost		**-11908.8**	**-14067.2**	**-17295.2**	**-19933.6**	**-20980.8**	**-21883.2**	**-7329.6**	**-7329.6**	**-7329.6**	**-7329.6**	**-33213.6**
NET BENEFITS	6806.786734	3026.866521	2720.267102	2350.993689	1402.259335	6744.694605	5164.629775	15506.1536	20611.1616	21761.3779	27098.0183	16582.47423

BENEFITS	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total Consumers Surplus	13165.5208	18047.1184	17455.4096	17455.4096	18047.1184	17455.4096	17381.446	18121.082	17529.3732	17455.4096	18047.1184
Total Producers Surplus	38370.86	37124.4	40268.4	43593.46	44205	46715.2	49619.86	48703.8	50077.5	52256.76	19465
Total Government Surplus	13810.91644	15322.83855	16916.38039	18455.05608	20099.05287	21914.06807	23936.01055	26140.71928	28578.29971	30853.47088	33023.53565
Externalities	4098.802065	4216.814589	4338.367489	4463.566976	4592.522448	4725.346583	4862.155443	5003.068568	5148.209088	5297.703822	5451.683399
Total Benefits	69446.0993	74711.17154	78978.55748	83967.49265	86943.6937	90810.0243	95799.47199	97968.66985	101333.382	105863.3443	75987.33745
Total Investment Costs	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200
Total Cost	**-200**	**-200**	**-200**	**-200**	**-200**	**-200**	**-200**	**-200**	**-200**	**-200**	**-200**
NET BENEFITS	69246.0993	74511.17154	78778.55748	83767.49265	86743.6937	90610.0243	95599.47199	97768.66985	101133.382	105663.3443	75787.33745

BCR (BY NPV METHOD)	**3.26**	2009-2030
ENPV	**₹ 234,314.98**	2009-2030
BCR (PROJECTED)	**10.37**	2015-2030

Tax shown above includes EOL, VOTL, VPCL.

Chart 8: Abridged Economic Analysis

A positive ENPV of INR 2, 34,314.98 is obtained for the project phase 2009 – 2030; and BCR of 3.26 for the period 2009 – 2030 is estimated using the discounted cash flow technique.

The project is economically sound and financially viable.

In accordance to the the UK Department for Transport (DfT) ‘Value for Money (VfM) Assessment Guidance’, as laid down in the HM Treasury (2006), the projects are categorized according to their benefit–cost ratios, adjusted for wider economic impacts. In our case, the estimated BCR of 3.26, with only micro externalities thus far considered, falls in the category of “High VfM” in the VfM Assessment criterion; and accordingly refinery projects like these should be accorded highest priority as they conform to all stipulated guidelines ensuring that projects are built on a strong economic and commercial case.

The estimated BCR of 10.37 in the projected phase 2015–2030, is in synchronicity with project guidelines. Improvements in efficiency in Research, Development and Demonstration (RD&D) in the continuous process plant's Energy Technologies can achieve a benefit-cost ratio nearing 15, as outlined by authors Galiana and Sopinka in the Working Paper Series (2014) published by the Copenhagen Consensus Center in their Energy Assessment Paper for the Benefits and Costs of the Energy Targets for the Post–2015 Development Agenda. While the projected phase of 2015-30 provides very optimistic profile of net revenue profile, it necessarily ignores the negative net revenue phase of such large projects which typically face a period of losses that cannot be ignored in a proper study of this nature. There is another aspect that needs consideration.

We consider in what follows the incorporation of macro externalities which span the entire economy consequent on the establishment of a large project producing goods with their character as universal intermediates. These effects are then incorporated with the social cost benefit analysis estimated thus far.

3b. Part II: Computable CGE Model for Economy-wide Effects and Projected Values

Motivation

Capacity expansion in the petroleum refinery sector is likely to unleash several effects that could be felt across the whole economy. First, there would be increased supply of various refined products available for end users – both in downstream industries as well as final consumers. This increase in the supply opens up the possibility of changes in domestic price of the refined products. For the downstream industries, the increased availability of refined products along with possible changes in their prices could change their cost of production, hence their product prices and demand for their products. Thus, those sectors can also witness an expansion in their output, which in turn can trigger further rounds of output expansion in all sectors. Besides, they could also have a larger exportable surplus. For the end users of refinery products (households, government) increased availability and price changes throws open the possibility that their fuel expenditures could come down, which they can use for increasing demand for other products and/or savings.

Second, for the refinery upstream industries – crude petroleum, electricity, transport services, etc., – the expansion of the refinery sector implies additional demand for these inputs. Hence, they are likely to ramp up their production and/or imports. In the case of crude oil, imports are likely to increase sharply, which can have an impact on the current account deficit and/or exchange rate, with attendant consequences for sectoral trade flows.

Third, the expansion of the refinery sector itself, and the induced expansion of other sectors of the economy would imply an expansion of employment and value added; i.e., gross domestic product (GDP) in the economy. This additional income would ultimately find its way to households in the form of wage income and returns to capital. They are likely to consume a part of this additional income and save the rest. The government too would get a share of this additional GDP in the form of direct taxes paid by households and production sectors, indirect tax on the additional demand for various commodities, which in turn is likely to improve its fiscal position (assuming that the government does not spend it away).

Fourth, the additional savings by households and the improvement in the fiscal position of the government would mean an increase in national savings and hence investment, which in turn would trigger additional demand for capital goods and hence overall output and GDP in the economy.

All these multiple channels through which the impacts of an expansion in the refinery sector are likely to flow have to be properly modelled by carefully capturing the various inter-sectoral and inter-agent linkages in a consistent manner. One analytical framework that can capture all such linkages and help in assessing the economy-wide impacts is the computable general equilibrium (CGE) modeling framework.

The CGE model

CGE models are economy-wide models that have been used widely in India and other countries to analyse several policy related questions wherein inter-sectoral and inter-agent linkages are important. In the Indian context, these models have been used to analyse questions relating to agricultural price policies, energy pricing policies, taxation issues, trade policies, welfare policies for the poor, etc. They have been used by academic researchers, by the government (Planning Commission, Ministry of Finance, Ministry of Commerce, Ministry of Agriculture, etc.), and various international organisation with interest in Indian economic policies (Australian Centre for International Agricultural Research, Carnegie Endowment for International Peace, European Union, Food and Agricultural Organisation, International Development Research Centre of Canada, United Nations Economic and Social Commission for Asia and the Pacific, United States Department of Agriculture, World Bank, etc.).

All CGE models have the following characteristics that render them particularly useful for analysing issues such as the one in focus in this paper.

- They include all economic agents, viz., producers (sectors of production), consumers (households), government, and the rest-of-the-world.
- They include all sectors of the economy, viz., agriculture, industry and services, with as much disaggregation as deemed necessary for analysing the problem at hand.
- They characterise the nature of supply, demand, and trade flows in all the goods and services produced and/or consumed in the economy, taking into account the behavioural characteristics of producers (who are assumed to maximize profits), consumers (who maximize utility), and the nature of inter-sectoral flow of goods and services in the production process.
- Production levels and the use of factors of production (labour, capital) are endogenously determined in the model.
- For all goods and services, and also all factors of production (labour, capital), CGE models solve for the equilibrium supply and demand and the price at which each of these markets clear; i.e., supply matches demand.

- They capture the complete flow of all goods and services in a consistent manner; i.e., the origin of the supply (domestic production / imports) and the end-use (as raw materials, final consumption, investment including inventory, exports) are explicitly tracked.
- Similarly, for factors of production too, they capture the complete flow in terms of the source of supply (households and/or government that own these factors of production) and their use in various sectors of the economy.
- By capturing the flow of goods and services and factors of production, and the market clearing prices, these models solve for the income-expenditure accounts for all economic agents (sectors, households, government, and the rest-of-world) and hence for the nation as a whole.
- Thus, these models capture the macroeconomic effects from microeconomic level; i.e., through a bottom-up approach.

This study uses the CGE model of the Indian economy developed by Ganesh-Kumar and Harak (2015). The model includes 18 sectors (4 agriculture, 10 industrial, 4 services) that produce 24 commodities (4 agriculture, 16 industrial, 4 services), 2 factors of production, 6 household classes besides the government and the rest-of-world (Table 1).

The present model is built upon a base version of the model developed by Ganesh-Kumar and Panda (2009) for the Planning Commission. These two models differ on two major counts:

i. The database used by Ganesh-Kumar and Harak (2015) is the social accounting matrix (SAM) [1] for the year 2011-12, whereas in the case of Ganesh-Kumar and Panda (2009) the SAM is for the year 2003-04. Further, the level of disaggregation of sectors, goods and services, factors and household classes also varies between the two SAMs / models.
ii. In terms of model structure, the present model has a more detailed specification of the energy use in different sectors of the economy. Specifically, a nested production function approach is adopted wherein every sector's output is produced by combining raw materials, energy and factors of production (labour and capital) that generate the value added (Appendix Figure 1). Energy used in a sector takes into account substitution possibilities between electrical and non-electrical energy. Further the non-electrical energy can come from the use of different fuels and the model allows for substitution possibilities amongst them. In the case of Fertilizers and Chemicals, the nested production function includes feedstock as an additional requirement and allows for the use of naphtha and natural gas both as a fuel and also as a feedstock (Appendix Figure 2). For details see Ganesh-Kumar and Harak (2015).

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[1] SAM is a matrix representation of the circular flow of income and expenditure in the economy arising out of (a) the buying and selling of goods and services for meeting the production (raw materials), consumption and investment needs of the society and its international trading partners, (b) the buying and selling of factors of production in the course of production process, and (c) financial transfers between agents (taxes, subsidies, foreign remittances, etc.) for which there is no counter-part exchange of goods and services. Thus, the SAM captures the income-expenditure flows of production sectors, households, government and rest-of-world, as well as the supply and demand for various goods and services and factors of production.

Table 1: Classifications in the CGE model

Activities (18)	Commodities (24)	Factors (2)	Households (6)
Food crops	Food crops	Labour	Rural - Bottom 30%
Other crops	Other crops	Capital	Rural - 30-70%
Animal products	Animal products		Rural - Top 30%
Forestry	Forestry		Urban - Bottom 30%
Coal	Coal		Urban - 30-70%
Natural gas	Natural gas		Urban - Top 30%
Crude petroleum	Crude petroleum		
Other minerals	Other minerals		
Fertilizers	Fertilizers		
Chemicals	Chemicals		
Manufacturing	Manufacturing		
Construction	Construction		
Electricity	Electricity		
Rail transport	Rail transport		
Road transport	Road transport		
Other transport	Other transport		
Other services	Other services		
Petroleum refining	Liquefied Petroleum Gas (LPG), Kerosene, High Speed Diesel (HSD), Motor Spirit (MS), Naphtha, Substitute fuels (SF), Lubes & Tar		

Source: Ganesh-Kumar and Harak (2015)

Simulation design and results

In the refinery sector gross refining margin (GRM) can be taken to represent the value addition in the refinery sector and captures the sector's contribution to national GDP. A GRM of 10% is widely construed as a reasonable level representing a long-term average for the sector. In recent years, the refining sector at the current total refining capacity in the country of about 200 m.t. across all refiners both private and public accounts for about 1 of the GDP of the country. This contribution to the national GDP essentially is from the 10% GRM. These data constitute the base-level around which scenarios are designed to capture the impact of an expansion in the refinery sector's capacity. Thus a 20 m.t. entry or expansion would roughly correspond to a 10% industry capacity expansion. This translates into 1% additional value addition or GRM as these products have the alternative of being imported from refineries abroad.

Altogether four scenarios were developed wherein the refinery sector's output is expanded by different amounts – 1%, 2.5%, 5%, and 10% – over the base level of 200 m.t. Broadly speaking, the simulation results indicate that the impacts are proportional at low levels of output expansion in the refinery sector. But the impacts are somewhat less than proportional as the magnitude of refinery sector expansion is raised. Considering this and also to maintain brevity, results for the following two scenarios are presented here:

Scenario-A: This scenario captures the situation where the refinery sector output is expanded by 1% over a base of 200 m.t.

Scenario-B: Here the refinery sector output is expanded by 5% over a base of 200 m. t.

The impacts of the expansion of the refinery sector are assessed at (i) the sectoral level (Tables 2 and 3) and (ii) macroeconomic, household and government levels (Table 4). At the sector level, the impacts on domestic prices, domestic demand, exports, domestic output and imports are assessed. At the macroeconomic level, the variables of interest are the exchange rage, GDP (aggregate and by broad sectors), aggregate exports and imports, and total investment in the economy. For households, per capita income across different classes, household consumption and household savings are examined. The key fiscal variables studied are direct and indirect tax revenue, total revenue of the government, total expenditure of the government and government's dis-savings.[2]

Expansion of the refinery sector undoubtedly triggers across the board rise in domestic demand, domestic output and exports for all sectors (Tables 2 and 3). However, the impacts upon domestic price and imports vary across commodities.

In Scenario A, following the expansion in the refinery sector price of kerosene and motor spirit alone fall by 0.1% and 0.2%, respectively, while the price of LPG, HSD, naphtha, substitute fuels and non-substitute fuels rise by 0.2% to 0.9%. In Scenario B, the price changes are larger than in Scenario A, and additionally the price of HSD also falls by 0.8%. These price changes give rise to substitution possibilities amongst various fuels setting off changes in the composition of demand. Further, they also cause a change in per unit cost of production in all sectors where the refinery products are used, and hence in their respective product prices with attendant implications for their demand.

The other channel through which the impacts of the expansion of the refinery sector spreads is through the backward and forward linkages with upstream / downstream industries. The expansion in the output of these upstream and downstream industries in turn triggers second round effects that eventually spread through the system.

The net-impact of the price effects and the inter-industry linkage effects is that in Scenario A, across commodities domestic demand rise between 0.4% for natural gas and 1.8% for coal & lignite. In Scenario B, it ranges between 1.2% (natural gas) and 6.6% (coal and lignite). Much of this is on account of a higher rise in raw materials demand, which is higher than demand by households for final consumption in both scenarios. Thus it is the backward and forward linkages with upstream / downstream industries of all sectors with all other sectors that drive overall expansion in domestic demand and hence domestic output.

[2] Note that the government dis-saving (i.e., negative savings) is derived from an economic classification of government's consumption and investment, and closely (but not exactly) corresponds to the combined (Central and States) revenue deficit. For a discussion on this see Planning Commission (2002).

Table 2: Sectoral impacts – Scenario A

Commodity	Domestic price	Domestic demand			Exports	Domestic output	Imports
		Raw material	Household	Total			
Food Crops	-0.1	1.1	0.5	0.7	0.4	0.7	-2.3
Plantation, Cash and Other Crops	-0.1	1.2	0.8	1.1	0.5	1.1	-0.1
Animal Husbandry and Fishing	-0.1	1.2	0.9	1.0	0.4	1.0	-0.9
Forestry	-0.3	1.3	0.3	0.8	0.5	0.9	-0.2
Coal and Lignite	-0.4	1.7	-0.6	1.8	0.6	2.0	-0.5
Natural Gas	1.7	0.5	-0.7	0.4	0.4	0.3	0.9
Crude Petroleum	-0.5	1.0	-	1.1	0.8	3.4	0.8
Other Minerals	-0.4	1.2	-	1.1	0.7	2.7	0.5
Fertilizers	0.4	1.0	-	1.0	0.3	1.1	-1.0
Chemicals	0.1	1.3	0.5	1.2	0.5	1.7	-0.8
Manufacturing	0.1	1.2	0.5	0.9	0.5	1.4	-1.2
Construction	0.2	0.9	-	1.1	-	1.1	-
Electricity	0.2	1.2	0.7	1.1	-	1.1	-
Rail Transport	0.0	1.2	1.0	1.1	0.4	1.1	-
Road Transport	0.0	1.1	0.9	1.0	0.4	1.1	-0.8
Other Transport Service	0.0	1.2	0.9	1.0	0.4	1.0	-
Other Services	-0.2	1.1	0.7	0.7	0.4	0.8	-1.5
Liquid Petroleum Gas	0.7	1.3	0.8	0.9	0.3	1.0	0.6
Kerosene	-0.1	1.1	0.9	0.9	0.4	1.0	-0.7
High Speed Diesel	0.2	1.1	1.1	1.1	0.2	1.0	0.0
Motor Spirit	-0.2	1.1	1.2	1.1	0.5	1.0	-0.8
Naphtha	1.5	1.2	-	1.2	0.2	1.0	1.4
Substitute Fuels	0.4	1.0	-	1.0	0.5	1.0	-0.1
Non-Substitutes Fuels	0.9	1.1	0.8	1.0	0.3	1.0	0.6

Source: Author's estimates using the CGE model discussed above

Table 3: Sectoral impacts – Scenario B

Commodity	Domestic price	Domestic demand			Exports	Domestic output	Imports
		Raw material	Household	Total			
Food Crops	-0.5	4.4	2.0	2.9	1.7	3.2	-9.4
Plantation, Cash and Other Crops	-0.6	5.1	3.2	4.4	1.9	4.5	-0.7
Animal Husbandry and Fishing	-0.6	4.8	3.7	4.0	1.8	4.1	-3.9
Forestry	-1.0	5.3	1.2	3.3	1.9	3.8	-0.9
Coal and Lignite	-1.2	6.4	-2.6	6.6	2.4	7.5	-2.5
Natural Gas	7.2	1.5	-2.8	1.2	1.6	0.9	3.1
Crude Petroleum	-1.6	4.8	-	5.1	3.2	14.4	3.8
Other Minerals	-1.0	5.0	-	4.4	2.9	11.2	2.2
Fertilizers	1.6	4.1	-	4.1	1.4	4.5	-4.0
Chemicals	0.6	5.4	2.1	4.8	2.0	7.0	-3.1
Manufacturing	0.4	5.0	2.1	3.8	1.9	5.8	-4.8
Construction	0.6	3.9	-	4.5	-	4.5	-
Electricity	0.4	4.9	3.0	4.6	-	4.6	-
Rail Transport	-0.2	5.0	4.3	4.7	1.8	4.6	-
Road Transport	-0.3	4.7	3.7	4.1	1.8	4.7	-3.6
Other Transport Service	-0.2	4.8	3.9	4.2	1.8	4.1	-
Other Services	-0.8	4.5	2.9	3.0	1.8	3.2	-5.8
Liquid Petroleum Gas	1.5	5.3	3.8	4.1	1.5	4.9	1.6
Kerosene	-1.6	4.5	4.4	4.2	2.2	4.9	-3.9
High Speed Diesel	-0.8	5.2	5.1	5.0	0.7	4.9	-1.2
Motor Spirit	-2.9	4.6	5.6	5.1	2.5	4.9	-5.2
Naphtha	5.4	5.1	-	5.2	1.3	4.9	5.0
Substitute Fuels	0.5	4.6	-	4.6	2.5	4.9	-1.3
Non-Substitutes Fuels	0.9	4.7	3.9	4.3	2.4	4.9	-0.8

Source: Author's estimates using the CGE model discussed above

Table 4: Macroeconomic, household and fiscal impacts - % change

Variable	Scenario A	Scenario B
Exchange rate	1.3	5.6
GDP-Total	1.0	4.1
GDP-Agriculture	1.0	4.1
GDP-Industry	1.5	6.2
GDP-Services	0.8	3.5
Total Export	0.4	1.8
Total Import	-0.6	-2.4
Total investment	1.3	5.2
Household per capita income		
Rural 1 : 0 to 30%	0.5	2.3
Rural 2 : 30% to 70%	0.7	3.2
Rural 3 : 70% to 100%	0.7	3.0
Urban 1 : 0 to 30%	0.6	2.5
Urban 2 : 30% to 70%	0.7	3.0
Urban 3 : 70% to 100%	0.7	2.9
Household consumption (total)	0.7	2.9
Household savings (total)	0.8	3.4
Direct tax revenue	0.7	2.9
Domestic indirect tax revenue	1.1	4.7
Government revenue - Total	0.8	3.1
Government expenditure	0.0	0.4
Government dis-savings	-8.9	-30.0

Source: Author's estimates using the CGE model discussed above

Domestic output rises by 0.3% (natural gas) to 3.4% (crude petroleum) in Scenario A while in Scenario B it ranges between 0.9% (natural gas) and 14.4% (crude petroleum). In many commodities domestic output expansion exceeds the expansion in domestic demand giving rise to larger exportable surplus. Consequently exports of all commodities rise, albeit by varying amounts. Apart from the microeconomic conditions of domestic supply and domestic demand, exchange rate depreciation[3] also acts as a catalyst enabling higher exports.

In several commodities where domestic production can compete effectively with imports such as agriculture, coal and lignite, fertilizers, chemicals, manufacturing, road transport, and some of the refinery products, there is a fall in imports (again exchange rate depreciation catalyses this). However, in commodities such as natural gas, crude petroleum, other minerals and refinery products such as LPG and non-substitute fuels, the expansion in domestic production is insufficient to meet the rise in domestic demand and consequently their imports rise significantly.[4]

The commodities whose imports rise are those that account for a substantial portion of the total import bill of the country. Thus the rise in their imports exerts pressure on the current account balance of the country.[5] In these simulations the amount of foreign capital inflows required to bridge the current account deficit is assumed to remain unchanged, and hence it is the exchange rate that adjusts to keep the current account in balance. In Scenarios A and B, the Rupee depreciates by 1.3% and 5.6%, respectively. The depreciating currency acts as a catalyst over and above the micro-level situation in influencing the changes in sectoral exports and imports.

The sum total of these changes at the sectoral level is that GDP in the country rises by 1% and 4.1% in Scenarios A and B, respectively. Figure 2 shows the impact on GDP at different levels of expansion of the refinery sector under various scenarios. It is clear, that the GDP impact is less than proportionate to the expansion in the refinery sector's output.

The output changes across sectors is such that under both scenarios industrial GDP rises relatively more than services GDP, while the rise in agricultural GDP is of a similar order as the rise in overall GDP. The changes in the trade flows are such that overall exports rise in real terms while imports shrink. Total investment in the economy rises by 1.3% and 5.2%, respectively in the two scenarios.

At the household level, clearly all households in both rural and urban areas witness a rise in their per capita income. The rise in per capita income is slightly more for the middle and higher income groups in both rural and urban areas. With per capital incomes rising all around, total

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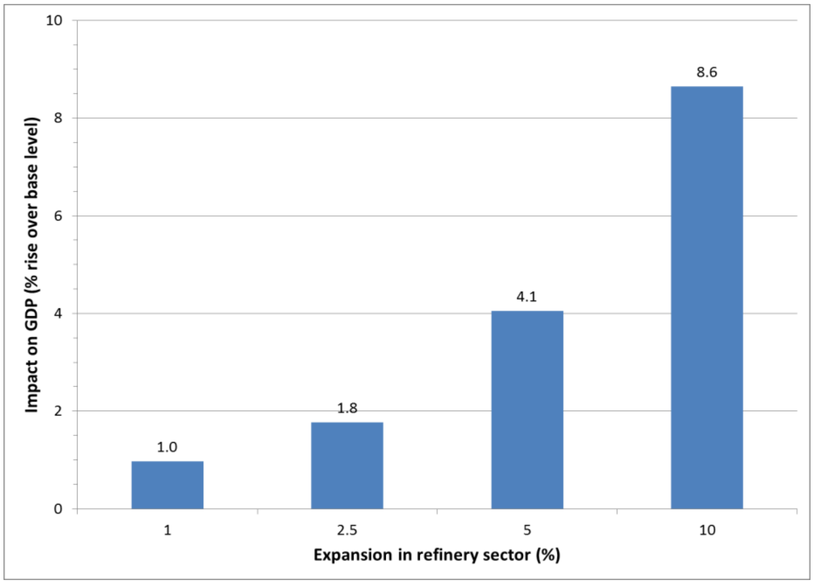
[3] More discussion on the exchange rate follows below.

[4] Note that the percent change papered in the tables is over their respective base levels. A given amount of change would imply a larger (smaller) percent change if the corresponding base level is low (high). Thus, for instance, the 3.4% rise in domestic output of crude petroleum is a much smaller amount than the 1.1% rise in its total demand or the 0.8% rise in its imports, both of which are over a larger base.

[5] The world price of all commodities is kept constant in these simulations.

household consumption rises by 0.7% and 2.9% in Scenarios A and B, respectively. Household savings too rises in the two scenarios by 0.8% and 3.4%, respectively.[6]

Figure 2: Impact on GDP at different levels of refinery sector expansion



Source: Author's estimates using the CGE model discussed above

With household incomes rising, government's direct tax receipts rise by 0.7% and 2.9% in Scenarios A and B, respectively. With the domestic demand and domestic output rising across all sectors, indirect tax collection too rises by 1.1% and 4.7% in the two scenarios. Total revenue[7] of the government in the two scenarios rises by 0.8% and 3.1%, respectively.

In contrast, government's expenditure remains more or less unchanged in the two scenarios. This is because in the simulations, it is assumed that all items of government expenditure, viz., current consumption by government, transfers to households and various subsidies, remain constant in real terms. As all the expenditure items are decided by government policy, this assumption may not be too unreasonable. This assumption also helps isolate the pure effects of the refinery expansion, without any confounding policy changes. The small change observed in government expenditure largely reflects the change in the nominal expenditure due to price changes.

With government's revenue rising and its expenditure largely constant, government's dis-savings falls significantly by 8.9% and 30% in the two scenarios. That is there is less crowding out of the total savings by the government. This, along with the rise in household savings seen earlier, implies that the total savings in the economy rises and allows the investment to rise in the two scenarios.

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[6] The model generates income, consumption and savings for each household class. For brevity, only aggregate consumption and savings over all households are papered here.

[7] Apart from direct taxes and domestic indirect taxes, the other sources of revenue for the government are customs duty and non-tax revenue consisting of public sector profits and fees largely.

CGE Model Exercise: Remarks

The above results are driven by several factors as follows:

- The strength of the backward and forward linkages that exist between the refinery sector with the rest of the economy, in particular and the strength of these linkages amongst other sectors in general. In the SAM and in the model, the data that determines these linkages are derived from the Input-Output Table for 2007-08 published by the Central Statistical Office (CSO) of the Government of India.

- The strength of the supply response in various sectors. It is assumed here that there is sufficient slack capacity in all sectors of the economy, which can be brought to production fairly quickly. Further, it is assumed that where necessary additional investments are forthcoming without much friction due to whatever reason.

- Behavioural response of households, in terms of their decisions to save or consume, which items to consume, in what proportions and how much they would substitute various items in their consumption basket. Household behavioural parameters in the model are derived from the nation-wide representative surveys on household consumption conducted periodically by the National Sample Survey Organisation (NSSO) of the Government of India. These are widely used by academic researchers to characterise various aspects of household behaviour. Most recent surveys pertaining to the year 2011-12 are used here. It is assumed that the household behaviour remains stable in the short- to medium-run and hence these behavioural parameters are held constant in the simulations.

- Government policies covering taxes, subsidies, current expenditure, etc., pertaining to all sectors and all households are kept constant in the present analysis. This was done to isolate the pure effects of the expansion of the refinery sector. The results obtained could differ were any of these policies to change.

- The current account deficit / foreign capital inflow is kept constant in the analysis here. This implies that foreign investors do not react in any manner to the expansion of the refinery sector and the consequent expansion of the economy. If, however, foreign capital inflow were to rise following the expansion of the economy triggered by the expansion of the refinery sector, then it could dampen the extent of depreciation of the Rupee. This in turn could alter the trade flows (both exports and imports) significantly. Such possibility, however, has not been considered here to keep the analysis simpler.

Keeping these assumptions that are part of the scenario specification, it is clear that expansion of the refinery sector will have overall positive effects on the economy. In the short to medium-run, the GDP, household incomes and the fiscal position improves. These effects are expected to spread through the economy over a period of 5-years. In the long-run, the positive benefits would flow through higher investments that would help keep the growth momentum. Analysis of the dynamic impacts over several years is, however, beyond scope of this exercise.

4 SCBA with Macro Externality: Integrating CBA with CGE Model

Petroleum products being universal intermediates, they have backward and forward linkages encompassing the entire national economy. Since the GDP is an aggregative measure of annual economic activity, it may indicate aggregative welfare in the economy in some very meaningful sense, and indeed it was the only metric of measuring welfare until recently. Hence, in the absence of anything superior, this macro indicator of externalities has been used as the metric of macro externality consequent on the expansion of the refinery sector. As our disaggregated results show, most of the macro externalities listed in the study are positively impacted. For instance, all the three major segments, agriculture, industry and services of the economy, experience expansions. Income, consumption, and savings of both rural and urban households also increase as a result, and there is virtually no noticeable increase in inequality as the bottom, middle and higher decile household groups see similar increases in their per capita incomes. Consequent on these changes, demand and output in the economy have also increased. The output of fertilizers, chemicals and all critical items of petroleum products, which have experienced shortage syndrome in the economy, are seen to get the boost in a healthy manner. Thus we may treat the GDP in this instance as a good metric to represent social welfare and included in the social benefits of this project.

The analysis in this study has been done using a Computable General Equilibrium (CGE) Model, as indicated earlier, to capture the effect of an expansion in the refinery sector on the national economy and its various sectors of activity. In keeping with the investment pattern of Essar Oil Refinery project, it is spread over three phases of capacity, in 2015 as it exists, and the installation of Train I and Train II and their staggered coming on stream to full capacity production.

Further, as mentioned earlier, in recent years, the refining sectors accounts for about 1% of the GDP of the country. This contribution to the national GDP essentially is from a GRM 10% (widely construed as a reasonable level representing a long-term average for the sector) and the current total refining capacity in the country of about 200 m.t.. The simulation exercises are built around these base-level data to generate their macroeconomic effects.

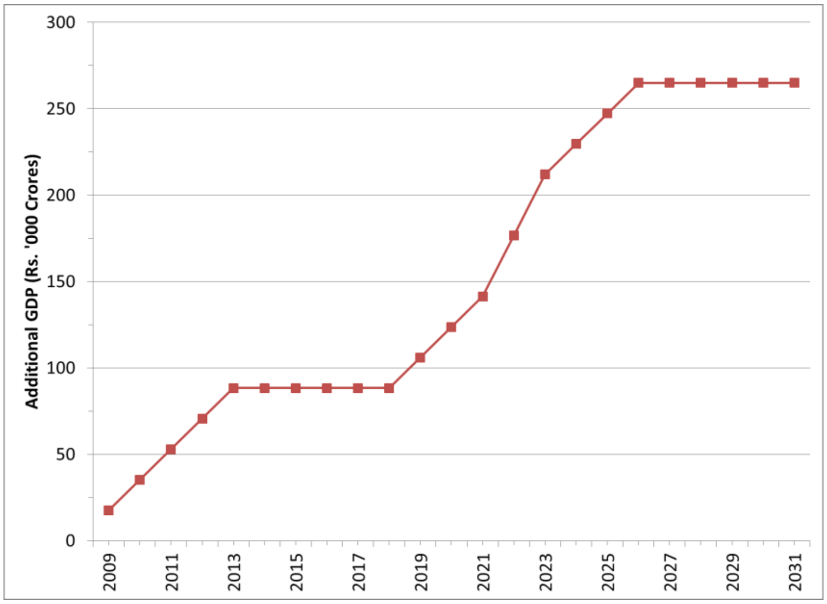
The model estimates that a 1% increase in the Petroleum Refining capacity of the economy, in three distinct doses, each dosage leading to a 1% increase in the country's GDP. For one dosage this works out to Rs.88,320 crores per annum once the full impact has spread through the economy. In reality, however, there are lags in the economy implying that it would take some time for the full impact to be realized. It is assumed that for the full impact to materialize, it is staggered over 5 years for each dosage. With this assumption the flow of additional GDP due to the expansion of the refinery sector in three dosages can then be worked out. Table 5 shows the detailed steps by which the flow of additional GDP is estimated for the three dosages that come up at different years. It is assumed in that calculation that the real GDP grows at 7% per annum in line with the perception of growth around 6-8 %. Further, an inflation rate of 4% is assumed in line with RBI's target inflation rate for the economy. Together, they produce a nominal GDP growth rate of 11% to provide the base for the economy wide multiplier effects of refinery expansion. Figure 3 shows the flow of additional GDP up to the year 2030 once all the three phases of refinery expansion is completed.

Table 5: Estimation of the flow of additional GDP – Scenario A

FY ending	Assumed growth rate in real GDP (%)	Assumed inflation rate (%)	Derived growth in nominal GDP (%)	Actual / projected nominal GDP Rs. Crores (BASE Level)	Impact factor - 1st phase	Impact factor - 2nd phase	Impact factor - 3rd phase	Impact factor - Total over all 3 phases	Scenario A: Additional nominal GDP Rs. Crores
2009				56,30,063	0.2			0.2	17,664
2010				64,77,827	0.4			0.4	35,328
2011				77,84,115	0.6			0.6	52,992
2012				88,32,012	0.8			0.8	70,656
2013				99,88,540	1			1	88,320
2014				113,45,056	1			1	88,320
2015				126,53,762	1			1	88,320
2016	7	4	11	140,45,676	1			1	88,320
2017	7	4	11	155,90,700	1			1	88,320
2018	7	4	11	173,05,677	1			1	88,320
2019	7	4	11	192,09,302	1	0.2		1.2	1,05,984
2020	7	4	11	213,22,325	1	0.4		1.4	1,23,648
2021	7	4	11	236,67,781	1	0.6		1.6	1,41,312
2022	7	4	11	262,71,236	1	0.8	0.2	2	1,76,640
2023	7	4	11	291,61,072	1	1	0.4	2.4	2,11,968
2024	7	4	11	323,68,790	1	1	0.6	2.6	2,29,632
2025	7	4	11	359,29,357	1	1	0.8	2.8	2,47,296
2026	7	4	11	398,81,587	1	1	1	3	2,64,960
2027	7	4	11	442,68,561	1	1	1	3	2,64,960
2028	7	4	11	491,38,103	1	1	1	3	2,64,960
2029	7	4	11	545,43,294	1	1	1	3	2,64,960
2030	7	4	11	605,43,057	1	1	1	3	2,64,960
2031	7	4	11	672,02,793	1	1	1	3	2,64,960

Source: NAS data and author's estimates using the CGE model discussed above

Figure 3: Flow of additional GDP due to a 1% expansion of refinery sector



Source: See Table 5 above for the workings

When this macro externality of CGE is integrated with micro externality of SCBA, it is observed that 1% rise in nominal GDP due to 1% increase in refinery capacity leads to the increase of BCR from 3.26 to 11.55 and rise of ENPV from INR 2,34,314.98 crores to INR 10,60,140.37 crores. This result is obtained by factoring the monetized impact of the investment multiplier in the petroleum-refining sector of the country.

The abridged economic analysis of all perceived surpluses and incorporating both micro and macro externalities is shown below.

ECONOMIC ANALYSIS OF ESSAR OIL

BENEFITS	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total Consumers Surplus		4060.6	4023.6	4127.2	3550.3	6597.6	6129.4	4809.1	7618.251	8209.96	8283.923	7840.142
Total Producers Surplus	4586.845	4018.3	5040.7	6147.8	10188	11964	10626	7084.1	10433.1	12316.3	13864.4	27973
Total Government Surplus	1597.9374	6220.6	7072.4	8705.5	6916.4	8466.3	9579.3	10212	9141.845	7799.677	9951.28	11590.03
Micro Externalities (SCBA)	622.00434	636.14	650.71	665.73	681.21	697.18	713.63	730.6	747.5657	765.0411	2328.015	2392.904
Macro Externalities (CGE)	0	17664	35328	52992	70656	88320	88320	88320	88320	88320	88320	105984
Total Externalities	622.00434	18300	35979	53658	71337	89017	89034	89051	89067.69	89085.16	90648.13	108377
Total Benefits	6806.7867	32600	52116	72638	91992	116046	115368	111156	116261	117411	122748	155780
Total Investment Costs		-11908.8	-14067.2	-17295.2	-19933.6	-20980.8	-21883.2	-7330	-7329.6	-7329.6	-7329.6	-33213.6
Total Cost		**-11909**	**-14067**	**-17295**	**-19934**	**-20981**	**-21883**	**-7330**	**-7330**	**-7330**	**-7330**	**-33214**
NET BENEFITS	6806.7867	20691	38048	55343	72058	95065	93485	103826	108931	110081	115418	122567

BENEFITS	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total Consumers Surplus	13165.52	18047.12	17455.41	17455.41	18047.12	17455.41	17381.45	18121.08	17529.37	17455.41	18047.12
Total Producers Surplus	38370.86	37124.4	40268.4	43593.46	44205	46715.2	49619.86	48703.8	50077.5	52256.76	19465
Total Government Surplus	13810.92	15322.84	16916.38	18455.06	20099.05	21914.07	23936.01	26140.72	28578.3	30853.47	33023.54
Micro Externalities (SCBA)	4098.802	4216.815	4338.367	4463.567	4592.522	4725.347	4862.155	5003.069	5148.209	5297.704	5451.683
Macro Externalities (CGE)	123648	141312	176640	211968	229632	247296	264960	264960	264960	264960	264960
Total Externalities	127747	145529	180978.6	216431.9	234224.8	252021.7	269822.5	269963.4	270108.6	270258.1	270412
Total Benefits	193094	216023	255619	295936	316576	338106	360760	362929	366294	370824	340948
Total Investment Costs	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200
Total Cost	**-200**	**-200**	**-200**	**-200**	**-200**	**-200**	**-200**	**-200**	**-200**	**-200**	**-200**
NET BENEFITS	192894	215823	255419	295736	316376	337906	360560	362729	366094	370624	340748

BCR (BY NPV METHOD)	**11.55**	2009-2030
ENPV	**₹ 1,060,140.37**	2009-2030

This assimilation of CBA with macroeconomic externality obtained from the CGE model framework is perhaps a unique endeavor in economic analysis of major infrastructure projects of any country. Thus the result obtained in this part of the estimation would not have peers to provide comparison with other infrastructure projects.

Summary and Conclusion

The modeling and simulation for Social Cost Benefit Analysis developed and presented in this paper is based on the European Commission's Guide to Cost Benefit Analysis of Investment Projects: Economic appraisal tool for Cohesion Policy 2014-2020 (European Commission Directorate General for Regional and Urban policy) authored by Davide Sartori et. al. The work on SCBA presented here is a unique model developed in the upstream petroleum refining operations in India. The work takes into account the Investment Cost, Operating Cost, Operating Revenues to arrive at the Financial Net Present Value of Investment (FNPV) and the Financial Internal Rate of Return (FIRR). A discount rate of 7.8% is applied in the project phase (2009 – 2030). The FNPV is negative in the project phase 2009 - 2030 (- INR 1746.40) as expected, owing to lumpy investments in the Construction Phase. The FNPV (C) turns positive to INR 3014.65 Crores in the Train – II Phase in 2020 – 2030. The FIRR is 16% for the project phase 2009 – 2030 and 85% for the projected period 2015 – 2030. A Sensitivity Analysis is also developed keeping varying the discount rate and the time horizon for the discounted cash flows.

The Consumer Surplus, the Producer Surplus and the Government Surplus is estimated using the available information obtained from company's internal database and appropriately projecting them till 2030 using assumptions grounded on dominant logic for forecasting of income and expenditures. While arriving at externalities, only immediate micro impact of the Essar Oil's Vadinar Refinery, namely, indirect employment, mother and child care, education and livelihood, supply of safe drinking water to the nearby geographies, preventive universal healthcare, awareness and avoidance of communicable diseases are majorly taken into consideration. A positive ENPV of INR 1060140.37 is obtained for the project phase 2009 – 2030; BCR of 3.26 for the period 2009 – 2030 is estimated using discounted cash flow technique. It moves up to 11.55 when the economy-wide macroeconomic externalities are taken account of in a CGE framework. The project is thus economically sound and financially viable.

In accordance to the UK Department for Transport (DfT) 'Value for Money (VfM) Assessment Guidance', as laid down in the HM Treasury (2006), the projects are categorized according to their benefit–cost ratios, adjusted for wider economic impacts. In our case, the estimated BCR of 3.26 with only micro externality into consideration falls in the category of "High VfM" in the VfM Assessment criterion and accordingly refinery projects like these should be accorded highest priority as they conform to all stipulated guidelines ensuring that projects are built on a strong economic and commercial case.

There is abundance of scope to reflect the strategic food and oil security of India from the macroeconomic perspective; the gradual increase in investor and consumer confidence with respect to self-reliance in production and consumption of oil and natural gas resources in the country and the broader social impact of the project, which may be taken up in subsequent research.

In conclusion, as is observed in this paper, SCBA as an analytical tool can be gainfully employed to appraise or evaluate large scale projects like Essar Oil's Refinery at Vadinar, Gujarat. The SCBA is able to suitably project the holistic societal improvement and enhancement of the quality of life of all stakeholders, directly or indirectly associated with the project. It is not merely the private costs and benefits, but the overall societal benefits which serves as the guiding principle for large scale projects like the Essar Oil refinery at Vadinar. The purpose of SCBA is to facilitate efficient allocation of resources, demonstrating the scope for increased welfare for society at large.

Acknowledgement

We would like to express our sincere gratitude and heartfelt thanks to Essar Oil Limited for giving us the opportunity of undertaking this research project on Social and Economic Impact Analysis of Vadinar Refinery of Essar Oil Limited, which proved to be challenging and involved. In particular, we are grateful to Mr. Lalit Kumar Gupta, Managing Director and CEO, Ms. Jaskinder Shingwekar, Vice President (Pricing, Comm., CP), Mr. Deepak Arora, CEO, Essar Foundation, Mr. Dheeraj Kapoor, Mr. Navdeep Singh and Ms Radhika Agarwal for their helpful role. We would also like to acknowledge Indira Gandhi Institute of Development Research and Durgadevi Saraf Institute of Management Studies, Mumbai for providing the scholarly environment.

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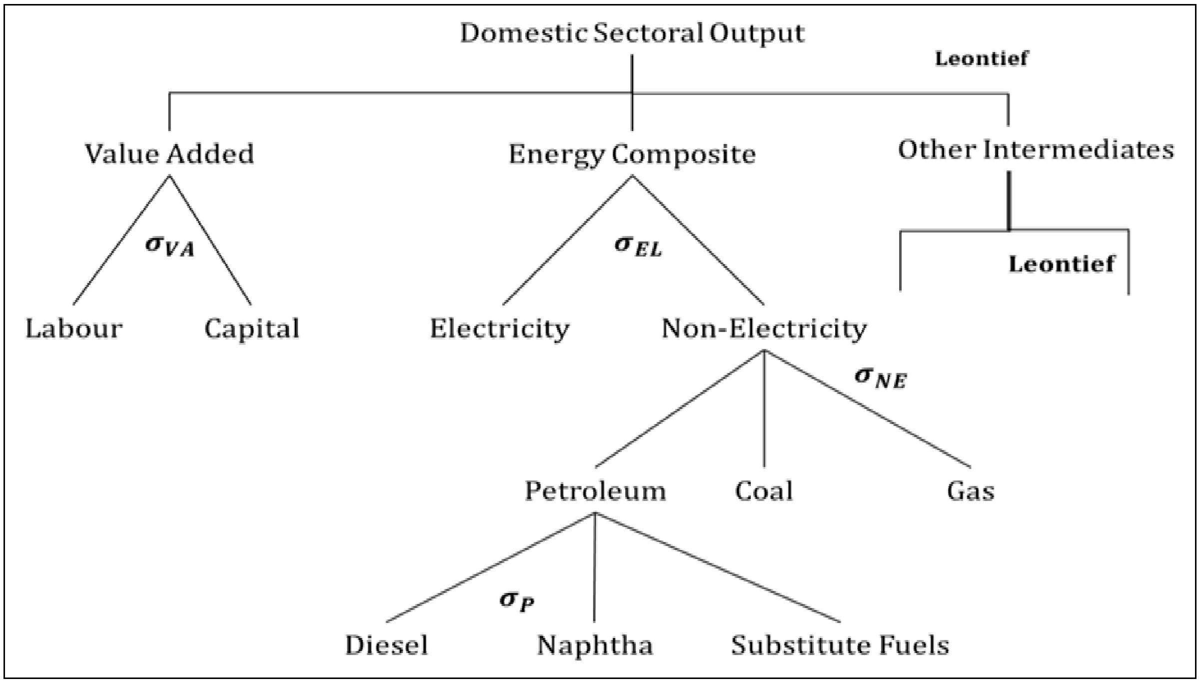
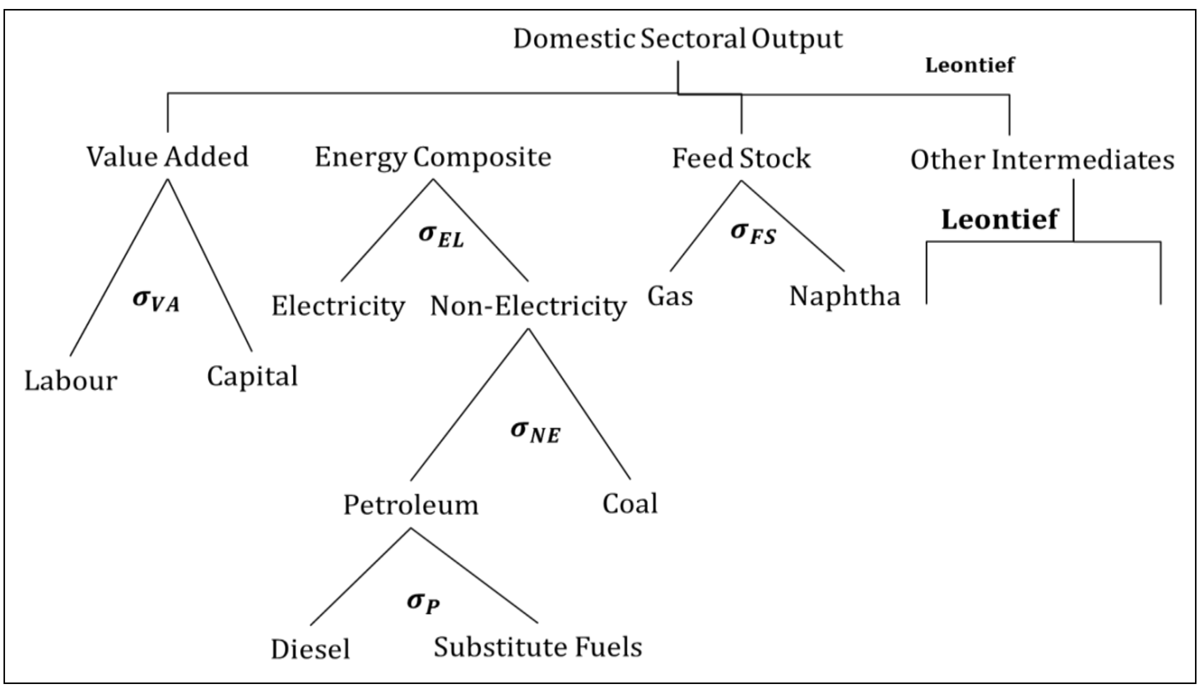
Appendix

Appendix Figure 1: Nested production structure for all sectors other than Fertilizers and Chemicals



Source: Ganesh-Kumar and Harak (2015)

Appendix Figure 2: Nested production structure for Fertilizers and Chemicals sectors



Source: Ganesh-Kumar and Harak (2015)

Appendix 3

Comparison of CBAs across Sectors (Nationally and Internationally)

A comparative analysis of the Vadinar Refinery is also made with other National and International transportation and infrastructural projects.

Project	Western Freeway Sea Link	Bandra Worli Sea link	MRTS, Thane	Multimodal International Passenger and Cargo Hub Airport at Nagpur	Mumbai-Pune Expressway; Mumbai Trans Harbour Link
BCR	1.74	1.79	2.53	1.61	1.43

Table A: Comparative Analysis of National Projects

It may be mentioned here that for Delhi International Airport Limited the BCR was estimated to be 3.78 (Chaudhuri, Vasigh, Chaudhuri, 2015)

TRANSPORTATION BENEFIT COST ANALYSIS		
Project	**Location**	**BCR**
Commercial Vehicle Information Systems and Networks (CVISN) Program (1)	Maryland and Virginia	12.5
Truck Bypass (6 Miles) Interstate 205 (I-205) Mountain House Parkway Interchange in San Joaquin County to a point west of the Interstate 580 (I-580) Grant Line Road Interchange in Alameda County, California Department of Transportation (Caltrans) (2)	California	1.3
Monorail (3)	Washington	1.23
Public Transport: public transport telematics system incorporating real-time passenger information, bus and train priorities at traffic signals, and schedule monitoring (4)	Helsinki, Finland	3.3
Rock County Airport Runway (5)	Wisconsin	4.9

Table B: Comparative BCRs for Selected International Transportation Projects

In case of CVISN Program life-cycle benefit/cost analysis is conducted taking into account the long term social benefits associated with the project.

The Port of Anchorage (POA), Inter-modal Expansion Program, Alaska, 2011	Roadway Rehabilitation Project, Romania, 2011	City Development Project, Italy, 2011	Portsmouth/Kittery Memorial Bridge Replacement Project, New Hampshire	State Highway Investment in New Zealand, 2010
2.5 (With $527 M Federal Grant; 1.3 – 1.8 (Without Grant)	1.002	2.748	1.6	2.04

Table C: Comparative Analysis of Miscellaneous International Projects

In the Oil Transportation Network: East West Link, prepared by the Victoria State Government, Australia, a BCR of 1.4, having over $1.4 billion of net economic benefit and an internal rate of return of 9 per cent has been observed.

Refinery Logistics Network, Westhom, Custer County, Oklahoma using a discount rate of 7%, obtained a BCR[6] of 7.68. In most cases, BCR lies in the range of 1.3 to 4.9. BCR of more than 10 are observed in those cases, where wider social aspects of the project are considered. However, none of the literature surveyed reports a methodology of employing a combination of SCBA and CGE modelling technique. Thus, it is a unique endeavour in its own merit.