

PETROLEUM ECONOMICS

A. Clò

Dept. of Economic Sciences, University of Bologna, Italy

L. Orlandi

RIE Srl, Energetic and Industrial Research, Bologna, Italy

Keywords: Petroleum, crude oil, energy, demand, supply, price, elasticity, risk, capital intensity, investment, E&P industry, competition, stability, growth, oil companies, vertical integration, internationalization, concentration, coordination, pricing policies, posted prices, spot markets, futures markets, newcomers, OPEC, structural determinants, economic growth, spare capacity, financial determinants, recession, investment's paralysis.

Contents

1. Basic conditions for petroleum economics
 - 1.1. High Capital Intensity and Risk Factor
 - 1.2. Level and Structure of Oil Production Costs
 - 1.3. Economies of Scale, Interdependences, Specificity
 - 1.4. The "Time Factor"
 - 1.5. The Demand Function
 - 1.5.1. The Energy Demand: Qualitative Specificities
 - 1.5.2. The Oil Demand: General Lines
 2. Market structure and price dynamics in twentieth century
 - 2.1. From The Pioneers To The American Oil Industry: 1859-1900
 - 2.2. From American to International Industry: 1900-1940
 - 2.3. Concentration and Coordination: 1940-1970
 - 2.4. Inertial Stability and Evolutionary Processes
 - 2.4.1. Newcomers on the Oil Market
 - 2.4.2. Administered Prices and Market Prices
 - 2.4.3. The Birth of OPEC
 - 2.5. Towards a New Equilibrium
 3. The new oil era: an unprecedented price escalation
 - 3.1. Structural Determinants
 - 3.2. The Financial Determinants
 - 3.3. World Recession in the Second Half of 2008: Back on Fundamentals
 - 3.4. OPEC Policies and the Risks of Cheap Oil
- Acknowledgments
Glossary
Bibliography
Biographical Sketches

Summary

The analysis follows the historical development, going over the various stages taking place since the beginnings of the oil industry up to nowadays. The reason is that each of

these shows structural characteristics, relations of strength, economic and political dynamics which cannot be immediately attributed to the traditional life cycle of an industry and which indeed can no longer be repeated.

There are two aspects which run horizontally through these historical dynamics. The first is the way in which the basic conditions of the oil economy have influenced the behavior of the various players and in particular of the oil companies, according to the specific external context in which they were operating.

The second aspect is the way the companies have attempted to respond to the challenge that has through the whole history of the oil industry: how to reconcile (short-term) competition with (long-term) stability of the markets. The initial phases, characterized by ruinous competition followed by close oligopolistic coordination, were followed by the disappearance of unequal relations of strength between producer states and companies that led to the predominance in international markets of conditions of broad, though not perfect, competition.

The last chapter is focused on the recent market dynamics characterized by two opposite phases: 1) a fast and unexpected escalation of oil prices, mainly driven by the financial transactions on futures markets implemented by non-commercial operators; 2) a deep and fast drop in prices driven by world economic recession: this condition born in US and then spread in a lot of country around the world.

In this mentioned last period, the consequent collapse of oil demand, due to the economic recession, caused an oversupply condition on the oil market with bearish effects on oil prices. This dynamic hides a potential and dangerous bullish factor: the investment's paralysis. The oil price fall by 100 U.S. Dollars per barrel in 4 months (in 2008) and the international credit crunch are writing off investment along the whole oil chain, especially in the upstream activities.

The low level of oil prices and the restriction of credit market access forced the oil companies to review, postpone and cancel several projects for being no longer profitable in this new business environment. In addition to this renewed reluctance to invest, a new element of pressure appears on the supply side: the fast and high decline rates in several non-OPEC oilfields. Are these ones warning signals of a new oil prices escalation?

1. Basic Conditions for Petroleum Economics

In order to understand the market dynamics, the company strategies, the policies and the price trends of the petroleum economy, we need to refer to a number of important "basic conditions". Each of these has a *different* influence according to the aspect that we intend to investigate, and *changes* in time according to technological developments and market situations.

Only a thorough analysis will help us to isolate the effect of each individual condition as well as, more importantly for analytical purposes, their combined effect. The following table summarizes the basic conditions that in petroleum economics are the most relevant

as regards the offer and the demand.

<i>Basic economic conditions of the oil industry</i>	
SUPPLY	DEMAND
High capital intensity and high risk	Low price elasticity
High scale and scope economies	High income elasticity
Increasing plant specificity	Differentiated elasticity
Low price elasticity	Cross elasticity

Table 1. Basic economic conditions of the oil industry

Before analyzing these conditions individually, we should first call to mind the sequence of events into which the oil industry is divided: 1) *mining activity*, including all those activities from the first geophysical prospecting up to the production, collection and loading of the oil; 2) *marketing* of the oil and/or its derivatives; 3) *transport*, from the production areas to the areas of oil refining and then to the areas of consumption of its derivatives; 4) *refining* of the oil; 5) *distribution* of its derivatives.

As we will see in the chapters to follow, motivations of economic convenience and strategic opportunity have compelled the majority of firms to operate in all phases of the oil cycle, though many of them have consolidated their business solely in activities upstream or downstream, in a marginal position with respect to the leading companies though often with no less profit.

1.1. High Capital Intensity and Risk Factor

The oil industry is by nature an industry with high capital intensity. This feature may be found in each of its phases and is particularly significant in mining activity, because of the high *level of risk* that characterizes it structurally. “*The very fact that the production of crude oil is always a leap in the dark*”, wrote Paul Frankel in 1946 in the book *Essentials of Petroleum*, which remains still unsurpassed in some of its intuitions, “*affects the stability of all the subsequent phases. No part of the oil, however far removed, can be altogether untouched by its capricious origins*”.

Investments in the research phase may limit the margin of risk, increasing the likelihood of success and in any case providing data and information useful for subsequent researches, but the fact remains that in spite of all the knowledge and experience gained over almost a century, the occurrence of oil in profitable quantities at any given point cannot be deduced theoretically but can ultimately be proved only by the act of boring a well”.

Hence the need to drill a large number of them, once a potentially interesting area has been identified, since the cost of many fruitless attempts has to be offset against the few which will be successful. And even once the actual presence of oil has been proven, there is no certainty that its extraction and marketing will be profitable, since this

depends on the costs that will be sustained globally and on current prices. To diversify the risk, oil firms have developed a strategy of horizontal integration, where possible, operating on a vast scale, in many countries with different levels of mineral and political risk, on different research themes extending over entire geographical areas. All this led inevitably to co-operation between various firms. In this way, few positive results were sufficient to repay the many negative ones.

These considerations refer to two levels of risk of a different nature, in addition to the normal commercial risk. We may define them as *geological risk*, (given by the imponderability of the unknown) and *technical risk* (errors in interpreting the data). In the case of oil, these will also include *political risk*: the effects of an unfavorable and unexpected change by the host governments of the operative conditions on which the firms had based their investment decisions (changes in property rights, in fiscal policy, etc.). The evaluation of these risks will influence the level of capital available to the firm for a certain investment, and thus its costs and the cost of the remuneration of the capital.

The hazardous nature of mining activities, being linked to the availability of capital to invest, helps to place the problem of the optimal decisions of investment, as well as decisions related to the prices, in terms of *survival* in time of the firms, rather than the maximization of their profits in the short term. For oil companies, who operate with fixed plants and not only in trading activities, the main requirement is to carry out their activities in *relative certainty* as regards the dynamics of the markets, so that they can rely on specific flows of income.

The companies will therefore have to dedicate enough finance towards research in order to ensure that operations continue until a find compensates a series of previous failures. This means they must be able to survive huge losses, though these might well be expected to be transitory. The above conditions have an important influence on the structure and behavior of the petroleum industry.

Need for high self-financing. Oil companies have historically taken the largest part (70%-80%) of the capital they required from internal available funds. There are at least three reasons to explain this need: 1) they are unable to be submitted to rigid and prefixed reimbursement plans; 2) the reluctance of the financial institutions to expose themselves in a high-risk sector; 3) the enormous size of the oil investments in which banks could only take a small part.

Large size of the firms. Mining risk is conditioned by the total capital availability, as well as, obviously, the ability to manage it. We could thus state that, within certain limits, the risk is a decreasing function of the available capital and thus of the company's size. The risk factor introduces a formidable barrier to entry, identifying – in relation to the entity it has in the various production areas and to the trend of the marginal costs of investment – the minimum size that a company must be to take part in the industry. Smaller firms have also entered the industry, though generally this is due to protective legislation mainly with state-controlled or national companies.

Integrated organization. Only those firms that produce *large and sufficiently stable*

flows of income are able to sustain investments in regular rhythms so that exploited reserves may be suitably replaced and their increase match the rise in demand. This is in order to preserve a long-term horizon in the exploitation of the oil fields and the acquired market positions. In order to achieve these objectives, oil companies have tended to operate at all phases of the oil cycle, so that: 1) hazard upstream activity constitutes an important but not determining element of the whole business; 2) achieving positive results in research and extraction is not affected by difficulties in selling the final product on the market.

Such high capital intensity and high mining risks influence the size of the firms, their number, their organizational, political and financial structure, and above all their supply and pricing policy.

1.2. Level and Structure of Oil Production Costs

For the producing company, oil production costs may be separated into *technical costs* and *fiscal costs*. The former refers to all the expenses borne for oil production until it is placed on the primary market. The latter regards the amount that firms have to pay the countries as owners of the resources and/or as receivers of taxes on profits (real or presumed).

Cost analysis is enormously important throughout the petroleum economy and is particularly influential in conditioning the behavior of the producers. This is due to three main aspects:

1) The enormous *diversity in levels of cost* from area to area of production, or even within the same area. The technical costs depend on a huge number of variables: difficulties encountered during the research stage (average number of drillings necessary to give a productive well), depth of the wells, nature of the rocks to drill, rate of interest to be paid on the investments, distance from the sorting points or loading points of the crude oil, etc. In 2006, for example, average production costs (or lifting costs, the cost to bring a barrel for oil to the surface) ranged from about 4 U.S. Dollars per barrel (excluding taxes) in Africa to about 8 U.S. Dollars per barrel in Canada. Besides the direct costs associated with removing the oil from the ground, substantial costs are incurred to explore for and develop oil fields (called finding costs) and these also vary substantially by region. In particular, they ranged from about 5 U.S. Dollars per barrel in the Middle East to 63 U.S. Dollars per barrel for US offshore.

The difference in costs has particular influence on the competitiveness of the producing companies and the prices. With a range of production costs not to be found in any other mining sector, it is clear in fact that in the petroleum industry prices are very unlikely to be fixed from the production costs to reach an international market price. If it were so - in other words if this result were achieved by operating conditions of perfect competition - the relatively more disadvantaged producers would be put out of the market as far as they were physically replaceable by the more efficient producers. As we shall see, this has never happened, thus proving that reasons outside economic rationality and pure competition have influenced the allocation of resources, investment policies and oil supply policies.

2) *High fixed costs/variable costs ratio.* This basic condition derives directly from the high level of investments (exploration and cultivation) required in order to start up production and from the relatively low level of operating expenses needed to sustain the mining stage. The more hazardous the extracting conditions (for example deep under the sea), or the more remote the oil field with respect to the port of shipment, the higher these costs are.

On average, the fixed to variable ratio is 4 to 1, though in the most unfavorable cases this ratio may be 1 to 1. Thus, in the majority of cases, the marginal cost is much lower than the average cost, and the curve of the production costs falls steadily over a long stretch as the output increases.

The consequence of this, combined with the huge expenses sustained by the producer *before* being able to produce, is extremely significant: the producer has every advantage in maximizing output (compatibly with the limits that derive from an optimal exploitation of the wells, in other words so as not to compromise its subsequent operation).

That he should extract one ton more or less is fairly irrelevant as regards the costs, given the expense that he has so far borne, while the differential advantage derived from the possibility of gaining part of his money back is considerable. If, on the other hand, difficulties in outlet emerge, instead of reducing or halting production, the operator will be interested in selling even at a lower price than the average cost as long as this is higher than the marginal cost: and the difference between the two values may be quite considerable.

3) *Low supply-price elasticity.* The (relative) rigidity of petroleum production in the short term is strongly supported by cost analysis and economic calculation. The decision to exploit an oil field is practically irreversible. An economic calculation that adopts the interest of the producer as criteria means that the production of an active oil well will practically never slacken.

It follows that *the supply is substantially anelastic to conjunctural price variations.* Instead their effects influence the stocks by increasing or reducing them or slowing down or speeding up delivery. When the price variations become relatively stable, the phases *preceding* extraction are the ones influenced. *First of all* there is the development of oil fields already discovered (but not already equipped with investments of development); *then* exploration and mineral research takes place.

Though they have no effect on the current supply, consistent increases or reductions in the oil prices, expected to be stable, alter the future supply through variations in the volume of investment. (d) *Supply/price elasticity in the long term will thus be much higher than it was in the short term.*

These statements are clearly represented in Figure 1, where the prices of petroleum and investments in world exploration and development activities are shown for the period 1980-2008. The correlation between the two curves is immediately evident.

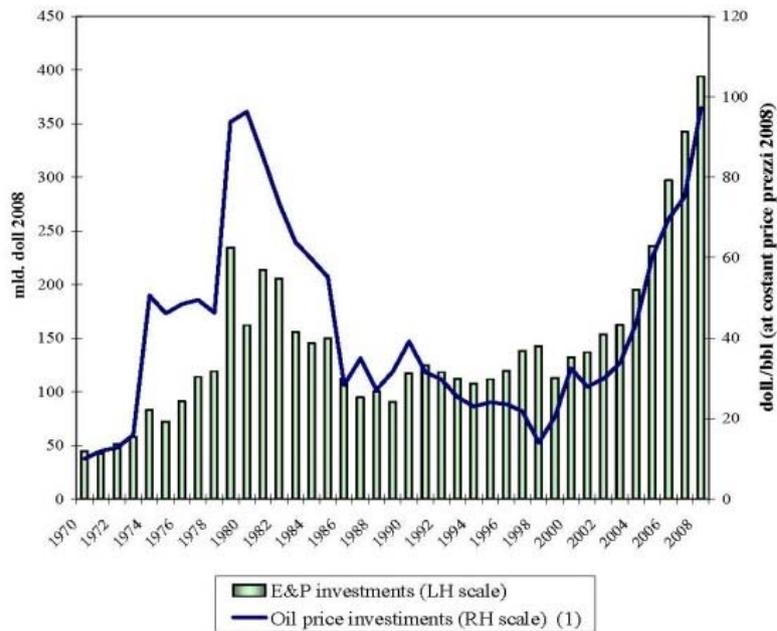


Figure 1. Worldwide Investments in Exploration and Production and Crude Oil Prices (1) For Crude Oil prices: 1970-1984: Arabian Light; 1985-2008: Brent Dated. Source: for oil prices, BP Statistical review and Platts Oilgram Price Report. For E&P Investments: Oil and Gas Journal and IFP.

Variations in the prices will thus influence the future supply in a positively correlated way. The final result is determined by a number of variables, a particularly important one being the *time factor* (see paragraph 1.4). The longer it takes to install new production capacities, the easier it will be for the sellers of a commodity (petroleum) to raise prices and keep them high before being affected by the competition of newcomers to the market of this commodity or of alternative commodities (coal, gas, nuclear, etc.). The time factor is generally given little importance and when this happens it is difficult to appreciate the real energy options, since the times of the choices may vary in one or two orders of magnitude.

1.3. Economies of Scale, Interdependences, Specificity

The basic conditions that we have so far analyzed all regard the production phase of the petroleum industry. It would however be wrong to maintain that only these have affected or can affect the behavior of its sellers (and therefore its prices). In a naturally integrated industry such as that of petroleum, the structure and behavior of each of segments can influence the behavior and results of the other phases. We therefore have to refer to the whole of the basic economics, attempting each time to understand which conditions, and in which sectors, were the most important.

Throughout the downstream phases two conditions in particular are to be highlighted: 1) the high economies of scale; 2) the close operative interdependence between them. Both conditions lead the companies to reason and decide in terms of *global optimization* of their decisions in both the short and long term: in the sense that the advantages of

considering the whole oil business as a unit far outweigh the sum of the single partial optimizations. This does not mean that at certain moments, independent companies – present at only one or two phases – cannot benefit more than integrated firms from particular market trends, but this does not apply in the long run (unless protective barriers are in operation).

How are the company policies affected by the existence of operative interdependences? We may answer this question by referring to the analysis of the *interdependent planning uncertainty* proposed by Malmgren in 1961 following the work of Coase in 1937. In his opinion, in a highly variable and uncertain context (certainly the case of petroleum), the *combined* planning of activities with a close degree of interdependence gives cost advantages and makes it easier to reach conditions of markets' balance.

The internal organization of the companies - in a better position to control the circulation of information, to set up compatible planning for complementary activities and to co-ordinate the expectations of the single units – will thus be preferred to the intermediation of the market, also because the prices are not efficient indicators of future events. Interdependence does not by itself generate difficulties if the pattern of interdependence is stable and fixed. In this case each sub-program can be designed to take account of all the other sub-program with which it interacts.

Difficulties arise only if programs rest on contingencies that cannot be predicted perfectly in advance. In case, coordinating activity is required to secure agreement about the relevant activities of the others. Vertical integration makes it possible not only to better plan the entity of the investments with respect to the expected market demands, but also to ensure a combined exploitation close to the optimal one and in any case better than that achievable through contracts which are inevitably incomplete.

The company is also able to be more accurate in planning the capacity level used which is needed to give stability to prices and production in the long term. This is, in turn, what helps to reduce the entity of the transaction costs.

The same conclusion – the preference for internal organization to the market – is reached if we make the analysis in terms of *external economies*. These originate when investments set up by two or more companies are profitable only if they do not operate independently of each other. If the firms in this interdependent group were integrated, the pecuniary external economies would become internal economies, with a resulting gain in profits to the investors of the integrated firm.

The technical and operative complementarities mean that certain investments are profitable only if other investments are made at the same time, and if the decisions in their management are adopted coherently with the maximization of the combined profit. This is possible only if the circulation of information is efficient. The close technical interdependence which runs between the subsequent phases of the petroleum industry – associated with a highly variable and uncertain environment – has brought out *economies of co-ordination* which have strongly favored the integrated structures of the major companies.

-
-
-

TO ACCESS ALL THE 30 PAGES OF THIS CHAPTER,
Visit: <http://www.eolss.net/Eolss-sampleAllChapter.aspx>

Bibliography

Adelman, M.A. (1972), *The World Petroleum Market*, 438 pp., Baltimore, John Hopkins University Press. [This work is one of the most important approach to the study of petroleum market].

BP Statistical Review 2008

<http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622>. [A complete and reliable database on energy sources].

Chandler A.D (1990), *Scale and Scope: the dynamics of industrial capitalism*, 860 pp., Cambridge, MA., The Belknap Press of Harvard University Press. [Representing ten years of research into the history of the managerial business system, this book concentrates on patterns of growth and competitiveness in the U.S., Germany, and Great Britain, tracing the evolution of large firms into multinational giants and orienting the late twentieth century's most important developments. Among the others, it analyses the development of the Major Oil Companies].

Clô A. (2000), *Economia e Politica del Petrolio*, 405 pp., Bologna, Editrice Compositori [The book analyzes the dynamics of petroleum market and the historical development of the oil industry, together with many aspects of energy resource economics].

Federal Trade Commission (1952), Staff Report, The international Petroleum Cartel, Whashington DC, US, Government Printing Office. [An important and detailed data source about the major oil company supremacy in the 1950s].

Financial Times, Oil Cartel Divided over level of cuts, October 10th, 2008. [An interesting and recent article about the problem of divergence among OPEC countries].

Frankel, P.H. (1946), *Essentials of Petroleum – A Key to Oil Economics*, London: Frank Cass, The Journal of Industrial Economics, no. 2, pp. 93-99. [This book propose an exhaustive analysis of the oil market fundamentals; the author underlines the inherent instability of the oil industry and its inability to self -adjusting].

Herold J.S. Inc (2007), *Global Upstream Performance Review*, 27 pp., <http://www.herold.com/docs/rrc0709p.pdf>. [This annual review contains several data about worldwide upstream activity and expenditures].

IEA, Oil Market Report, from January 2007 to December 2008. [This monthly report contains important data and forecast about oil demand and supply; updated on a monthly basis].

IEA, World Energy Outlook 2008, 578 pp., Paris, OECD/IEA Head of Publications Service. [The publication contains an exhaustive oil market outlook. It provides energy projections to 2030, region by region and fuel by fuel. It incorporates the latest data and policies].

IHS Herold Inc, <http://www.ihsindexes.com/>. [On this website, IHS Herold Inc., in collaboration with Cambridge Energy Research Associates - CERA, publishes the Upstream Capital Cost Index mentioned within this essay].

International Monetary Fund (IMF), World Economic Outlook Update, January 2009. [One of the most important database concerning global economic indicators, also divided by regions]

OPEC (2008), OPEC Statistical Bulletin 2007, 138 pp., Austria, Ueberreuter Print und Digimedia. [This annual Bulletin contains all OPEC countries data].

Orlandi L. (2007-2008), L'aumento dei costi incide sul settore E&P, Riserve di petrolio: diversi metodi di valutazione, Mercati petroliferi: le previsioni del RIE, Il petrolio fa novanta, Greggio: oltre 100 dollari tra finanza, crescita economica e politiche OPEC, Economia e petrolio: tra decoupling e globalizzazione, Crisi domanda-prezzo del petrolio: quali combinazioni possibili, Petrolio: I pericoli del Cheap Oil, Rome Italy, Notizie Statistiche Petrolifere, Unione Petrolifera. [These are the most recent essays written by the co-author about the oil market].

Penrose, E.T. (1960), Middle East Oil: The International Distribution of Profits and Income Taxes, *Economica*, August, pp. 203-213. [One of the first text analyzing the oil exporting countries dynamics].

Platts Oilgram Price Report, New York, The McGraw Hill Company. [This daily report is the most important source of oil prices data; we used the prices data published in this report to create historical series].

Biographical Sketches

Alberto Clò was born in Bologna, Italy, in 1947. He holds a degree in Political Science (University of Bologna). Since 1977 he has been carrying out studies, researches and consultancy activities in the energy field at national and international level. In 1980 he founded the “*Energia*” review, of which he is editor-in-chief. From 1995 to 1996 he took office as Minister of Industry and Minister of Foreign Trade *ad interim*; he was President of the Council of the EU Industry and Energy Ministers during Italy's six-month presidency in 1996. In that year he was also decorated “*Cavaliere di Gran Croce of the Republic of Italy*”. Since 1999 he has been a director of Eni S.p.A.; he is an independent director of Atlantia S.p.A., Italcementi S.p.A. and De Longhi S.p.A. He was also a director of ASM Brescia S.p.A. until December 31st, 2007. He teaches Industrial Organization and Economics of Public Utilities at the University of Bologna.

He is the author of several books as well as of over a hundred essays and articles on industrial and energy economics and he is also contributing to various newspapers and business magazines. In 1997, he published the volume entitled “*Economia e politica del petrolio*” translated abroad with the title “*Oil Economics and Policy*”. In 2004, he was scientific advisor of the book “*ENI 1953-2003*”, in 2005 published “*Energia e Tecnologia*”, “*Appunti di Economia Industriale*” and in 2008 “*Il rebus energetico*”.

Lisa Orlandi was born in Bologna, Italy, in 1977. He holds a degree in Economics from the University of Bologna. Since 2001, he has been carrying out studies, researches and consultancy activities in the energy field, becoming a senior energy consultant at RIE Srl- Ricerche Industriali ed Energetiche, in Bologna (Italy). Since 2002, she is tutor of Industrial Organization at the University of Bologna, under the scientific responsibility of Professor Alberto Clò. She is a member of the scientific committee of “*Energia*” review and author of several essays and article about energy, especially on petroleum market field. She gave her contribution to the writing of the volume “*Oil Economics and Policy*” (Author: Prof. Alberto Clò) and to the book “*ENI 1953-2003*”.

She is the authors of several essay, the most recent being “*The danger of Cheap Oil*”, “*The oil markets: RIE price forecasting*”, “*Crisis-oil demand: some possible outlooks*”; all these articles have been published by Unione Petrolifera in 2007 and 2008. She is now senior consultant at RIE Srl- Ricerche Industriali ed Energetiche, Bologna, Italy.