The Market for Heavy Sour Crude Oil in the US Gulf Coast:

The PEMEX/PDVSA Duopoly

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with Liliana Figueroa

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In the process of completing this study I have accumulated intellectual debts that are too numerous to mention. Nevertheless, I would like to express my gratitude to a number of individuals and institutions without whose collaboration the study would not have been completed, certainly not in its present form. As ever, it all began with an idea put forward by Robert Mabro: that I should try and express in academic terms the commercial experience that I accumulated during my stint as manager for Crude Oil Exports at PMI Comercio Internacional, the international trading arm of Petróleos Mexicanos (PEMEX). Given the composition and destinations of PEMEX's exports, this suggestion inevitably meant writing about the market for heavy sour crude oil in general, with a focus on the US Gulf Coast in particular. Notwithstanding his very busy life, Adrián Lajous spent long hours reading four — as I recollect it — different drafts of this study, always displaying patience and understanding above and beyond the call of duty. His advice was invariably profitable, as was that of John Mitchell and Charles Henderson. The contribution of Liliana Figueroa to the study was decisive. She completed the statistical and modeling work that underlies the core chapter of the study by juggling her own very demanding research schedule, and she never betrayed any impatience at my inopportune and constant pestering. The same can be said for Gabriela Cano, whose computer wizardry enabled me to put together many time series and data bases in a hundredth of the time it would have taken me had I been on my own. My efforts at data collection were also made much easier by the disinterested collaboration of Raúl Manzo, César Covarrubias, Roberto Carmona, Sandra Hernández, Tere Martínez and Maricarmen Orozco. Sadek Wahba provided me with some extremely important and hard-to-find documents. Finally, Judy Mabro's thorough copy-editing left my manuscript without errors of form. All of these individuals did their best to enlighten me and to improve the contents of the study. The errors that remain, whether through ignorance or obstinacy, are strictly my own.

In a letter to Daniel Halévy that prefaces the first French edition of his *Réflexions sur la violence*, Georges Sorel wrote the following *apologia pro obra sua*: "I do not have an academic chair, I am not a populariser and neither do I aspire to be the head of a party; I am but a self-taught writer who offers some people the blocks of notes that have served for his own instruction". These words describe my own situation well. Unlike Sorel, though, it has been my good fortune to count on a succession of excellent guides into the intricacies of the oil business: Adrián Lajous, Robert Mabro, Eduardo Martínez del Río, Pedro Haas, Raúl Cardoso, Xavier Trabia, Bernard Mommer, Miguel Bueno, Raúl Manzo, Paul Horsnell, Ernesto Estrada. I would like to thank my wife Sonia, my children José Miguel and Lucía, my sisters Michéle and Erika and my parents Celia and Juan for just about everything else. Miguel Moreno Sánchez is not here to thank him anymore, so I can only dedicate this book to his memory. I would also like to dedicate this book, with the greatest respect and admiration, to Adrián Lajous.

THE AUTHORS

Juan Carlos Boué was born in Mexico City, Mexico, in 1966. He took a degree in Public Administration at El Colegio de México. Between 1990 and 1999, he held various analytical and market intelligence posts at PMI Comercio Internacional, the international trading arm of PEMEX, Mexico's national oil company. For a two-year period (1997–99), he was commercial manager for crude oil exports, as well as secretary to the International Petroleum Trade Committee (Comité de Comercio Exterior de Petróleo or COCEP), the collegiate governmental body that oversees PEMEX's international trading activities and approves changes in the adjustment factors of Mexican crude pricing formula. In 1992, he spent a year as a visiting research fellow at the Oxford Institute of Energy Studies, on secondment from PEMEX. While on this assignment, he wrote a monograph on various aspects of the Venezuelan petroleum industry which was published by Oxford University Press as *Venezuela. The Political Economy of Oil* (1993). Between 1994 and 1997, he read for a D.Phil in Politics at Wolfson College, Oxford University. He has published articles on the political economy of petroleum as well as on trading and taxation in various international affairs and economics journals. Married, with two children, he currently lives in Oxford and works as Senior Research Fellow at the Oxford Institute for Energy Studies.

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EXECUTIVE SUMMARY

A study of the market for heavy sour crude derives its importance from the role this market plays in the supply of petroleum products to key consuming countries, particularly the USA. Imports of heavy sour crude account for around a quarter of all US crude imports; and this crude variety is probably responsible for a similar proportion of the total domestic gasoline output in the USA.

The study of this market enables the author to investigate interesting issues of wide relevance:
– What factors determine the institutional arrangements that govern supply relationships between a crude oil producer and its customers?
– Why are some transactions internalised through vertical integration?
– Why are many transactions governed by long-term contracts?
– What determines the structure of such contracts and why are they used instead of simple spot transactions?

The world oil market is segmented into two major and quite distinct sets: one for general-purpose crudes, the other for speciality grades. Heavy sour crudes are the most important in the speciality group. These crudes can only be transformed into light fuels in deep conversion refining plants. This means asset specificity that leads in turn to the emergence of bilateral monopolies. Thus, the commercial parties in the heavy sour crude market have to maintain long-term relationships that will always be under threat given the constraints on substitution arising precisely from this asset specificity. The maintenance of these relationships is further complicated by a number of facts. Firstly there is a relatively small production volume of heavy sour crude available, although this same volume is large when set against the global availability of deep conversion capacity. Secondly, production of heavy sour crude is highly concentrated in only a few countries (with Canada, Mexico, the USA and Venezuela being the most important) and even fewer countries make a meaningful volumetric contribution to the international trade of this commodity. Thirdly, rigidities on both the production and the processing side of the heavy sour trade limit arbitrage and lengthen the amount of time it takes for the market to adjust to a situation of excess supply (or demand).

The book describes the market for heavy sour crude in the Gulf Coast (USGC) region, which is by far the largest of its kind in the world. This market is also of critical importance to the economic well-being of Mexico and Venezuela, since it absorbs a high proportion of their crude oil exports. Competition in this market takes place between only two players who place stringent non-resale conditions on their crudes: PEMEX and PDVSA. Although one would expect that participants in a market with problematic transactional characteristics would rely to a large extent on vertical integration, the study shows that the least integrated firm (PEMEX) seems to enjoy advantages over the more integrated firm (PDVSA), as revealed by a number of key indicators.

The corporate motivations of PEMEX and PDVSA, and their commercial policies are described. They led both companies to include in their respective commercial policies very distinct safeguards against breakdown and premature breach of their relationships with customers. The effects of these behavioural patterns on the every-day business of these customers are also investigated.

One of the book's theses is that the two-tiered market for heavy crude in the USGC has been created and perpetuated by the marked differences in the commercial policies followed by the duopolists since 1986, and by the learning process through which their customers have gone.

The process of price formation (and the outcomes of such processes) in the USGC market for heavy sour crudes are analysed. The most important finding is that a very wide price differential exists between Mexican and Venezuelan crudes. It appears to be unwarranted by any quality considerations. The magnitude and persistence through time of this price differential can only be explained if one posits that the USGC market for heavy sour crudes is a stable two-tiered duopoly, where one of the duopolists has successfully taken the lion's share of the high value end of the market and in consequence gets substantially higher prices for its crudes.

The surprising result is that a duopoly consisting of two equal-sized members should have a leader and a follower, while theory suggests that such a duopoly would yield co-operative outcomes. The book proposes explanations for this unusual phenomenon.

In conclusion, the authors suggest that, as a result of recent political changes in Venezuela, the institutional evolution of the USGC market for heavy sour crude might conceivably be heading towards a stage of greater convergence between the commercial practices of PEMEX and PDVSA. Such convergence might also result in PEMEX and PDVSA interacting commercially in a way that corresponds more closely to the conventional economic wisdom of how duopolists behave. The type of interaction would probably not lead to outright collusion, but the existence of better signalling mechanisms and channels of communications between the firms would certainly tend to inhibit aggressive undercutting practices. In any case, the future demand growth in this market will depend upon the shifting of the risk associated with variations in the light/heavy price differential from deep conversion refiners to PDVSA and PEMEX. Collaboration could significantly reduce the net present costs of the protection mechanisms offered to deep conversion refiners in order to ensure that the upgrading plants are built as and when required.

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ABBREVIATIONS

AD	Acción Democrática (Venezuelan political party)
ANS	Alaska North Slope
API	American Petroleum Institute
BD	Barrels per day
BCF	Bolívar Coastal Field
BCFD	Billion cubic feet per day
CERI	Canadian Energy Research Institute
CFD	Contract for Differences
CIF	Cost, Insurance and Freight
COCEP	Comité de Comercio Exterior de Petróleo (Mexico)
COPEI	Comité de Organización Política Electoral Independiente (Venezuelan political party)
CPG	US Cent per Gallon
DOE	Department of Energy (USA)
DOT	Department of Transport (USA)
EIA	Energy Information Agency (USA)
EOR	Enhanced oil recovery
E&P	Exploration and production
ERA	Economic Regulatory Administration
FCC	Fluid catalytic cracking unit
FERC	Federal Energy Regulatory Commission (USA)
FLRPS	Federal Law of Responsibilities for Public Servants (Mexico)
FOB	Free on Board
FRV	Fiscal reference value (Venezuela)
FSO	Floating storage and off-loading
GDP	Gross domestic product
GOMOCS	Gulf of Mexico Offshore Continental Shelf
GPW	Gross product worth
GSP	Government Selling Price
GT&Cs	General terms and conditions
ICHH	International Centre for Heavy Hydrocarbons
IEA	International Energy Agency
IMF	International Monetary Fund
IRR	Internal rate of return
IPE	International Petroleum Exchange of London
ISTEA	Intermodal Surface Transportation Efficiency Act (US)
LCRC	Lyondell Citgo Refining Company
LDC	Less developed country
LDNR	Louisiana Department of Natural Resources
LLS	Louisiana Light Sweet
LNG	Liquid natural gas
LPG	Liquid petroleum gases
MEM	Ministerio de Energía y Minas (Venezuela)
MBD	Thousand barrels per day
MMB	Million barrels

MMBD	Million barrels per day
MMBTU	Million British thermal units
MMS	Minerals Management Service (USA)
MMT	Million tonnes
MMUSD	Millions of dollars
MSOGB	Mississippi State Oil and Gas Board
MTBE	Methyl tertiary butyl ether
NGCI	Nelson Generalised Complexity Index
NEB	National Energy Board (Canada)
NHS	National Highway System (USA)
NOC	National oil company
NPC	National Petroleum Council (USA)
NWE	Northwest Europe
NYMEX	New York Mercantile Exchange
OAPEC	Organisation of Arab Petroleum Exporting Countries
OCS	Offshore Continental Shelf
OPEC	Organisation of the Petroleum Exporting Countries
OECD	Organisation for Economic Cooperation and Development
OSP	Official Selling Price
PADD	Petroleum Administration for Defense District (USA)
PDVSA	Petróleos de Venezuela S.A.
PEMEX	Petróleos Mexicanos
PIW	Petroleum Intelligence Weekly
R/P	Reserves to production ratio
RVP	Reid Vapour Pressure
SAGD	Steam assisted gravity drainage
Saudi Aramco	Saudi Arabian National Oil Company
SEC	Securities Exchange Commission (USA)
SOGBA	The State Oil and Gas Board of Alabama
SPR	Strategic Petroleum Reserve (USA)
STAA	Surface Transportation Assistance Act (USA)
TAN	Total Acid Number
TEA-21	Transportation Equity Act for the 21st Century (USA)
TRC	Texas Railroad Commission
UN	United Nations
UOP	Universal Oil Products
USD	US Dollars
USD/B	US Dollars per barrel
USD/T	US Dollars per Ton
USGC	US Gulf Coast
VLCC	Very Large Crude Carrier
WT%	Percentage by weight
WTI	West Texas Intermediate
WTS	West Texas Sour

1. INTRODUCTION

In practical terms, the oil industry and industrial economics go way back, to the days when Standard Oil's entrepreneurial tactics gave companies involved in the "biggest business" an unsavoury reputation that has stuck to them ever since. In formal terms, the association between oil and the study of industrial organisation is also one of long standing: Joe Bain (who is generally credited — together with Edward Mason — with launching the study of modern industrial economics as a discipline in its own right) derived the pillars of the "structure-conduct-performance" paradigm[1] from his empirical study of the operations of the oil industry in the US West Coast.[2] Up to 1973, the empirical furrow ploughed by Bain was profitably widened by many other scholars interested in finding out how the oil market functioned: Frankel, de Chazeau and Kahn, McLean and Haigh, Hartshorn, Adelman, Penrose, Frank, and finally Blair, who was responsible for the report on the *International Petroleum Cartel* prepared for the US Senate[3], one of the best — and arguably still the most important — piece of work ever done about the industrial economics of international oil. Unfortunately, as Mabro observes, after 1973, “the rich stream of works on the industrial economy of oil dwindled to a trickle … [as] the oil shock turned attention away from the industry towards … OPEC, an organisation which was then suddenly perceived as endowed with alarming power”.[4] The ultimate purpose behind studying a market is to shed light on the process of price formation in it and, throughout the 1970s, the determination of the price of oil was seen (for good reasons) as a process involving mainly geopolitics, rather than the ways in which buyers and sellers of oil interacted. As a consequence, "library shelves filled up with books about OPEC, often written in haste and most of them, sadly, poor in understanding and insight. The price of oil was construed as an OPEC affair, but the question of how and why OPEC set this price or that price in any relevant instance was rarely, if ever, answered in a fully satisfactory manner."[5]

Paradoxically, OPEC's rise to prominence obliterated the oil market from the public eye precisely at the moment when global oil demand and supply began to be balanced through the interaction of genuine arm's-length buyers and sellers, as opposed to the internal transfer mechanisms of the companies that controlled the bulk of the world's oil reserves. By 1981, the limits to OPEC's power to fix the price of oil had become

quite evident and the "answer to the question of what determines the oil price" gradually became "encapsulated in two deceptively simple words: the market".[6] The market taught OPEC a lesson during 1981—2 and even more so during 1985—6. As a result, OPEC faded away from both the headlines and research agendas.[7] However, in the aftermath of this realignment of power, most people became convinced that the most advisable course of action was to leave this deified market to its own devices. What these devices were, however, was not deemed worthy of being investigated in detail, even though “the loss of inside information that used to have direct operational effects upon the whole crude trade . . . [was] to some extent offset by a widening, perhaps deepening and certainly accelerating flow of information about and through the trade, via its open markets”.[8] Thus, it has come to pass that the oil industry, government policy makers and the general public increasingly rely on oil trade journals and/or oil industry consultants to digest this mass of *data* into usable *intelligence*, which can be used to gain "a comprehensive picture of international oil markets in all their broad scope and complexity".[9]

By its very nature, to say nothing of its cost, the work carried out by trade journals and oil consultants has a restricted circulation, and thus can only make a limited contribution in dispelling the darkness that surrounds oil markets, their actual mode of operation, the actors that participate in them, their performance and, finally, relationships with each other and their role in the formation of oil prices. Consultants and trade journals certainly have access to "a wealth of data and information from a wide array of unique and hard-to-access sources".[10] In many cases, though, the rigour of their work is compromised by an urgency to deliver news stories or reports to tight deadlines, or by a necessity to follow the ebb and flow of the managerial fads or, at times, by the need to push a certain ideological line. As a rule, trade journals and consultants do not avail themselves of hard-to-find data in order to question ideas that oil industry participants and outside observers may hold to be 'self-evident', but which in actual fact are not "thoroughly argued and solidly established truths, merely preliminary statements which on close examination open a research agenda".[11] Consider, for instance, the issue of downstream vertical integration by the national oil companies (NOCs) of major oil-exporting countries. Conventional wisdom has it that such a strategy permits exporters not only to "lock in secure market outlets" but also to reduce their vulnerability "to competitive market pressures".[12] It is very easy to

find this statement repeated time and again in trade journals, but the questionable assumptions that underlie it have almost never been seriously examined, let alone challenged.[13]

The present study is an exercise in applied economics whose main objective is threefold: firstly, to identify the modes of industrial organisation underlying the market for heavy sour crudes; secondly, to assess their efficacy; thirdly, to chronicle and explain the transformations that these structures have undergone through time. The study of the market for heavy sour crude is justifiable on practical grounds because of the great importance that this market has in the supply of petroleum products in key consuming countries, particularly the USA. Imports of heavy sour crude account for around a quarter of all US crude imports, and heavy sour crude oil runs are probably responsible for a similar proportion of the total domestic gasoline output in the USA. The study of this market is also of great interest at a theoretical level, since its microeconomic characteristics make it an ideal empirical vehicle to examine issues related to the organisational choices of firms, and which find expression in questions like the following: "what factors determine the institutional arrangements that govern supply relationships between input supplier and their customers? Why are some transactions internalised through vertical integration? Why are many transactions governed by long-term contracts? What determines the structure of such contracts and why are they used instead of simple spot transactions?"[14]

By mode of industrial organisation, one can understand both the "means by which *order* is accomplished in a relation in which potential *conflict* threatens to undo or upset opportunities to realise *mutual* gains", and also the overall "institutional framework in which the integrity of a transaction, or related set of transactions, is decided".[15] The study of modes of industrial organisation implies a theoretical exploration on the various dimensions on which transactions differ, the essence of the challenges that these differences pose and the nature of the commercial mechanisms through which these challenges can be overcome. Such an analysis poses considerable demands in terms of the required empirical substratum. As Williamson warns

> assessing transactions and assigning them to governance structures in a discriminating … way requires much more microanalytic knowledge of economic activity and organisation … Price and quantity of course remain relevant, but the contractual devices by which prices are made to track costs, the manner in which adaptations are effected, and the safeguards that are provided are not only germane but are sometimes decisive.[16]

Fortunately, the centrality of oil to the economic affairs of the USA means that the US Department of Energy (DOE) publishes price and import data at a level of disaggregation that is nothing short of extraordinary: quality (API gravity and sulphur content), volume, and other relevant information (port of entry, final destination, identity of buyer and final user, and so on) for all US crude oil and products imports on a cargo-by-cargo basis, as well as volume-weighted monthly delivered and FOB price series for crude oil exports from many countries as well as for specific crude streams. The DOE also publishes domestic crude oil first purchase prices by refining district, by API gravity and by selected crude stream, as well as refinery input of crude and feedstocks, quality (API and sulphur content) of the crude charged to refineries, and net production and per cent yield of petroleum products (all of these aggregated to the refining district level). In addition, the Louisiana Department of Natural Resources (LDNR) and the Texas Railroad Commission (TRC) publish highly disaggregated monthly input, output, inventory and sales figures for all individual refineries in those key states.

The study is divided into six chapters, in addition to this introduction. Chapter 2 provides some general considerations on transaction cost economics and idiosyncratic exchange, as well as a characterisation of the international oil market from a transactional point of view. This characterisation shows that the world oil market is segmented into two major and quite distinct sets: one for general purpose crudes, the other for specialty grades. The market for high viscosity, high sulphur crudes is by far the most important in the specialty group. These crudes can only be transformed into light fuels in specialised and costly deep conversion plants. As a result, the market for such crudes is in thrall to the problems inherent in bilateral monopoly due to asset specificity, since the profitability of deep conversion refineries depends on processing stable volumes of the low quality feedstocks for which they were specifically designed. Thus, commercial counterparts in the sub-market for heavy sour crude have to maintain long-term relationships that will always be under threat from their

inability to describe and discount all the relevant contingencies pertaining to the supply of the crude for which certain specific facilities are suited (since the various heavy sour commercial blends are not necessarily close substitutes for one another). The maintenance of such relationships is further complicated by a number of facts. Firstly, in absolute terms, there is a relatively small production volume of heavy sour crude available, although this same volume is large when set against the global availability of deep conversion capacity. Secondly, production of heavy sour crude is highly concentrated in only a few countries (with Canada, Mexico, the USA and Venezuela being the most important) and even fewer countries make a meaningful volumetric contribution to the international trade of this commodity. Thirdly, rigidities on both the production and the processing side of the heavy sour trade limit the strength of the forces of economic arbitrage as well as lengthening the amount of time it takes for the market to adjust to a situation of excess supply (or demand).

Chapter 3 functions as a bridge between the theoretical intuitions presented in the previous chapter and the empirical findings derived from an analysis of the wealth of microanalytic market data relating to the US refining sector, and compiled by the DOE. The first part of the chapter is essentially a description of the market for heavy sour crude in the US Gulf Coast (USGC) region, which is by far the largest of its kind in the world. This market is also of critical importance to the economic well being of Mexico and Venezuela, since it absorbs a high proportion of their crude oil exports. But quite aside from these facts, the selection of the USGC market as the central focus of attention for the study is warranted because the transactional handicaps identified in Chapter 2 affect it in an acute fashion. This market is particularly suitable to analyse and assess the effects of diverse instruments and strategies of commercial competition under adverse transactional conditions because the concentration of deep conversion facilities within the USGC (and the inflexibility of such plants in terms of their feedstock requirements) means that the refining system in the zone is more exposed to the complex microeconomic problems generated by idiosyncratic commercial relationships than any other refining centre, in the USA or elsewhere. This exposure is exacerbated because the market for heavy sour crude in the USGC is one for *waterborne imports* exclusively (which means that there is no credible short-haul supply alternative for refiners in the area), and also because competition in this market takes place between only two players that place stringent non-resale conditions

on their crudes: PEMEX and PDVSA. Intuitively, one would expect that participants in a market with such problematic transactional characteristics would rely to a large extent on vertical integration in order to conduct their exchange. For legal reasons, of course, foreign refiners have been effectively barred from integrating upstream in either Mexico or Venezuela, so vertical integration in this market would have to take the form of downstream integration into refining and marketing by PEMEX and PDVSA. But whereas PDVSA has bought shares in a large number of deep conversion plants, PEMEX has restricted its acquisitions to just one refinery. Paradoxically, in light of the fact that this is a market where vertical integration should in theory be a source of considerable competitive advantage, we show that the least integrated firm (PEMEX) seems to enjoy a position of commercial dominance over the more integrated firm (PDVSA), as expressed in a number of key indicators. The behaviour of these indicators through time suggests that the history of the market for heavy sour crude in the USGC since at least 1990 can be seen as a record of the gradual and progressive deterioration of the *quality* of PDVSA's fairly constant market share

In Chapter 4, we provide a background to the current dynamics of competition within the USGC duopoly for heavy sour crudes through a chronicle of the genesis of this duopoly in the late 1970s and early 1980s. Modes of industrial organisation are historically contingent social constructs, with unique features that have evolved in response to particular forces or needs, and which reflect the manner in which participants in a market have adapted to circumstances in their business environments, as well as their relationships with governmental entities. Thus, we underline the corporate motivations of PEMEX and PDVSA (whether their character be purely economic or otherwise) that led both companies to incorporate in their respective commercial policies very distinct safeguards against breakdown and premature breach of their relationships with customers. We also show the effects that these behavioural patterns have had on the everyday business of the firms that constitute the buying end of this tightly knit market.

In Chapter 5, we present and defend the hypothesis that the two-tiered market for heavy sour crude in the USGC has been created and perpetuated by the marked differences in the commercial policies that each one of the duopolists has followed

since 1986, on the one hand, and by the learning process that their customers have gone through in that time, on the other. We suggest that the concrete entrepreneurial practices (and the governance structures that underlie them) of PEMEX and PDVSA have played a key role in the evolutionary process of the market for heavy sour crudes in the USGC. After identifying and delineating the salient characteristics of the commercial policies of both companies (i.e. the nature of their term contracts, their stance vis-à-vis the spot and term markets, their degree of reliance upon inter-affiliate transactions, their efforts at export diversification and the nature of their pricing mechanisms), we argue that PDVSA has tended to exacerbate the bilateral monopoly problems inherent in repeated transactions involving heavy sour crudes (mainly by eroding the already scarce transparency in the market for such oil), and to increase the bargaining power of its commercial counterparts. This has had a discernible effect on the prices that Mexican and Venezuelan crudes are able to command in the market, a point that can be best appreciated through an examination of the microeconomic dynamics that predictable commercial behaviour on the part of a seller might tend to induce in lifters of heavy sour crudes.

Chapter 6 deals with the processes of price formation (and the outcomes of such processes) in the USGC market for heavy sour crudes. Their most important aspect is the existence of a very wide price differential between Mexican and Venezuelan crude that appears unwarranted by any quality considerations. The magnitude and persistence through time of this price differential can only be explained if one posits that the USGC market for heavy sour crudes is a stable two-tiered duopoly,[17] where one of the duopolists has successfully taken the lion's share of the high value end of the market and in consequence gets substantially higher prices for its crudes, while the other has ended up being cast in the role of supplier to more marginal plants (and this has a negative impact on its realisation prices). We point out that a large part of the differential between Mexican and Venezuelan prices can be explained in terms of the generous discounts applied to PDVSA's transfers of crude oil to affiliates in the USA. However, on the basis of statistical and econometric analysis we also show that there is a residual — albeit far from negligible — magnitude that cannot be accounted for by such transfer prices, and which therefore confirms the disparity in the competitive positions of both duopolists, and the deterioration in the quality of PDVSA's market share. Moreover, the differentials between the prices charged by each duopolist seem

to be relatively impervious to arbitrage (i.e. the customers buying the high-priced crude are nonetheless reluctant to change suppliers), even though the USGC market for heavy sour crude does not display the conditions that are supposedly required to confer stability on this sort of non-cooperative competitive outcome (notably the existence of massive asymmetries in size between firms). As a conclusion to the chapter, we offer a *post hoc* theoretical interpretation that can account for this very peculiar two-tiered structure, on the basis of a duopolistic market leadership model incorporating consumer loyalty.

In Chapter 7, we present a summary of our findings. We suggest that, as a result of recent political changes in Venezuela, the institutional evolution of the USGC market for heavy sour crude might conceivably be heading towards a stage of greater convergence between the commercial practices of PEMEX and PDVSA. If that were to be the case, the concrete conditions that have sustained a two-tiered duopoly will tend to lose importance. More importantly, such convergence might also result in PEMEX and PDVSA interacting commercially in a way that corresponds more closely to the conventional economic wisdom of how duopolists behave. The type of interaction would probably not lead to outright collusion, but the existence of better signalling mechanisms and channels of communication between the firms would certainly tend to inhibit aggressive undercutting practices. Quite aside from whether such convergence takes place or not, the future demand growth in this market will depend upon the shifting of the risk associated with variations in the light/heavy price differential from deep conversion refiners to PDVSA and PEMEX. Collaboration between these two firms — and possibly others — could significantly reduce the net present costs of the protection mechanisms that each one of them will have to offer deep conversion refiners in order to make sure that the upgrading plants necessary to keep up with the growth in heavy sour crude supplies are built.

NOTES

[1] This paradigm posits that "market structure (the number of sellers in the market, their degree of product differentiation, the cost structure, the degree of vertical integration with suppliers and so on) determines conduct (which consists of price, research and development, investment, advertising and so forth) and conduct yields market performance (efficiency, ratio of price to marginal cost, product variety, innovation, profits and distribution)" (Tirole 1988: 1).
[2] Bain 1944—7.
[3] Frankel 1946; de Chazeau and Kahn 1959; McLean and Haigh 1954; Hartshorn 1962; Adelman 1972; Penrose 1968; Frank 1966; Blair 1978; US Senate 1952.
[4] Mabro 1992: 6—7.
[5] Horsnell and Mabro 1993: 1.
[6] Mabro 1992: 7.
[7] See Mabro 1998b: 13.
[8] Hartshorn 1993: 121.
[9] *ICOMH* 1997: A1.
[10] *ICOMH* 1997: *ibid.*
[11] Horsnell and Mabro, *op. cit.*: 2.
[12] *ICOMH*, *op. cit.*: F35.
[13] Two notable exceptions are Aït-Laoussine and Wood-Collins 1988, Robinson 1989a.
[14] Joskow 1985: 281.
[15] Williamson 1996: 11—2.
[16] Williamson 1996: 143.
[17] In technical jargon, this oligopoly can be characterised as one where a stable Stackelberg (as opposed to Nash—Cournot) equilibrium prevails.

2. GENERAL CONSIDERATIONS

The motto "crude oil" designates all gas-free liquid hydrocarbons whose viscosity is equal to or lower than 10,000 millipascals/second, at a pressure of one atmosphere and original reservoir temperature.[1] This definition masks the considerable differences that exist between individual crudes as regards the physical characteristics that determine their respective economic values, however. Such differences imbue the trade for the various types of crude oil with distinctive features, because they affect the degree of freedom that refineries have to vary the composition of their crude inputs.

The Relative Economic Value of Crude Oil

The economic value of a particular crude oil depends upon three main factors: the costs that its processing entails, the cost of transporting it to a specific location and, most important of all, the volume and relative prices of the products that can be obtained from it (in other words, its Gross Product Worth, or GPW). The GPW of a crude is obtained by multiplying its yield of each type of petroleum product in the marginal refining configuration by its spot market price. The marginal refining configuration is that which clears the market by coming on- and off-stream in response to changes in the supply/demand balance for petroleum products. This configuration will generate a net variable margin tending towards zero (hence permitting refiners to cover the capital costs of the plant used to produce the marginal products yield, but no more).

There is a widespread belief that this freedom is very limited for all refiners, since it is held that "refineries are custom built to handle a particular type of crude", and that the cost of switching between crudes is prohibitively high.[2] This inaccurate perception describes the state of affairs that characterised the industry before the onset of the oil shocks and the great nationalisations of the 1970s. At that point in time, processing and transportation costs represented a significantly higher proportion of the price of crude oil than they do today. Moreover, the *raison d'être* of the Seven Sisters' extensive refining network was to monetise the differential petroleum rent generated by their oil production in the Middle East and Venezuela (as opposed to making profits on a stand-alone basis[3]). Hence, it made sense to minimise any downstream leakage of this rent by gearing the operations of refineries towards specific crudes. Also, as Bamberg notes, “refineries were designed to convert specific crude oil into

products *in proportions that matched the demands of particular markets*. They were not general purpose plants that could convert any crude oil into any yield of products … [although] there was some scope for adjustment to meet variations in conditions".[4] Indeed, the production and refining operations of the Seven Sisters were so finely tuned that the allocation of resources in the world oil industry outside the USA, Canada, Mexico and the centrally-planned economies depended on the internal transfer mechanisms of the companies that controlled the bulk of the world's oil reserves. Thus, up until the early 1970s, true arm's-length deals between third parties were seen only as an equilibrium instrument of last resort, used to remedy temporary imbalances arising from unexpected breakdowns in either the internal transfer mechanisms of the integrated companies or the long-term supply contracts that these companies maintained with non-affiliated refiners.[5]

From the late 1970s onward, the consolidation of spot and forward oil markets as centres of price discovery and price formation for the great majority of internationally traded crude oil, on the one hand, and the appearance of oil futures markets in response to the risk management needs of the industry, on the other, have made the global oil marketplace much more liquid. This has increased the opportunity costs faced by those firms whose rigid organisational structures pose a hindrance to their exploitation of the continuous (and evanescent) arbitrage windows that characterise the modern oil game. In turn, it has heightened the perception of obsolescence that has grown around integrated forms of organisation in all those markets where economic arbitrage operated with a reasonable degree of efficiency.[6]

Even though flexibility has become the byword for today's refining industry, there exist some refineries whose capability to switch between various feedstocks is truly very limited. Thus, the international oil market can be conceptually segmented into two distinct sets. On the one hand, there is a market for high and medium gravity crudes that can be processed in all refineries, ranging from the most complex to the simplest. On the other hand, there exists a market for non-fungible grades that have a very high value in specialised plants, and a considerably lower value in general purpose refineries. In the latter market, the scope for commercial exchange is restricted, with a small number of sellers mirrored by a similarly small number of buyers. Moreover, this exchange has a highly idiosyncratic tinge, since substantial

processing economies can be achieved not only by designing these specialised plants around a specific crude diet but also by restricting divergences from their design diets to the minimum (since switching costs for these plants are not trivial).

Refinery Complexity

Complexity is a measure of the capability to produce high-value end products in preference to residuals, given by the relative sizes and technical characteristics of the various units that conform a refinery (or refining system). Refinery complexity can be expressed through complexity indices, the best known of which is the Nelson Generalised Complexity Index (NGCI), developed by Wilbur Nelson in the 1960s to quantify the total cost of refining facilities on the basis of the relative cost of the various plants that conform them against the cost of a crude distillation unit. The distillation unit has a value of 1, and all other units are rated in terms of their cost relative to this unit. The NGCI for a given refinery is calculated by adding up the results obtained from multiplying the complexity factor for each unit in the refinery unit by the throughput of this unit relative to the overall crude distillation capacity.

There are four main markets for specialty crudes. Probably the most esoteric is the one for very waxy Asian grades suitable for direct burning in Japanese power plants. Almost as small in volume terms is the market for heavy crudes that are suitable feedstocks for low viscosity index naphthenic base oils (mainly used in the manufacture of transformer oils, process oils, and so on). Dwarfing these two markets in importance is the one for crudes which can be used in the production of paraffinic lube bases, which are high viscosity index oils used in the manufacture of motor oils, transmission oils and the like (products that account for about 90 per cent of global demand for lubricants). Paraffinic lubricant feedstocks are generally light and amenable crudes, which means that lubricant plants can – in principle — run on a great variety of crudes.[7] Nonetheless, the capability of lubricants plants to switch between alternative feedstocks is constrained because stabilising of a lubes train in a refinery is not a straightforward task (indeed, there are those who say that lubes production still requires equal parts of art and science), and a stable crude slate is a *sine qua non* requirement if a lubes plant is to meet stringent quality control targets on a consistent basis.[8] Finally, the largest specialty crude market in volume terms is that for crudes with low gravities and high sulphur contents. These can be used in the manufacture of asphalt or, alternatively, they can be transformed into light fuels in very specialised and costly deep conversion plants that give refiners the possibility of

substituting more expensive raw materials (i.e. lighter crudes) with cheaper ones by means of a more intensive application of capital.

The Market Value of Heavy Sour Crudes

Crudes with low API gravities (i.e. high density or specific gravity, or low volume to weight ratio) are less valuable because volatile compounds (like those that make up gasoline, kerosene or diesel) account for only a minor part of their composition, which is skewed towards fractions with higher boiling temperatures. Their high sulphur contents also makes them less valuable because sulphur compounds are pollutants, and their presence in petroleum products dramatically lowers the market price of the latter.

Lubricants are the least substitutable of all the by-products of crude oil (even more so than motor fuels), but the demand patterns of lubricants plants really have no bearing on the behaviour of oil prices (because their feedstock requirements represent a minuscule part — less than 2 per cent — of the world's crude oil throughput). In contrast, deep conversion refineries account for a much higher — although still minor — share of the total installed refining capacity in the world (in the USA, for instance, coking capacity is equivalent to about 14 per cent of atmospheric distillation capacity). Moreover, the influence of deep conversion plants on the oil market at large is considerable, since they play a key role in the supply of light fuels in some of the most important oil-consuming regions: deep conversion plants running heavy sour crudes produce around a quarter of all the light fuels consumed in the USA.

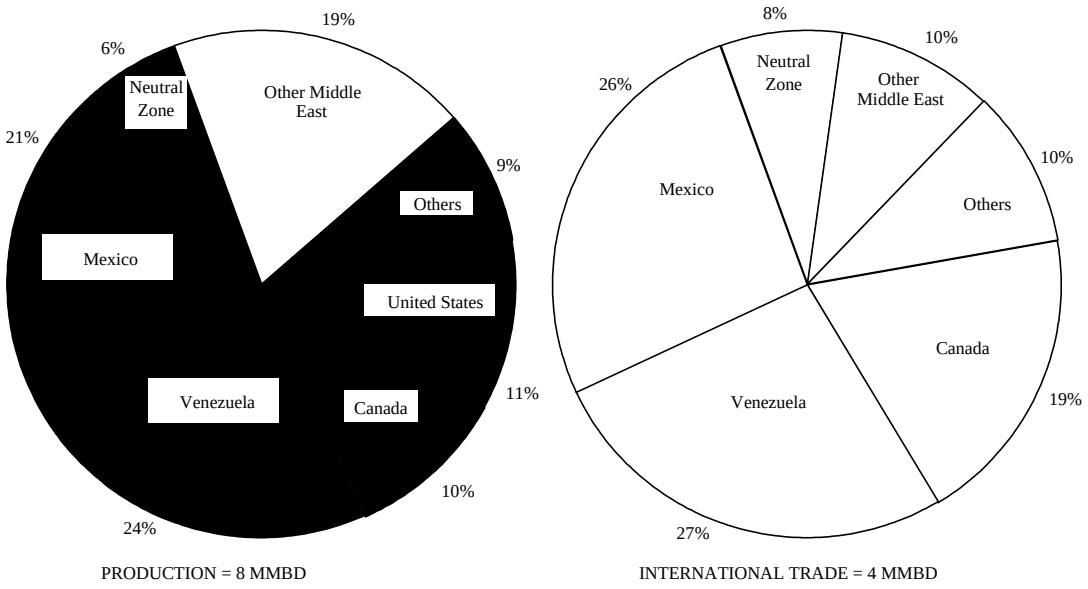
2.1 The Supply of Heavy Sour Crude

In terms of its size, the sub-market for heavy sour crude oils — conventionally defined as those that have an API gravity of 25° or less,[9] and a sulphur content of 1.0 per cent or more — represents but a fraction of that for light and medium crudes. On a worldwide basis, reserves of light and medium crudes are considerably more abundant than reserves of conventional heavy sour crudes.[10] In addition, the output slate of some exporters with large reserves of heavy sour crude has been skewed towards lighter grades, because the latter command higher prices. Thus, light and medium grades account for an overwhelming percentage of global crude production: in 1998, for instance, world oil output was about 66.5 MMBD,[11] while world output

of heavy (both sweet and sour) grades came only to about 9.2 MMBD.[12] In turn, about 1.2 MMBD of the latter figure is accounted for by crudes (produced mainly in Argentina, Brazil, Brunei, Cameroon, China, Egypt, Indonesia, and the North Sea) that have a low API gravity, but are also less sulphurous.[13]

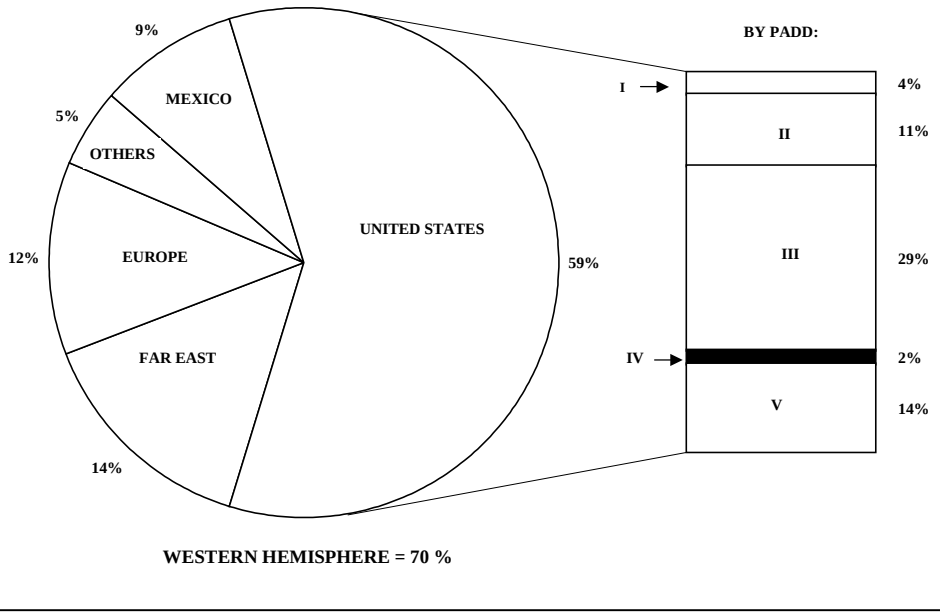
There are currently very few producers whose output of high sulphur low gravity crudes approximates, let alone exceeds, the 500 MBD per day mark (see Figure F2.1). If one considers only internationally traded crude oil, the picture is more unbalanced still: heavy sour crudes accounted for — approximately — 4 MMBD of the 37 MMBD of crude oil that moved in international trade in 1998 (the year at the end of a brief period when worldwide output of this type of crude was not constrained by OPEC quotas or other negotiated supply restrictions). The difference between output and the volume of international trade is due, in part, to the domestic processing requirements of some major producers of heavy sour crude (like Mexico). However, it also reflects the fact that a proportion of the exportable heavy sour output does not reach the international oil market in that form, because many producers of low quality streams — Saudi Arabia, Kuwait, Iraq, Ecuador — blend them into higher quality export streams (Arabian Heavy, Kuwait Blend, Fao Blend, Oriente, respectively).

FIGURE F2.1: THE SUPPLY SIDE OF THE WORLD MARKET FOR HEAVY SOUR CRUDE (1998)



Both on the supply and the demand sides, the heavy sour crude scene has a strong Western Hemisphere bias. Together, the USA, Canada, Mexico and Venezuela account for upwards of 65 per cent of global output. The latter three countries contribute around 75 per cent of the internationally traded heavy sour crude. On the demand side, concentration is also the rule: the USA alone consumes nearly 60 per cent of global output of this type of crude, and provides a market for about 70 per cent of the internationally traded heavy sour crude streams (Figure F2.2). About 90 per cent of the heavy sour crude produced in the US comes from, and is processed in, PADD V[14] (specifically, in California). Refineries in PADD III, which includes the US Gulf Coast (USGC), absorb nearly 30 per cent of the total worldwide supply of heavy sour crude oil. Most of this supply is imported, with USGC refineries accounting for approximately 65 per cent of total US imports of heavy sour crudes (and about 80 per cent of non-Canadian heavy sour imports). Both California and the USGC rely to a large extent on heavy sour crude to meet their crude requirements: in the former region, domestic heavy sours account for about 70 per cent of output and about 60 per cent of crude runs, while in the latter, imported heavy grades are responsible for about a third of total crude imports and a quarter of crude runs.

FIGURE F2.2: THE DEMAND SIDE OF THE WORLD MARKET FOR HEAVY SOUR CRUDE (1998)

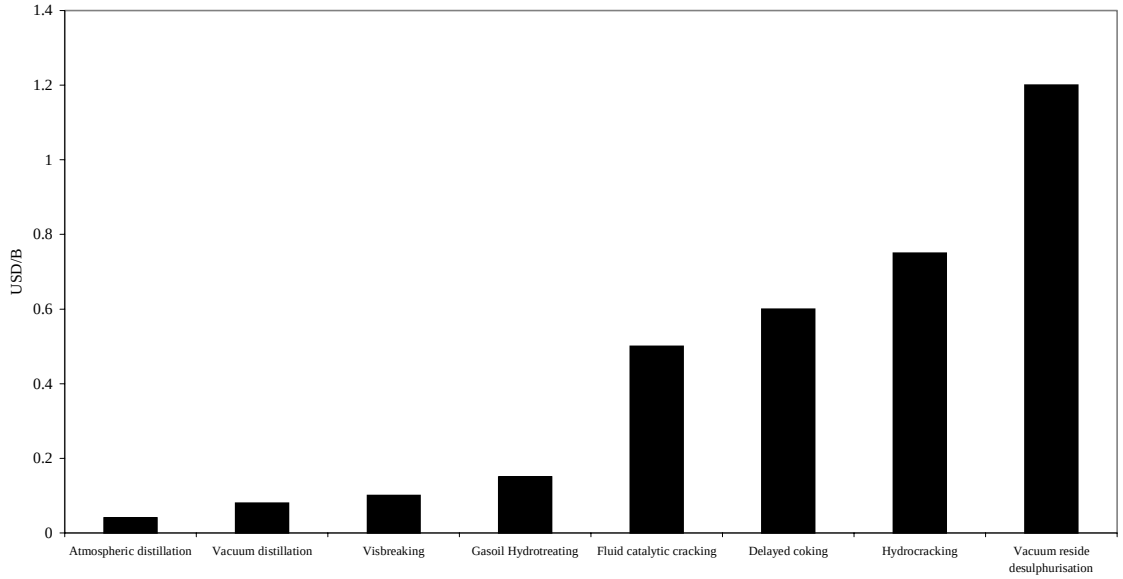


The supply of heavy sour crude oil is highly price-inelastic in the short to medium term. Because of the high production costs that prevail in the USA and Canada, output of heavy sour crude responds quickly to prices, but only when these are falling; in these same areas, supply increases in times of rising prices are constrained by the physical limitations of very mature reservoirs. Production costs in Mexico and Venezuela are relatively low, and this means that, in the short to medium term, in neither of these countries does output respond to low prices in the way that it does in North America.

2.2 The Demand for Heavy Sour Crude: Deep Conversion Plants

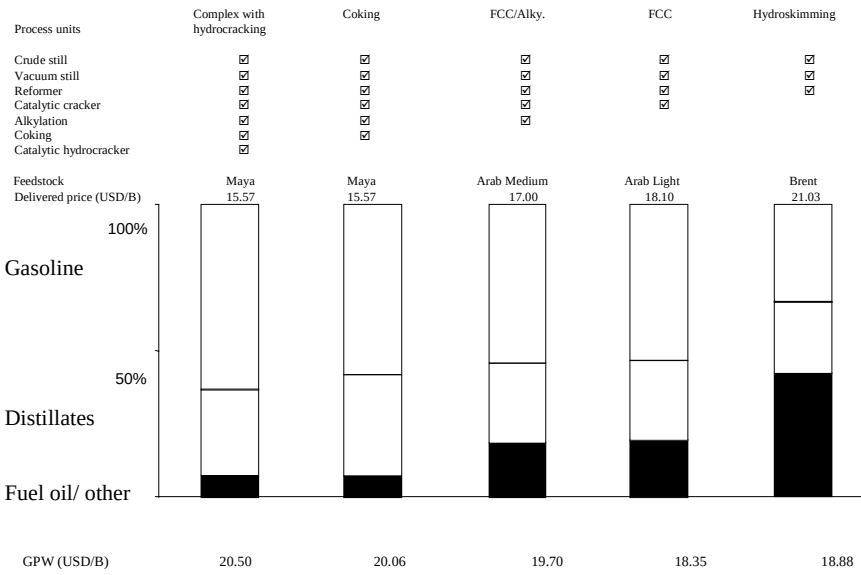
Most of the heavy sour crude processed in major oil consuming centres is run by companies that have decided to capitalise on its most favourable characteristic — a low acquisition cost — to increase their variable refining margins. Deep conversion offers refiners the possibility of obtaining high value products from low cost raw materials (i.e. atmospheric, vacuum and cracked residua) through the adoption of a material balance that is very different from that required by the processing of more amenable grades. This is not an altogether easy path to travel, however. The plants that can handle this sort of material balance (notably cokers, which are thermal conversion units that operate at extreme temperatures and pressures) are very expensive to build and run in comparison to less complex ones (Figure F2.3). Nevertheless, the potential rewards for refiners that decide to go down this route can be substantial, since deep conversion plants generate much higher GPWs than less complex plants. As can be appreciated in Figure F2.4, in 1997,[15] the GPW of a US coking refinery exceeded that of a hydroskimming refinery by around 1.30 USD/B. Moreover, the landed price of a typical coker feedstock (Mexican Maya crude) was 15.57 USD/B, so the coking margin came to 4.49 USD/B. In contrast, the landed price of a typical hydroskimming feedstock (North Sea Brent blend) was 21.03 USD/B, meaning that this type of plant would have generated a negative margin of 2.15 USD/B on every barrel of Brent processed that year.

FIGURE F2.3: VARIABLE OPERATING COSTS FOR VARIOUS REFINING PROCESSES, NWE AREA



SOURCE: Gray and Hudson 1995

FIGURE F2.4: REFINERY COMPLEXITY AND PRODUCT SLATE VALUE (1997 PRICES)



The market for heavy sour crude oil is characterised by a demand function with a very pronounced slope (see Figure F2.5), in which processing margins fall significantly as one moves towards progressively less complex plants. Thus, the coming on-stream of new deep conversion plants, so long as it is not accompanied by an increase in the

supply of heavy sour crudes, has a *strongly positive* impact on the price of all the heavy sour crude in the market, and not just on the crude processed in the new conversion capacity.[16] This means that heavy sour crude oil producers have a clear cut incentive to increase the aggregate demand for these crudes, since this will have a positive repercussion on the price of the rest of the volume that the producer sells in any given local market (in other words, it will lead to a tightening in the price differential between clean and dirty products). In contrast, the slope of the demand function for light and medium crudes is modest, and the differential between the GPWs achievable by refining them in simple or more complex configurations relatively small (Figure F2.6). The light products yield of such crudes when subjected to atmospheric and vacuum distillation is high relative to their yield of bottoms, and the former yield can be further increased to almost 100 per cent by the straightforward expedient of charging these bottoms to an FCC unit. The quality and further processing requirements of these bottoms will vary significantly according to the sulphur content of the crude from which they were produced, but these requirements will always be less severe than those posed by heavy sour crudes. Under normal circumstances, subjecting higher quality crudes to a severe upgrading process like coking will make sense mainly if a refiner wishes to obtain a specialty product (anode grade coke, say), or if a refinery is in a position to exploit a location advantage by so doing (because of its geographical situation relative to a certain crude oil pipeline, for instance[17]).

Graphical Representation of the Oil Market

Oil markets can be represented as step production functions. The Y values are the typical refining margins for the different refining configurations, arranged either ordinally or cardinally (ordinal measures rank yields by decreasing order of complexity while cardinal measures rank yields by the GPWs obtained in each configuration). The X values represent the total processing capacity available for each one of those configurations (determined on the basis of design capacities for the various plants, since actual capacity is affected by the type of crude oil processed), the sum total of which represents total crude demand (conversely, the total volume of crude supplied will determine the amount of refining capacity needed for the market to clear.). The actual shape of this demand curve — number and size of steps, and difference in refining margins obtainable at each step — depends on the overall complexity of the refining system in a given area. The various types of processing capacity present in a system will be run sequentially in decreasing merit order of complexity.

FIGURE F2.5: SCHEMATIC REPRESENTATION OF THE MARKET FOR HEAVY SOUR CRUDE OIL

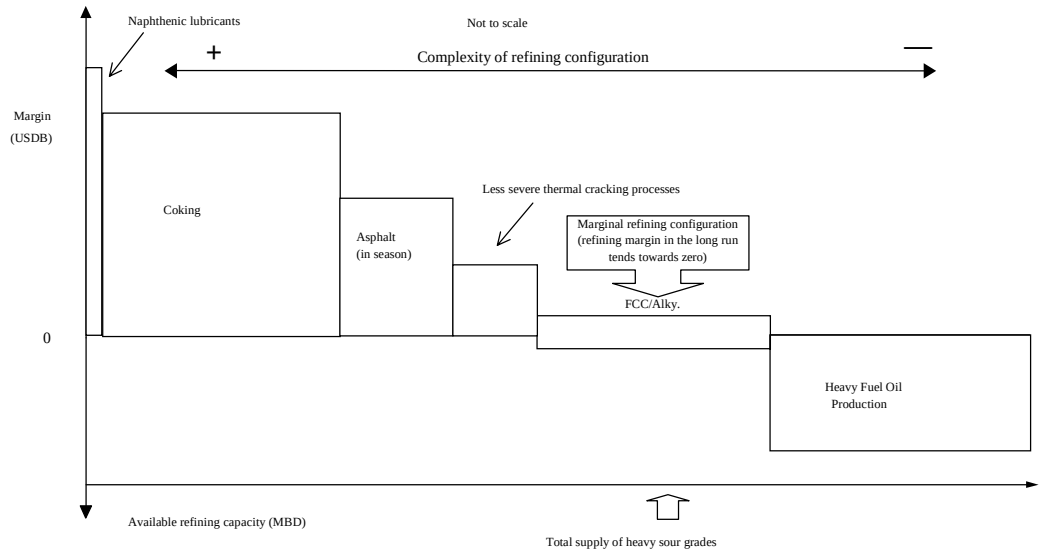
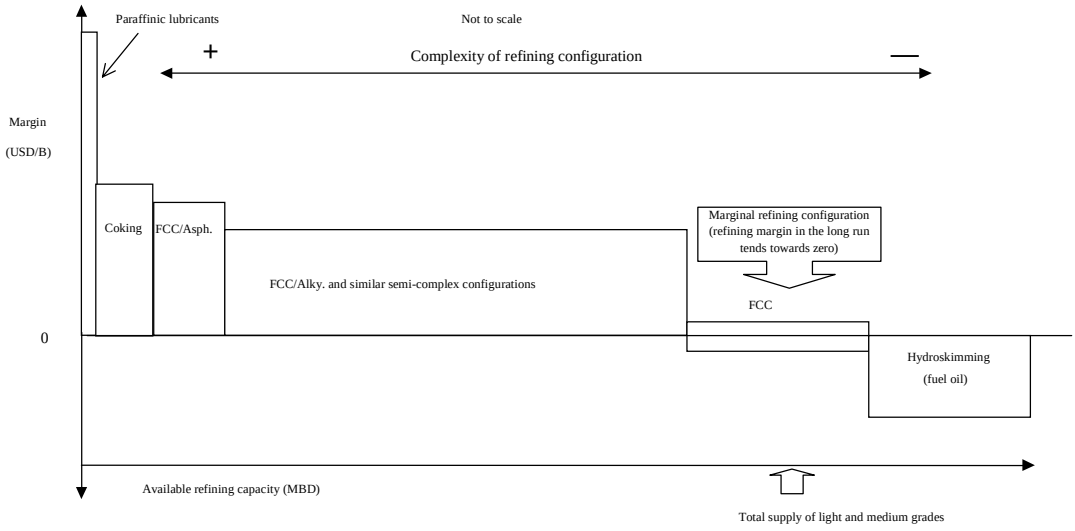


FIGURE F2.6: SCHEMATIC REPRESENTATION OF THE MARKET FOR LIGHT AND MEDIUM CRUDE OIL

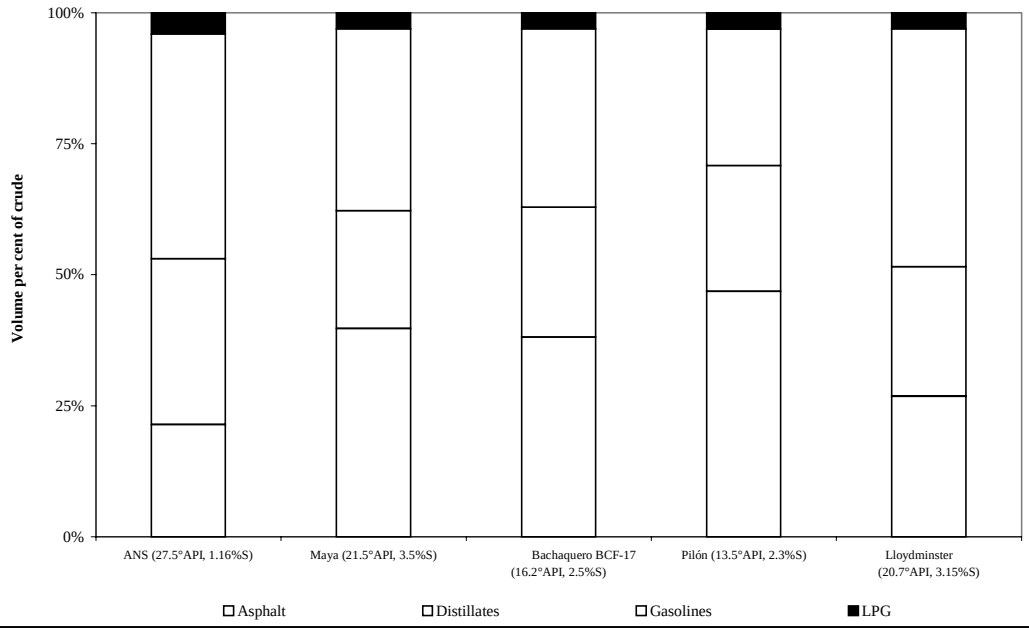


2.3 The Demand for Heavy Sour Crude: Asphalt

Asphalt is a product that commands a relatively high price, and can be produced with minimum refinery hardware at a very low cost. Asphalt specifications do not require

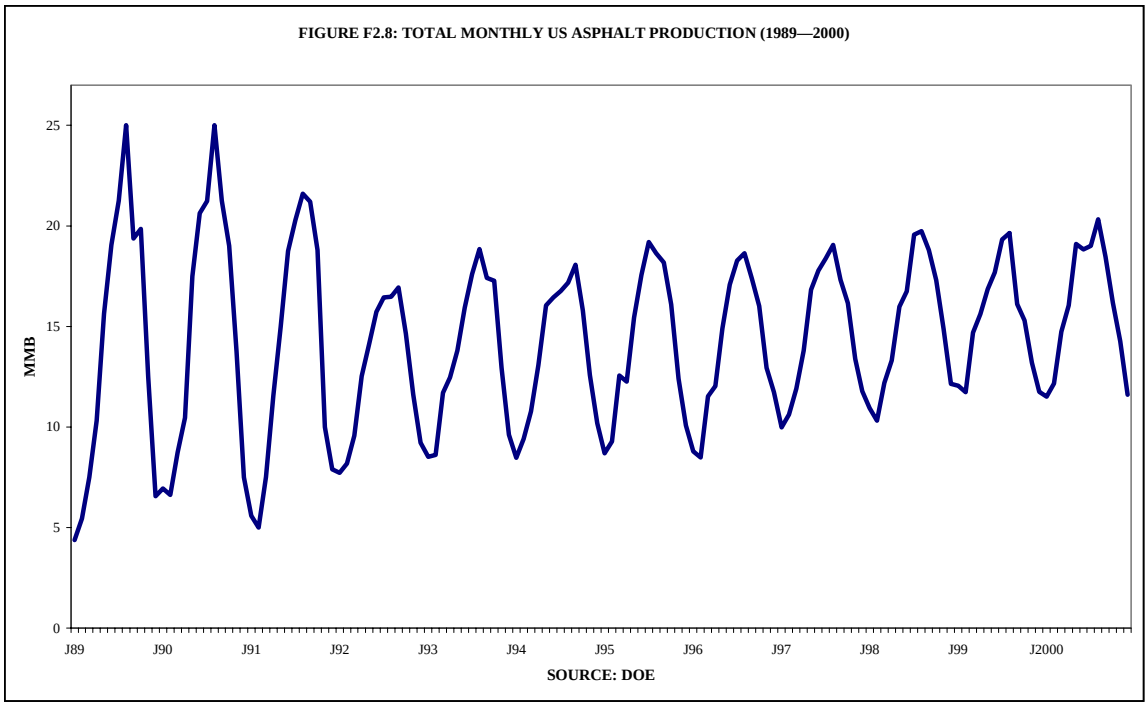
low viscosities and sulphur levels (indeed, sulphur actually improves asphalt quality). This eliminates the need for either hydrotreating residual fuel oil, or blending valuable cutter stock in the residual pool, both of which add to refinery profitability. Hence, like deep conversion, asphalt production offers refiners an attractive alternative to turn some of the least redeeming traits of heavy sour crude oils to profitable advantage (Figure F2.7).[18]

FIGURE F2.7: REFINED PRODUCT YIELDS OF SELECTED CRUDES, ASPHALT CONFIGURATION



Asphalt accounts for only a very small share of total petroleum product consumption in the most important oil-consuming markets (around 3 per cent in the USA, for instance). Moreover, the asphalt market is characterised by an extreme seasonality, which means that the scope for asphalt production is restricted to the summer months. Thus, asphalt production can absorb but a fraction of the heavy sour crude available in the oil market at any time. The behaviour of the asphalt market has a considerable influence on the price of heavy sour crudes during the paving season but, in the long run, the key driving force behind the heavy sour market (at least from the early 1980s onwards, when fuel oil production in the USA ceased to be profitable) has been the processing economics and transactional characteristics of the deep conversion market segment. As Figure F2.8 shows, the large variations in demand for asphalt mean that the crude demand of asphalt refineries fluctuates throughout the year. In contrast, the

crude demand of deep conversion refineries is stable, because of their need to maintain the highest processing rates possible.[19] Asphalt refiners certainly prefer to have a stable crude slate (because that makes quality control easier), but their hardware is rather more flexible than that of deep conversion refiners, and their feedstock switching costs are, consequently, much smaller.[20]



2.4 Transactional Characteristics of the Market for Heavy Sour Crude

Like other specialty plants, deep conversion refineries have to be built and operated with one particular base load in mind. Building flexibility into this sort of unit not only requires significant incremental capital outlays but also entails substantial opportunity costs (in terms of excess capacity in some processing units). Processing specific feedstocks enables the refiner to achieve an optimal use of his conversion assets from a technical point of view. Thus, even when running at capacity, deep conversion refineries face substantial opportunity costs if, for whatever reason, they deviate from the base load that optimises their operations. By the same token, sellers of heavy sour crude oil face the prospect of much lower realisation prices if deep conversion refiners decline to buy their output. Thus, there is a strong bilateral

dependence between deep conversion refiners (as buyers) and the sellers whose crudes are used to conform the base slates of the former. This dependence — which, in technical terms is referred to as a condition of bilateral monopoly brought about by asset specificity — is the source of potentially ruinous contractual hazard but also of very significant productive benefits for both buyers and sellers. For these reasons, commercial counterparts in the market for heavy sour crude oil are forced to maintain long-term relationships that will always be under threat from their impossibility to describe "all relevant contingencies pertaining to the supply of a good or service", and to discount these contingencies "with respect to both likelihood and futurity".[21]

The Base Load and Base Slate of a Refinery

The *base load* of a refinery need not consist of a specific crude blend; rather, it is a volume of crude charge with well defined characteristics — in terms of API, sulphur and other parameters like metals, asphaltenes, etc. — that the refiner puts together using one or several of the crudes available in the market. The crude or crudes that a refiner uses to conform this base load, on the basis of contractual commitments that cannot be unwound in the short term, constitute that refiner's *base slate*.

In marked contrast to the situation described above, the market for light and medium crudes is both liquid and reasonably efficient, because large numbers of producers, end users and traders exchange in it a fungible commodity that can be processed anywhere and is produced in large volumes. This characteristic, plus the fact that a sizeable volume of this type of crude is sold on a purely spot basis, permits buyers to tap alternative sources of supply easily while giving sellers ample opportunities to find buyers for their volume. General purpose refineries can certainly derive some advantages from processing only one particular type of crude: a constant supply of crude oil of uniform quality means that a refiner can adjust his facilities to boost the yields of some products through an improved optimisation of cut points and unit/process severity, enhance the quality of these products thanks to simplified blending, and reduce inventory requirements, downtime and direct and indirect labour. However, these advantages are overshadowed by the opportunities associated with commercial arbitrage. To a large extent, then, the code of conduct that prevails in the market for light and medium crudes is that inherent in what Macneil calls the "neo-classical contract" for individual transactions: "sharp in by clear agreement,

sharp out by clear performance".[22] However, that does not mean that reputation and identity of the participants in this sub-market are irrelevant (as they are in the quintessentially faceless futures markets). As Horsnell and Mabro observe regarding the forward Brent market (probably the most developed of these markets), "[it] is a small world, where the participants are very well known to each other",[23] and where there is also an unwritten code of conduct which, while "similar to that of a private club", nonetheless compels quite a high degree of observance from participants, since "in the longer term no serious trader wishes to be blackballed".[24] Nevertheless, the most important requirement for participating in this market is not so much commercial reputation as financial wherewithal for, as these same authors point out, "companies in the market are more likely to refuse to trade with participants they suspect. They are far more worried about the credit-worthiness of trading partners than they were in the past. Companies running into financial difficulties tend to find that the number of those prepared to deal with them dries up very quickly".[25]

The condition of asset specificity has a major incidence on the behaviour of prices in the market for heavy sour crudes. In particular, the relatively steep switching costs that deep conversion refiners face when they have to alter their crude slates influences the reservation prices that they would be prepared to pay for their supplies.[26] The recorded commercial performance by a seller (especially in terms of a perceived keenness to restrict supplies opportunistically at the margin or price-discriminate against clients whose demand elasticities are known to be very low) will strongly condition the scope for future trades. Thus, the prices at which specific cargoes change hands in this market are *path dependent*, and all individual transactions are imbued with a relational character. This means that commercial reputation (which is a function of the memory of market participants) is of paramount importance in this market, with the names of firms becoming labels of sorts, "plainly printed with the bottled essence of [their] past behaviour".[27] Unsurprisingly, most commercial relationships in this market are mediated by term supply contracts: an upgrading plant that does not "term out" a significant part of its base load charge will be at the mercy of either opportunistic suppliers or of the unpredictable vagaries of the residuals market (which is where a refiner would have to turn in order to acquire coker feed if heavy sour crude supplies were to suddenly dry up). Hence, the price of term

volumes of heavy sour crude that constitute a refiner's base slate may incorporate a security premium element not present in the price of volumes that are not termed up.

Participants in the market for light and medium crudes likewise maintain on-going commercial contacts, but transactions involving light and medium crude oils (especially those that occur on a spot basis) can be said to be discrete — as opposed to relational — because both the recurrence and the price at which future deals will take place are not contingent upon the division of surplus between counterparts that occurred in previous deals. Both on the selling and the buying side, the tempo of the market is set by arbitrageurs, out to extract as much surplus from their counterparts as they possibly can, using any legal (and, on occasion, illegal) means at their disposal. Indeed, the prevalence of this live and die by the sword ethos means that, so long as they are important enough, some firms can lapse into quite serious breaches of trading etiquette (e.g. mounting squeezes and corners, not answering their telephones to avoid being 'clocked' with wet cargoes) without their standing in the market at large being compromised.[28] As Williams observes, "in markets where traders constantly search for a tiny price discrepancy or an opportunity to move more quickly than others … [and] where clever trading is the norm, the line separating acceptable from unacceptable practice cannot be easily drawn, yet it can be easily crossed", so much so that it is difficult to define when "aggressive trading become[s] market tampering".[29] For this reason, liquid markets of this type have little by way of memory. Actors that drive the hardest possible bargain in this market will not impact the prices that their counterparts will be willing to pay in as yet unrealised transactions. At most, they will only motivate these counterparts to try and give in the future as good as they have received in the past.

The margin of manoeuvre of sellers and buyers in the market for light and medium crudes will tend to be more limited to the extent that they sell (or buy) by means of term contracts, which are not as flexible as pure spot transactions. Hence, as Bacon and Mabro point out, "crude oil exchanged under long-term contracts (or, more exactly, within the framework of long-term relationships between a buyer and a seller) is likely to be priced differently from oil sold in spot transactions … [but] the differential is unlikely to reflect exactly the economic value of the security that term contracts afford sellers in a glut or buyers in times of shortage."[30] But even though

there will always be "odd situations where the term price involves a premium in a buyer's market when it should be sold at a discount, or where it involves a discount in a seller's market instead of a premium",[31] competition and arbitrage will tend to limit both the duration and severity of these distortions between term and spot prices. The same is not true for heavy sour crudes, however.

2.5 Economic Drivers of the Market for Heavy Sour Crude

As we have noted before, the economic rationale for deep conversion plants therefore lies in the high processing margin that can be generated by upgrading large amounts of very low value feedstocks (residuals obtained from heavy sour crudes) into light products like gasoline and diesel, compared to those obtainable in less sophisticated configurations in which these crudes have to be used to produce high sulphur fuel oil. This margin differential is highly correlated to the differential between light and heavy crudes, and also to the differential between clean and dirty products (see Figures F2.9 and F2.10).

FIGURE F2.9: DEGREE OF CORRELATION BETWEEN SELECTED VARIABLES, 1992—2000

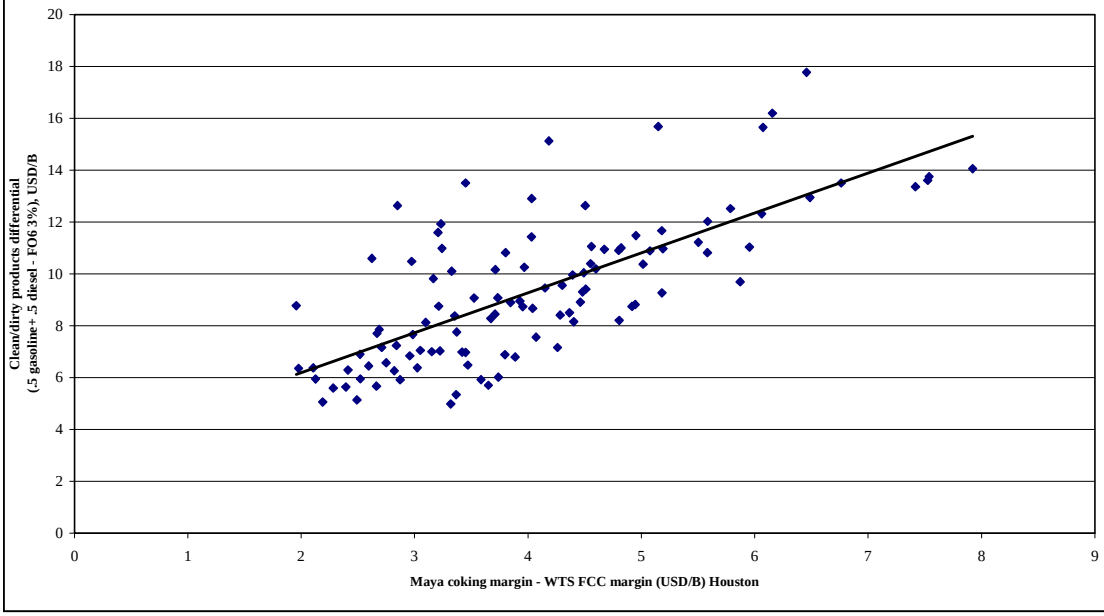
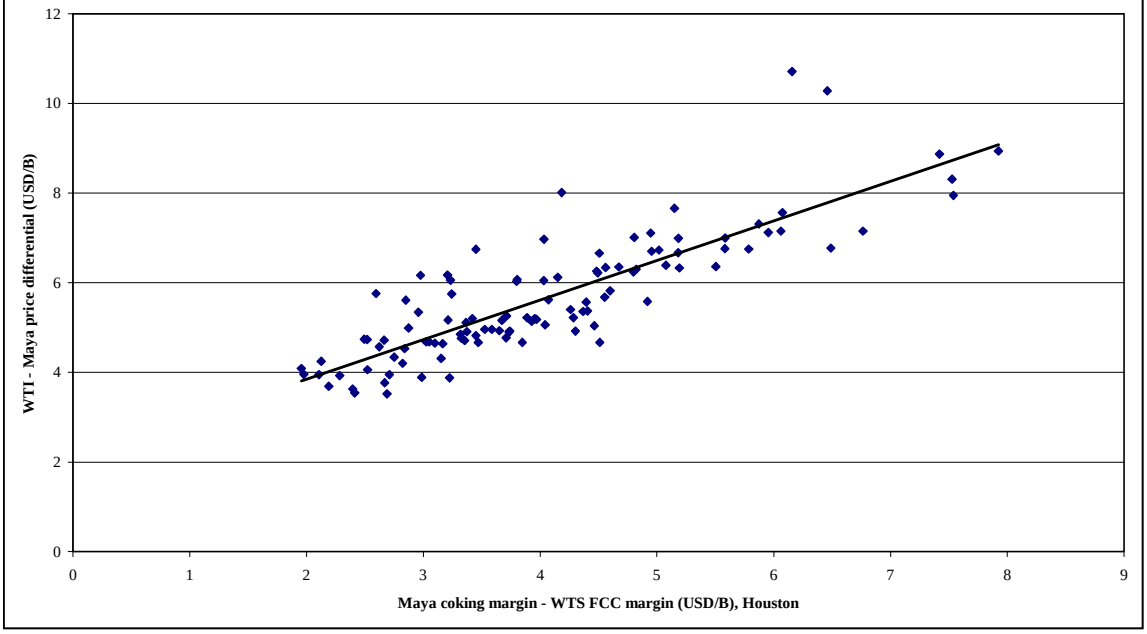


FIGURE F2.10: DEGREE OF CORRELATION BETWEEN SELECTED VARIABLES, 1992—2000



The processing margin of deep conversion plants hinges essentially on the behaviour of the light/heavy differential (the margin will be larger when the relative price of heavy products against light products is low). To an important extent, it also depends on the international price of oil (since this price determines the upper boundary for the absolute — rather than the relative — price of fuel oil). Thus, the returns on upgrading investments will vary according to the interaction through time between these two factors. Simplifying, one can say that this interaction can take four main forms, summarised in Table T2.1 for the period 1992—2000 in the form of a matrix. These are: wide differentials with high absolute crude prices, wide differentials and low absolute prices, narrow differentials and low absolute prices and, finally, narrow differentials and high absolute prices.[32] The first price/differential scenario is excellent for both refiners and producers of heavy sour crudes, but has seldom materialised since 1986 (the years 2000—2001 are notable exceptions to this). The structural transformation of the international oil market from a cartelised seller's market into a commoditised buyer's market explains the prevalence of the second and third differential/price scenarios from 1986 onwards: both are unfavourable to crude producers, although the third scenario is quite ruinous for refiners as well. The fourth scenario is the least convenient one for refiners, but in the past fifteen years it has not been common either, not least because long spells under such conditions tend to put

refining companies out of business and, hence, to exert downwards pressure on the price of crude. It is clear, therefore, that between 1992 and 2000 at least, the interaction between crude prices and differentials has been apparently favourable for deep conversion refiners. Indeed, since the early 1980s, the price of heavy sour crude oil relative to that of light crudes has been moderate. Although this price differential has exhibited a cyclical pattern of behaviour, the periods during which it has been wide have been longer and more common than the periods during which it has been low. Nevertheless, historical returns on coking investments — particularly in the USA — have not only been very volatile but also rather poor (i.e. expected returns have been higher than observed returns). As a result of the unpredictable way in which the light-heavy differentials have widened and narrowed, US refiners have adopted an extremely cautious approach with regard to capital projects exposed to this differential risk.

Table 2.1: Frequency of Different Crude Price and Crude Price Differentials Scenarios (Daily Ten-Day Moving Average), 1992—2000

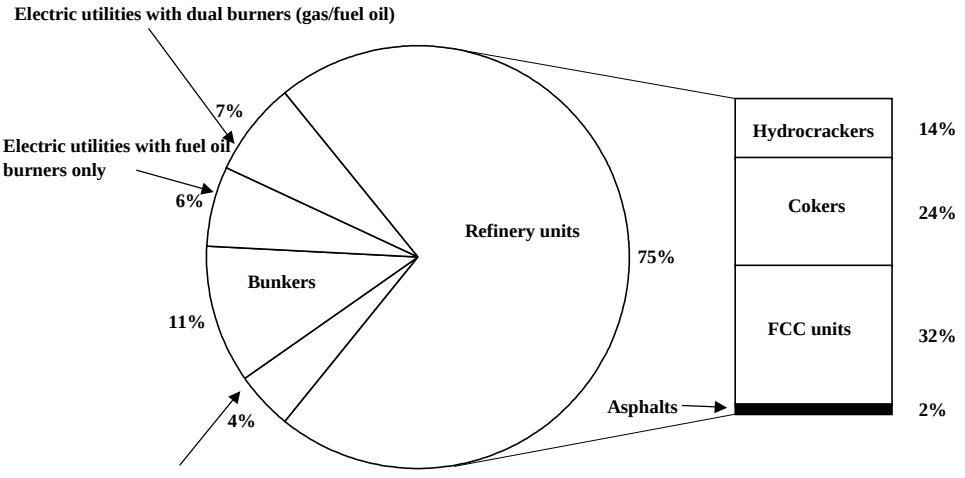
		LIGHT/HEAVY DIFFERENTIAL	
CRUDE PRICE		*WIDE (WTI - Maya ≥ 5)*	*NARROW (WTI - Maya < 5)*
	HIGH (WTI ≥ 18 USD/B)	**381**	**399**
	LOW (WTI < 18 USD/B)	**1,504**	**474**

Sources: *Platt's* , PEMEX

The logical counter for narrow light-heavy differentials is an increase in the supply of heavy sour crudes. Traditionally, though, no producer of this type of crude has been in a position to increase its output significantly in the short term. Refiners can try to palliate the effect of very narrow light-heavy differentials by supplementing their crude charge with residuals (vacuum gas oils, long atmospheric residues, uncracked fuel oil) sourced from other markets. However, the impact that this type of arbitrage can have is limited, since the availability of such residuals is both restricted and subject to strong variations (being as they are — literally — residual by-products of a

process geared to the manufacture of light fuels). Nevertheless, the fact that refiners that normally process heavy sour grades can also physically handle lighter crude varieties means that very narrow light-heavy differentials tend not to endure for long. Thus, heavy sour crude can only appreciate against lighter grades up to the point where deep conversion refiners will start to find the substitution of the former with the latter economically attractive, after taking switching costs into consideration. This substitution threshold, in a word, determines the ceiling price for heavy sour crude oil. This ceiling is very rigid because, as Figure F2.11 shows, processing units in refineries absorb the bulk of the 650° F cut produced worldwide, with coking plants being the recipients of the material that is poorest in quality. Thus, even small downwards adjustments in the relative amount of low quality residuals charged to cokers will have a major effect on their supply/demand balance in any given area.

FIGURE F2.11: DEMAND STRUCTURE FOR RESIDUAL STREAMS (650°F+ MATERIAL) IN THE USGC, 1999



SOURCE: DOE

Since the supply of heavy sour crude oil, particularly in the Western Hemisphere, is highly price-inelastic, the main corrective mechanism when wide differentials between dirty and clean products prevail is the incentive this gives refiners to build processing capacity specifically tailored to heavy sour crudes. Investments in additional upgrading capacity take a considerable amount of time to mature, so wide

light-heavy differentials can subsist for long periods, during which existing deep conversion plants may enjoy windfall profits. This situation arises because general-purpose refineries are only able to absorb very limited amounts of heavy sour crudes, even when the price of these feedstocks is very low. In other words, the competitive equivalence principle between light and medium crudes, on the one hand, and heavy sour crudes, on the other, does not hold.

The Competitive Equivalence Principle

The competitive equivalence principle assumes that all crudes are perfect substitutes for one another in the marginal refining configuration, where they all generate the same processing margin (i.e. zero). If a refinery generates a greater margin from one specific grade, it will demand more of that grade and the price of this grade will go up; if a given grade generates a lower margin than some other one, less of the former will be demanded, and its price will be depressed. This principle posits that refiners will always be able to switch between different crudes (regardless of how far apart these might lie on the quality spectrum), and that the relative prices of any pair of crudes will always reflect the correct economic valuation of their characteristics at the margin (differences in their respective GPWs, processing and transportation costs, and any other relevant factors).

The fact that arbitrage between heavy sour crudes and better quality grades is blocked by physical constraints means that downward adjustments in the supply of the latter has little effect on the price of the former, whenever there exists a situation of excess supply of residuals. Indeed, under normal circumstances, light and medium crude market factors have only a slight impact on the degree of competition prevailing in the market for heavy sour crudes. Their contribution is limited to making the latter not so much competitive as contestable, and then mainly *in extremis* (i.e. during those rare periods when the price of the heavy sour crudes relative to lighter grades is so high that deep conversion refineries become almost indifferent between these two types of feedstock).

Heavy Sour Crudes and the Competitive Equivalence Principle

The adverse physical characteristics of heavy sour crudes mean that there are many refineries that cannot process these crudes, even if their price is effectively zero. Secondly, unlike better quality crudes, heavy sour crudes interact in a very complex fashion with other feedstocks, and therefore their true economic value for a given refiner will differ significantly from the value calculated on the basis of the standalone yield of the incremental heavy sour barrel (these interactions can only be accurately modelled by means of linear and non-linear programming techniques).

The forces of arbitrage that link the markets for light and medium crude and heavy sour crude to one another are clearly asymmetrical. As a result, since the mid-1980s, the lower boundary for the price of heavy sour crude in times of wide light/heavy differentials has not been determined directly, through the incremental demand for heavy sour crude from general purpose refiners in times of low prices for heavy sour grades. Instead, it has been determined indirectly, through indirect inter-fuel competition between residual fuel oil and coal in electricity generation in those consuming countries where there is a large capacity of thermally efficient coal-fired plant running on baseload.[33] Such capacity is overwhelmingly concentrated in the USA, a country that, in addition, is the coal producer whose marginal costs of production determine the price of internationally-traded coal in the Atlantic basin, if not on a worldwide basis.[34] Interestingly, inter-fuel switching at electricity generation plants with a dual burning capability plays a key role in the arbitrage between natural gas and fuel oil, but not between the latter and coal. As is clear from Figure F2.12, low fuel oil prices do not elicit a large switch away from coal at the margin at those US power plants that can burn either of these two fuels. Rather, the floor price for heavy sour crude is a function of the fuel oil price at which it becomes attractive for power generators to operate less efficient generating capacity that is wholly residue-fired on a round-the-clock basis (instead of as peaking capacity, as is normally the case), thereby displacing at the margin electricity that some baseload coal-fired power plants would have generated on the basis of coal acquired via spot —i.e. interruptible — purchases. Given the considerable non-fuel cost advantages that fuel oil enjoys over coal — better combustion, lower emissions, lower storage, handling and safety costs, and so on — the threshold at which power generators begin to find this switch attractive hovers around a price level of 1.60 USD/MMBTU for spot fuel oil (equivalent to a Maya crude price of about 10 USD/B).

FIGURE F2.12: SPOT FUEL OIL PRICES AND PURCHASES BY US ELECTRIC UTILITIES, 1980—1999

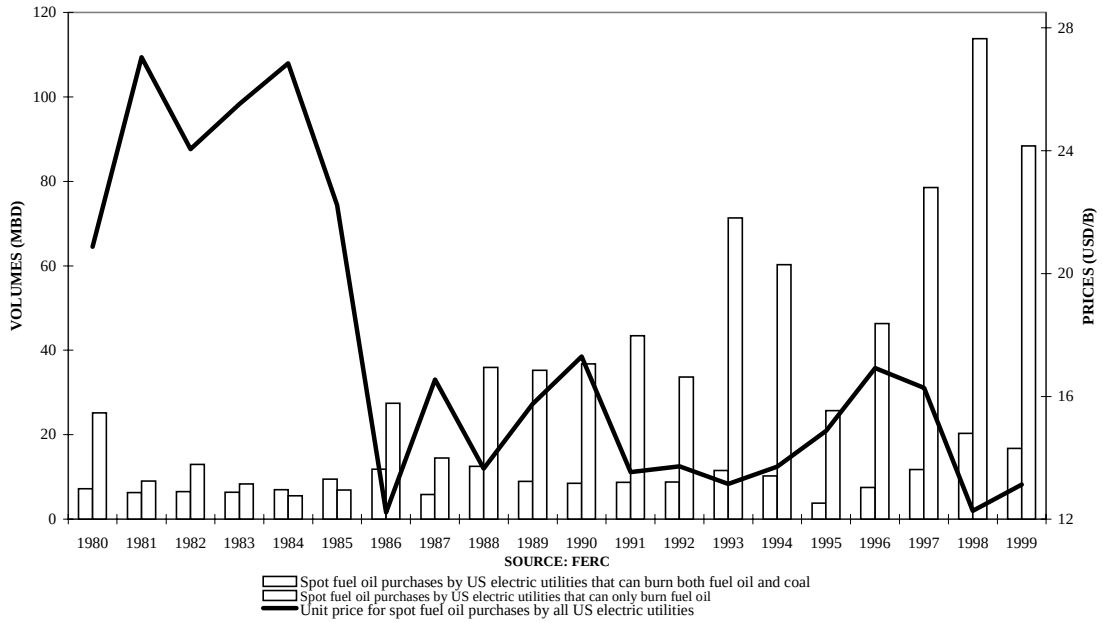
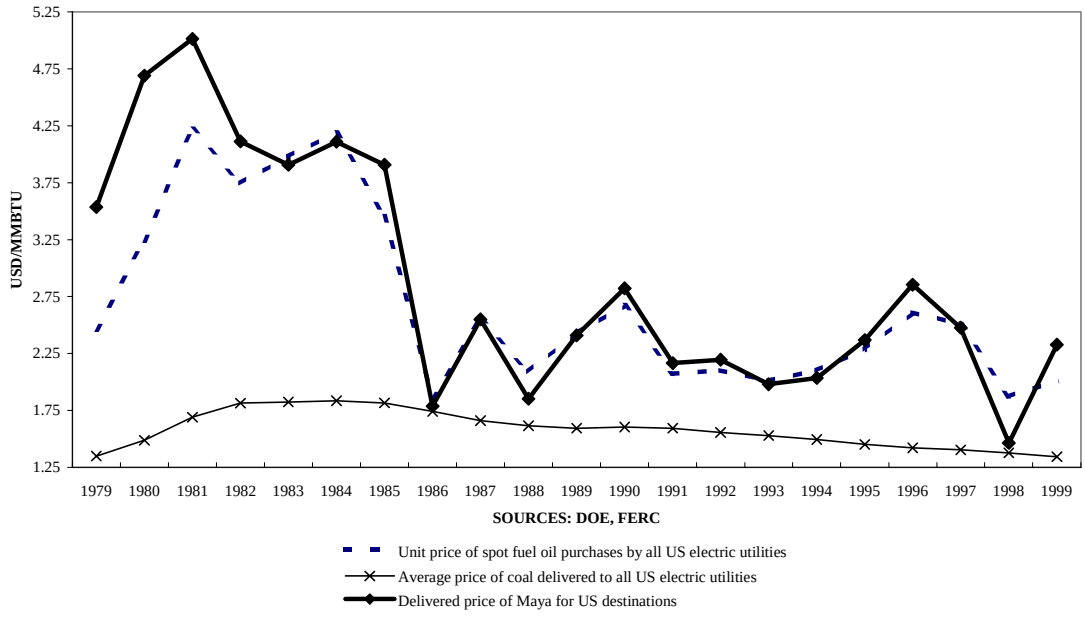


FIGURE F2.13: BEHAVIOUR OF COAL, FUEL OIL AND HEAVY SOUR CRUDE PRICES, 1979—99



The existence of such a rigid floor price might be considered a source of solace for producers like Mexico, the Neutral Zone and Venezuela (but not Canada or California), since their production costs for most of their crudes (2—4 USD/B, on average) are comfortably below this threshold. However, this is small consolation

when set against another hallmark of the market for heavy sour crude: supply-wise, it is finely poised, and a very small imbalance is all that is needed to push the price towards the floor (this happened during 1986, 1988, 1998 and, to a lesser extent, between 1991 and 1994). This unfortunate characteristic reflects the fact that world demand for residue is restricted to a few specialised end uses: as a feedstock for refinery conversion units (60 per cent of the total), as a fuel for marine vessels and industrial burners that cannot burn other fuels (approximately 20 per cent of the total), as a fuel for power generation units that cannot burn coal or natural gas (about 18 per cent of the total) and, finally, as a fuel for power units and industrial burners that have a dual burner capability.

To the extent that residual fuel oil supply exceeds demand in the first three (captive) uses, the fourth (which at any one time will account for, at most, 2 per cent of total residual demand) becomes the locus where supply and demand balance at the margin. This is an extremely thin demand segment, which is actually getting thinner all the time, since both power generators and manufacturers (especially the latter) continue to reduce their consumption of fuel oil, almost regardless of the relative prices of fuel oil and natural gas.[35] The demand function in this segment has a pronounced slope, which explains why even the smallest excess supply has the potential to take out the floor from under the residual fuel oil market and, by extension, from under the heavy sour crude market (as Figure F2.13 shows). By the same token, non-baseload power stations can restore equilibrium to the market relatively quickly, because there exists sufficient idle oil-fired capacity to mop up excess fuel oil volumes. However, there are certain circumstances under which even these incremental purchases by power stations might not be enough to spur a rebound in the price of heavy sour crude. Such circumstances materialised in 1998, when spot fuel oil purchases by US electric utilities reached record levels. As a result of these purchases, the spread between gasoline and fuel oil prices collapsed to very low levels, but the generalised and long-lasting depression affecting the crude oil market at large meant that the absolute price of heavy sour crude could not benefit from this narrowing of differentials. This was because the heavy sour crude price was already at a level at which deep conversion refiners would have started to switch away to lighter crudes had it gone any higher. Thus, in 1998, an unprecedented situation developed whereby the ceiling price and

the floor price for heavy sour crude oil actually coincided, for a distressingly long stretch of time.

2.6 The Relative Price of Heavy Sour Crude: Processing Economics

There are many reasons why heavy sour crude oils are more difficult and costly for refiners to run than general purpose grades. A low API gravity makes heavy sour crudes more difficult to pump, and some crudes with particularly high pour points (i.e. a very high resistance to flow) cannot be handled by non-heated pipelines, vessels or storage tanks. More expensive heated storage is generally required to handle the vacuum gas oils and asphalts obtained even from those crudes that do not themselves require such storage. Also, many long distance pipelines apply surcharges related to the viscosity of the crude to be pumped to their transportation tariffs. Another problem typically encountered when processing heavy sour crudes involves desalting (i.e. passing an electrical current through the crude to remove contained salts before charging it to the atmospheric still). Heavier grades are more difficult to desalt due to their high viscosities and low gravities. Refiners can compensate for this by desalting at higher temperatures (which often involves moving the desalter to the crude preheat train to provide the required temperature) or, more expensively, by blending the heavy crude with diluents like naphtha or condensate. Nevertheless, two-stage (and in some cases, three-stage) desalting is virtually mandatory if the salt content in heavy sour crude is to be reduced to one pound per 1000 barrels. Heavy sour crudes may also cause problems in the preheat train because their low flow rate tends to retard heat transfer. To overcome this problem, refiners have to increase their exchanger surface area or increase the duty of the crude heater in order to generate the required tower flash temperature.

The high sulphur content of heavy sour crudes is problematic because sulphur compounds (hydrogen sulphide, mercaptans, tiophenes and elemental sulphur) are corrosive to carbon steel at temperatures above 600°F. Therefore, processing these crudes requires investment in high-chromium steel components, and also increases maintenance and turnaround expenses in a refinery. Sulphur is also highly poisonous to catalysts and, in the form of hydrogen sulphide, to humans. Therefore, handling sulphur requires costly safety precautions. Refiners also have to remove sulphur

catalytically from gas oils and distillates produced in the crude distillation and coker units by means of hydroprocessing plants. The hydrogen uptake of hydrocrackers that process coker (as opposed to virgin) gas oils is higher due to olefin saturation. Finally, emission limits mean that refiners have to recover sulphur from contaminated still gases by converting it into free sulphur through an oxidation process.

Heavy sour crudes also contain many other types of contaminants and undesirable elements. For instance, some grades — notably those from Venezuela — contain naphthenic acids. These are extremely corrosive to the flash sections of the crude and vacuum towers, as well as heaters, transfer lines, and overhead condensers, and therefore require investments in special metallurgy and/or acid neutralisation processes. Other Venezuelan grades also have relatively high nitrogen content, which causes various processing problems (notably catalyst poisoning). Most heavy sour crudes also contain various metals (nickel, vanadium, mercury) and non-metals (arsenic), whose presence in even minute concentrations affects catalyst activity severely. Vanadium is particularly problematic because it is corrosive, poisons catalysts and can cause significant deterioration in refractory furnace linings and stacks. Generally, heavy sour grades also have a high asphaltene content, which renders them unstable at temperatures above 1000° F. This makes it necessary to modify vacuum tower operations (by increasing heat transfer through more intensive pumping and also by minimising vacuum still residence time or prevent the residual from cracking and the vacuum still from coking up) to achieve acceptable gas oil yields. Also, asphaltene-rich crudes restrict the operational flexibility of vacuum distillation units because any increase in the still cut point above 1000° F will promote thermal cracking and the formation of coke, as well as contaminate the heavy gas oil cut with metals and asphaltenes (which will render it unsuitable to serve as a catalytic cracker feed). Finally, asphaltenes make life complicated for even the most complex refineries because under certain reaction conditions (such as those found in a coking plant) they tend to form shot coke. Shot coke is a high density form of carbon that is extremely difficult to both handle and grind, and which would be almost valueless from an economic point of view even if it did not contain very high concentrations of metals and sulphur (which, alas, it does).

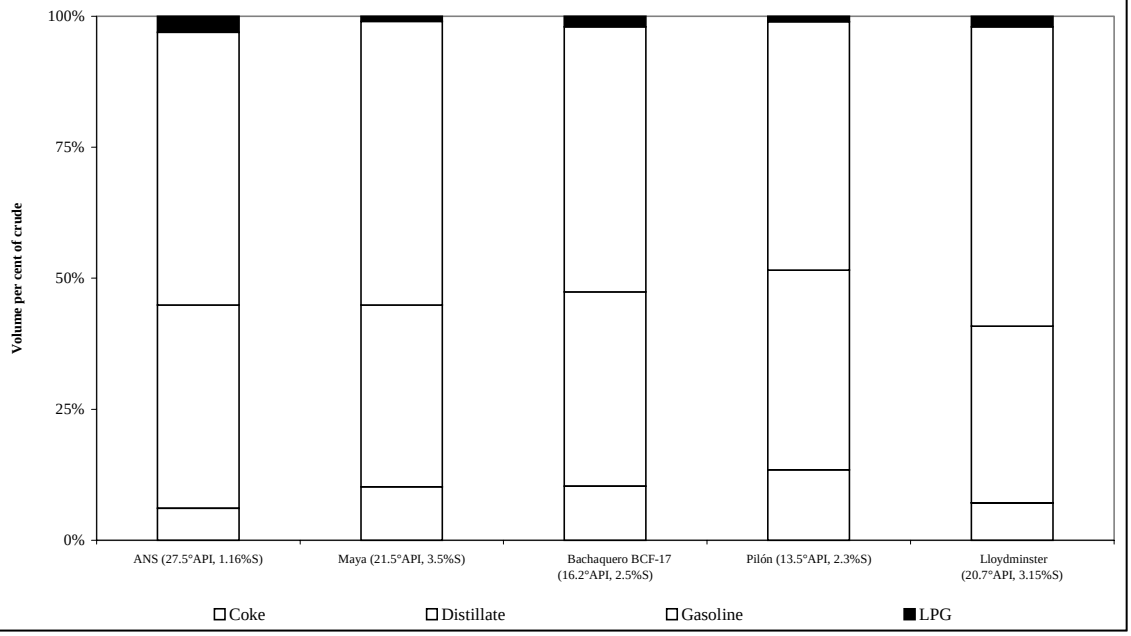
Coking (in its various guises) has become the process of choice for refiners seeking to obtain full conversion of the heavy sour crude barrel, particularly in the USA. Coking is a thermal cracking process of great severity (i.e. one that breaks down molecules with a high molecular weight into lighter molecules, by means of very high temperatures and pressures), which transforms a residue feed into a variety of lighter streams as well as a solid residue (coke, an allotropic form of carbon). In contrast, deep conversion hydrocracking processes employ fixed bed catalysts in the presence of high pressure hydrogen to crack heavy feedstocks into lighter products. Although from a strictly technical standpoint refiners can achieve efficient full conversion of the bottom of the heavy sour barrel by any of these two routes, coking processes have revealed themselves to be more cost-effective, hence their popularity. In turn, delayed coking has become the most widespread coking technology, notwithstanding its great mechanical complexity. In this semi-batch process, the coking reactions take place in a drum which gradually fills up with coke, and which, when full, has to be taken off-line and emptied while another drum takes it place. Even though continuous coking processes (fluid coking and flexicoking) produce less by way of almost valueless solid residue, delayed coking technology has lent itself better to standardisation and modularisation. As a result, the main licensors of delayed coking technology are able to offer potential entrants into the deep conversion segment an attractive combination of lower costs relative to other technologies and, more importantly, much diminished project execution risks (i.e. cost overruns, timetable delays). Thus, it has become the most commonly utilised process for upgrading in deep conversion fuels refineries: currently, there are some 125 refineries around the world — including about 50 in the USA — which have delayed cokers. Of these plants, about 100 were designed and built by Foster Wheeler, with Bechtel accounting for the balance.

2.7 How Far Does Asset Specificity Bite? The Limited Substitutability of Heavy Sour Crudes

As we have said, there is only limited arbitrage between the market for heavy sour crudes and that for general purpose grades. In many developed countries — and particularly in the USA — tightening environmental legislation and product specifications have reduced the universe of potential processors of heavy sour crudes to deep conversion and specialty (i.e. asphalt and naphthenic lubes) refineries.

However, the degree of isolation of the heavy sour crude segment from the rest of the oil market does not mean that competition amongst sellers of heavy sour blends necessarily has to be particularly intense and fierce. This is because, due to their yield and quality differences, individual heavy sour crudes are not good substitutes for one another (at least where refining processes of great complexity and operational severity are involved). Indeed, yield differences in deep conversion configurations are striking, given the apparent physical similarity of the various heavy sour streams (Figure F2.14).[36]

FIGURE F2.14: REFINED PRODUCT YIELDS OF SELECTED CRUDES, COKING CONFIGURATION



To underscore the imperfect substitutability of heavy sour crude oils, we can enumerate the general differences in process intensity and the upgrading investment associated with two important heavy sour crudes with different yield-related and quality-related process requirements: Mexico's Maya and Venezuela's Bachaquero BCF-17. This exercise is only intended to provide general information about the competition for refining capacity between the two crudes, and does not address any questions regarding the current or expected value of yield differences, the behaviour of inter-crude price differentials or upgrading investment economics.

Yield differences between heavy sour crudes will affect almost every plant in a deep conversion refinery. Processing relatively heavier crudes will always entail modifications in the atmospheric column to achieve efficient heat exchange, on the one hand, and the flow rates for vapour and liquids necessary for efficient fractionation, on the other. The extent of these modifications will depend both on the design of a particular plant and on the characterisation of the other crudes that conform the refinery's normal base slate. However, the generalisation can be made that heavier crudes (like BCF-17) will always require more extensive facility changes in the crude distillation area than comparatively lighter crudes (like Maya). Being heavier, BCF-17 produces a larger volume of vacuum residue than Maya, which means that the Venezuelan crude requires more coking capacity per barrel than the Mexican crude, if complete conversion of the residue fraction is to be achieved. A larger coker capacity means that a proportionately greater volume of coker gas oil, distillates and lighter products will have to be run through hydroprocessing and hydrotreating units, and this translates into a higher hydrogen and catalyst consumption.

BCF-17 is more viscous than Maya. Thus, it requires the use of high gravity recycle and/or larger desalters in the crude feed train of the distillation unit. Whereas Maya desalting involves only two stages, BCF-17 desalting involves three, and this translates into higher electricity consumption. Moreover, the desalting of BCF-17 has to take place at a higher temperature (because viscosity inhibits water separation), and this tends to promote the decomposition of sulphates and salts and the formation of acids, with a consequent increase in the corrosion of tubes, stills and heat exchangers. However, higher temperatures also promote coking reactions in the atmospheric residue, so refiners cannot make this separation problem go away just by applying heat. Instead, they have to modify their atmospheric tower operations to increase recirculation at the top end of the distillation column, and they also have to install additional heat exchangers in the central part of the column and increase the number of separation trays. A higher viscosity also poses special problems for heat exchange in the vacuum distillation unit (to prevent coking reactions in pipes, for instance), and it increases the frequency with which pumps for the residue streams have to be replaced.

BCF-17 also has higher nitrogen content than Maya. The presence of nitrogen gives rise to yield penalties in FCCs and hydrocrackers (which have nitrogen-sensitive catalysts), and also quality problems in products (corrosivity for jet fuel, water solubility for distillate fuels). The nitrogen content of the Venezuelan crude also means that, even though the sulphur content of Maya is higher, hydroprocessing units have to run at much higher severities when processing the Venezuelan crude, with the consequent increase in hydrogen and utilities consumption. The high acidity of the Venezuelan crude also poses some extra problems in terms of metallurgy, particularly in the distillation column. However, BCF-17 has a clear advantage over Maya in terms of sulphur content (2.5 per cent versus 3.5 per cent by weight). The higher sulphur content of the Mexican crude increases its relative costs in terms of sulphur conversion and handling. Roughly speaking, and other things being equal, processing a barrel of BCF-17 requires about 75 per cent of the desulphurisation capacity required to process a barrel of Maya. Desulphurisation capacity, of course, is quite costly to build and, in proportional terms, even more expensive to run (because of its high hydrogen, energy and catalyst consumption).

The extent to which a particular refinery will find itself locked into a relationship of dependence towards a supplier of heavy sour crude will vary depending on the specific size, technical characteristics and operating layout of its constituent plants. It is no exaggeration to say that every deep conversion refinery has bottlenecks that are the product of its historical development. Therefore, the sensitivity of each one to a raw material change will vary greatly. On the whole, though, it is fair to say that fewer bottlenecks will actually translate into a greater asset specificity and, hence, dependence. Of course, the efficiency of operations that such dependence brings about will be a powerful incentive for a refiner to eliminate any slack in the system, even if such slack may be what gives him room to manoeuvre on the commercial front. Moreover, crude gravity introduces a certain asymmetrical element into the competition between heavy sour blends, for the simple reason that, other things being equal, it is easier to switch from a heavier to a less heavy feedstock than vice-versa, since the latter option is more likely to lead to the sub-optimisation of processing installations other than the coker (because of the greater vacuum residue yield of heavier grades).

Quality differences between heavy sour crudes exert a key influence on the profitability of existing deep conversion refineries in terms of variable costs (including hydrogen and catalyst costs). In contrast, the impact of yield differences is felt most strongly at the level of capital costs, which makes them a key driver behind the expected profitability of additions to deep conversion capacity and new-build upgrading projects. Nevertheless, they are not as important as is the extant refining configuration in determining the overall cost of upgrading projects. In this sense, for instance, refineries with spare capacity in hydroprocessing and sulphur conversion (and, less importantly with surplus hydrogen production or access to keenly priced hydrogen supplies) will generally have the lowest revamping costs associated with a coking project, regardless of what particular heavy sour crude is chosen as a feedstock (FCC refineries designed to process light sour crudes and coking refineries with suboptimal downstream process utilisation tend to have surplus capacity available in these complementary processes, and are generally the best candidates for coking expansion projects). However, feedstock choice is still a crucial factor in the profitability of upgrading projects, since the capital investment requirements faced by some projects can vary by up to 50 per cent or more depending on the actual processing option selected. On the whole, every refining company contemplating an upgrading project will attempt to strike a balance between its capital limitations, its potential for capital and cost recovery, and the value of its product slate against the potential reduction in raw material costs to determine its preferred feedstock options. Ultimately, though, the *expected* differences in raw material price will determine the individual heavy sour blends that are seen as the ones offering the most economic and manageable investment options. The issue of whether certain crudes might be more prone to generate uncertainty than others, therefore, will play an important role in the evaluation (and eventual selection) of design feedstocks for new upgrading facilities. This is a point of great importance, to which we shall return later when we examine the comparative attraction as feedstocks that Mexican and Venezuelan heavy sour crudes have for refiners in the USGC.

2.8 A Summing Up

What, then, are the main issues that economic actors engaged in the local or international trade of heavy sour crude always have to contend with? First of all, there is a relatively small production volume of heavy sour crude available in absolute terms, although this volume is large when set against the global availability of deep conversion capacity. Second, the production of heavy sour crude is highly concentrated in only a few countries. Third, even fewer countries make a meaningful volumetric contribution to the international trade in heavy sour crude oil. Fourth, because of the low production costs in Mexico and Venezuela, the supply of internationally traded waterborne heavy sour crude oil exhibits a low price elasticity; in contrast, the supply of North American (i.e. Canadian and American) pipelined heavy sour crude is highly elastic in low oil price environments (a reflection of high production costs), but very inelastic in high oil price environments (a reflection of the geological maturity of these areas). Fifth, rigidities on both the production and the processing side of the heavy sour trade limit the strength of the forces of economic arbitrage as well as lengthening the amount of time it takes for the market to adjust to a situation of excess supply (or demand).

All of these characteristics would probably qualify as minor irritants for participants in the market for heavy sour crude, were it not for the fact that this type of crude is a non-fungible commodity whose value for highly specialised and costly deep conversion refineries is considerably higher than in general purpose refineries. Thus, the market for heavy sour crudes is characterised by the prevalence of vertical commercial relationships imbued with problematic risk allocation characteristics, which means that it is impossible for participants to take either their wares or their custom elsewhere when these irritants turn into major nuisances. In essence, the plight of participants in this market (and of refiners even more so than producers, since the former have to live with tighter margins) comes down to the fact that they will never be in a position to appreciate the finer points of the famous maxim coined by Winston Churchill: “safety and certainty in oil lie in variety and in variety alone”.[37]

NOTES

[1] World Petroleum Congress 1984: 5.
[2] al-Obaidan and Scully 1993: 1529.
[3] This was because the "key to assured profitability was an uninterrupted flow of crude through refining to the final buyer. To the extent that control over any of the downstream stages rested in the hands of others, the flow might be interrupted, thus curtailing the production of crude and the consequent all-important after-tax profits" (Blair, *op. cit.*: 237). The US majors' downstream earnings in Europe and Japan over 1967—72, for instance, returned on average -1 per cent and 1.4 per cent (respectively) on net book investment, while in the major producing countries upstream returns averaged in excess of 40 per cent (Lichtblau 1975: 305).
[4] Bamberg 2000: 481; italics ours.
[5] As Silvan Robinson, former head of the Shell International Transport Company (1989b: 163) points out: "We had supply departments, not trading departments. There were small units dealing in exchanges or loans to balance supply and demand at the margin and improve logistics, but the main emphasis was on a centralised system distributing in as rational a manner as possible supplies from the company's production … or brought in under long term contracts."
[6] Thus Silvan Robinson: "*Integration … is out*. The trading function is needed to keep the flows going. And it adds value in two ways. First, it reduces supply costs: through trade optimisation, back hauls and by relentlessly searching out particular markets that can make the most of a particular crude or blend of crudes or by meeting specifications by blending two off-specification products. *The market and trading are a more efficient mechanism for doing this than central supply allocation, with its calculated value structures*. Second, trading adds value by price arbitrage, by perfecting markets" (1989b: 169; italics ours).
[7] This is true even for plants that produce lubes through catalytic hydrocracking processes (as opposed to the more traditional forms involving solvent extraction processes).
[8] In addition, the process to certify a crude as a lube feedstock is both time consuming and expensive. On the problems of lube oil production, see Farrel and Zakarian 1986, and World Bank 1982.
[9] The use of this cut-off point means that some crudes which are normally thought of as heavy (notably Arabian Heavy, Iranian Heavy, Kuwait Export Blend, Suez Blend) are excluded from the definition and, therefore, from consideration by this study. However, the physical and chemical properties of these crudes sets them apart from genuinely heavy blends like Maya or BCF-17. In any case, there is a sound practical reason for choosing 25° API as a cut-off point: the US Department of Commerce uses this figure as the sole criterion for identifying heavy crude oil.
[10] This picture is inverted when one takes into account tar sands and extra-heavy crude accumulations. At 892 billion barrels of oil *in situ*, the Athabasca tar sands dwarf the proved oil reserves of the entire Middle East. And the Orinoco Oil Belt in Venezuela contains no less than a *trillion* barrels of extra-heavy oil *in situ*.
[11] This figure includes about 2.3 MMBD of field condensates.
[12] This figure does not include Canadian tar sand output used in the production of light syncrude.
[13] The most important among these crudes are Argentina's Escalante (24.1° API, 0.19% S, and output of about 150 MBD), Brazil's Marlim (19.2° API, 0.78% S and output of 500 MBD in 2000, but only 200 MBD in 1998) Brunei's Champion (23.7° API, 0.13% S, and output of about 80 MBD), Cameroon's Lokele (19.6° API, 0.41% S, and output of about 20 MBD), China's Shengli (24.2° API, 0.9% S, and output of about 500 MBD), Indonesia's Duri (20.3° API, 0.19% S, and output of about 200 MBD), and the UK's Captain (20° API, 0.5% S, and output of about 60 MBD).
[14] Acronym for Petroleum Administration for Defense District, a territorial division of the US dating from the Second World War. There are five PADDs in all. PADD I encompasses Connecticut, Delaware, the District of Columbia, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia and West Virginia. PADD II covers Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee and Wisconsin. PADD III is composed of Alabama, Arkansas, Louisiana, Mississippi, New Mexico and Texas. Colorado, Idaho, Montana, Utah and Wyoming make up PADD IV, and PADD V covers Alaska, Arizona, California, Hawaii, Nevada, Oregon and Washington. The US Virgin Islands, Puerto Rico and some other US possessions like Guam are sometimes collectively referred to as PADD 0.

[15] 1997 prices are used because they are more representative than the ones that have obtained in the rather atypical 1998—2001 period.
[16] When PEMEX decided to become Shell USA's partner in a new deep conversion refining venture in Deer Park, Texas, it calculated that, so long as the volume of heavy crude supplied to the US market remained relatively stable over 1995-2005 and beyond, the shift in the Maya demand curve brought about by the coming on stream of the new plants would generate monetary benefits way in excess of the profits expected from these facilities.
[17] This is the case of the Belle Chasse refinery in Louisiana, whose strategic location close to the onshore delivery point of Louisiana Heavy Sweet crude enables it to process large volumes of this feedstock, which it can obtain at especially attractive prices.
[18] ANS yields are included to provide a parameter of comparison with lighter grades.
[19] The demand pattern of high conversion refineries in the US also exhibits certain seasonal variations linked to the gasoline market, but these variations are less pronounced than those of asphalt refineries (many shut down altogether during the low demand months, for instance). The seasonality in asphalt is a function of the weather, which has to be mild enough to permit paving and construction activities (about 85 per cent of total asphalt demand is accounted for by paving grades).
[20] There are a few asphalt refineries whose capability to handle light ends is so limited that they can only process especially heavy grades (14° API or less), which can many times be charged directly to a vacuum tower without any previous distillation. However, these refineries are invariably very small, and hence their peculiarities have little impact on the market at large.
[21]Williamson 1989: 226.
[22] Macneil 1974: 691.
[23] Horsnell and Mabro, *op. cit.*: 112.
[24] *Ibid.*: 138.
[25] *Ibid.*: 148.
[26] See Klemperer 1987a, 1987b, 1987c.
[27] Fombrun 1996: 33.
[28] For some illustrative examples, see Horsnell and Mabro, *op. cit.*: 130—147. See also Sas 1987a, 1987b, 1989.
[29] Williams 1995: 17-8.
[30] Bacon and Mabro 1990: 19.
[31] *Ibid.*
[32] Ten-day moving averages have been used in this analysis. It is reasonable to suppose that this is near the minimum time that has to elapse before a price/differential combination can begin to have a perceptible effect (positive or negative) on a refinery's profits.
[33] Baseload capacity in this context means "the minimum amount of electric power delivered or required over a given period of time at a steady state". Peak load capacity is "capacity of generating equipment normally reserved for operation during the hours of highest daily, weekly or seasonal loads" (*EPCPPE* 1993: 154).
[34] Ellerman (1995) suggests that the USA is the sole price setter in the world coal market. Humphreys (1995) considers that this plausible hypothesis underestimates the role that Australia plays in Pacific basin coal markets, but acknowledges that the USA is certainly the marginal supplier to Atlantic basin markets.
[35] As the DOE notes, manufacturers (at least those in the USA) "[do] not seem inclined to increase [fuel oil] use relative to gas, even in the face of more equivalent prices … Manufacturers prefer natural gas to fuel oil when they can reasonably choose either fuel" (EIA/DOE 2000).
[36] Once again, ANS yields are meant to provide a parameter of comparison with lighter grades.
[37] Bamberg, *op. cit.*: 13.

3. THE ANATOMY OF THE MARKET FOR HEAVY SOUR CRUDE OIL IN THE US GULF COAST

The US Gulf Coast (USGC) refining region comprises the whole of the states of Alabama and Missouri, plus the Texas Gulf Coast Refining District[1] and the Louisiana Gulf Coast Refining District[2] (as defined by the US Bureau of Mines during the 1940s). Within this territory there are 42 operating refineries, which together produce a significant porportion of the petroleum products consumed in the US market, the largest in the world by far. Table T3.1 shows the evolution of the key role that the USGC refining system has played in the US oil scene from 1987 to the present day.

Out of the thirty US refineries with a nameplate distillation capacity of 200 MB or more, eighteen are located in the USGC, as are seven of the ten largest US refineries (see Table T3.2). Indeed, the USGC accounts for about 40 per cent of the total installed distillation capacity in the USA. To a considerable extent, this reflects the key role that both Louisiana and Texas (especially the latter) have played in the evolution of both the American and the international oil industries. In addition, the operations of many of the now venerable USGC plants were traditionally outward-oriented (first sending product to the Eastern Seaboard of the USA and, eventually, to the whole world), unlike those of the more numerous and smaller plants that sprung up in the vicinity of major inland American oilfields, like East Texas.[3] The "tidewater refineries" of the USGC were built to relatively large scales, and this has enabled them to escape the sort of attrition that has decimated the ranks of refineries elsewhere in the USA.

USGC refineries share a number of features that can be used as criteria for ring-fencing the region in terms of the orientation of its oil trade and its logistics. With insignificant exceptions,[4] all of them are located either next to the sea or on major inland waterways (like the Mississippi river, the Houston Ship Channel or Lake Charles) near to the coast. Since most cover the bulk of their feedstock requirements with imports, they do not have to ship imported supplies through long stretches of pipeline (a major advantage in terms of transportation costs and operational logistics).

Likewise, these refineries also have access — in different degrees — to both onshore and offshore domestic US production (transported through extensive pipeline systems), but their runs of domestic grades account for a much lower proportion of their total crude runs than that which is characteristic of other regions (like PADD II). Finally, most of these refineries have access to one or more of the giant products trunklines (Colonial, Plantation, Explorer) that link the main consuming centres in the north of the USA with the USGC.

TABLE T3.1a: Evolution of the Role of the USGC Refining System in the US Petroleum Market (1987—93)

	1987	1988	1989	1990	1991	1992	1993
USGC crude runs (MMBD)	5,221	5,365	5,462	5,363	5,292	5,286	5,336
As a percentage of total US runs	0.40	0.40	0.40	0.39	0.39	0.39	0.39
As a percentage of total US runs (excluding PADD V)	0.50	0.50	0.50	0.49	0.49	0.48	0.48
USGC input to coking plants as a percentage of US total	0.39	0.39	0.40	0.39	0.40	0.41	0.42
USGC input to hydrocracking plants as a percentage of US total	0.41	0.37	0.39	0.38	0.38	0.36	0.39
USGC input to FCC plants as a percentage of US total	0.42	0.43	0.43	0.43	0.43	0.42	0.43
USGC gasoline production (MBD)	2,713	2,746	2,767	2,721	2,676	2,902	2,776
As a percentage of total US gasoline production	0.40	0.39	0.40	0.41	0.38	0.40	0.39
As a percentage of total US gasoline production (excluding PADD V)	0.48	0.47	0.48	0.50	0.47	0.48	0.47
USGC heavy sour crude imports (MBD)	530	495	466	568	554	805	961
As a percentage of total US heavy sour imports*	0.46	0.45	0.46	0.47	0.42	0.57	0.59
USGC total crude imports (MBD)	2,050	2,396	2,866	2,924	2,890	3,341	3,630
As a percentage of total US crude imports*	0.43	0.46	0.46	0.46	0.47	0.52	0.51
USGC heavy sour imports as a percentage of USCG crude imports	0.26	0.21	0.16	0.19	0.19	0.24	0.26
Percentage of total US crude imports landed at USGC ports*	0.52	0.59	0.59	0.61	0.62	0.62	0.62
Percentage of total US heavy sour crude imports landed at USGC ports*	0.63	0.63	0.65	0.64	0.56	0.63	0.68

* Includes Puerto Rico and US Virgin Islands

Source: DOE

TABLE T3.1b: Evolution of the Role of the USGC Refining System in the US Petroleum Market (1994—2000)

	1994	1995	1996	1997	1998	1999	2000
USGC crude runs (MMBD)	5,530	5,569	5,831	5,990	6,099	6,186	6,288
As a percentage of total US runs	0.40	0.40	0.41	0.41	0.41	0.42	0.42
As a percentage of total US runs (excluding PADD V)	0.49	0.48	0.50	0.49	0.49	0.50	0.50
USGC input to coking plants as a percentage of US total	0.43	0.45	0.46	0.45	0.46	0.45	0.42
USGC input to hydrocracking plants as a percentage of US total	0.38	0.41	0.40	0.41	0.41	0.42	0.40
USGC input to FCC plants as a percentage of US total	0.43	0.43	0.45	0.44	0.44	0.48	0.46
USGC gasoline production (MBD)	2,896	2,955	2,968	3,040	3,115	3,112	3,175
As a percentage of total US gasoline production	0.39	0.39	0.38	0.39	0.39	0.40	0.40
As a percentage of total US gasoline production (excluding PADD V)	0.47	0.47	0.46	0.46	0.47	0.48	0.48
USGC heavy sour crude imports (MBD)	1,049	1,113	1,353	1,555	1,542	1,292	1,284
As a percentage of total US heavy sour imports*	0.66	0.66	0.68	0.65	0.64	0.63	0.51
USGC total crude imports (MBD)	3,843	3,916	4,242	4,488	4,695	4,691	3,797
As a percentage of total US crude imports*	0.52	0.52	0.53	0.52	0.51	0.52	0.40
USGC heavy sour imports as a percentage of USCG crude imports	0.27	0.28	0.32	0.35	0.33	0.28	0.34
Percentage of total US crude imports landed at USGC ports*	0.61	0.61	0.63	0.61	0.62	0.62	0.60
Percentage of total US heavy sour crude imports landed at USGC ports*	0.70	0.70	0.71	0.68	0.66	0.66	0.66

* Includes Puerto Rico and US Virgin Islands

Source: DOE

Refineries in the regions bordering the USGC (inland Texas, northern Louisiana and Arkansas, Oklahoma and the Wood River area of the US Midcontinent, and the Caribbean) can exhibit one or more of these features, but never all of them at once. This makes these markets qualitatively different from the USGC market. Indeed, even though these markets are linked — sometimes intimately so — to the USGC, they are not part, or even extensions, of the latter; rather, they function as hinges, joining the USGC with other parts of the American and international petroleum markets. Refineries in the Wood River area, for instance, are large consumers of imported waterborne crudes and, until very recently, were not in a position to cover any significant part of their requirements with Canadian oil. Moreover, their buying patterns exerted a perceptible influence on prices of imported crude in the USGC. However, the fact that these refineries are at the end of a long stretch of pipe means not only that sales of imported crude to these plants will tend to be done on a different basis to the one used for USGC transactions (generally leading to reduced netbacks for sellers) but also that their imported supplies will face longer transit times and depend on the vagaries of pipeline scheduling and prorationing (problems that USGC refiners do not have). By the same token, refineries in the Caribbean share with their USGC counterparts a central location in the Atlantic basin that enables them to receive crude shipments from all the major oil-exporting countries. Furthermore, these refineries ship a large proportion of their products output to PADD I (just like USGC refineries). However, unlike USGC refineries, Caribbean plants are not in a position to obtain any ratable domestic pipeline barrels, and this translates into major differences regarding the manner in which plants in both regions operate.

TABLE T3.2: US Gulf Coast Refineries. Ownership, Location, Charge and Production Capacities per Calendar Day as of 31/12/2000

Refiner	*Location*	*Crude capacity (MBD)*	*Coking capacity* (MBD)*	*Asphalt production (MBD)*
Deep Conversion Refineries				
Exxon Mobil Corp.	Baytown, Tx.	508	42 (40)	--
Exxon Mobil Corp.	Baton Rouge La.	485	105	--
BP p.l.c.	Texas City, Tx.	433	40	--
Exxon Mobil Corp.	Beaumont, Tx.	343	45	--
Citgo Petroleum Corp.	Lake Charles, La.	310	100	--
Koch Industries Inc.	Corpus Christi, Tx.	297	14	--
Chevron Products Co.	Pascagoula, Miss.	295	71	--
Deer Park Refining Limited Partnership	Deer Park, Tx.	275	60 (25)	4.4
Lyondell Citgo Refining Company Ltd.	Houston, Tx.	269	87	--
Phillips 66 Co.	Belle Chasse, La.	250	25	--
Conoco Inc.	Westlake, La.	245	65	--
Motiva Enterprises LLC	Port Arthur, Tx.	245	50	--
Premcor Inc.**	Port Arthur, Tx.	225	38 (80)	--
Motiva Enterprises LLC	Norco, La.	220	21	--
Phillips 66 Co.	Sweeny, Tx.	205	58	--
Orion Refining Corp.***	Good Hope, La.	200	75	--
Chalmette Refining LLC	Chalmette, La.	183	33	--
Citgo Petroleum Corp.	Corpus Christi, Tx.	152	38	--
Crown Central Petroleum Corp.	Pasadena, Tx.	100	13	--
Coastal Refining and Marketing Inc.****	Corpus Christi, Tx.	100	18	12
TOTAL		5,340	998 (145)	16.4
Cracking refineries				
Marathon Ashland LLC	Garyville, La.	232	(35)	40
Motiva Enterprises LLC	Convent, La.	225	--	--
Atofina Petrochemicals Inc.*****	Port Arthur, Tx.	176	--	4.3
Valero Energy Corp.	Texas City, Tx.	165	--	--
Murphy Oil U.S.A. Inc.	Meraux, La.	95	--	--
Valero Energy Corp.	Corpus Christi, Tx.	94	--	--
Valero Energy Corp.	Krotz Springs, La.	78	--	--
Valero Energy Corp.	Houston, Tx.	83	--	--
Marathon Ashland LLC	Texas City, Tx.	72	--	--
TOTAL		1,220	(35)	44.3
Specialty refineries				
Shell Chemical Co.	Saraland, Ala.	85	--	--
Shell Chemical Co.	Saint Rose, La.	55	--	--
Placid Refining Co. LLC	Port Allen, La.	48	--	--
Hunt Refining Co.	Tuscaloosa, Ala.	43	13	10.8
American International Refinery Inc.	Lake Charles, La..	30	--	0.9
Canal Refining Co.	Church Point, La.	30	6	--
Trifinery Petroleum Services Inc.	Corpus Christi, Tx.	30	--	18
Ergon Refining Inc.	Vicksburg, Miss.	23	--	--
Coastal Mobile Refining Co.******	Chickasaw, Ala.	20	--	10.5
Calcasieu Refining Co.	Lake Charles, La.	16	--	--
Southland Oil Co.	Sandersville, Miss.	11	--	4.5
Southland Oil Co.	Lumberton, Miss.	6	--	3.1
Haltermann Products GmbH *******	Channelview, Tx.	2	--	--
TOTAL		399	19	47.8
GRAND TOTAL		**6,959**	**1,017 (180)**	**108.5**

* Numbers in parentheses indicate new coking capacity under construction
** Formerly Clark Refining and Marketing Inc.
*** Formerly TransAmerican Refining Corp.
**** Leased to Valero Energy in 2001, with an option to purchase that will be exercised after 2002
***** A subsidiary of TotalFinaElf
****** A unit of El Paso Petroleum Markets, a division of El Paso Merchant Energy Group
******* Formerly Specified Fuels and Chemicals LLC

Sources: DOE, *O&GJ*

USGC refineries are of great importance to the market for heavy sour crude because, taken as a group, they represent the most impressive concentration of deep conversion capacity in the world. Installed coking capacity in this region (approximately 1 MMBD) accounts for 50 per cent of total US coking capacity, with the West Coast coming in second with 22 per cent of the total. Moreover, coking capacity in the USGC is set to grow by nearly 200 MBD in the near future. Much of the deep conversion capacity in the region, though, is recent in origin: PADD V accounted for 39 per cent of total US coking capacity in 1983, with the USGC trailing at 28 per cent. The accelerated growth in the complexity of the USGC refining system has gone hand in hand, firstly, with the decline in Texas and Louisiana domestic production; secondly, with the increase in US imports of heavier, more sulphurous, crudes and, finally, with ever tighter environmental legislation in the USA and other developed countries. In contrast, the configuration of West Coast plants has always been sophisticated relative to the US average, because of the adverse physical characteristics of the feedstocks that refiners in that part of the world have had to deal with since the turn of the nineteenth century. Thus, while the growth in coking capacity (additions plus capacity creep) in California over the 1983—2000 period amounted to slightly over 100 MBD, refineries in the USGC region added nearly 750 MBD of coking capacity over the same period.

The degree of sophistication of the USGC refining complex sets it apart from areas like Northwest Europe, the Mediterranean or even the US PADD I, where high conversion refineries tend to process better quality sour grades (like Arab Heavy, Iranian Heavy or Suez Blend) to produce fuels, while using really heavy material in the manufacture of asphalts and specialty products only. The deep conversion market segment for heavy sour crudes is characterised by the prevalence of vertical commercial relationships imbued with very problematic risk allocation characteristics. Thus, the concentration of deep conversion facilities within the USGC and the inflexibility of these very expensive plants in terms of their feedstock requirements together make refiners in this region extremely vulnerable to the governance problems associated with bilateral monopoly and asset specificity. These problems relate to the fact that bilateral monopoly gives counterparts an incentive to exchange the quantity that jointly maximises their profits, while also giving them incentives to devote considerable resources to haggling over the price at which the exchange will take

place.[5] Whenever such haggling occurs, it will do so under conditions of opportunistic behaviour and bounded rationality, which will greatly increase the transaction costs that parties to a commercial agreement have to face, for a number of reasons. Firstly, opportunism implies that commercial counterparts can make empty threats or promises, in the expectation that they will reap advantage from so doing. Secondly, there is no efficient bargaining mechanism under conditions of asymmetrical information.[6] Finally, bounded rationality limits the reach of planning, and makes it impossible to ascertain whether the problems that surface during the lifetime of a contract are the result of genuinely unforeseen circumstances, rather than of a counterpart's deliberate non-compliance with contractual terms and conditions.[7]

The simultaneous presence of asset specificity, stochastic markets, bounded rationality, asymmetric information and opportunistic behaviour in recurrent transactions poses a dilemma for commercial counterparts:

> the parties that contract now know that later on there will be gains from trade between them to be exploited. It is important that these gains from trade be exploited correctly (i.e., that there be an efficient amount of trading *ex post*) and that they be divided properly in order to induce the efficient amount of specific investment *ex ante* … [However,] under bilateral monopoly, each party wants to appropriate the common surplus *ex post*, thus jeopardising the efficient realisation of trade *ex post* and the efficient amounts of specific investments *ex ante*.[8]

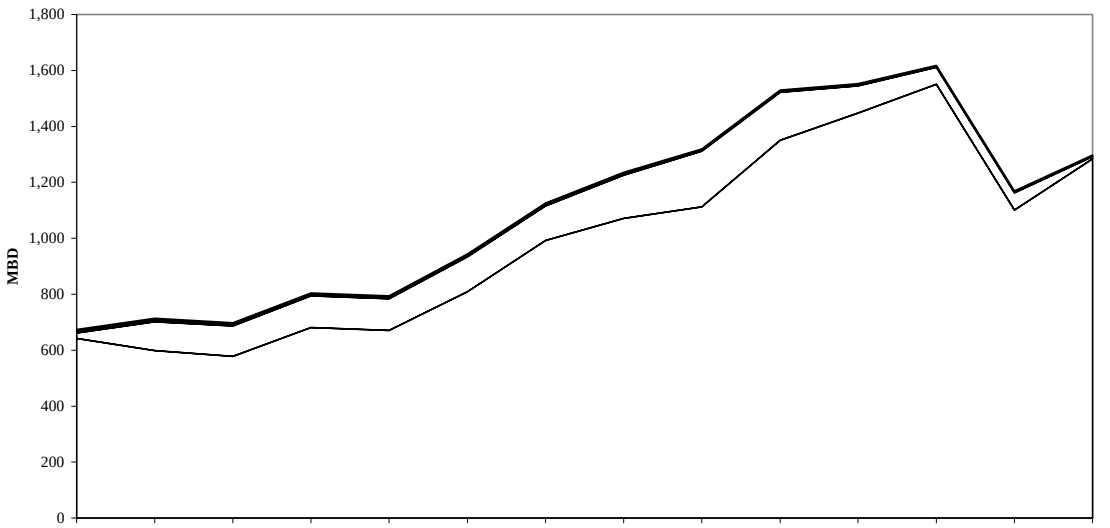
In the USGC market for heavy sour crude, the poignancy of this dilemma is exacerbated by three additional factors. Firstly, nearly all the heavy sour crude processed in the USGC consists of imports, transported to the region by tanker. Secondly, USGC refiners have no credible short- or even medium-haul supply alternatives to these imports. Finally, the supply of heavy sour imports to the area is in the hands of only two companies: PDVSA and PEMEX.

3.1 The Supply of Heavy Sour Crude in the USGC Market

The USGC market for heavy sour crude is a market for *waterborne imports*. Production of heavy sour crudes in the region has always been minimal[9] (Figure F3.1), overshadowed even by the volume of blended Californian crudes that some refiners used to ship through the All-American pipeline (a line that has now been definitely decommissioned[10]). Of late, availability of domestic heavy sour crudes has

increased somewhat due to the coming on-stream of certain fields in the deepwater US Gulf, but most of the output in this region actually consists of medium sour grades like Mars (31°API, 2 per cent sulphur content) or Poseidon (27.7°API, 2.1 per cent sulphur content). Moreover, because of logistical constraints, access to these new domestic crudes is restricted to refineries in Louisiana. Thus, the majority of the USGC heavy sour crude requirements have to come from outside the region by ship, with no realistic short-haul alternative.

FIGURE F3.1: THE SUPPLY OF HEAVY SOUR CRUDE IN THE USGC (1987—2000)



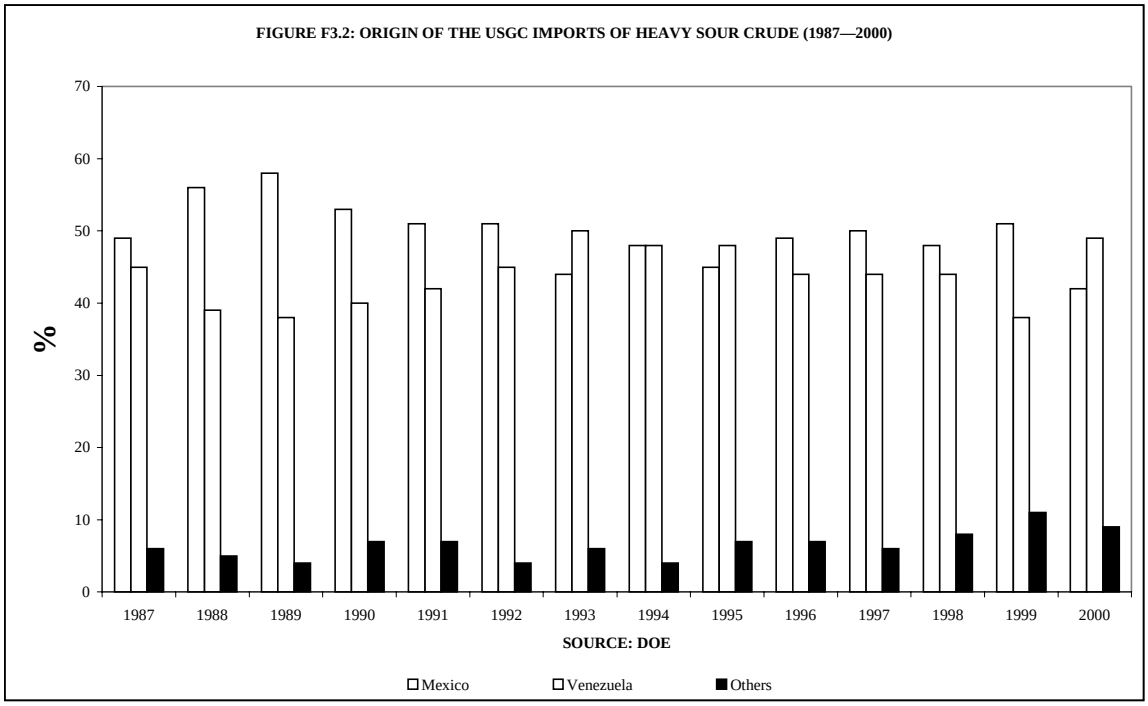
SOURCES: DOE, MSOGB, SOGBA, TRC

The West Coast is even more highly geared towards the processing of heavy sour feedstocks than the USGC, but deep conversion refineries there have traditionally met their requirements with domestic California production. There is an extensive pipeline infrastructure dedicated to these grades, which sustains a market that makes it possible for California refineries to meet unforeseen eventualities and supply shortfalls with short-haul and ratable heavy sour barrels (so long as there are no system-wide problems, of course). The situation in the Northern Tier refining complexes (centred around Chicago and Saint Paul) is not that different, even though deep conversion refineries in this zone satisfy most of their heavy sour crude requirements with imports, rather than domestic grades. The lion's share of these

imports (about 75 per cent) is accounted for by Canadian heavy grades (Lloydminster, Cold Lake, Bow River) delivered to these refineries via branches of the IPL/Lakehead pipeline system. Thus, refiners in the Northen tier can meet supply shortfalls or shave demand peaks with tradable pipeline crudes. Indeed, the logistical situation of Canadian producers of heavy sour crude oil actually reduces the incentive of deep conversion refineries in this zone to term up the whole of their requirements. Since these refineries constitute the main market outlet for landlocked Canadian blends,[11] there is a considerable risk that volumes that producers have been unable to place will have to be shut-in. Some refiners in the area have become very adept at using their limited term commitments (or their term commitments with non-Canadian sellers) as a lever to force Canadian producers (some of whom do not have very deep pockets) to lower their prices.[12]

3.1.1 The Main Players

The universe of sellers in both the West Coast and the US Northern Tier is composed of a large number of firms, ranging from small independent producers to large integrated oil companies. Such diversity is completely absent from the USGC market, where only two NOCs — PDVSA and PEMEX — have an overwhelming presence. Heavy sour crudes from these sources account for around 90 per cent of the market for this type of imports into the USGC (Figure F3.2).[13] The remaining 10 per cent is distributed amongst various countries (Guatemala, Syria, Italy, the Neutral Zone), but the companies that market these volumes are incapable, either on their own or as a group, to exert any decisive influence on the conduct of the market at large. Moreover, since PDVSA and PEMEX have very stringent clauses against resale operations in their contracts, neither Venezuelan nor Mexican crudes can be counted upon to serve as barrels of last resort for companies that might suddenly find themselves short of crude[14] (all the more so during the summer, peak demand season). This is especially true for PEMEX, because PDVSA's operational leeway is greater thanks to its extensive storage and port facilities (this advantage is compensated by the fact that Venezuela and the Caribbean are farther away from the USGC than Mexico).



Conoco has joined the ranks of larger sellers in the USGC heavy sour market, thanks to its entitlement to half the output from the Petrozuata extra-heavy crude production and upgrading project. From 1998 to 2001, Conoco marketed about 55 MBD of Zuata blend (early production Zuata bitumen blended with Mesa crude). With the completion of the Zuata upgrader, Conoco started to sell about 70 MBD of Zuata syncrude (20-22° API, 2.3% sulphur content).[15] However, the incorporation of Conoco as a seller in this market has only had a marginal effect on its degree of concentration on the supply side. The same can be said for Texaco, which expects to increase output from onshore heavy oil fields in its Neutral Zone concession to 420 MBD by 2005. During 2000, total US imports of Ratawi (24.2° API, 4% sulphur content) and Eocene crudes (15—18° API, 4% sulphur content) came to about 10—15 MBD, but this will grow substantially (perhaps even surpassing the 100 MBD mark) in the coming years. Once again, though, this will not alter the balance of power in the USGC, particularly if PADD V continues to account for most of the US imports of Eocene. More significant in their implications could be KPC's plans to export a new heavy sour crude (24°API, 4 per cent sulphur content), to be extracted from some of the country's southern oilfields. KPC considers that, by 2005, it may be producing up to 400 MBD of this crude, and that the bulk of this volume will go to the USGC. If these plans were to come to fruition, KPC would definitely become an important

player in the deep conversion segment in the USGC. Nevertheless, for the foreseeable future at least, PEMEX and PDVSA will continue to dominate this market, and their respective pricing and volume allocation policies will have a major influence on the profitability of deep conversion refineries in the USGC region.

3.1.2 Mexican and Venezuelan Heavy Sour Blends

PDVSA markets between 15 and 20 different heavy sour blends in the USGC. The large number of Venezuelan commercial segregations, to a certain extent, reflects the fact that some of them are produced in the elderly fields located in or around Lake Maracaibo, while others are blended from streams produced in the Oficina area and the Orinoco Oil Belt, to the east of the country. However, some of PDVSA's corporate and commercial strategies also contribute to this bewildering variety. For instance, some Venezuelan blends (like Mesa and Furrial, say) are virtual clones of one another and their segregation is explained by the fact that, until recently, their marketing was handled by separate organisations (in this case, Corpoven and Lagoven, respectively). Likewise, PDVSA's willingness to use its very flexible production and storage infrastructure to prepare crude cocktails tailored to the specific needs of some customers has encouraged the proliferation of commercial segregations that are 'blends of blends'.[16] Exports of Venezuelan heavy sour crudes are handled by a number of Venezuelan marine terminals (six in Lake Maracaibo plus the Paraguaná and Puerto La Cruz refineries, and the Jose terminal for syncrudes). The draft and tonnage of vessels loading at Lake Maracaibo terminals are restricted by the need to clear the bar at its mouth, but this is of no great consequence for PDVSA's competitiveness in the US Gulf, since most of the heavy sour crude exported from Mexico and Venezuela to the region is shipped in vessels that fit in the Maramax category, and not in VLCCs.

In contrast, since 1979, PEMEX's exports of heavy sour have consisted essentially of only one blend, Maya, produced wholly in the offshore fields that were discovered and developed in the late 1970s and early 1980s in the Sound of Campeche. On Mexico's Atlantic coast, Maya crude is exported from three deepwater ports, all of which can handle VLCC traffic: Cayo Arcas, Dos Bocas and the FSO vessel Ta' Kuntah. In 1998, however, PEMEX began exporting small quantities (about 8—10

MBD) of a blend called Altamira, produced in some of the oldest active fields in Mexico. This crude used to be processed exclusively at PEMEX's Ciudad Madero refinery (at a rate of about 20 MBD) but exporting part of this volume became necessary for this plant to comply with new sulphur content limitations for heavy fuel oil in Mexico. Altamira crude is loaded at the Madero marine terminal, whose operational restrictions limit cargo sizes to about 200 MB.

Table T3.3: Typical Characteristics of the Main Mexican and Venezuelan Heavy Sour Export Blends

	° API	Sulphur content (%)	Vanadium (ppm)	Total Acid Number (Mg KOH/gr)	Pour point (°C)	Production volume* (MBD)
Mexico						
Maya	21.5	3.50	217	0.30	-13	1,600
Altamira	15.8	5.50	273	0.81	0	22
Venezuela						
Bachaquero BCF-13**	12.2	2.71	465	3.65	0	100
Bachaquero BCF-17**	16.5	2.53	361	2.52	-32	300
BCF-21.9**	21.8	2.11	150	1.76	-37	100
BCF-24**	23.4	1.89	271	1.20	-37	150
Boscán	10.2	4.80	1,190	1.48	+17	100
Caripito	17.3	1.96	212	1.40	-10	50
Caripito Light	24.0	1.64	106	0.49	-40	50
Cerro Negro Blend***	16.3	3.30	360	3.30	0	80
Lagotreco Medium	23.4	2.27	386	0.93	-15	15
Laguna	10.9	2.72	446	3.33	+21	40
Laguna 22	21.9	2.10	234	1.95	-42	15
Laguna Medium Blend	23.6	2.07	313	1.03	-34	40
Leona 24	24.1	1.71	80	0.53	-34	150
Maralago 22	22.1	3.12	604	0.70	-29	15
Menemota	21.3	2.50	472	1.15	-2	70
Merey	16.0	2.49	295	1.24	-12	160
Morichal	12.2	2.78	274	2.83	+7	10
Pedernales	20.5	2.80	235	0.76	-26	15
Pilón 13.5	13.5	2.66	300	2.05	-9	20
Pilón 14.5	14.5	1.92	137	1.62	-4	30
Tía Juana Heavy	11.0	2.66	411	4.22	+12	40
Zuata Blend****	16.0	2.80	360	3.30	0	115

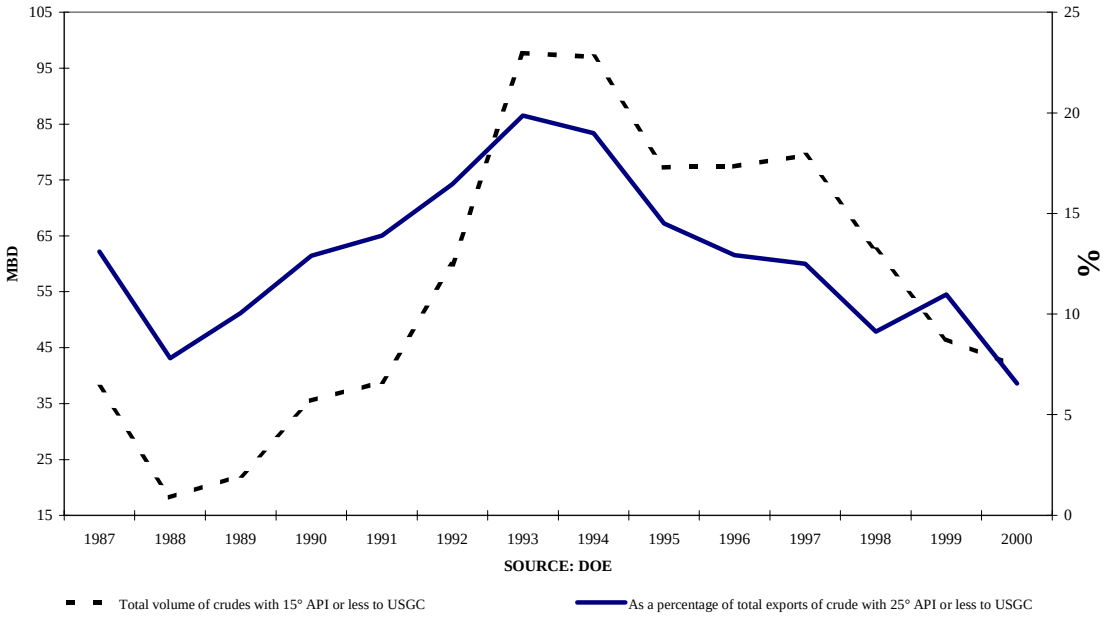
* Venezuelan production volumes for commercial blends are estimates
** BCF = Bolívar Coastal Field
*** A blend of Cerro Negro whole crude (8.2°API, 4.1% sulphur) with Nigerian Oso condensate (45°API, 0.05% sulphur)
**** A blend of Zuata whole crude (9.3°API, 3.4% sulphur) with Venezuelan Mesa crude (30°API, 1% sulphur)

SOURCES: PDVSA; PEMEX; MEM; *O&GJ*; CEPET 1989; Cerro Negro; Petrozuata

A few of the Venezuelan heavy sour crudes exported to the USGC (Boscán, Laguna, Morichal, Pilón, Tía Juana Heavy) are unsuitable for high conversion purposes, thanks to particularly deadly combinations of very low gravity, high acidity[17], very high sulphur and metals content and, in some cases, a high nitrogen content (see

Figure F3.3). Moreover, the pour points of some of these crudes mean that they have to be shipped in special coiled vessels, which naturally increases their transportation costs. However, their very high yield of vacuum residue makes them the preferred feedstock for refineries geared only to the production of asphalt. For refineries that have a large vacuum distillation capacity relative to their atmospheric distillation capacity, processing heavy crudes with a higher yield of light ends (like Maya, say) is not a good option, since it leads to bottlenecks that limit their processing rates. Hence, this particular niche (represented in the US Gulf by plants like Coastal Chickasaw and Trifinery Corpus Christi) is occupied almost exclusively by Venezuelan crudes. Similarly, heavy sour Mexican crude is an unsuitable feedstock for the manufacturing of naphthenic lubricants. This market niche is also entirely occupied by Venezuelan heavy sour crudes. However, there is only one refiner in the USGC region specialising in the manufacture of naphthenic lubes (Ergon Vicksburg), and most of the naphthenic base oil requirements of the USGC are met with imports sourced from PDVSA affiliates in Venezuela and Curaçao.

FIGURE F3.3: PDVSA. EXPORTS OF CRUDES WITH 15° API OR LESS TO THE USGC AREA (1987—2000)



The heavy sour syncrudes produced in PDVSA's strategic association projects in the Orinoco also have unique physical peculiarities. These syncrudes have a lower

vacuum residue content than that of conventional crudes of similar gravity, but they produce diesel fuels with a very low cetane number. Since they contain a large component of olefinic compounds (which arise from thermal cracking processes and, hence, are absent from conventional crudes), their customer base will tend to be restricted to refiners having a high percentage hydroprocessing capacity *and* a high percentage conversion capacity for material in the gas oil boiling range. The hydrogen deficiency of syncrudes, and the need to subject them to extensive hydrorefining and/or hydrocracking processes to enhance their value, means that the price of natural gas – a key driver of hydrogen production economics – has a significant impact on their market prospects (because syncrudes will be disdvantaged against conventional crudes at higher natural gas prices). The high nitrogen content and very low UOP "K" factor[18] of the syncrudes — the latter due to the presence of cracked streams —also adversely impacts the FCC conversion of their vacuum gas oil fraction (by as much as 25 percentage points in comparison to Maya). Hence, these traits affect the overall refinery volume gain, unless there is significant upgrading of the vacuum gas oil by means of high-pressure hydroprocessing.[19] The nitrogen content of these syncrudes may also lead to higher sulphur plant loading factors (due to ammonia production), as well as a faster deterioration of the catalyst of the hydrotreating units for FCC feed (due to increased reactor temperatures required to compensate for higher nitrogen levels). In addition, Venezuelan syncrudes (which are a blend of naphtha, coker gas oils, straight run distillates and vacuum residue) will not be suitable for long-term storage, as they will only remain stable and not polymerise for a maximum period of six weeks or so. Although this period is sufficient to cover the normal time elapsed between the production of syncrude in Venezuela and its processing in a refinery in the USGC, it will probably limit the operational flexibility of syncrude customers, more so in times of lax product demand. In the light of these factors, it is quite reasonable to conclude that for USGC refiners, "only long-term commercial operations will determine the ease of operation with these non-conventional refinery feedstocks".[20]

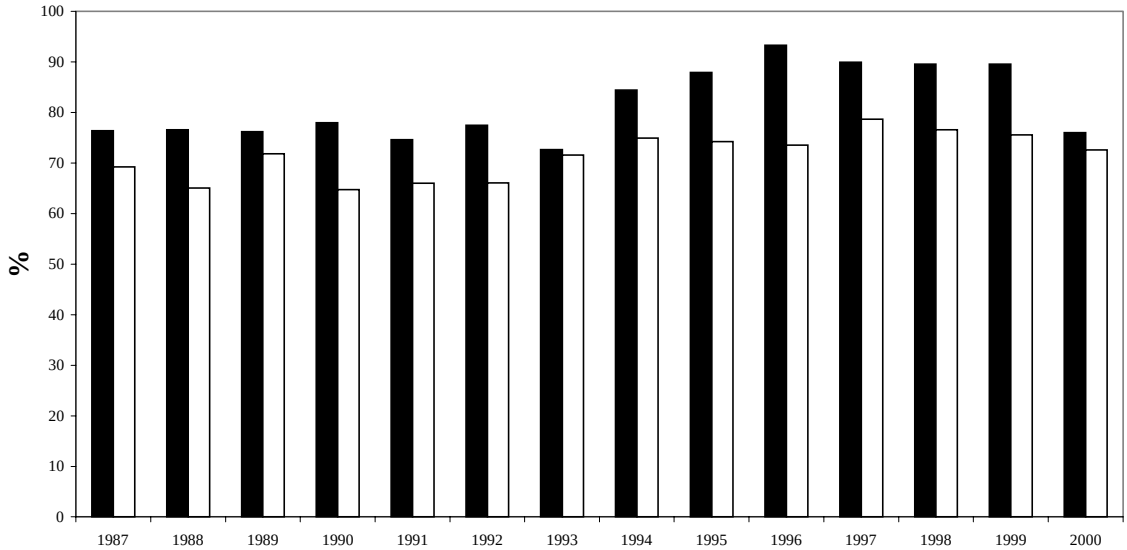
3.2 Market Shares and Patterns of Competition

Since the late 1980s, PEMEX's share of the USGC market for heavy sour crude has tended to be slightly larger than that of PDVSA, hovering around the 50 per cent

mark. Nevertheless, in volumetric terms, this market can justifiably be characterised as almost a pure duopoly, since the size advantage of PEMEX (in terms of both its market share and its exportable heavy sour crude surpluses) relative to that of PDVSA is trivial, and Venezuelan production decisions influence this market to a very important extent. But when one considers *qualitative* issues related to the market shares of these two players, the picture that emerges does not conform to the idea of how an archetypical duopoly should look and behave.

First of all, over the years, the proportion of PEMEX's heavy sour exports to the USA going to the USGC has been significantly higher than that of PDVSA (Figure F3.4). This difference should have price implications for the companies, since the USGC offers the best netback value for their heavy blends, partly because of the great complexity of refineries in the zone but mainly because their clients in the region do not have to be compensated for the cost of transporting crudes further inland by pipeline (as their clients in the Midcontinent would have to be). Thus, one of the duopolists is managing to concentrate a significantly higher porportion of its oil exports in a specific high-value region, at the expense of the other duopolist.

FIGURE F3.4: PERCENTAGE OF HEAVY SOUR CRUDE EXPORTS TO THE USA ACCOUNTED FOR BY REFINERIES IN THE USGC, BY COMPANY (1987—2000)



SOURCE: DOE

Of even greater potential significance are the differences between the weighted complexities (expressed in terms of Nelson's Generalised Complexity Index[21]) of the heavy sour customer portfolios of PDVSA and PEMEX. At first glance, the complexity figures for both companies look quite similar (Table T3.4). BUT this superficial homogeneity conceals an interesting fact; namely, that the high average complexity figures for PDVSA reflect the large volumes of crude it sells to affiliates. PEMEX also sells a considerable amount of Maya crude to an affiliated party, but these sales have a negligible effect on the overall weighted complexity of its client portfolio. Thus, the comparison between the weighted complexities of the arm's-length customers of the duopolists is markedly advantageous for PEMEX. Regardless of similarities in terms of volume availabilities and commercial preferences, PEMEX manages to sell considerably larger volumes of heavy sour crude than PDVSA to the sort of customer that would be expected to pay the highest prices for this sort of feedstock. This advantage can be put into an even better perspective by asking how much crude would the duopolist with the less complex portfolio have to sell to a reasonably sophisticated refinery (with a NGCI of 9) to equal the weighted complexity of the other duopolist's portfolio. This complexity equalisation exercise shows that such a refiner would have to purchase around 30 MBD, a not inconsiderable figure if one considers that it is equivalent to the average size of PDVSA's five largest arm's-length contracts (see below).

Table T3.4a: Weighted Nelson Generalised Complexity Index of US Refineries Processing Mexican and Venezuelan Heavy Sour Crudes (1987—1993)

	1987	1988	1989	1990	1991	1992	1993
PDVSA	7.90	8.49	8.33	8.44	9.08	9.91	9.77
Excluding affiliates	6.92	7.49	7.58	8.35	8.38	9.12	8.25
PEMEX	9.29	9.63	9.40	9.55	10.43	10.56	10.30
Excluding affiliates	--	--	--	--	--	--	10.30
Complexity Equalisation Volume (MBD), NGCI = 9	18	14	13	14	17	22	26
Excluding affiliates	30	27	23	15	26	26	37

Sources: DOE, *O&GJDB*

Table T3.4b: Weighted Nelson Generalised Complexity Index of US Refineries Processing Mexican and Venezuelan Heavy Sour Crudes (1994—2000)

	1994	1995	1996	1997	1998	1999*	2000
PDVSA	9.56	9.64	10.35	9.89	10.32	10.40	9.69
Excluding affiliates	8.32	8.64	8.80	9.24	8.91	7.61	8.04
PEMEX	10.04	10.28	10.32	10.22	10.24	9.94	9.71
Excluding affiliates	10.04	10.38	10.48	10.35	10.48	10.07	9.78
Complexity Equalisation Volume (MBD), NGCI = 9	24	33	-1.5	22	5	20	1
Excluding affiliates	34	35	39	29	34	31	22

* PEMEX volumes include 11 MMB of Maya sold from SPR facilities

Sources: DOE, *O&GJDB*

The general impression that PEMEX enjoys a dominant position at the high value end of the USGC market for heavy sour crude is reinforced when one considers the configuration of, and the volumes lifted by, the five most important arm's-length clients for each company.[22] The weighted complexity figures for the two sets are comparable, but PEMEX clients lift volumes that are, on average, twice as large as those lifted by PDVSA clients (Table T3.5). A similar disparity results when one divides the total sales figures for each company by the number of unaffiliated refineries that bought crude from them in each particular year.

Table T3.5a: Average Volume of Heavy Sour Crude Lifted by Type of Customer (1987—1993) MBD

	1987	1988	1989	1990	1991	1992	1993
PDVSA							
Five Largest Arm's-length Customers	25	19	21	32	18	26	27
Complexity of Five Largest Arm's-length Customers (NGCI*)	7.80	8.81	7.30	7.99	10.25	9.36	9.36
Volume by Refinery	17	17	14	15	13	21	27
Excluding Affiliates	11	10	9	13	9	13	12
PEMEX							
Five Largest Arm's-length Customers	51	55	53	56	57	62	58
Complexity of Five Largest Arm's-length Customers (NGCI*)	9.97	10.12	8.25	10.25	11.38	10.21	10.20
Volume by Refinery	15	18	22	21	22	27	26
Excluding Affiliates	--	--	--	--	--	--	28

*NGCI= Nelson Generalised Complexity Index

Source: DOE

Table T3.5b: Average Volume of Heavy Sour Crude Lifted by Type of Customer (1993—2000) MBD

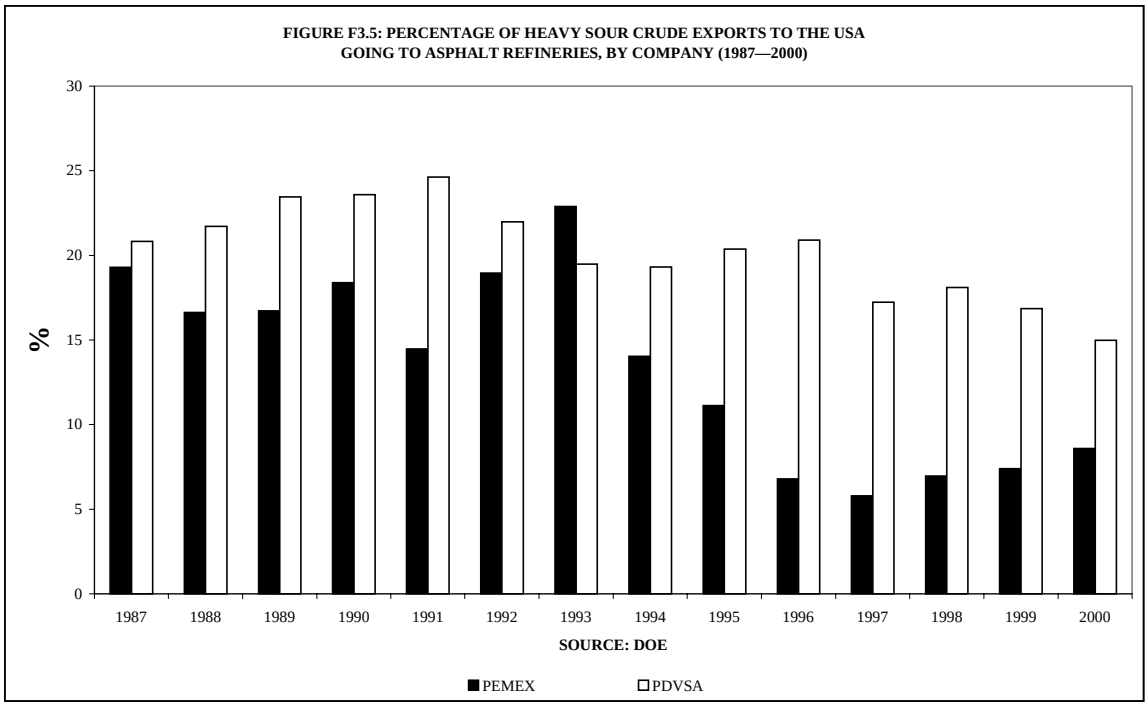
	1994	1995	1996	1997	1998	1999**	2000
PDVSA							
Five Largest Arm's-length Customers	29	29	29	37	30	21	31
Complexity of Five Largest Arm's-length Customers (NGCI*)	9.09	11.07	10.20	8.61	8.80	7.90	7.90
Volume by Refinery	30	28	33	36	36	25	26
Excluding Affiliates	14	13	16	17	15	10	12
PEMEX							
Five Largest Arm's-length Customers	72	59	72	79	77	58	64
Complexity of Five Largest Arm's-length Customers (NGCI*)	10.09	10.19	10.31	9.76	9.90	9.20	10.70
Volume by Refinery	29	39	39	48	46	31	31
Excluding Affiliates	30	33	30	37	37	26	25

*NGCI= Nelson Generalised Complexity Index
** PEMEX volumes include 11 MMB of Maya sold from SPR facilities

Source: DOE

The evolution of PEMEX's sales pattern throughout the years also indicates that this company has been able to shed marginal clients not only by concentrating its sales to Gulf Coast refiners but also by reducing the proportion of its sales to asphalt refineries (Figure F3.5). In no small measure, this was due to the construction of the coker at the Deer Park refinery (which came on stream in late 1993), since this plant absorbed volume that would otherwise have gone to clients focused on the manufacture of asphalt. Thus, PEMEX's incursion downstream in the US refining sector has leveraged its commercial position *vis-à-vis* its most important arm's-length deep

conversion clients. In contrast, PDVSA's high degree of downstream vertical integration on a US-wide basis has not translated into any greater commercial leverage in the deep conversion segment, as confirmed by the stability of the percentage of its total US sales of heavy sour crudes that is still accounted for by asphalt refineries.



Thus, by most standards, PEMEX seems to be the clear market leader in the USGC, even though, paradoxically enough, this is a market where vertical integration of the sort that PDVSA has pursued so aggressively would be expected to confer a significative competitive advantage. However, the fact that each duopolist has concentrated on a particular market niche could be symptomatic of nothing more than the physical differences between Mexican and Venezuelan crude oils identified earlier. But, if there existed a genuine commercial asymmetry that had nothing to do with quality issues, then one would expect it to be reflected on the relative prices that PEMEX and PDVSA have been able to realise for their US exports. After all, realised prices are the ultimate indicator of the strength or weakness of the competitive position of companies (prices compress nearly all the information about a commodity,

and are more visible than the quantities to which they correspond). This is a crucial matter, and we shall return to it in due course.

NOTES

[1] Constituted by the following counties of the State of Texas: Newton, Orange, Jefferson, Jasper, Tyler, Hardin, Liberty, Chambers, Polk, San Jacinto, Montgomery, Harris, Galveston, Waller, Fort Bend, Brazoria, Wharton, Matagorda, Jackson, Victoria, Calhoun, Refugio, Aransas, San Patricio, Nueces, Kleberg, Kenedy, Willacy and Cameron.

[2] Constituted by the following parishes of the State of Louisiana: Acadia, Allen, Ascension, Assumption, Avoyelles, Baldwin, Beauregard, Calcasieu, Cameron, East Baton Rouge, East Feliciana, Evangeline, George, Hancock, Harrison, Iberia, Iberville, Jackson, Jefferson Davis, Jefferson, Lafayette, Lafourche, Livingston, Mobile, Orleans, Pearl River, Plaquemines, Pointe Coupeé, Rapides, St. Bernard, St. Charles, St. Helena, St. James, St. John the Baptist, St. Landry, St. Martin, St. Mary, St. Tammany, Stone, Tangihapoa, Terrebonne, Vermilion, Vernon, Washington, West Baton Rouge, and West Feliciana.

[3] Although many Gulf Coast refineries were located in the vicinity of major oil strikes.

[4] The Southland Refining Co. refineries located in Mississippi are landlocked and only run domestic heavy crudes produced in the Baxterville field, which at a current ouput of around 2 MBD is the largest domestic source of heavy sour crude within the USGC area proper.

[5] Williamson 1991: 46.

[6] Myerson and Satterthwaite 1983.

[7] As Hay and Morris (1991: 77) point out with regard to cartelistic agreements, "stochastic demand means that firms may experience some loss of demand even though no other member of the cartel has cheated, an … [this in itself] creates the scope for cheating".

[8] Tirole, *op. cit*.: 21.

[9] Oilfields that produce heavy crude in the region were identified on the basis of the *1995 US Heavy Oil Database*, published by the DOE and available at the website of the International Centre for Heavy Hydrocarbons (www.oildrop.org).

[10] Design capacity of the All-American pipeline was 330 MBD, but shipments averaged about 115 MBD throughout its lifetime (1987—1999). The line was emptied in February 2000.

[11] Small volumes of Cold Lake crude can be sent to Vancouver, where they can be loaded on vessels for export to the Puget Sound area and California. These exports are so uneconomical that they qualify for a subsidy from the Canadian government whenever they occur.

[12] This explains why the prices of heavy Canadian crude oils since 1986 have tended to experience greater volatility than the prices of light reference grades (see Heath, Chan and Stariha 1995: 97). See also Heath *et. al.* 1993.

[13] PEMEX's 1999 figures include the 11 MMB of Maya that the company sold from Strategic Petroleum Reserve (SPR) facilities.

[14] Swapping loading dates with other customers is a way in which a company can obtain crude at very short notice, but this presupposes the cooperation of the other refiner and the approval of the seller. PEMEX grants waivers for resale of cargoes already in the water only under exceptional circumstances.

[15] The Petrozuata partners (Conoco and PDVSA) "intend to market the entire production of the project to third-party purchasers" (Petrozuata, 1997: 58). In contrast, output from the Cerro Negro upgrading project will be channeled exclusively to the refineries of PDVSA's partners in the project (ExxonMobil and Veba Öl). Cerro Negro syncrude will be sold to third parties only in exceptional circumstances.

[16] Leona is a 50/50 mix of Mesa and Merey, while BCF-21.9 consists of 77 per cent BCF-24 and 23 per cent BCF-17, and Caripito is made up from 30 per cent Furrial and 70 per cent Pilón.

[17] Total Acid Number (TAN), measured in milligrams of potassium hydroxide per gram.

[18] The UOP "K" factor indicates the degree of aromaticity of a particular feedstock.

[19] For all these aspects, consult the technical sections in both Petrozuata (1997) and Cerro Negro (1998).

[20] Petrozuata 1997: C-11.

[21] The complexity factors for different refining units can be found in Johnston 1992: 195—202.

[22] Every individual refinery is considered a client for the purposes of this exercise.

4 GENESIS OF THE USGC MARKET FOR HEAVY SOUR CRUDE: 1981—1986

The internal structure of oligopolistic markets is the result of unique historical processes energised by unique events, individuals and corporations, framed in their turn by concrete industry and product characteristics. As Kuenne observes,

> oligopolies are *communities* in important respects. Individual units within such communities have important competitive interests that make them rivals in their goal seeking. But as members of an acknowledged community they have common interests that imply co-operative relations. Their actions, therefore, will be motivated by a blend of rivalrous and cooperative goals in mutual recognition of a *rivalrous consonance of long term interests*.[1]

The study of a concrete oligopoly from an applied economics viewpoint clearly has to dwell, in as much microeconomic detail as possible, on the outcomes of the commercial interaction of individual firms with their competitors, clients and suppliers. In addition, however, it is desirable that it incorporates the cultural aspects that underlie this interaction (that is to say, the sociological matrix of power relationships in that market). After all, in every community where "individual actors are few enough in number to impact the industry in personally identifiable ways", there will exist a "power structure, or a web of perceptions among firms, that has an important bearing upon their decisions. The binary, firm-to-firm, combination of rivalry and co-operation that constitutes an important component of their decision-making is the operational expression of that power structure".[2]

This ‘oligopolies as communities’ approach offers a fruitful avenue for understanding the dynamics of competition within the USGC duopoly for heavy sour crudes. The evolution of these dynamics since the emergence of this duopoly in the late 1970s and early 1980s owes much to the corporate motivations of PEMEX and PDVSA (whether their character be purely economic or otherwise) and to the safeguards against the breakdown and premature breach of commercial relationships (i.e. the governance structures) that they have incorporated in their respective commercial policies. Thus, contextualising these motivations and commercial strategies through a discussion of the exogenous events that gave rise both to them and the governance structures in this market simplifies the task of unravelling the “tangled complex of

perceived threats, desires for stability, personality idiosyncrasies, legal and other social sanctions, competing sub-unit bureaucratic goals and industry mores"[3] that underpin the duopoly for heavy sour crude in the USGC.

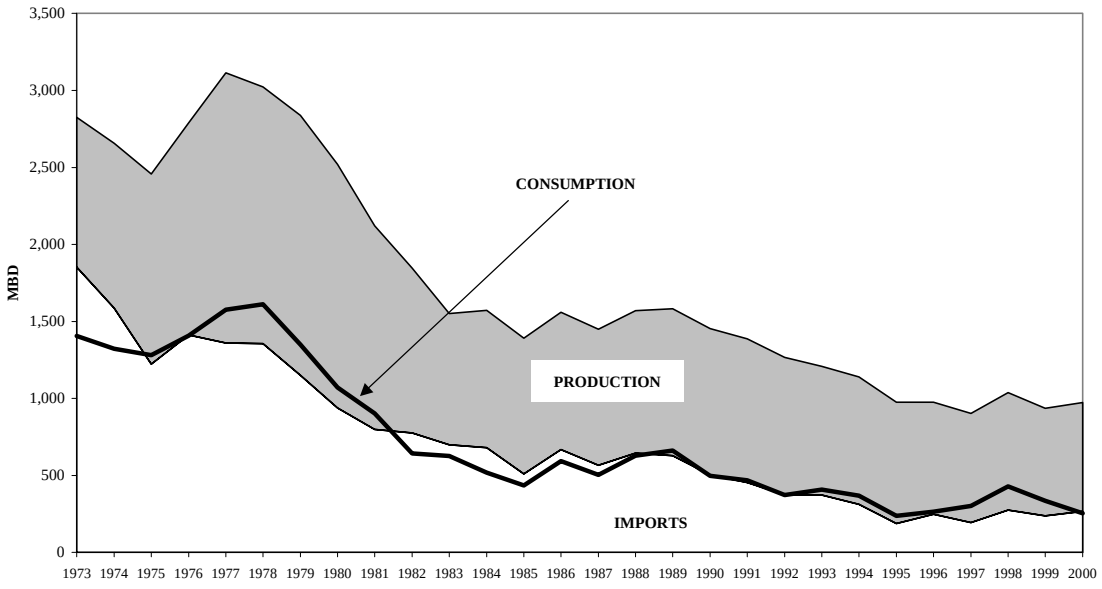
4.1 The Birth of the Deep Conversion Market

The market for heavy sour crude in the USGC only assumed its current duopolistic form after 1980, as PEMEX began exporting sizeable volumes of Maya crude oil on the heels of its discovery and rapid development of the supergiant fields in the Sound of Campeche. Before then, the only source of US imports of heavy sour crudes was Venezuela. However, at that time, environmental standards meant that such crudes could be — and were — used as general-purpose refinery feedstocks (albeit ones with markedly higher processing costs). Moreover, the production of residual fuel oil on a large scale was still a reasonably profitable activity. Thus, Venezuelan crudes faced competition from a wide variety of crudes, and did not enjoy a monopolistic position in the deep conversion segment. Indeed, such a segment did not actually exist at the time because few — if any — refineries in the region geared their operations to the destruction of residue produced from heavy sour crudes. Even USGC coking plants processed higher quality feedstocks, in order to manufacture anode grade coke.[4] Thus, before 1980, the only market segment that was geared towards heavy sour feedstocks was the one constituted by asphalt refineries, where Venezuelan crudes had a dominant position (as they still do).

During the early 1980s, power stations in the USA stopped using fuel oil for electricity generation purposes, partly in response to clean air legislation but mostly because President Carter's National Energy Policy made it an urgent priority to substitute fuel oil with other primary energy sources (coal, natural gas and nuclear energy) which were abundant in the USA and, crucially, not under the control of OPEC. As a result, US demand for residual fuel oil contracted brutally (after peaking during the late 1970s at 1.7 MMBD, it has since declined relentlessly to approximately 300 MBD; see Figure F4.1). Coupled with the adoption of progressively tougher sulphur content specifications for all petroleum products and the continued growth in the demand for gasoline and diesel, the rapidly shrinking market for fuel oil led to a widening of the price differential between light and heavy

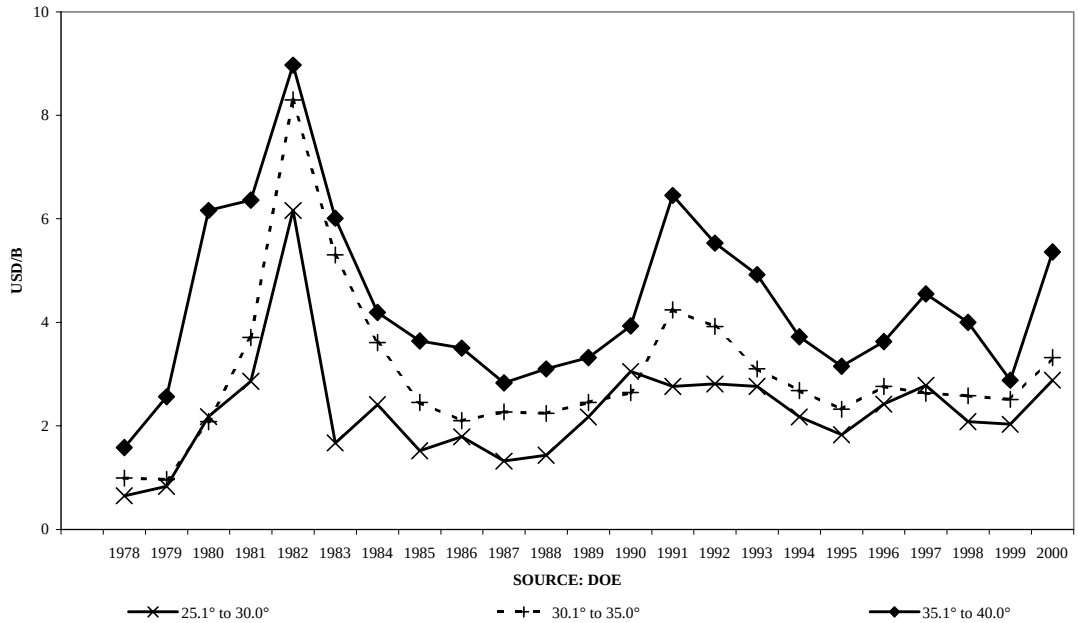
crudes, heralding the sort of structural segmentation that is characteristic of the US oil market nowadays (Figure F4.2).

FIGURE F4.1: US PRODUCTION AND IMPORTS OF FUEL OIL, AND CONSUMPTION TO GENERATE ELECTRICITY AT ELECTRIC UTILITIES (1973—2000)



SOURCE: DOE

FIGURE F4.2: PRICE DIFFERENTIALS (LANDED BASIS) BETWEEN US CRUDE IMPORTS WITH GRAVITY BETWEEN 20.1° AND 25.0° API, AND LIGHTER CRUDE IMPORT BASKETS (1978—2000).



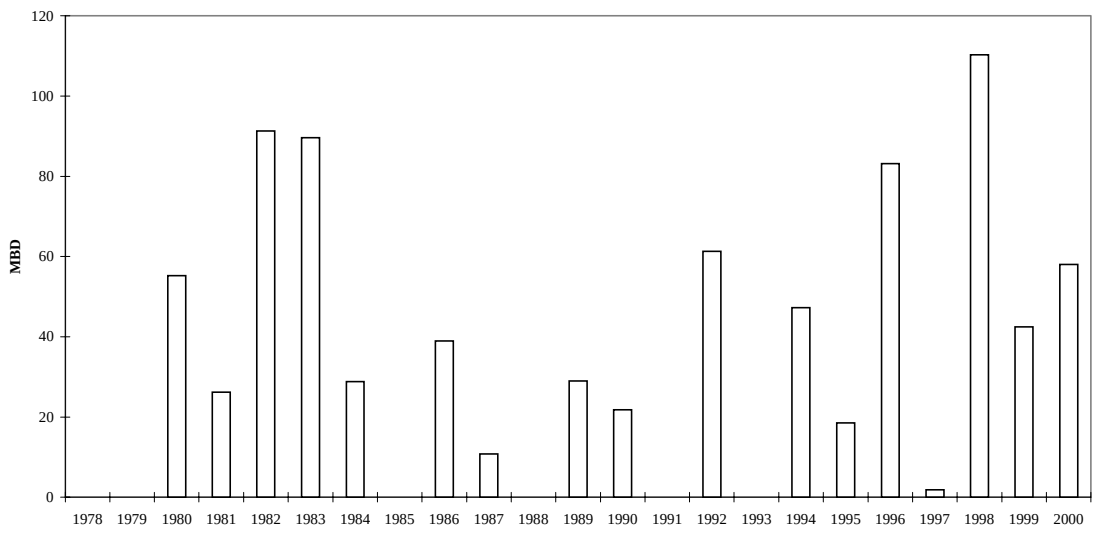
SOURCE: DOE

The de-regulation of the US petroleum market (finalised in January 1981, when the Reagan administration removed all remaining price and allocation controls on crude oil and petroleum products) also played a key role in this process of market segmentation.[5] The 1970s-vintage petroleum-related legislation in the USA actually *fostered* the production of fuel oil in the country: during the 1973-7 period, the output of residual fuel oil by American refiners jumped from 971 MBD to 1.65 MMBD (see Figure F4.1 above). There were a number of factors that acted as perverse incentives to produce fuel oil. On the one hand, the different import fees levied on crude oil and refined products after 1974 — 0.21 USD/B and 0.63 USD/B, respectively — favoured import substitution. Thus, US product imports fell by 1.1 MMBD during this interval (with most of this volume accounted for by fuel oil formerly sourced from the Caribbean entrepôt refineries).[6] On the other hand, the byzantine entitlements system underlying the Mandatory Oil Import Programme encouraged the construction of very small and simple refineries geared towards fuel oil production: 56 new refineries with a processing capacity of 10 MBD or less were constructed — at a rate of almost one per month — between 1974 and 1979, and only six of these could produce any gasoline.[7] Finally, price controls inhibited refiners from spending on deep conversion capacity: a large part of the savings to be realised from lowering crude costs would be passed on to consumers in the form of low product prices, and the capital invested in upgrading projects would never generate an adequate return.[8] After the deregulation of fuel oil prices in 1976, a complicated "tilt rule" was introduced in order to encourage investment in upgrading capacity: "tilting" gave refiners scope to recover losses associated with the sale of unregulated products by allowing these costs to be pooled into their refundable gasoline costs, thus making gasoline production and marketing more profitable. In practice, though, the rule did not serve to promote upgrading investments because up until the moment when price controls were finally removed, a "soft market for gasoline … inhibited the pass-through of the 'tilted' costs to a large extent".[9]

The impact that deregulation had on the genesis of the deep conversion market was profound. On the one hand, the artificial fuel oil boom created by US petroleum legislation magnified the demand shock in the fuel oil market during the early 1980s. On the other hand, even as US demand was plummeting, oil companies put off investing in upgrading facilities because price controls limited the potential

profitability of such investments, and refineries were able to increase their output of this product by the simple expedient of running more light crude. Thus, deregulation provided the momentum to push the deep conversion market on its way. Significantly, the suddenness with which deregulation was implemented after President Reagan took office also meant that a very large amount of deep conversion capacity was added in the USGC at the same time (as Figure F4.3 clearly shows). This clustering behaviour, as we shall see in a later chapter, compromised the profitability of these projects (with the partial exception of those that were focused on serving niche markets, like the small coker at Hunt Tuscaloosa).

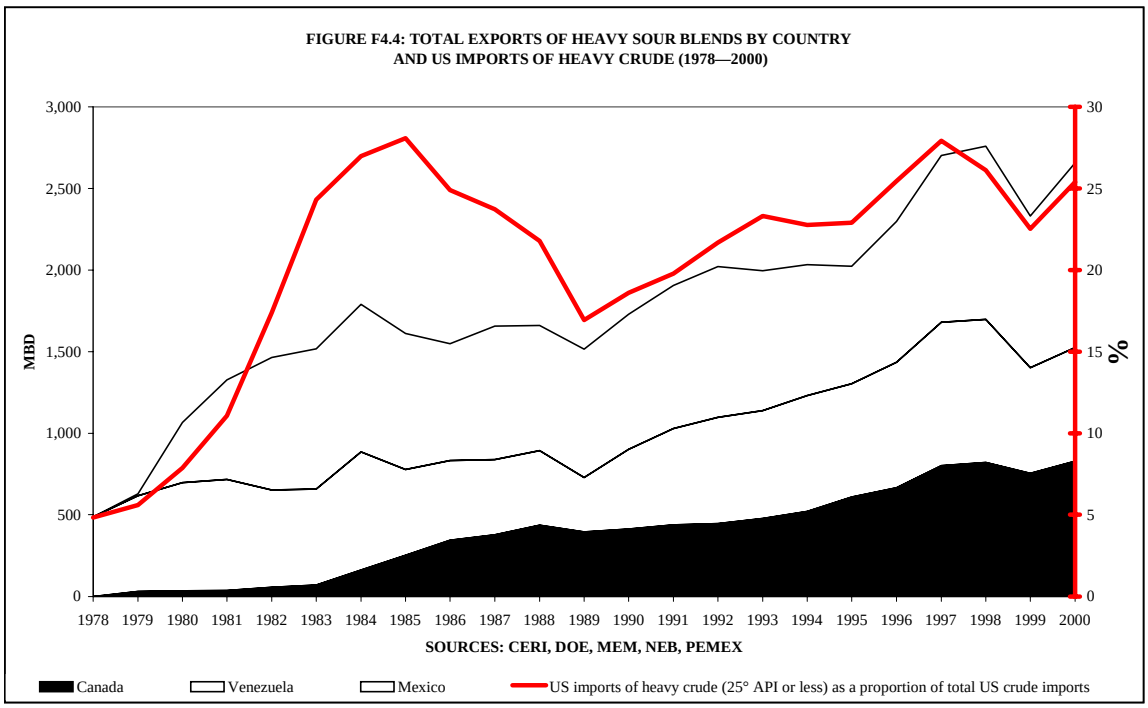
FIGURE F4.3: NET YEARLY ADDITIONS TO COKING CAPACITY BY REFINERIES IN THE USGC AREA (1978—2000)



SOURCE: DOE

These developments on the demand side of the oil market equation coincided with a rapid expansion in the supply of heavy sour volumes to the USA. This expansion — which convinced refiners that investments in upgrading capacity were inevitable — was the result of four more or less contemporary events. Firstly, after 1978, Saudi Arabia restricted the export share of Arab Light in total exports to 65 per cent, mainly as an indirect and inconspicuous measure to regulate its overall output. Secondly, from 1980 onwards, there was a marked acceleration in the rate of decline in the output and exports of Venezuelan light and medium grades: in 1981, the share of

heavy sour crudes in total Venezuelan output reached the 40 per cent mark for the first time, while heavy sour exports accounted for 55 per cent of total Venezuelan exports). Thirdly, a situation comparable to that of Venezuela developed in Canada: from 1973 to 1983, total Canadian crude production declined by 25 per cent, but heavy sour output increased by 40 per cent over the same period (and, to make matters worse, Canadian demand for heavy sour crude declined 42 per cent from 1980 to 1983, while total Canadian demand declined by 18 per cent[10]). Finally, starting in late 1979, there was the dramatic expansion in the amount of Mexican heavy sour crude oil reaching the international oil market (Figure F4.4).

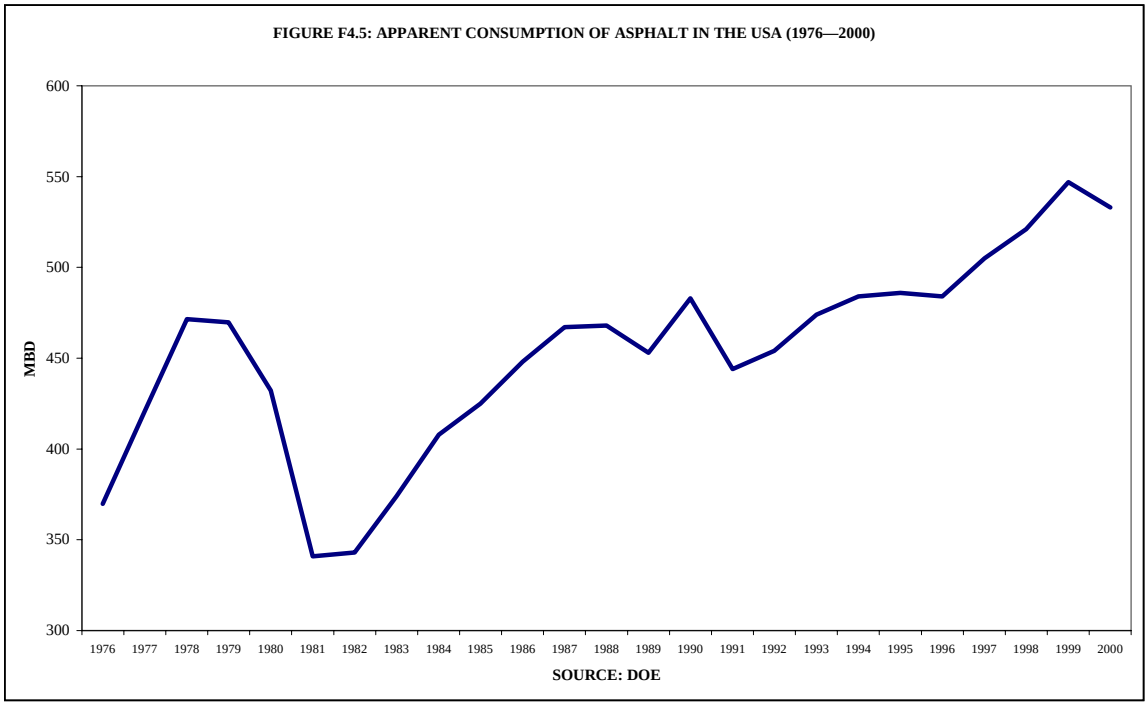


Throughout the early 1980s, as a result of the confluence of the demand- and supply-side factors detailed above, many refiners in the USGC significantly expanded their deep conversion capability.[11] A US Senate report on the domestic refining industry remarked: "much of [the available US refining] capacity cannot process heavy and sour crude oil into light petroleum products . . . even though these crudes are becoming an increasing fraction of world supply. Thus, new investment is desirable despite an apparent excess capacity in the refining industry".[12] The investments did take place, but their performance proved very disappointing. Throughout most of the 1980s, the DOE found that investment in heavy sour processing capacity had an

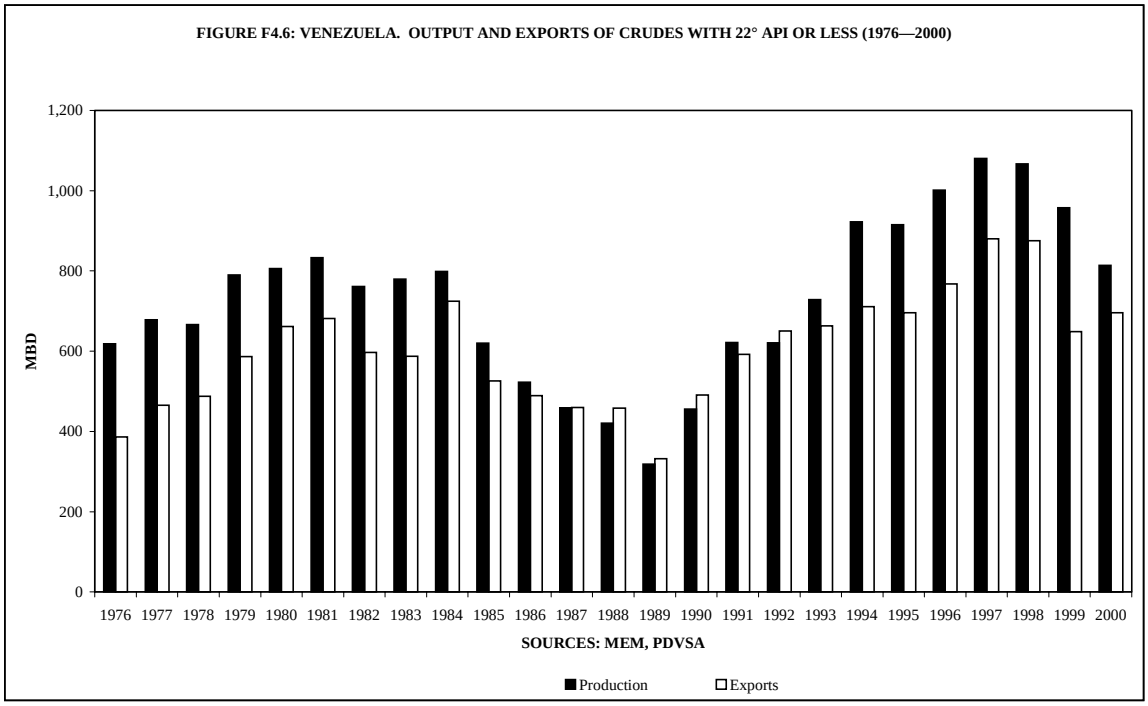
adverse effect on the profitability of refiners, even though it contributed to a significant fall in their raw material costs.[13] This was largely because many refiners hit upon the idea of revamping their respective plants at the same time, thereby bringing about a clustering of upgrading projects. As the *Oil and Gas Journal* put it,

> refiners who launched a multibillion dollar upgrading wave … are caught in an economic squeeze play. The surge in US refinery retrofits has tightened heavy crude/residual oil supplies … Also, demand and prices for gasoline and other light products are falling far short of projections made when refiners committed to the projects. As a result, refinery upgrades based on a crude price spread of at least 8 USD/B are seeing razor thin returns because the differential has been halved to 4 USD/B or less.[14]

In addition, up to 1988, the light/heavy price differential was affected by the buoyant asphalt market which followed the enactment (during January 1983) of the Surface Transportation Assistance Act (STAA). This was focused largely on major new construction or reconstruction (rather than regular maintenance) for the US highway network. It was financed by a 5 CPG federal gasoline tax and a part of the fees levied on heavy truck users, and it led to a major increase in the level of federal funding that had previously been available to states under the Highway Trust Fund (HTF) scheme (between 1982 and 1983, for instance, allocations to states from the HTF rose from USD 7.6 billion to nearly 13 billion). This type of federal government spending had a very beneficial — and lasting — impact as regards the recovery of US asphalt consumption (Figure F4.5).



As things turned out, PEMEX managed to capture a considerable proportion of the upgrading capacity added by the investment effort of US refiners during the 1980s. PEMEX was a newcomer to the heavy sour crude oil scene in the US, but the commercial leeway of the incumbents in this market — PDVSA, first and foremost, and to a lesser extent Saudi Aramco — was hamstrung by their respective OPEC quotas (for obvious reasons, quotas tended to affect their heavier, least valuable, crude streams). A look at PDVSA's heavy sour crude production and exports figures between 1981 and 1986 is all that is needed to understand this company's inability to check the advance of its Mexican competitor. Indeed, Venezuelan data imply that quota restrictions brought about a situation in which exports of heavy Venezuelan crudes actually exceeded output during some years (Figure F4.6).[15]



PEMEX was also fortunate in that the expansion of its heavy sour production took place at a time when Saudi Arabia had explicitly adopted the role of swing producer within OPEC. The US refining industry was only awoken from its torpor regarding investment in deep conversion capacity after 1978, once Aramco had adopted the policy of increasing the share of Arab Heavy in the Saudi export mix. Paradoxically, by the time upgrading investments began to come on stream, Arab Heavy had been relegated to a rather marginal position in the deep conversion segment, because the contraction in Saudi output disproportionately affected this crude, in a way that led to its almost complete disappearance from the international oil market during the 1982—6 period. The abandonment of the swing producer's role by the Kingdom in 1986, however, was not accompanied by a return to prominence for Arab Heavy in the USGC market for heavy sour crude. For one thing, USGC refiners found that Arab Heavy was really too good a feedstock for coking plants.[16] Also, Saudi Aramco gradually shifted the focus of its commercial efforts for Arab Heavy to the Far East, leaving an affiliate (Star Enterprise) as the main US recipient of this type of crude.

4.2 The Heavy Sour Market under the Government Selling Prices (GSP) System

The bullishness that developed in the main oil-exporting countries after the two Oil Shocks was somewhat tempered by the weakening of oil prices in 1981—2, as the market made it evident that the dizzy heights which it had attained in the aftermath of the Iranian revolution were unsustainable. As a major international daily put it at the time:

> dozens of oil companies have suspended or phased out [contracts] … After years of submission to the price demands of the oil exporters, the willingness of oil companies to force a showdown with … producers has come as quite a shock. 'I have never seen contracts suspended on this scale' said the chief negotiator for an oil company … [Previously] even in times of oversupply like the present, the companies were willing to pay uneconomic prices just to maintain a … relationship with a producing country. But times have changed.[17]

The clearest confirmation of just how much times had changed lay in the fact that, in March 1982, OPEC was forced to implement a system of individual production quotas, even though the output of two of its key members was greatly affected by the fact that they were at war with each other. This quota agreement failed to stop the rot and its members continued to lose market share relentlessly (with those that had to compete head to head with North Sea producers being the hardest hit of all[18]). It was only when Saudi Arabia began to curb its output (explicitly assuming the role of swing producer) that the oil price stabilised somewhat. Nevertheless, major oil exporters in general gradually began to adopt what they saw as more market-responsive commercial practices (such as the reduction in the time between price notifications). PDVSA, however, decided to go much further than this, and it embarked upon a very ambitious programme of downstream integration into the refining sectors of major consuming countries that continues to this day.

4.2.1 Vertical Integration as the Antidote for Market Weakness: the PDVSA view

According to the company's official history, PDVSA's interest in international vertical integration (commonly referred to as *internationalisation*) began at the very moment that it was born (1976),[19] and the long time that had to elapse before PDVSA signed an association agreement with Veba merely reflected that "this was a new field … in which [PDVSA] was to act as a pioneer".[20] These claims are slightly exaggerated,

because Venezuela was not the first major oil exporter to acquire refining capacity overseas. For instance, the government of Iran had acquired a 17.7 per cent stake in South Africa's Natref refinery as far back as 1971, while PEMEX itself bought 34 per cent of a Spanish refinery — Petróleos del Norte, or Petronor — in late 1979 (and KPC started its own downstream expansion in 1982). However, it is true that during the late 1970s and early 1980s, PDVSA was alone among the major NOCs in preaching that overseas vertical integration, down to the gasoline pump level, offered producers "the *only* means … [through which they could achieve] the flexibility necessary to guarantee the placement of [their crude oil] production".[21] At that point, other NOCs were either considering or going ahead with investments in refining capacity abroad, but these were not really prompted by the defensive motives adduced by PDVSA. Rather, these actions were justified by the idea that oil producers had to get more from their oil than the mere dollar price of the barrel, which was held not to reflect its true scarcity value and accelerating depletion (such benefits could take the form of technology transfer, direct foreign investment in non-oil activities, the industrialisation of oil through refining and petrochemical activities, and so on).

In the specific case of Kuwait, portfolio investment considerations played an important role in justifying its expansion abroad, as did the leeway that the ownership of an overseas refining system gave KPC in bypassing restrictive OPEC price accords. In PEMEX's case, the Petronor operation was essentially prompted by the desire of the Mexican government to make a gesture of friendship to the new democratic government in Spain.[22] For a number of reasons, this refinery was attractive for these purposes: it was conveniently available (as a result of Gulf Oil's exit from the Spanish refining and marketing sector), and its acquisition would involve a small expenditure on the part of PEMEX. As it turned out, the refinery proved to be well suited to process large volumes of Maya crude (partly because heavy fuel oil production was still a viable economic proposition for Mediterranean refineries at the time, but largely because the main markets for Spanish fuel oil were in Africa). In addition, PEMEX's incursion in the Spanish crude market (which was not limited to sales to Petronor) was welcomed by both the government and other Spanish refiners, since it served to broaden a supply base which was highly dependent on volumes secured through state-to-state contracts from countries whose output was greatly disrupted during the late 1970s: Iran, Iraq and Libya. However, these positive aspects were merely icing on the

cake for PEMEX, and it cannot be emphasised strongly enough that the Petronor acquisition was a political move that did not respond to an explicit overseas vertical integration strategy on the part of the Mexican NOC.

In 1982, thanks to the abrupt fall in oil prices, PDVSA managed to convince the Venezuelan government (presided at the time by Luis Herrera Campíns) that there were significant advantages to be derived from establishing a downstream presence in important consuming countries. As a result, the government allowed the company to strike its first joint venture agreement with Veba Öl (a company in which the West German government had a substantial shareholding at the time). However, the idea that having captive clients increased Venezuela's volumetric security lost much of the lustre it held for the government after OPEC's March 1983 production accord enabled member countries (Saudi Arabia excepted) to place their crude with relatively more ease than in 1982. This, coupled with the high cost of the German acquisition[23] and the fact that this deal was conceived and carried out during a COPEI (Christian-democrat) administration, prompted President Jaime Lusinchi to order the immediate suspension of the internationalisation programme almost as soon as his AD (social-democratic) administration had taken office in early 1983. PDVSA did not comply fully with this ban: in 1983, the company had paid Veba 16 MMUSD for a call on half of Veba's remaining refining and primary petrochemical operations not covered by the Ruhr joint venture,[24] and in 1985 PDVSA quietly exercised this option, thereby increasing its overseas refining capacity by nearly 50 MBD. Nevertheless, it is clear that, at that point in time, the internationalisation programme was almost completely stalled.

If one leaves aside PDVSA’s aggressive pursuit of vertical integration, the company’s commercial practices and experiences during the 1982—86 period appear broadly comparable to those of other OPEC NOCs, with one significant proviso: in 1983 the Venezuelan company had convinced the Ministry of Energy and Mines (MEM) that it be permitted to withdraw heavier blends from the OPEC system of price differentials. Throughout this transition period in the oil market, PDVSA exploited the commercial leeway that this measure afforded it in various ways. For instance, in late 1985 PDVSA began to sell large volumes (100 MBD+) of heavy crude on a quasi-netback basis to Citgo[25] (a company with whom the Venezuelan government would eventually

allow PDVSA to subscribe a formal joint venture agreement). Likewise, PDVSA signed a number of long-term contracts to supply about 65 MBD of heavy crudes to lubricants and asphalt producers in the USA and Europe, incorporating preferential pricing formulae. These formulae were based on those embedded in its 30 MBD supply contract with Swedish company Nynäs (dating from 1983), which adjusted the official Venezuelan posted price downwards whenever this price exceeded "an agreed 'equitable' differential with a basket of lighter crudes".[26] By means of these and related initiatives, as well as of its sales to Ruhr Öl, PDVSA managed to reduce its exposure to volumes sold on a GSP basis by a considerable margin. In addition, between 1977 and 1981, the company completed a major revamp at two of its Venezuelan refineries (Amuay and El Palito), which enabled it to process more of its heavy sour crude domestically without increasing its output of residual fuel oil.[27] Nevertheless, a substantial proportion of PDVSA's exports were still transacted on the basis of GSPs, and MEM's steadfast support of OPEC's official price accords[28] — at a moment when all of PDVSA's main competitors in the oil market (bar PEMEX) were selling their crude through netback arrangements — eventually led to a massive fall in liftings of non-heavy grades by arm's-length customers. This situation was only reversed when PDVSA began applying retroactive discounts to liftings by arm's-length customers,[29] as the Venezuelan government was traumatically persuaded that PDVSA's affiliates needed more "commercial flexibility … to adapt … to the new dynamics of the petroleum market".[30]

4.2.2 PEMEX and the Commercial Catastrophe of 1982

The weakening of the oil market in 1982 hit PEMEX particularly hard, because its very high export prices caused the company's crude oil exports to contract strongly at a moment when the Mexican government began to realise that it was in the grips of a major economic catastrophe. For instance, PEMEX was supposed to sell its Isthmus crude at parity with Arab Light but in the very tight market situation that developed after the Iranian Revolution, Isthmus was sold at parity with the deemed marker price fixed by OPEC[31] (and ignored by Saudi Arabia). Thus, by the end of 1980, the Isthmus-Arab Light differential was 2.50 USD/B, and it averaged 6 USD/B during the first half of 1981. In January 1981, even the price of Maya (34.50 USD/B) was higher than that of Arab Light (32 USD/B). Moreover, customers resented some of

PEMEX's commercial practices (notably its insistence on making the lifting of Isthmus crude conditional on the lifting of similar volumes of Maya[32]).

In response to a rapidly deteriorating commercial situation,[33] in June 1981 PEMEX director general Jorge Díaz Serrano reduced Mexican prices by 4 USD/B. At that point, a smaller adjustment would probably have been sufficient to restore the competitiveness of Mexican crudes, but Díaz Serrano's advisers insisted that only an adjustment of this magnitude would satisfy some of PEMEX's US customers. Moreover, the implementation of the price cuts was suicidal from a political point of view: the Mexican cabinet only learned about the cuts upon reading a press cutting from the *New York Times* which was sent via courier to the presidential residence by the staff of the secretary for National Patrimony, José Andrés de Oteyza. Thus, president José López Portillo demanded that his close friend Díaz Serrano fall on his sword, and the price cuts were withdrawn by a relieved Cabinet (whose members, in any case, clung to the belief that the price of Mexican oil would keep pace with the government's inexhaustible revenue needs[34]).

PEMEX's commercial position continued to deteriorate after the sacking of Díaz Serrano, because of the reluctance of the Energy secretariat to sanction any downward adjustment in Mexican GSPs had made the country's crude prohibitively expensive. The day of reckoning for the Mexican NOC duly came in July 1981, when exports of crude fell to 500 MBD (compared to a figure of 1,350 MMBD for April of that same year[35]). This traumatic reduction in export volumes meant that price cuts as large as those originally advocated by Díaz Serrano had to be adopted. The attempt of the Mexican government to hold the price line in 1981, *coûte que coûte*, proved to be both ill-advised and disastrous. One cannot help but speculate that the long-term interests of both Mexico and PEMEX at this crucial juncture would have been better served by a more flexible approach to the pricing of Mexican oil.

The main commercial legacy of the Díaz Serrano fracas was the establishment in December 1982 of a Foreign Oil Trade Committee (COCEP), whose explicit approval was made a prerequisite to any modification in the price of Mexican crudes.[36] Some analysts consider the *raison d'être* of this committee to be the spreading "responsibility for pricing moves among … government entities",[37] through a

ratification process that ensured that key ministries were kept abreast of developments in the international oil market and, hence, could not adduce ignorance of the commercial background to PEMEX's pricing decisions. Through this ratification process, the argument goes, the influence of domestic political factors in PEMEX's commercial decision process would be tempered, and the company's commercial decisions would be safeguarded from the fact that Mexican GSPs had become imbued with political symbolism. This argument is plausible but inaccurate: after July 1981, both PEMEX and the government were perfectly aware that the company's view on pricing issues, in an ever more uncertain market, would tend to prevail. Nevertheless, Díaz Serrano's successor at the helm of PEMEX, Mario Ramón Beteta, felt the need for an institutional mechanism that would facilitate the flow of information between the company and the federal government (Díaz Serrano had embraced a culture of secrecy as a means of furthering his political aspirations). In other words, the Committee was intended to be a forum where pricing decisions could be discussed and structured as a matter of *routine*, in a way that would inhibit members of the cabinet from seeing pricing reviews as opportunities to score political points. In this neutering of PEMEX's commercial activities, the COCEP initiative has been very successful: both cabinet ministers (and then vice-ministers) as well as the PEMEX high hierarchy gradually ceased to attend the Committee meetings, delegating instead this responsibility to middle-ranking officials from the ministries and the company.

The COCEP initiative aside, PEMEX's commercial operations were little changed in appearance by the events of 1981—2. Up until mid-1985, just like the majority of OPEC NOCs, PEMEX continued to sell its oil on the basis of minimally responsive GSPs, even in the face of systematic quota violations, a sluggish rate of growth in world oil demand and rapidly rising production flows from other non-OPEC regions. Beneath this appearance of continuity, however, substantial organisational changes were being introduced by a management team transplanted from the Secretariat of National Patrimony. This team (derisorily called "the smurfs" by the Oil Workers' Union) was given the task of putting PEMEX's international marketing operations on a sounder footing than the one bequeathed by Díaz Serrano.[38] Even though its members were newcomers to the oil scene, they were quick to grasp that the Mexican NOC had a public image problem that would dog its long-term commercial prospects, because it conveyed the idea that the company was not a serious and reliable supplier.

PEMEX's standing had certainly not benefited from the allegations of corruption surrounding its activities, or from the gaoling of Díaz Serrano in August 1983. However, even more damaging to the market's perception of the company was the chaotic manner in which PEMEX's international operations had been handled until then. For instance, even though PEMEX had gone from being a net oil importer in 1973 to become the fourth or fifth largest seller of oil in the world by 1980, the company had not drawn up a set of GT&Cs to govern exports of Mexican oil (instead, it relied on the conditions stipulated in the contracts it had used to import oil, merely substituting the word 'seller' for 'buyer' wherever the latter appeared). In addition, the company kept no computerised record of liftings and had no measuring devices (for either volumes or crude quality) at any of its rather inadequate marine terminals.[39]

These and other aspects of PEMEX's international operations began to be methodically addressed after 1982, as part of a process aimed at shoring up the company's battered reputation as a serious commercial entity in the eyes of the multinational oil majors (which were singled out as a preferred sort of customer because of a perception that their planning horizons would tend to place value on PEMEX's importance as a supplier in the long run and, hence, make them less inclined to take advantage of the company's shortcomings and lack of international marketing experience). PEMEX made great strides to clean up its act between 1982 and 1985, but the ramping up of Saudi Arabian output and the Saudi adoption of netback pricing during the latter year prompted a marked decline in its commercial fortunes, especially since heavier streams accounted for a good part (40 per cent is a reasonable guesstimate) of Saudi incremental volume. A move to retroactive pricing (intended to "provide breathing space to draw-up a new market responsive price mechanism"[40]) proved ineffectual, and PEMEX once again saw its crude exports falling precipitously. Mexican export volumes stabilised only after PEMEX's introduction of public pricing formulae in April of that year (see below). The success of this untried commercial mechanism, which was eventually copied by many other oil-exporting countries, owed as much to the degree of respectability that PEMEX commanded in the market by then as to the high quality of the analytical work that had gone into the design and implementation of the formulae.

4.3 The Watershed of the 1986 Price Crisis

The uneasy equilibrium that the Saudi assumption of the role of swing producer brought to the international oil market after 1982 came to an abrupt end almost four years later, when the Kingdom decided that its loss of market share had become intolerable, and that it was necessary to discipline ofther producers who were free-riding on Saudi restraint. The first Reverse Oil Shock took a rather long time to unfold: Saudi Arabia introduced netbacks around September 1985, and yet the oil price started to plummet in earnest only after January 1986 (by which time the Saudis had managed to claw back around 2 MMBD of the export volume they had lost since 1982).[41] When the price collapse finally came, though, it was cataclysmic: the price of first month Brent crude dropped from over 30 USD/B in December 1985 to a low of 8.82 USD/B by July 1986. Some analysts have attributed both the extent and the speed of this decline to the fact that, unlike spot sales or unofficial discounts, netbacks reflect product price changes instantaneously and, as a result, give refiners an incentive to flood products markets indiscriminately. Mabro rightly dismisses this view, however, because it "assumes that refiners have access under the netback deals to unlimited quantities of crude, that there are no constraints on the capacity of their plants, and that they are at any time able to move any volume that they care to process physically on the product market".[42] As this author says, "even in the polar case where all transactions are on a netback basis, it is the crude oil supply decisions (and not the netback contract as such) which, given the demand functions for products, determine oil price movements".[43]

Oil policy makers in both Mexico and Venezuela had to react quickly in response to market dynamics that appeared unthinkable even after the experience of 1982. However, the 1986 emergency elicited very different policy responses from their respective NOCs. For its part, PDVSA sought to secure its market outlets by continuing to buy refineries abroad, following the strategic guidelines it had laid down in 1982. PEMEX, in contrast, decided to base its commercial policy on governance mechanisms designed to safeguard relationships characterised by a high degree of closure through fostering mutual trust between the contracting parties (and not through the coercive power conferred by ownership).

4.3.1 The PDVSA Response to the 1986 Crisis: Vertical Integration, Price Opacity

The 1986 oil market crisis put PDVSA's internationalisation programme beyond the partisan disputes that so obstructed its progress after Lusinchi took office. Thanks to the manner in which PDVSA presented the stylised facts of the 1986 price crisis to the Lusinchi administration, the latter began to see internationalisation as not only highly desirable but well nigh inescapable. As Humberto Calderón Berti (who was in charge of the energy portfolio during the COPEI Herrera administration) quipped, "oil exports had to decline, foreign exchange earnings had to drop alarmingly and the international oil market's deterioration had to worsen for the government to [approve] the negotiations PDVSA had been conducting with several companies and to accept that internationalisation is good for the country".[44]

At an extraordinary meeting of the PDVSA shareholders' assembly (attended, among others, by president Jaime Lusinchi and leaders of the two dominant Venezuelan political parties, AD and COPEI), the company's president and executive vice-president (Juan Chacín and Pablo Reimpell, respectively) explained that Venezuela would only be able to "avoid netback pricing arrangements by entering into these [new] overseas joint ventures". They did not clarify, however, that the supply contracts underlying these joint ventures would be structured around netback formulae. They also claimed, rather implausibly, that "Venezuela's broad range of crudes and products had permitted PDVSA to sell at above-market prices" up until late 1985, but warned that the company was bound to encounter severe volume and pricing problems after April 1986 "if investment plans [were to be] delayed any further", since "some of its customers [would probably] switch to other oil suppliers with whom netback deals had already been worked out".[45] The picture that these two executives painted might have been vague and somewhat far-fetched, but it had the desired effect: PDVSA's internationalisation programme gathered an irresistible momentum after the oil price collapse. To date, PDVSA has established shareholdings (or leases) in nineteen refineries outside Venezuela. Fourteen of these agreements, accounting for 89 per cent of PDVSA's overseas refining capacity, were concluded after 1986, with five of them involving deep conversion refineries located in the USGC.[46] Moreover, since 1986, affiliated refineries have absorbed about half

of PDVSA's total crude exports to the USA (and a somewhat higher proportion of its sales into the USGC).

It is clear that the manner in which PDVSA presented the causes and possible repercussions of the 1986 crisis to the Venezuelan Executive lies behind the celerity with which the internationalisation programme was put back into gear. Consider the following interview, granted at the time by energy minister Arturo Hernández Grisanti to *Platt's*:

> without elaborating, Hernández Grisanti said that "those of us who have the responsibility and the information" regarding market conditions are aware that "beginning March or April the situation could become complicated", [which meant] that the government would have to make decisions very soon, because there were "a series of elements in the petroleum market situation that could make the placing of our exports difficult".[47]

Later Venezuelan accounts of the netback crisis have always stressed that the decisions that Hernández Grisanti was referring to concerned two fundamental policy changes: firstly, whether PDVSA would be permitted to establish shareholdings in more refineries abroad and, secondly, whether MEM was prepared to abandon its control over the pricing of Venezuelan oil. For instance, Andrés Sosa Pietri (president of PDVSA from 1990 to 1993), explained the government's about face as regards the internationalisation programme in the following terms:

> in January 1986, exports are below the million barrel per day mark, and there are days without any liftings. The national government is alarmed and it has more than enough reasons to be … With sales at their lowest point ever, the government … gives back to PDVSA the liberty to determine prices as well as the liberty to assure markets and avoid a repetition of situations like those experienced in January. Thus, the internationalisation programme begins anew.[48]

However, Sosa's account (which synthesises the conventional Venezuelan wisdom on these issues) is inaccurate in one critical respect: by the time the government consented to lift the suspension on the internationalisation programme, PDVSA had already obtained from the ministry this much vaunted liberty to determine export prices. This faculty was enshrined in a joint MEM-Ministry of Finance resolution which stated that the company's fiscal liabilities would henceforth be calculated on the basis of "prices declared by the taxpayer" (with no distinction made between arm's-length prices and transfer prices), as opposed to GSPs announced by MEM. In

addition, the resolution (signed by Hernández Grisanti in January 1985) was made retroactive to January 1984, which meant that PDVSA was also able to defuse any potential problems arising from past shipments to Ruhr and to those customers with whom it had signed long-term supply contracts incorporating preferential pricing formulae.[49]

The carefully thought-out way in which PDVSA prepared the ground for taking sole control of Venezuelan commercial policy indicates that the collapse of oil prices presented the company with the *opportunity*, more than the *motivation*, to accelerate and expand its downstream integration strategy. In order to make the most of this opportunity, PDVSA decided to adopt a completely opaque pricing system that would lessen the chances that the transfer price formulae designed to guarantee the profitability of overseas refining investments might, at some point in the future, come under unwelcome ministerial or congressional scrutiny. This move was prompted by the fact that, back in 1983, when the AD congressional fraction found that the netted-back FOB price on the volumes sent to Germany was substantially lower — by around 2 USD/B — than official Venezuelan posted prices, they had raised a scandal that had almost sunk the whole internationalisation programme.[50] With the adoption of an opaque pricing mechanism for arm's-length sales, PDVSA pre-empted a possible repetition of this episode. Confusion and secrecy thus became the bywords for PDVSA's commercial policy in the aftermath of 1986, as a trade journal discovered as soon as the main elements of this policy were in place:

> PDVSA will continue using prices 'notified' to clients … [keeping] the specific list for individual grades secret to avoid political embarrassment … and to allow room for manoeuvring in individual negotiations. Price decisions will be determined by feedback from customers as well as the market readings by PDVSA intelligence gatherers, and there will be compensation clauses built into agreements to protect buyers.[51]

PDVSA's pursuit of vertical integration and opacity also introduced a new element into its commercial policy, which gave rise to dynamics that should have been recognised as being damaging to a seller whose most important arm's-length commercial relationships were characterised by a high degree of asset-specificity. Simply put, this element was an incentive to maximise the income derived from the sale of arm's-length volumes by always driving for the hardest bargain possible with

non-affiliated customers, so as to compensate in some way for the extremely high cost of sales to affiliates (50 per cent of PDVSA's export volumes are invoiced at steeply discounted prices that are not only used to finance the acquisition of refining assets but also to give these assets a high level of profitability). Again, this incentive was picked up by trade journals at the time:

> 'Fast to move up, but slow to move down' is the way PDVSA describes its pricing tactics which eschew free-falling netback and automatic prices … [and instead attempt] to retreat slowly when necessary and take every opportunity to regain commercial ground, even pennies at the time … There's more style than substance to Venezuela's disdain for netback pricing, with PDVSA admitting it must match … main-rival Mexican crudes to compete in the key US market. But it defends [its] notified prices, often based on judgement calls, to conserve a certain degree of pricing sovereignty.[52]

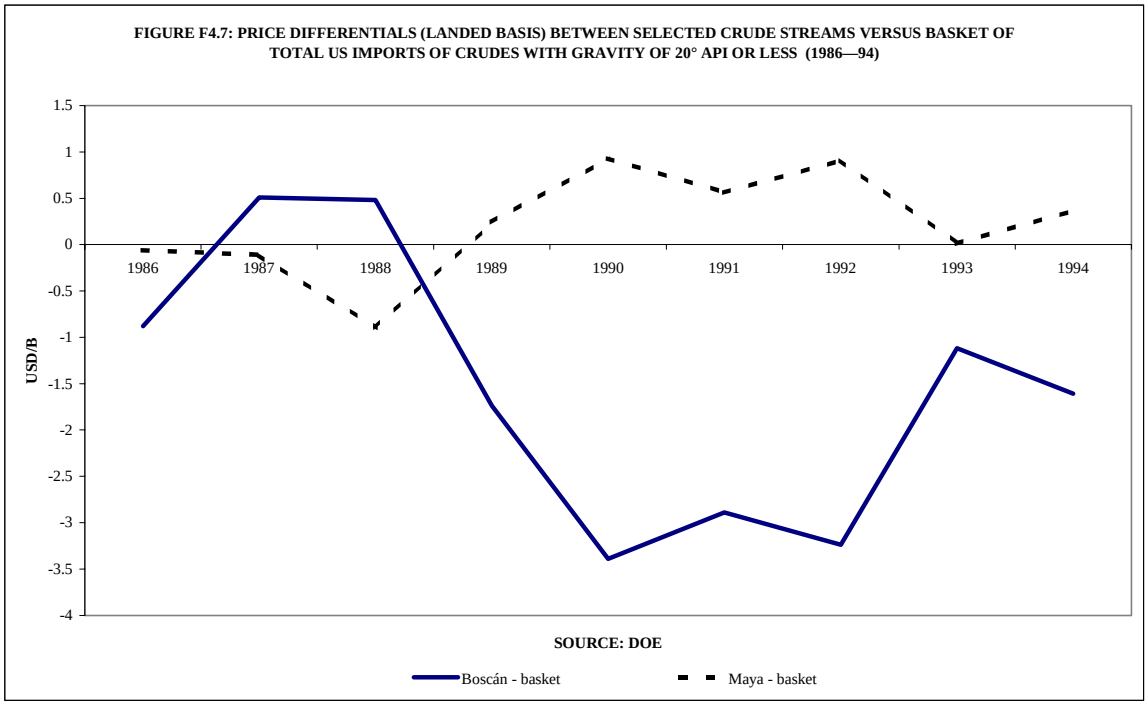
What the trade journals did not highlight was that this *modus operandi* would inevitably put PDVSA's relationships with non-affiliated clients on a very adversarial footing. PDVSA negotiated pricing terms individually with every customer, in an effort to make sure that the price they paid for every one of their cargoes of Venezuelan crude reflected not only the relative strength of the market at the time it was sold but also their geographical location and the margins obtainable in their particular refining configurations. If the market tightened, Venezuelan prices would go up fast. If it slackened, PDVSA would try to use its market power to resist downwards adjustments. Of course, this stance gave PDVSA's customers every incentive and justification to retaliate in kind, particularly in view of the Venezuelan NOC's need to match actions taken by other major sellers (notably PEMEX). Thus, the logical corollary of the fact that PDVSA customers could expect no mercy during tight markets was that, in slack markets, the company would be forced to trade at the price its customers considered right (and their idea of what this price should be would inevitably be tinted by the memory of their last bruising encounter with PDVSA). But, quite apart from strengthening the propensity of PDVSA's clients to behave mercenarily (which is never a good thing for a large seller), the company's commercial policy also had the potential of becoming a powerful adverse selection mechanism, reducing the incentives that clients with deep conversion facilities had to enter into term contracts for large volumes of Venezuelan heavy sour crude. Deep conversion facilities, after all, are precisely the type of "transaction-specific sunk investments [that] generate a stream of potentially appropriable quasi-rents equal to

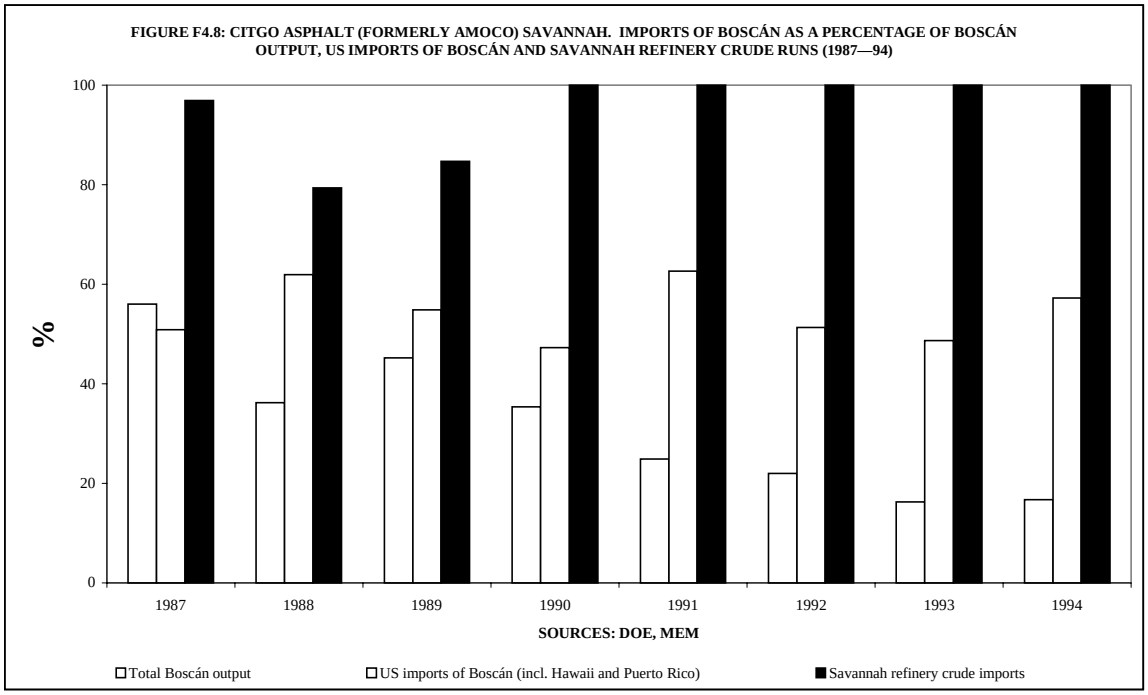
the difference between the anticipated value in the use to which the investments were committed and the next best use".[53] And from 1986 onwards, PDVSA made it clear to its clients that it would go after these quasi-rents whenever market conditions were favourable for so doing. Thus, with this new commercial policy, PDVSA ran the risk of exacerbating the daunting bilateral monopoly problems inherent in repeated transactions involving heavy sour crudes (mainly by eroding the already scant transparency in the market for such oil).

This risk was further enhanced by the lifting privileges enshrined in Venezuelan supply contracts. Before the onset of the price crisis, PDVSA's operating affiliates — Lagoven, Maraven and Corpoven — had responded to the increasingly choppy market conditions by giving their clients freedom to adjust their liftings unilaterally (in terms both of volume and crude quality) according to their circumstances at any given point in time. After the netback crisis, however, PDVSA's operating affiliates were unable to rescind these ultra-flexible contractual arrangements with their arm's-length customers, because the latter were loath to give up the generous commercial concessions to which they had become accustomed in the absence of credible price commitments similar to those embodied in the transparent pricing mechanisms adopted by by PEMEX (commitments which PDVSA could not imitate, given the opacity that its overseas refining operations required).[54]

The problems intrinsic to PDVSA's avowed objective to be "fast to move up and slow to move down" can be clearly appreciated by contrasting the behaviour of Boscán prices against the price of other Venezuelan extra-heavy crudes between 1990 and 1992. As can be seen in Figure F4.7, this period witnessed a significant contraction in the differential between the price of this very low quality grade and the weighted price of US crude imports with a gravity of 20° API or less (throughout this period, Venezuela accounted for 95 per cent of such imports). The increase in the relative price of Boscán was not caused by a reduction in the penalty attached to the sulphur content of crude: the price of Maya relative to that of this import basket decreased slightly over the same period, even though the sulphur content of both was almost the same. Rather, it seems to have been motivated by the deliberate targeting of a refinery that not only processed Boscán almost exclusively, but had also traditionally accounted for a very high proportion of both the total output and the US imports of

this crude (Figure F4.8). The negative effect that the increase in the price of Boscán had on the profitability of this refinery forced its then-owner, Amoco, to choose between closing it altogether or finding a buyer for it. Amoco opted for the latter course of action, selling it to PDVSA (through Citgo) in late 1992. This change in ownership was immediately reflected on the relative price of Boscán, which went down between 1993 and 1994 (after which year the DOE stopped publishing this price series). While this case probably represents an extreme example of PDVSA's willingness to target the processing margins of some customers when conditions are favourable, it is not too difficult to understand how even less acute pricing squeezes than this could have left PDVSA's customers with a strong aversion to having large term exposures to Venezuelan volumes.[55] Moreover, such an aversion would be expected to have a significant negative effect on Venezuelan realised prices. As Klemperer notes, in markets characterised by high switching costs (like that for heavy sour crude oil), customers' reservation prices will tend to be rather lower than one would reasonably expect whenever a seller has established a reputation for exploiting the semi-monopoly situations that switching costs give rise to.[56]





4.3.2 The PEMEX Response: Transparent Public Pricing Formulae

Almost as soon as Shaykh Yamani had delivered his fateful address on the state of the oil market to the Oxford Energy Seminar in September 1985,[57] the management team in charge of PEMEX's international trading activities saw that a major conflagration was about to engulf both the company and the international oil industry as a whole. As a matter of extreme urgency, this team turned its attention to devising alternative commercial instruments to supersede the GSP system, which was rightly seen as doomed to disappear. The company had been pondering upon the inadequacies of GSPs for some time already, in connection with attempts to measure the costs of its export diversification policy after the structural transformation of the international oil market into a buyers' market (1981—2). The fact that under the GSP system one FOB price was valid for all destinations meant that Mexican GSPs were set at levels reflecting the conditions of PEMEX's more marginal European customers. The upper price thresholds of these customers were significantly below the prices that refiners with more complex plants in the USA would have been ready to pay for Mexican crude (especially so in the case of Maya). Some managers within PEMEX thought that alternative pricing mechanisms might help to bring about a reduction in the amount of money that the company was leaving on the table. Of course, market

conditions leading to the 1986 crisis ensured that such a reduction would be unattainable. Nevertheless, the speculative analytical effort that PEMEX devoted to the possibility of market-linked pricing proved very useful after September 1985. Indeed, even with the head start that this effort gave to the search for pricing mechanisms suitable for turbulent environments, formulae were introduced only in March 1986, by which time Mexican crude exports had fallen to a little over 1 MMBD. Thus, more than six months had to elapse between the first ominous signs of the gathering storm and the implementation of the measures that were to keep the company's marketing operations from foundering. The reason for this delay is easy to pinpoint: the wide array of conflicting vectors that PEMEX had to reconcile to arrive at a new commercial policy that would be both economically and politically viable.

From the outset, those in charge of framing the new commercial strategy knew that the Mexican government would only accept mechanisms which it was convinced would accurately reflect movements in the general oil price level in the world petroleum market, while ensuring the competitiveness of Mexican export crudes against the set of close substitutes from other countries that were sold in the same markets.[58] PEMEX was also reconciled to the fact that the post-1985 balance of power between producers and refiners meant that it had to satisfy the clamorous demands by the latter in the sense that the task of discovering the "economic" price of crude should be entrusted exclusively to an abstract entity reverentially referred to as The Market. In addition, the company realised that any commercial policy based upon "complex and differentiated contracts … requir[ing] ample discretional power in their negotiation and operation"[59] would swamp its limited institutional and managerial resources. Lastly, the company also discarded the possibility of going for downstream vertical integration *à la* PDVSA in order to safeguard its market share. Since vertical integration effectively suppresses the firm-versus-market divide, the acquisition of downstream assets held the tantalising promise of giving PEMEX full volumetric security on a portion of its exports.[60] However, the cost of acquiring and managing refineries would have made this option unacceptable to the Mexican government, quite aside from the fact that PEMEX would have been unable to cope with the demands that overseas vertical integration would have placed on the limited pool of managerial talent available to it during that period.

These problems undoubtedly constrained the range of possible commercial options open to PEMEX, although they were not more demanding than those confronting many other oil companies in the wake of 1986. However, PEMEX had to face an additional and unique predicament, which was to tax the ingenuity of its management to the utmost. This was that any new pricing mechanism would have to be flexible enough to reflect even very short-term changes in the market, but in a way that minimised the individual discretion of the company's officials in their everyday commercial activities. This apparently contradictory requirement was not born from the need to allay public concerns in the sense that there should be no scope for corruption in the international marketing of Mexican crude oil (the legacy of the Díaz Serrano years notwithstanding). Rather, it reflected the impossible demands placed on public sector entrepreneurs by Mexican legislation (specifically, the Federal Law of Responsibilities for Public Servants, or FLRPS for short), which was (and will continue to be) fundamentally incompatible with the "business judgement rule."

According to Gilson, the essence of this common-sense rule is the recognition that "absent bad faith or some other corrupt motive, directors are not normally liable to the corporation for mistakes of judgement, whether those mistakes are classified as mistakes of fact or mistakes of law". Gilson also points out that "the court's abdication of regulatory authority through the business judgement rule may well be the most significant contribution to corporate governance",[61] mainly because it makes it possible for officers in a company to get on with their job and not worry about a potential personal liability for damages stemming from their business decisions. Officials in Mexican state-owned companies, however, are denied the protection of the business judgement rule, and this makes their lives *qua* entrepreneurs rather complicated. Under the terms of the FLRPS, the discharge of their everyday responsibilities can render them personally liable to both criminal prosecution and administrative sanctions, not only in instances of deliberate misconduct (i.e. corruption) but also whenever a decision of theirs – through an error of judgement and/or execution – causes a damage to the patrimony of the Nation.[62] Moreover, the vagueness of this law invests it with an arbitrariness that makes it an ideal vehicle for politically motivated persecution.[63] The implications of these characteristics for a merchant firm are significant, and conducive to bureaucratic paralysis. In oil trading terms, for instance, a literal reading of the FLRPS is tantamount to saying that traders

have to beat (or at least equal) the market in every single one of their deals. If they are successful, they will merely be doing their job. If they fail, however, they are open to being hauled over the coals because their lack of business judgement led to damage to the Nation. Little wonder, then, that PEMEX was anxious to find a mechanism that could ensure that the key outcomes of its commercial activities (i.e. the prices of its crudes) were generated exogenously (with limited input from individuals within its marketing organisation).

After a drawn-out process of analysis and consultation with the Mexican government, PEMEX concluded that public pricing formulae structured around quotations for marker crudes (ANS, Brent, LLS, WTS, WTI) offered a good combination of simplicity, flexibility, low cost and ease of implementation, supervision and monitoring. Such formulae had the added attraction of making the company's commercial decisions transparent to its political masters. However, it would be mistaken to think that formulae became PEMEX's commercial vehicle of choice purely through *faut de mieux*, because the appreciation of the microeconomic advantages inherent in formulae *qua* pricing mechanisms played a key role in their eventual selection.

Even before the netback crisis erupted, some PEMEX managers had decided that for a producer with a heavy sour crude resource endowment the size of PEMEX's, the substitution of rules for entrepreneurial discretion could be a good way of facing the transactional characteristics of the recently evolved deep conversion market. They realised that in very volatile markets (like that for crude oil),

> the most … important limitation of a long-run relationship is the presence of outside opportunities … [F]orcing the parties to stick to each other through high penalties for breach may hurt them if there are no gains from trade or … if better outside opportunities are available to one or both of the parties. As breach may be desirable, contract[s] must find the optimal trade-off between flexibility and the prevention of opportunism.[64]

A pricing mechanism that involved constant haggling with customers was not seen as a sound foundation upon which to build PEMEX's commercial relationships because, quite aside from its unsuitability to the Mexican institutional environment, its long-term viability would be compromised by the fact that, "as durable transaction-specific

investments become more important, the transaction costs associated with mediating vertical relationships using conventional spot markets increase."[65] Thus, PEMEX's attention focused on devising governance mechanisms to neutralise the dangers of desertion and misrepresentation that can plague commercial relationships characterised by a high degree of closure (like those of PEMEX and its clients with deep conversion plants). Since the common ownership of idiosyncratic refining assets was not an option open to PEMEX at the time, the company analysed the wide panoply of contractual practices that were meant to blur the boundaries between firms and markets, and could therefore give a company like itself a greater security of outlet than that which it would have enjoyed had it relied solely on spot markets to place its output. In the end, PEMEX concluded that safeguarding the stability and integrity of its heavy sour crude relationships would best be accomplished by the deliberate, voluntary and verifiable limitation of the liberty of action and decision of both parties to these relationships. This abdication of certain prerogatives would ideally function as a guarantee of good behaviour regardless of fluctuating market conditions, thereby enabling PEMEX and its customers to meet a variety of unforeseen circumstances without dissipating valuable resources identifying possible future contingencies, codifying acceptable responses to these contingencies, and monitoring these responses.

PEMEX's public pricing formulae mechanism revolves around a complex framework of credible commitments, whose microeconomic properties are to be covered in detail in the following chapter. However, the cornerstone of this framework is PEMEX's explicit renunciation of the faculty of setting Mexican export prices unilaterally. More than anything else, it was this move (which PDVSA refused to imitate, on the dubious grounds of "pricing sovereignty"[66]) that gave PEMEX the commercial flexibility that its customers demanded in the post-1986 oil market environment. However, as a *quo* to the *quid* represented by this major concession, PEMEX expected these customers to consent to a new set of general terms and conditions (GT&Cs), which would be much more restrictive in volume terms than those embedded in the supply contracts of the Díaz Serrano era. These new GT&Cs were the legal expression of PEMEX's clearly stated preference for selling crude on a term (as opposed to a spot) basis, under the aegis of long-lived and stable commercial relationships resting on a scrupulous adherence to contractual volumes by both buyer

and seller. The main objective of these GT&Cs was to render PEMEX's supply contracts as inflexible as its pricing formulae were flexible, thus making it clear to refiners that they would significantly jeopardise their possibilities of lifting Mexican oil in the future were they to engage in behaviour that was contrary to the spirit of a genuine long-term relationship for the sake of short-term considerations. In this way, PEMEX addressed the problematic tendency underlined by Macaulay that "often businessmen do not feel they have a 'contract' - rather, they have 'an order'. They speak of 'cancelling the order' rather than 'breaching our contract'".[67] By making the unilateral cancellation of a single order synonymous with a breach of contract (and greatly increasing the potential penalty attached to such breach), PEMEX invested every individual transaction with a *relational* character. In marked contrast, PDVSA's commercial policy revolved around constant negotiation and vague (rather than explicit) volumetric commitments, aspects which stressed the *discrete* nature of transactions involving Venezuelan crude. Thus, this company arguably made itself vulnerable to the kind of conduct identified by Macaulay because, as Masten observes,

> in discrete transactions, parties are generally free to bargain or not bargain as they please … The relative latitude afforded transactors in simple exchanges provides them both the ability and the incentive to adapt their behaviour to events and information as they arise. That latitude, however, also provides transactors a tactic to extract rents … Thus, although flexible, [discrete] market transactions are relatively exposed to the potential for holdups and reneging".[68]

In sum, when PEMEX introduced pricing formulae in 1986, the company was acting upon the hypothesis that formulae would prove an ideal vehicle for safeguarding commercial relationships against the hazards of opportunism through the elimination of the scope for haggling and strategic misrepresentation, all the while economising on bounded rationality. Had this conviction not been held within PEMEX as strongly as it was, the scepticism – even outright opposition – towards the idea of formula pricing that held sway in some quarters of the Mexican government (particularly the Ministry of Finance) would have led to the stillbirth of this novel and untried mechanism at the first sign of teething problems. Such problems, unsurprisingly, were very much in evidence during the 1986—7 transition phase. European refiners, for instance, rejected PEMEX's first pricing formulae for the region, because they incorporated Flotta and Urals crudes (neither of which was seen as supporting a

sufficiently large volume of spot trade[69]). Likewise, many US customers resisted PEMEX's move towards more stringent and inflexible supply contracts, and some companies went so far as to stop their liftings of Mexican crude rather than submit to the new contractual terms. However, the eventual success achieved by pricing formulae is a testimony to the business vision of their original designers. Under a great deal of pressure and playing for very high stakes, they put together a commercial policy whose constituent elements had been chosen on the basis of the three basic principles that underlie all succesful strategic actions: "to know what one can do on the basis of the available means, and to do it; to know what one cannot do, and refrain from trying; and to distinguish between the two".[70] As a result of their efforts, PEMEX was able to derive advantage from the necessary, thereby turning one of its major corporate weaknesses — its lack of managerial depth — into something resembling a commercial asset.

4.4 Conclusions

Netbacks did not cause the 1986 price collapse; excess supply did. However, as Mabro notes, "different methods … would have caused the collapse to happen sooner or later, and price movements to display fluctuations of different amplitudes … [and] they would also have produced different patterns of leads and lags between products and crude markets".[71] The impression that "competition explains the price collapse, but the pricing method determines the features of price movements"[72] was one shared by the team in charge of PEMEX's international trading operations. These officials believed that even if in the long and medium run, prices tend to converge to a level warranted by the aggregate supply decisions of producers (given the state of demand), in the short (actually very short) run, prices will move primarily according to actors' expectations regarding these aggregate supply decisions. They concluded that the manner in which information is transmitted in the market plays a crucial part in shaping these expectations and may therefore have an important influence in determining the actual path that short-term prices follow on their way to medium-run convergence.[73] Thus, although PEMEX managers were ready to admit that netback-type contracts *per se* could have had little impact on prices in the medium to long run, they also saw such contracts as being structurally unsuitable to convey information

and considered that, in 1986, these contracts had exerted a pernicious influence both on the amount of time it took prices to converge and on the magnitude of the divergence between short-run and medium-run prices.

PEMEX ascribed the structural unsuitability of netbacks to a number of factors. Firstly, the prices for individual cargoes generated by netbacks were opaque, for they were derived *ex post* from product prices unknown at the time each cargo was lifted. This opacity was compounded by the fact that the parameters of each netback formula were secretly and individually negotiated with every refiner (many times for each and every one of his refineries). Moreover, the calculation of each formula involved a significant subjective element on the part of the seller, and entailed the use of assumptions that many times were nothing short of heroic (in terms of relevant refining costs, transportation costs, product prices, and so on). Finally, the functioning of netbacks depended heavily on the disclosure to over-eager sellers of information privy to potential buyers. Understandably, refiners tried to turn all these factors to their advantage by pressing sellers to include in their netback formulae as many cost elements as possible (with suitably inflated values), on the one hand, and to give them very attractive processing fees, on the other. In this way, every refiner could be sure of achieving a positive refining margin (whose exact magnitude only he knew) when running crude acquired under netback conditions. Crucially, though, he could *not* be sure that his competitors would not be able to negotiate better terms for themselves. In the end, and sooner rather than later, this uncertainty — coupled with a persistent supply overhang — drove each refiner to "challenge sellers by pointing to the more attractive terms of competitors, often on the basis of flimsy information",[74] long before the terms originally agreed upon were due to expire.

In the light of this very negative diagnosis of the microeconomic properties of netback-type contracts, it is hardly surprising that, after 1986, PEMEX decided to adopt a commercial mechanism that was as far removed from netbacks in every possible aspect except one: the responsiveness to changes in spot market conditions. Significantly, PDVSA did not share these conclusions, and it chose to implement a commercial policy *vis-à-vis* non-affiliated customers that not only embraced some of the salient characteristics of netbacks but actually took them to their extreme. In many ways, as we shall now demonstrate, the evolution of the USGC market for

heavy sour crude since the netback crises has followed a path determined by the very different policy options that PDVSA and PEMEX chose after 1986.

NOTES

[1] Kuenne, *op. cit.*: 126. Italics in original.
[2] *Ibid.*
[3] *Ibid.*: 149.
[4] During the late 1970s, anode grade coke fetched a price of about 120 USD/T, while coke for burning sold for 15 USD/T.
[5] The definitive account of US government intervention in the oil industry, for its exceptional thoroughness if not necessarily the soundness of its conclusions, is Bradley, 1996 (for the issues mentioned in these paragraphs see vol. II: 1159—1239).
[6] FEA, 1977: II-7.
[7] API, 1980: 9.
[8] Lichtblau, 1978: 2.
[9] ERA/DOE, 1980: 59.
[10] CERI, 1985.
[11] Refinery investment peaked in 1982, and declined steadily between then and 1988. Investment rebounded sharply in that year in response to the anticipated adoption of environmental regulations restricting gasoline volatility (RVP) and the sulphur content of diesel fuel (EIA, 1990: 4).
[12] US Senate, 1981: 6.
[13] *DPDAMRM*, 1987: 6.
[14] *O&GJ*, 30 April 1984: 17.
[15] This anomalous situation was probably brought about by the spiking of some heavy crudes with residual fuel oil (drawn from the 40 MMB of stocks accumulated at the enormous earthen reservoirs at the Paraguaná refineries throughout the late 1970s). By 1981, as these stocks continued to mount in the face of the crumbling international demand for high sulphur fuel oil, PDVSA was forced to reduce its refining operations to a bare minimum, while importing gasoline from Trinidad in order to guarantee domestic supplies (*OB*, July 1982: 74).
[16] For instance, the coker at Chevron's Pascagoula refinery was constructed with Arab Heavy in mind as a feedstock. Although the refinery runs a large volume of this crude, most of the coker feed comes from Maya.
[17] *NYT*, 7 August 1981: D1.
[18] In March 1982, Nigeria was selling only 630 MBD out of a quota of 1.3 MMBD.
[19] "The National Petroleum Industry has always been conscious of the need to integrate vertically in markets outside Venezuela … [and] from the first year of the nationalisation onwards, Petróleos de Venezuela and its subsidiaries were analysing investment alternatives abroad" (CEPET, *op. cit.*, vol. II: 176).
[20] *Ibid.*
[21] *Ibid.* : 159. Italics ours.
[22] Diplomatic relations between Spain and Mexico had been particularly fraught — to the extent of being formally broken on one occasion — during Franco's twilight years.
[23] PEMEX paid 28.8 MMUSD for its share in the 240 MBD refinery, a much lower figure than the 250 MMUSD that the purchase of the 250 MBD Gelsenkirchen plant cost PDVSA (in cash disbursements plus assumed debt). The German plant was far more complex than the Spanish one (5.5 versus 2.0 NGCI), but the price paid by PDVSA still appears high.
[24] Randall, 1987: 207.
[25] *PIW*, 17 February 1986: 4.
[26] *PIW*, 5 September 1983: 8.
[27] See Boué, 1993: 111—4.
[28] Venezuela officially cut all ties to official OPEC pricing in February 1986 (see *PIW*, 17 February 1986: 3).
[29] See "Venezuela Joins Pricing Free-for-All as OPEC Ties Erode" (*PIW*, 17 February 1986: 3-4).
[30] *PON*, 11 February 1986: 1.
[31] For a succinct explanation of the deemed marker price concept, see Mabro, 1984.

[32] See *PIW*, 5 May and 11 August 1980. To an extent, this policy initiative mirrored the one implemented by Saudi Arabia starting in 1978 with regards to Arab Light and Arab Heavy exports (see Mabro, 1978).
[33] In April 1981 Ashland notified PEMEX that it would stop lifting 90 MBD of Mexican crude.
[34] It is worthwhile to remember that the Mexican debt crisis erupted in August 1982.
[35] PEMEX's American customers in particular pared their liftings to 105 MBD from a level of 750 MBD.
[36] *Comité de Comercio Exterior de Petróleo*. On the Committee, see Grayson, 1988: 71—3. The author was secretary of the Committee between August 1997 and September 1999.
[37] Grayson, *ibid.*: 71. Morales, Escalante and Vargas (1988: 253) characterise the Committee as a mechanism for "collective decision-making … that permits decisions to be weighed from different perspectives, avoiding the concentration of decisions in a single actor".
[38] Beteta made it clear from the moment he became director general that he regarded PEMEX's systems for control, planning and information processing and transmission as inadequate. He stressed the need to create a more modern and efficient administration and strategic planning through the creation of more intermediate management levels, in charge of routine and operational tasks. This orientation set him on a collision course with the Union (see Morales, Escalante and Vargas, *op. cit.*: 196).
[39] The inability of Mexico's marine terminals to handle large vessels meant that, for some time, PEMEX had to load these vessels at Curaçao, with crude transported there from Mexico in smaller ships. This operation was, needless to say, very costly.
[40] *PIW*, 6 January 1986: 1.
[41] Interestingly enough, the Saudi adoption of netback contracts actually delayed the oil price collapse by two or three months. Mabro (*ibid.*: 40) was the first to point out that the alternatives to netback contracts — spot sales and discounts on official prices — were at that time "less attractive to buyers because of uncertainty about the competitive price at the time of delivery and the greater downstream risks" and therefore would probably "have … caused prices to collapse earlier" than they did.
[42] *Ibid.*: 31.
[43] *Ibid.*: 32.
[44] *PON*, 27 January 1986: 1.
[45] *PON*, 23 January 1986: 4.
[46] See Boué, 1997.
[47] *PON*, 21 January 1986: 2, and see also Hernández Grisanti, 1988.
[48] Sosa Pietri, 1993: 74-5.
[49] *Gaceta Oficial*, 11 January 1985 (no. 33,142). See also Pérez, 1988, vol. III, Tome II: 1592.
[50] The comparisons between official prices and the Ruhr netbacks can be seen in Guevara, 1983: 141.
[51] *PIW*, 17 February 1986: 3.
[52] *PIW*, 13 October 1986: 4.
[53] Joskow, *op. cit.*: 286.
[54] *PIW*, 11 September 1989: 1-2.
[55] This experience parallels that of Ecuador, whose extreme form of opportunistic behaviour between 1978—82 left it bereft of large term customers, and delivered it into the hands of the traders who now handle most of the country's oil exports.
[56] Klemperer, 1987a, 1987b.
[57] See Mabro (ed.), 1986: 165—8.
[58] Horsnell and Mabro, *op. cit.*: 292.
[59] PEMEX, 1986: 2.
[60] Some economists question whether such suppression ever takes place, arguing that "integration by itself changes neither human nature nor the technological nor informational environment confronting transactors" (Masten, 1996: 11). However, as Masten points out, the internalisation of production alters the legal relationships of transactors to each other in a way that makes transactional holdups much less likely, firstly because "the law places greater burdens on employees … to obey directives, disclose information and otherwise act in the interests of an employer", and secondly because "while independent contractors can appeal to courts to resolve disputes, top management exercises ultimate authority in disputes between internal divisions: it is its own court of last resort" (*ibid.*).
[61] Gilson, 1986: 741.
[62] *FLRPS*, article 32. There are also provisions in the law that contemplate the restitution to the Nation of the damage caused by the public servant.

[63] In this sense, it is worthwhile to recall that Díaz Serrano was jailed in connection with alleged irregularities in the purchase of some ships. He was never censured for the way in which lax practices by Permargo, a drilling company assigned some of PEMEX's biggest exploration contracts (and in which he was a shareholder, in direct contravention to the FLRPS) led to the blow-out of the Ixtoc-1 well, an accident that caused environmental damages conservatively estimated at 600 MMUSD.
[64] Tirole, *op. cit.*: 27.
[65] Joskow, *op. cit.*: 286.
[66] *PIW*, 27 January 1986: 3; 13 October 1986: 4. Whatever sovereignty PDVSA retained over its pricing was in any case lost when the company began to sell its crude on the basis of discounts or premia to the Maya formula.
[67] Macaulay, 1963: 61.
[68] Masten, *op. cit.*: 9—10.
[69] *PIWK*, 1986: 15.
[70] Van Creveld, 1985: 102.
[71] *Ibid.*
[72] *Ibid.*
[73] Mabro acknowledges this when he writes that netbacks, by preventing "prices from performing their role as signals for the efficient allocation of resources" may have "confuse[d] economic agents and elicit[ed] imperfect responses" from them (*ibid.*: 36).
[74] *PIWK*, *op. cit.*: 4. A former chairman of Veba Öl, for instance, said that his company's model netback contract revolved around "flexible prices and an escape clause that allow[ed] buyer or seller to cancel the deal if either refuse[d] to renegotiate in response to changed market conditions" (*PON*, 10 April 1987: 4).

5. THE INSTRUMENTS OF COMPETITION IN THE USGC MARKET FOR HEAVY SOUR CRUDE: A COMPARATIVE PERSPECTIVE

PEMEX and PDVSA are quite alike in many ways. They produce comparable volumes of crude, both are wholly state-owned and both operate in similar political and institutional environments. Naturally, there are also important differences between them. For instance, since its inception, the Venezuelan oil industry has been oriented towards export markets, and PDVSA is merely the latest historical manifestation of this country's long-standing status as an "oil factory" (to use Rómulo Betancourt's memorable phrase). The linkages of the Venezuelan NOC with the domestic economy of its home country traditionally have been almost as tenuous as those established by the concessionaires that exploited the country's oil resources before the nationalisation of the Venezuelan oil industry. In contrast, for much of its existence (1938—1976), PEMEX was a purely inward-looking firm, with a very limited interaction with the international oil market. After 1976, the company became a major oil exporter, but the supply of the domestic Mexican market (which, being as large as that of Italy or France, dwarfs the domestic markets of other oil-exporting countries) still absorbs around half of its crude output. Also very significant is the fact that PDVSA's freedom of action has always been constrained by Venezuela's membership of OPEC (except during the 1996—8 period, when the cartel almost unravelled as a result of the company's deliberate quota-busting production policies). In contrast, PEMEX has only ever seen its output decisions being negotiated with other oil exporters when crises in the oil market have forced the Mexican government into a stance of constructive engagement with OPEC (like in 1986 and 1998).

In the recent past (from 1986 onwards), PDVSA and PEMEX have been well matched in commercial terms. Figures F5.1 and F5.2 show the oil exports of both companies broken down by type of crude. As can be appreciated, they have placed similar amounts of oil in the international market. Moreover, they have tended to sell roughly comparable volumes of better quality grades (the bulk of PDVSA's sales of such crudes are concentrated towards the medium range of the quality spectrum, while PEMEX's have gradually tilted towards the light end). The largest share of their respective export volumes, however, is accounted for by the heavy sour grades. In

turn, the majority of their exports (especially of heavy sour blends) are sold to customers in the USA.

FIGURE F5.1: PDVSA. CRUDE OIL EXPORTS BY GRAVITY (1976—2000)

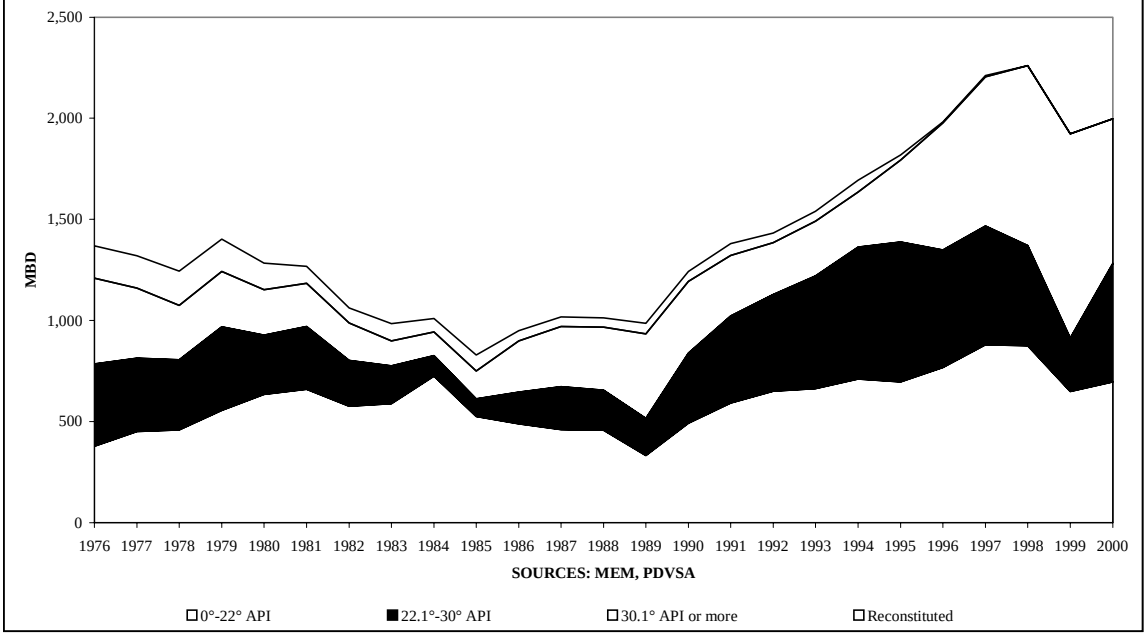
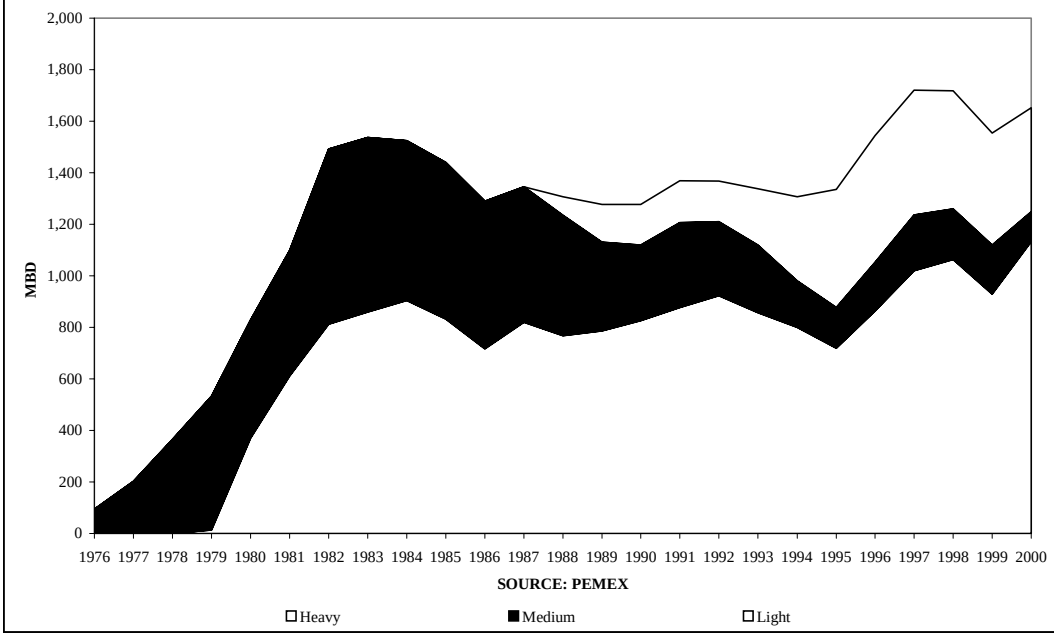


FIGURE F5.2: PEMEX. CRUDE OIL EXPORTS BY TYPE (1976—2000)



For all these similarities, the contrast between the commercial policies and procedures of both companies (as regards their relationships with the spot market, their attitudes towards vertical integration and export diversification and the nature and rationale of their pricing policies) could scarcely be more pronounced. This is significant since, as Geroski, Ulph and Ulph point out, "empirical studies of prices frequently attempt to explain the movement of prices over time solely in terms of the variation in market fundamentals such as costs and demand. However, since different forms of pricing conduct [i.e. commercial practices] are likely to have a significant effect on the level of prices, it seems reasonable to think that changes in conduct may play an important role in explaining price dynamics".[1]

The model that these authors developed to examine this proposition indicated that, at a global level of aggregation and quite aside from supply and demand factors, price levels in the oil market were indeed responsive to variations in conduct induced by the endogenous behaviour of producers. This intuition, validated once again by the behaviour of the international oil market during the 1998 price crisis, would also seem to hold for lower levels of aggregation. For instance, recent investigations into the workings of oil markets have shown that, quite aside from their response to the interplay of demand and supply, price outcomes in those markets are heavily influenced by the nature and peculiarities of the trading instruments and trading practices that participants use to engage in exchange.[2] Changes in such instruments and practices can bring about significant alterations in everything from inter-crude price relationships to the term structure of oil prices, as can be proved by comparing the behaviour of the price of Dated Brent before and after the rise of the Brent Contracts for Differences (CFDs), for instance.[3]

In the case of the USGC market for heavy sour crude the distinctive elements in the commercial policies of PEMEX and PDVSA have clearly given rise to growing differences in terms of key indicators like the weighted complexities of these companies' respective customer bases. On intuitive and theoretical grounds, differences of this nature would be expected to have a considerable incidence on the prices realised by each company through time. Therefore, it follows that the price dynamics in the USGC market during the past decade might have had something to do with, for instance, the disincentives for deep conversion clients with potentially large

appropriable quasi-rents to subscribe term contracts for large volumes of Venezuelan heavy sour crude. Thus, on the basis of the non-price data presented in Chapter 3, it is possible to arrive at the tentative hypothesis that the individual ways in which PEMEX and PDVSA responded to the 1986 price crisis could have had a major influence on the process of price formation in the market for heavy sour crude in the USGC (and could therefore be responsible in part for the perplexing asymmetries underlying the duopolistic configuration of this market).

The aim of the remainder of this study is to test this hypothesis rigorously. To do so, in this chapter, the salient characteristics of the commercial policies followed by PDVSA and PEMEX will be delineated, and the microeconomic effects that these distinctive characteristics induce in the customers of both companies will be discussed. In a subsequent chapter, these effects will be related to the patterns of price behaviour observed in this market since the early 1990s.

5.1 The Nature of Venezuelan and Mexican Term Contracts

Venezuelan term contracts are options — rather than obligations — to buy a specified volume of a given crude grade every *x* period of time.[4] These contracts grant buyers the discretionary power to decide how much oil will be lifted in a given month (if the client decides not to lift a cargo, *force majeure* need not be declared and the refiner's possibilities of lifting Venezuelan oil in the future are not affected). Customers are only obliged to lift a certain proportion — defined casuistically — of a notional contractual volume over the life of the contract. However, just as a Venezuelan customer can nominate as much or as little crude as he wants, PDVSA may, at its sole discretion, choose to supply volumes inferior to those nominated by any of its customers. PDVSA acknowledges that its "general terms and conditions do not require specified volumes to be bought or sold", but this is not seen as very problematic since "historically a majority of PDVSA's customers have taken shipments on a regular basis at a relatively constant volume throughout the year."[5] This might be true, but it is also true that the very flexible Venezuelan contracts do not offer any volumetric security to non-affiliated buyers, or, as a seller, to PDVSA itself.[6] In this, they are very different from the rigid supply contracts used by PEMEX since 1987.

Mexican term contracts stipulate that the customer has the obligation to lift a specified volume of crude every *x* days, and also to make good losses due to underlifting within the duration of the contract or face possible claims for damages.[7] By the same token, however, PEMEX is obliged to supply customers with their contractual volumes in a timely manner, regardless of the size of their contract. The rigidity of the Mexican term contracts functions as a volume guarantee for both buyer and seller. This guarantee is unrelated to the security of supply idea that, before 1986, led major oil exporters to assume — wrongly, as it turned out — that buyers would always be willing to pay over the odds in order to maintain long-term relationships with them. The value of the security these relationships offered was questionable, given the frequency with which sellers unilaterally altered contractual terms (making these long-term relationships that added nothing to the oil companies' bottom line). The security that PEMEX's contracts offer, however, does contribute to the bottom line of refiners whose profits hinge largely on the reliability of supply of one specific grade of crude.

Volume and pricing considerations (see below) aside, the content of Mexican and Venezuelan term contracts is, so far as the author has been able to ascertain, very similar. Nevertheless, PEMEX and its customers, on the one hand, and PDVSA and its customers, on the other, appear to give quite different interpretations to contractual clauses (lifting tolerance, declaration of *force majeure*, etc.) that are superficially alike. In the light of the very different orientations of the commercial strategy of both companies, this is not really surprising. As Karl Llewellyn observes, “the major importance of legal contract is to provide a framework for well-nigh every group organisation, and for well-nigh every type of passing or permanent relation between individuals and groups”. This framework, however, “almost never accurately indicates real working relations”, and only really “affords a rough indication around which such relations vary, an occasional guide in cases of doubt, and a norm of ultimate appeal when the relations cease in fact to work”.[8]

5.2 The Nature of the Commercial Relationships of PDVSA and PEMEX

Under normal circumstances, it is neither possible nor desirable (for reasons of operational and commercial flexibility) for PDVSA or PEMEX to place the whole of their available export volumes with term customers. In other words, both companies have to sell crude by means of non-term (i.e. spot) transactions[9] on a regular basis. This holds true even for heavy sour crudes, particularly during the season of high demand for both gasoline and asphalt. However, the manner in which both companies deal with spot deals is again very different.

Since 1990, PDVSA "has shifted its third-party crude oil sales more heavily toward spot-linked transactions, which it had shunned previously but has since embraced wholeheartedly".[10] These transactions are conducted on the basis of "flexible, negotiated pricing … often at formulas triggered on the day of arrival".[11] Thus, spot marketing has become a central plank of PDVSA's overall commercial strategy. In contrast, PEMEX views spot transactions merely as a *complement* to contractual transactions. The main thrust of PEMEX's commercial strategy has always been to forge stable, long-lived relationships with refiners, mediated by formal term contracts (as opposed to verbal or tacit agreements that do not require specified volumes to be bought or sold). Hence, a sizeable proportion of its spot sales are in the form of additional or extra-contractual cargoes for existing contractual customers, whose nominations of such volumes respond to unforeseen events or demand peaks. PEMEX will also sell spot cargoes to non-contractual customers, in the form of trial cargoes whose ultimate objective is to attract these customers to its contractual orbit. However, only under exceptional circumstances will the company consider placing a cargo under true spot conditions (i.e. different from the standard contract terms specified in its GT&Cs). In other words, spot and contractual cargoes are priced with the same formulae over the same standard valuation periods, and are governed by the same operational and financial clauses. This uniformity of conditions is in stark contrast with PDVSA's *modus operandi*, which is characterised by the fact that "a single client may hold an annual contract for one volume and quarterly contracts for incremental amounts, while also purchasing crude sporadically on a spot basis at different price formulas".[12]

5.3 Downstream Vertical Integration

PDVSA and PEMEX have given a very different priority to downstream vertical integration into refining and marketing. Nowadays, PDVSA has either a full or partial share in nine refineries located in US territory (including the US Virgin Islands). Of these, five are located in the USGC (Table T5.1). In contrast, PEMEX has a 50 per cent shareholding in only one US deep conversion refinery, and its downstream presence is more recent in origin (1993). While far from small in absolute terms, PEMEX's sales of Maya crude to affiliated parties in the USA have accounted for a maximum of 20 per cent of Maya exports to this country, which is much lower than the 50 per cent figure that PDVSA has consistently posted since 1986.

Table T5.1: Equity Participation in USGC Refineries by PEMEX and PDVSA

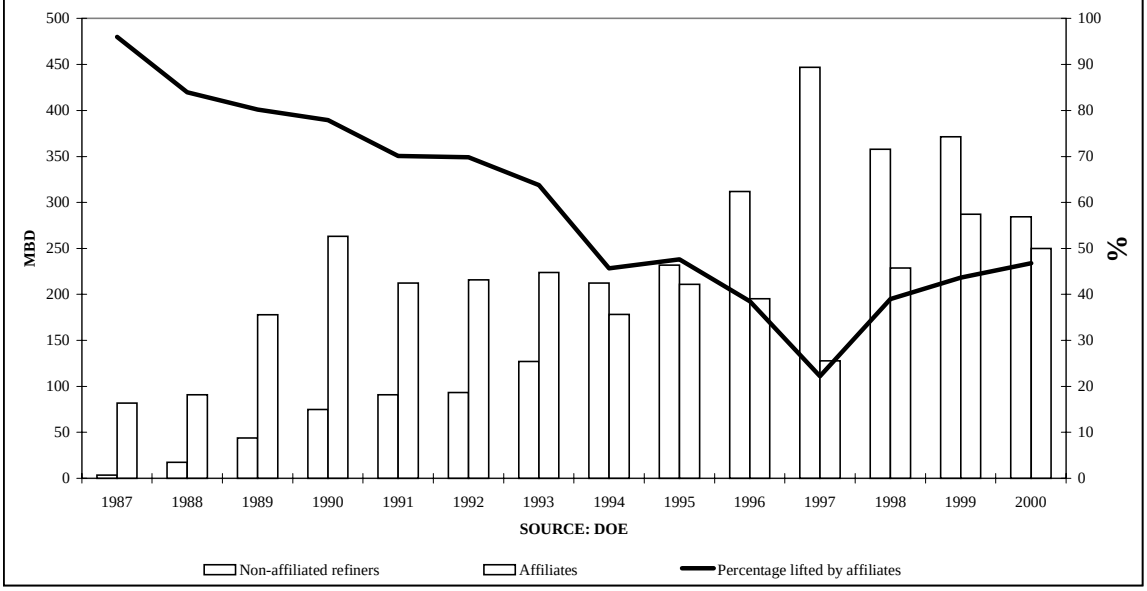
	Location	% Share	Partner (if applicable)	Date	Supply contract (MBD)
PEMEX					
Deer Park Refining Limited Partnership	Deer Park, Tx.	50	Shell US	1993	min. 150
PDVSA					
Citgo Petroleum Corporation	Lake Charles, La.	100	--	1986	120 (50)***
Citgo Petroleum Corporation	Corpus Christi, Tx.	100	--	1986	130 (15)***
Lyondell-Citgo Refining Company	Houston, Tx.	41.2*	Lyondell	1993	230
Chalmette Refining Limited Liability Company	Chalmette, La.	50	ExxonMobil	1998	90
Merey Sweeny Limited Partnership	Sweeny, Tx.	50**	Phillips	2001	165

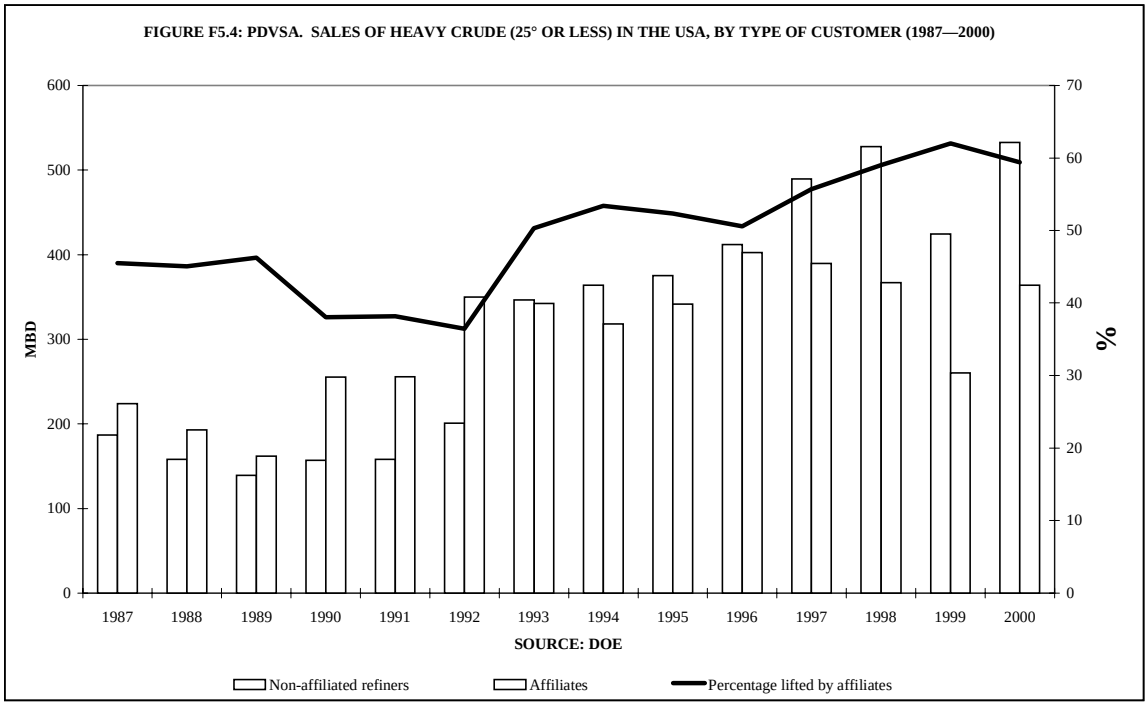
* PDVSA had an option, expiring in September 2000, to increase its participation to 50%. The option was not exercised.
** 50% interest in the coking facility only
*** Figures in parentheses denote additional volume that can be supplied at PDVSA's option

PEMEX's sales to affiliates under long-term contractual conditions only involve heavy sour crudes, which means that it has used vertical integration to leverage its position in this market. In contrast, PDVSA's vertical integration drive has not really sought to defuse the latent dangers posed by the idiosyncratic commercial relationships characteristic of this market. If anything, it might have made some of them potentially more acute. This counterintuitive point can be appreciated by examining the pattern of PDVSA's exports of light and medium crude to the USA (plotted in Figure F5.3).

As the figure shows, PDVSA's refineries in the United States have absorbed anything between a quarter and 90-plus per cent of the Venezuelan light crude placed in this market since 1987. Thus, PDVSA has withdrawn from the market large volumes of crudes whose commercialisation should, in theory, pose no great problems. Admittedly, PDVSA's refining affiliates have also absorbed at least 50 per cent of the company's exports of heavy sour crudes to the USA (Figure F5.4). On the whole, however, PDVSA has tended to rely on pure market mechanisms to place precisely those crudes that would seem least suited to move through such channels.

FIGURE F5.3: PDVSA. SALES OF LIGHT AND MEDIUM CRUDE (25° OR MORE) IN THE USA, BY TYPE OF CUSTOMER (1987—2000)





Consider also Table T5.2, which shows that the weighted quality of the crude that PDVSA's US subsidiaries have lifted has been appreciably better (i.e. higher API gravity and lower sulphur content) than that of the crude bought by PDVSA's arm's-length customers. Citgo's two asphalt refineries are an exception to this, but their volume is dwarfed by that destined for PDVSA's deep conversion refineries. Before 1998, only LCRC's Houston plant was running a genuinely heavy Venezuelan diet (the diet of the Lake Charles refinery is lower in quality than that shown in the table, as up until 2001 this plant complemented its runs of Venezuelan material with large volumes of Maya crude). LCRC's crude supplies are the only ones whose quality has deteriorated over time (as a result of an expansion in coking capacity finalised in 1997). Moreover, the greater convergence in the qualities of volumes sold to affiliates and to third parties evident after 1995 is not symptomatic of the former becoming heavier. Rather, the average quality of crude sold to third parties has improved because third parties have been the preferred type of customer for the large volumes of incremental light and medium crude that PDVSA has had to place in the American market since that date.

Table T5.2: Average Quality of Crude Exports to the USA, by Customer (1987-2000)

	Citgo (Champlin), Corpus Christi		*Citgo, Lake Charles*		*PDV Midwest (Uno-Ven), Lemont*	
	API	%S	API	%S	API	%S
1987	26.06	1.60	25.18	1.60	--	--
1988	25.06	1.64	25.61	1.54	--	--
1989	25.57	1.51	26.04	1.50	31.20	1.18
1990	25.38	1.44	26.40	1.42	30.30	1.17
1991	24.79	1.00	25.51	1.22	30.17	1.10
1992	25.30	1.06	24.50	1.41	29.17	1.30
1993	22.90	0.98	24.20	1.43	28.15	1.40
1994	21.46	0.79	23.70	1.39	28.59	1.40
1995	23.69	1.05	24.20	1.51	28.70	1.38
1996	24.66	1.16	23.76	1.59	29.68	1.33
1997	24.95	1.26	23.99	1.53	30.51	1.19
1998	25.93	1.23	25.45	1.24	30.46	1.03
1999	24.43	1.45	25.68	1.31	30.86	1.03
2000	23.67	1.68	25.15	1.58	30.39	0.86

	LCRC (Lyondell), Houston		*HOVENSA, St. Croix*		*Chalmette Refining, Chalmette*	
	API	%S	API	%S	API	%S
1987	--	--	--	--	--	--
1988	--	--	--	--	--	--
1989	--	--	--	--	--	--
1990	--	--	--	--	--	--
1991	--	--	--	--	--	--
1992	--	--	--	--	--	--
1993	22.85	0.90	--	--	--	--
1994	22.07	0.39	--	--	--	--
1995	22.05	0.50	--	--	--	--
1996	21.70	1.53	--	--	--	--
1997	17.13	2.31	--	--	--	--
1998	17.13	2.32	29.89	0.96	20.26	2.40
1999	17.85	2.20	30.29	0.95	17.68	2.43
2000	16.77	2.44	31.07	0.94	17.54	2.82

	*PDVSA Asphalt Refineries**		*All PDVSA Affiliates*		*US Arm's-length clients*	
	API	%S	API	%S	API	%S
1987	--	--	25.61	1.60	15.65	2.68
1988	--	--	25.34	1.59	17.55	2.42
1989	14.40	3.15	26.73	1.45	19.04	2.03
1990	13.29	3.04	26.40	1.45	19.76	2.07
1991	13.06	2.76	25.69	1.24	20.26	2.16
1992	12.83	2.71	25.27	1.36	20.20	2.11
1993	13.03	3.31	23.62	1.33	20.52	2.06
1994	13.13	3.25	22.90	1.21	22.51	2.01
1995	12.35	3.55	23.48	1.31	22.43	2.02
1996	12.32	3.66	23.50	1.61	23.31	1.86
1997	12.43	3.68	21.49	1.93	25.20	1.67
1998	12.33	3.78	22.43	1.80	25.30	1.75
1999	12.04	4.18	23.45	1.73	26.06	1.60
2000	11.48	3.72	22.37	1.94	23.89	1.89

* Citgo Asphalt Paulsboro, Citgo Asphalt Savannah

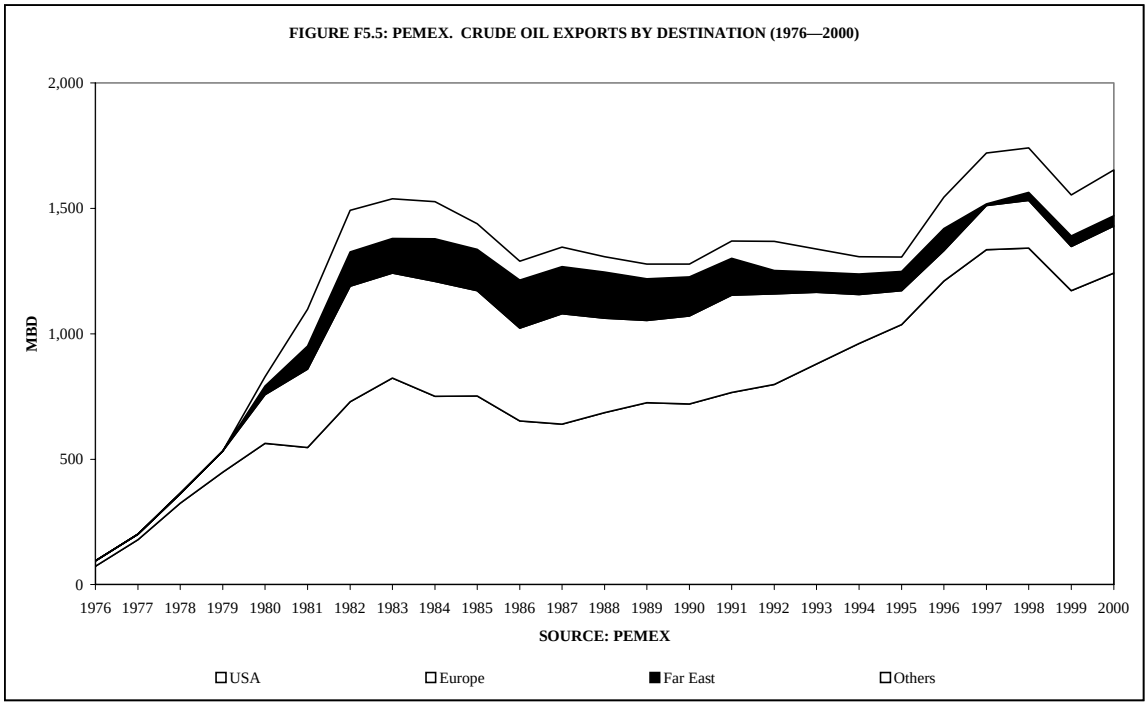
Source: DOE

5.4 Export Diversification

The perception that the major oil producers have regarding the location of the marginal refining capacity in different markets over both the short and the long term has an important incidence on their commercial policies and decisions. Since the price at the margin is the one that clears the market at a given level of supply, all those

producers that sell uniform prices generated by public pricing formulae applicable to different regions (for instance, Saudi Aramco and PEMEX) have had to structure these formulae on the basis of the marginal refining yield at the relevant reference points for these different markets (see below). These producers are able to price-discriminate between geographical zones by means of the no-resale clauses included in their supply contracts, and their allocation of incremental volume between markets at a given moment in time is largely a revenue maximisation response to what they see as the marginal conditions in these markets. In particular, these producers will often decide to shift volume away from the markets where they concentrate their sales (largely because prices there are the highest), because they perceive that the supply of any more incremental volume will drive the marginal price down (which will in turn lower the price for all their exports into a given market). A cargo sold into a different market might command a lower absolute price, but the producer may nonetheless obtain a higher marginal income by not selling it into his primary market (because the lower marginal price of this particular cargo only affects the price of a much smaller intra-marginal volume in this secondary market).

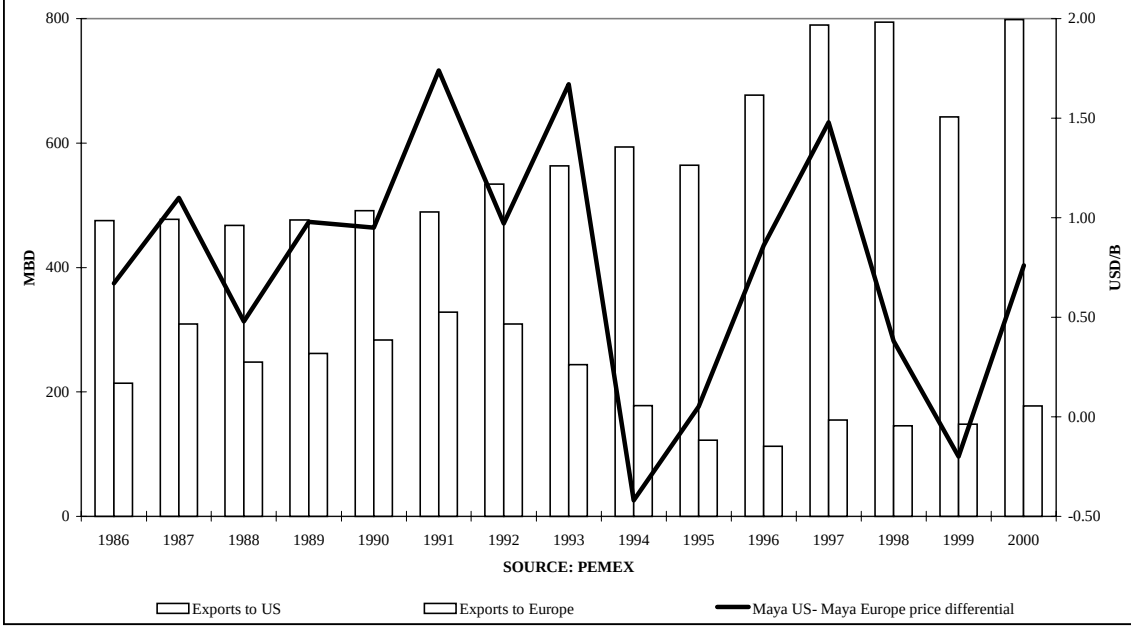
From the moment when both PDVSA and PEMEX coincidentally became significant actors in the world oil scene (1976),[13] both companies adopted policies of deliberate export diversification. However, these policies were rather different in both motivation and implementation. PEMEX's diversification policy stated that no single country could be the recipient of more than 50 per cent of Mexico's oil exports and, just as importantly, that Mexican oil could not cover more than 20 per cent of the import requirements of any given country. The backdrop to this policy, which was quite rigidly enforced until the late 1980s (Figure F5.5), was a geopolitical one. The surge of Mexican oil production was contemporary to the USA's levelling accusations against OPEC countries of waging the moral equivalent of war (to use Henry Kissinger's phrase). Thus, the Mexican political leadership decided that diversification was advisable not only because it desired to avoid the proverbial placing of all of its oil eggs in a single basket but also because it did not want the USA to feel overtly dependent towards Mexican crude at a time of heightened international tension over oil issues.



After 1986, with the introduction of different pricing formulae for the USA and Europe, it became possible for PEMEX to calculate exactly the costs of export diversification. In view of the poor state of Mexican public finances, and of the increasing degree of integration between the American and Mexican economies, the government decided to relax gradually the restrictions on channelling more than 50 per cent of its oil exports to the USA (which provided PEMEX with the best netback on its sales). PEMEX's diversification policy was thus reformulated as a mechanism to maximise export income: sales to US customers would henceforth be a function of how much volume could be absorbed by the American market without prices of Mexican export blends being significantly affected.[14] Once this threshold was reached, European refiners would ideally be given preference, because incremental sales to these customers would generate a higher marginal income for PEMEX (since the adjustments necessary to move the last barrels would affect the price of a much smaller volume of crude than the one going to the USA). This rationale for diversification was especially important in the marketing of Maya (Figure F5.6), because the highly segmented nature of the American market for heavy sour crudes meant that a slight increase in sales to the USA could trigger a significant deterioration in the price of all the crude sent to this market. In contrast, the nature of

the market for better quality crudes meant that PEMEX did not harbour any qualms in selling all its available Olmeca light crude (400+ MBD) to American refiners.

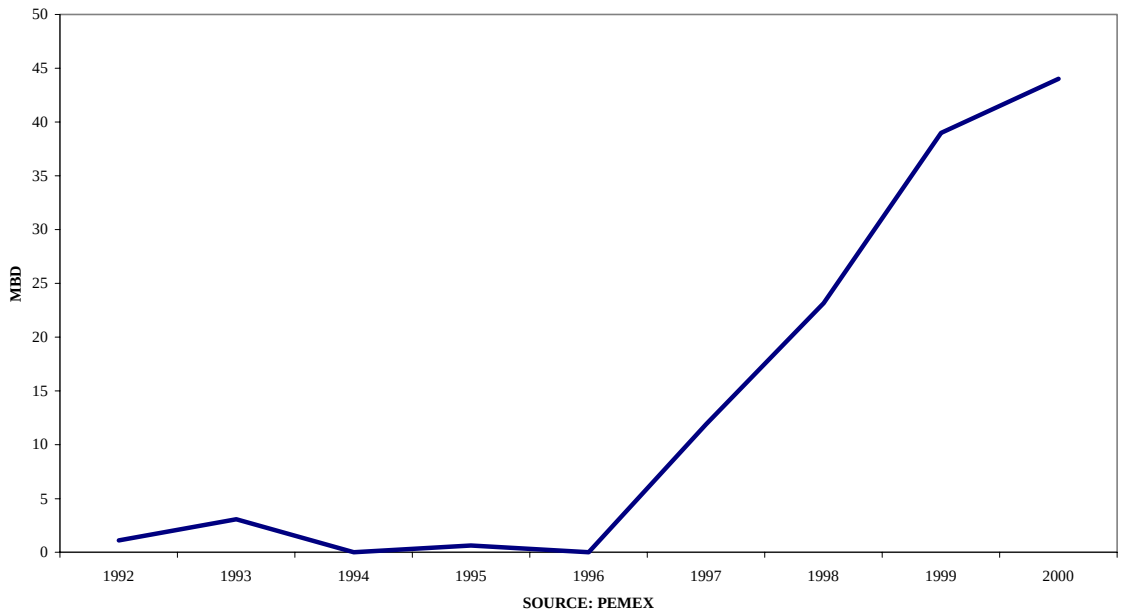
FIGURE F5.6: PEMEX. COMMERCIAL INDICATORS FOR MAYA CRUDE OIL (1986—2000)



The income maximisation dimension of PEMEX's diversification policy has been enhanced by the company's successful penetration of the complicated West Coast crude market (Figure F5.7). This market has a high strategic value for PEMEX, for a variety of reasons. Firstly, exports to the West Coast market offer PEMEX a higher netback than exports to Europe. Secondly, the relative isolation of the Californian market means that the Maya volumes sent there do not undermine the price of Maya in the USGC and, therefore, the marginal income generated by exports to the USWC is also very attractive. Thirdly, as production of heavy sour production in California continues to decline rapidly (and with no realistic prospect of the moratorium on drilling in the Californian OCS being rescinded), PEMEX will increasingly be able to push Maya into high-value outlets vacated by domestic grades, perhaps beyond the 150 MBD mark which currently represents PEMEX's goal for West Coast exports in the medium term. Fourthly, the option of increasing exports to the West Coast has the added attraction of being too costly for PDVSA, since the latter has no natural outlet to the Pacific (the small volumes of Venezuelan crude exported to PADD V are used

solely for the manufacture of asphalt). Finally, prices for heavy sour crude in the West Coast are bound to increase — perhaps up to parity with the USGC — as local sources of heavy sour crude become exhausted, and Californian refiners have to source heavy sour supplies from further afield, away from alternative markets like the USGC or the Far East.

FIGURE F5.7: PEMEX. EXPORTS OF MAYA CRUDE TO THE US WEST COAST (1992—2000)



SOURCE: PEMEX

The objective of PDVSA's original diversification efforts was to reduce its commercial dependence *vis-à-vis* the Venezuelan ex-concessionaires. At the time of the nationalisation of the oil industry in that country, the sales of Venezuelan crude were geographically diversified, but the liftings of ex-concessionaires accounted for about 80 per cent of Venezuelan exports (with a large proportion of this volume being absorbed by the Exxon and Shell refineries in Aruba and Curaçao, as Figure F5.8 shows). This degree of dependence *vis-à-vis* a very small base of contractual clients was excessive by any standards, particularly since the lack of international marketing experience of PDVSA's managers at the time would probably have condemned to failure any attempt to place Venezuelan crudes in alternative destinations (the amount of contact that the concessionaires' Venezuelan personnel had had with the international oil market before 1976 was limited, since — with the notable exception

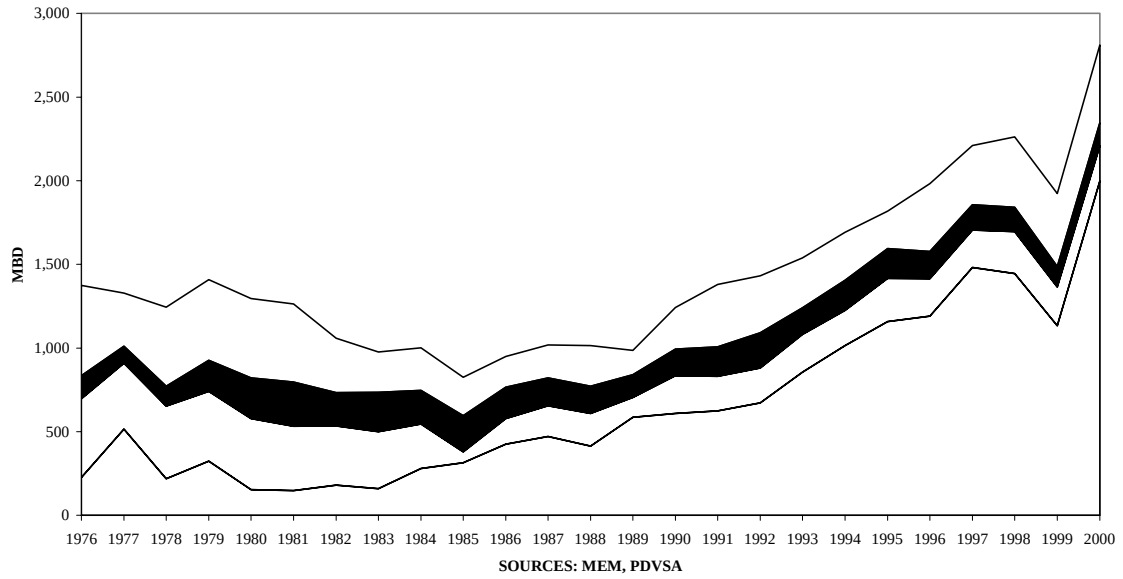
of Shell — none of them maintained a dedicated crude trading department in Venezuela). Unsurprisingly, in the negotiations that followed the nationalisation, the ex-concessionaires played the trump card of PDVSA's vulnerability for all it was worth, and were thus able to gain many unusual and valuable privileges; to wit:

a) Ex-concessionaires received a fee of about .20 USD for every barrel of oil they lifted.[15]
b) Ex-concessionaires had the right to reduce, unilaterally, their crude liftings by up to 10 per cent of contractually stipulated volumes, whenever they deemed market circumstances to be unfavourable (or, alternatively, to increase liftings by 10 per cent during buoyant periods).[16]
c) PDVSA was barred from "entering markets served by the buyers of its crude if the latter [judged] that [this] would affect their sales" in those markets; moreover, in those cases where PDVSA might be interested to present bids in order to penetrate a market not served by the ex-concessionaires, the latter reserved the right to undercut PDVSA's bid with bids of their own (which, at their discretion, could include Venezuelan crude supplies).[17]
d) PDVSA could only modify its prices quarterly, and then only after consulting the ex-concessionaires.[18]
e) Ex-concessionaires could terminate their contracts under very favourable conditions.[19]
f) PDVSA agreed to let supply contracts run for two years, extendable by two more years at the behest of only *one* of the parties to the contract.
g) The concessionaires were recognised the right to transfer their contractual rights to third parties and to resell their assigned volumes of crude freely, with no restrictions on final destination.

In the short run, PDVSA was not in a position to refuse the ex-concessionaires' exorbitant demands, but its first medium-term strategic business plan made the diversification of the customer base a matter of extreme urgency. The chaos that descended on the oil market in the aftermath of the Iranian revolution swelled the ranks of potential clients for Venezuelan crudes. Moreover, this event coincided with the coming up for renewal of the supply contracts that PDVSA had signed in 1976. Logically, the existence of a long list of interested buyers bolstered PDVSA's

negotiating position, and the company took full advantage of this to rid itself of those contractual clauses which it found most onerous, arguing — with implacable logic — that "changed conditions from five years ago require new arrangements".[20] Thus, after 1980, Venezuelan customers found that their contracts would restrict volumetric flexibility, eliminate long phase-out periods and incorporate many new restrictions (like a reduced duration of only one year, strict destiny clauses, resale restrictions and substantial increases in the amount of heavy crude which would have to be lifted in exchange for an entitlement to light and medium crudes[21]). Even after this extensive revamping of PDVSA's contractual portfolio, however, Shell and Exxon managed to hold on to certain important pricing privileges (volumes destined for their refineries in Aruba and Curaçao would still be priced with preferential formulae that included an adjustment factor related to the price of fuel oil in New York harbour). In the event, only a couple of years passed before PDVSA rescinded these contractual clauses as well, whereupon its commercial emancipation became a tangible reality, and the long-term viability of the Aruba and Curaçao refineries (which had traditionally been by far the most important individual lifters of Venezuelan crude) received a fatal blow.[22]

FIGURE F5.8: PDVSA. CRUDE OIL EXPORTS BY DESTINATION (1976—2000)



PDVSA's efforts to diversify sales away from ex-concessionaires were certainly successful: currently, ex-concessionaires account for less than 15 per cent of total Venezuelan crude exports. However, after 1983—5 (when liftings by the ex-concessionaire interests in the Netherlands Antilles ceased), PDVSA has conceded little importance to the question of geographic export diversification. The company has consistently tried to concentrate as much volume as possible in the US market, with scant regard for marginal income considerations (i.e. the degree to which the discounts attached to the last barrels affect the price of the rest of the Venezuelan volume placed in the USA). PDVSA's ongoing sales into other markets (Europe, the Caribbean) have been largely determined by the liftings of affiliated companies, rather than a conscious income maximisation effort (affiliates account for the bulk of the Venezuelan crude sold in these markets). For many years, the main exception to PDVSA's overriding concern to concentrate sales in the USA was Central America, a market that was very attractive for PDVSA because it used to charge refiners in the area premium prices for reconstituted Venezuelan crudes. However, this outlet has now lapsed into insignificance, since PDVSA's sales to Central American countries have diminished drastically in the wake of the progressive liberalisation of oil markets in the area.

5.5 The Nature of Pricing Mechanisms

The most striking difference in the commercial approaches of PDVSA and PEMEX can be found in their respective pricing mechanisms and practices. PDVSA's pricing mechanism is opaque (in other words, third parties have only an approximate idea about the prices at which deals between PDVSA and specific customers are being done). It is predicated on constant and direct face-to-face negotiations with non-affiliated clients, which means in turn that "pricing terms are set individually to suit the needs of customers … [and FOB] crude oil costs vary among customers".[23]

The cornerstone of PEMEX's commercial policy is its pricing formulae, which the company developed as an alternative to netbacks back in 1986 and which have since been adopted by the NOCs of many important oil-exporting countries (see Appendices I and II). These formulae are available in the public domain, on the one

hand, and are applied to all customers (including affiliates) in a given geographical area without any distinctions, on the other hand. They are structured around marker crudes (WTS, LLS, Dated Brent, and so on) that are not only quoted daily in reliable oil price information services like *Platt's*, but which also support a sizeable volume of spot trade, and are not subject to OPEC production quotas or similar production restrictions. The existence of these formulae means that the prices of PEMEX crudes reflect market conditions promptly, and that a large part of this price is determined by markets over which the company has no control.

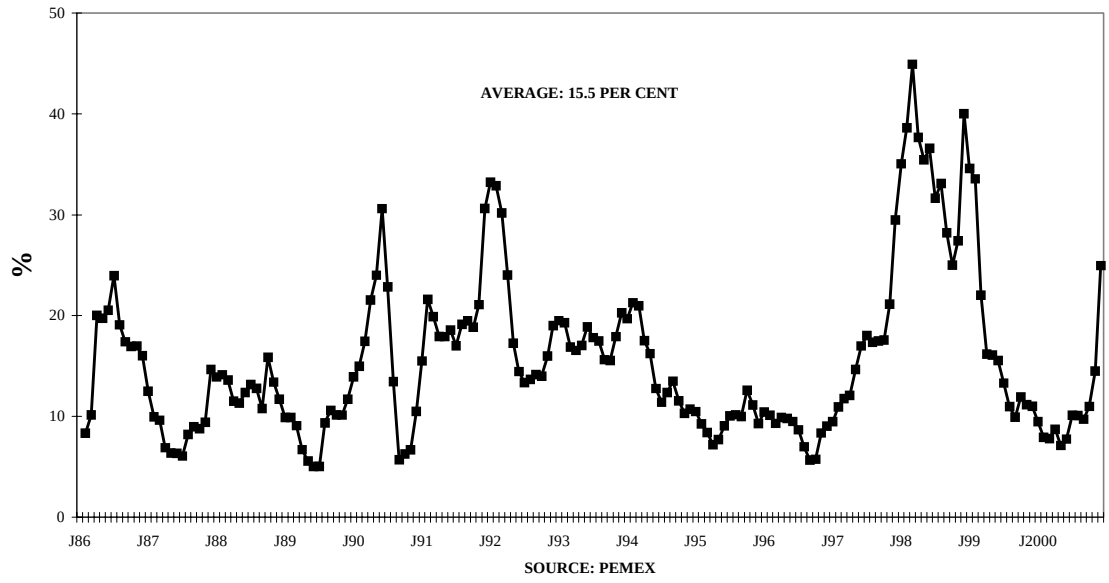
Unlike netbacks, public pricing formulae do not guarantee buyers a refining margin. Nevertheless, formulae enable the seller of crude (and especially of heavy sour crude) to make a number of high-power credible commitments that, in principle, are very attractive for refiners with complex plants. These credible commitments are:

a) Guarantee of non-expropriation of quasi-rents: When a seller adopts a pricing formula, he is accepting explicitly that most of the value of his crude will be determined by exogenous factors. For a refiner who is satisfied with the composition of the formula (in terms of its constituent elements and the relative weights accorded to each one of them), this amounts to a reasonably credible promise of non-expropriation of the quasi-rents generated by very complex plants. By tying himself to a formula, the seller is, up to a point, openly renouncing the option of behaving opportunistically by demanding extortionate prices to his customers in tight markets. The seller retains a residual pricing discretion, in the form of the monthly adjustment factor incorporated in the formula. However, this is only a fine-tuning instrument, and its contribution to the final crude price is generally very small, as Figure F5.9 shows.

b) Guarantee of uniform pricing: Refining is a business of margins and, therefore, the main focus of a refiner's attention will always be the relationship between the price of crude and products (more than just the absolute price of crude itself). One of the main worries for a refiner will always be that one or more of his competitors get access to cheaper sources of crude oil, because "any company that acquires oil on advantageous terms can cause damage to the profitability and production of other refiners if it has excess capacity at its disposal".[24] In practice, "different types of property rights,

different modes of access to primary supplies of crude oil and differences in bargaining power *vis-à-vis* producers mean that crude oil of the same specification [can be] acquired at different prices and on different terms by different buyers",[25] with the price differential of crude oil exchanged under long-term contracts and oil sold in a spot transaction "unlikely to reflect exactly the economic value of the security that term contracts afford".[26] Pricing formulae address this issue: their transparency assures buyers that the FOB price of a certain crude will be the same for all of them, regardless of the volumes that each one of them might lift or of the strength of their relative bargaining position *vis-à-vis* a given seller (formulae, of course, cannot eliminate locational advantages or disadvantages).

FIGURE F5.9: PEMEX. PERCENTAGE OF THE MAYA FOB PRICE FOR US DESTINATIONS ACCOUNTED FOR BY MONTHLY ADJUSTMENT FACTOR (1986—2000)



SOURCE: PEMEX

c) Insurance against market volatility: Pricing formulae generally incorporate a delayed valuation element to protect the client against movements in the price of oil taking place whilst cargoes are in transit to their final destination.

d) Limited insurance against local market distortions: Uniquely, Mexican formulae are structured around baskets of different crudes and products. The different components of the formulae do not move in unison, and this enables the formulae to

dampen distortions arising from temporal supply/demand imbalances affecting only a single crude or local market.

Pricing formulae are not without their disadvantages, of course. The inevitable simplifications that have to be incorporated into the calculation of relevant transportation costs and marginal refining configuration for any formula may lead to the exporter's setting the price of crude *X* at a level that makes it competitive with a certain reference crude in the eyes of the refiner that values crude *X* the least (in other words, the crude will be undervalued for all buyers except one). The segmentation within the heavy crude oil market means that the differences between the reservation prices of marginal and intra-marginal customers can be very large (although it is possible for a heavy crude oil seller to attenuate this effect by making sure that his customer base is relatively homogenous). Also, nearly all the international marker crudes are light and sweet, which makes it difficult for the prices generated by a heavy sour crude formula to track the marginal refining value of these markers exactly. PEMEX's decision to include fuel oil in its Maya formulae — a decision often criticised because it allegedly complicates the formula, making it more difficult to hedge Maya cargo in futures markets and exposing clients to the eccentric behaviour of the illiquid fuel oil market[27] — was meant to enhance the tracking accuracy of the Maya formula. This fuel oil element ensures that the product yield of the synthetic barrel constituted by the various crudes included in the Maya formula approximates as closely as possible the yield that can be obtained by processing one barrel of the Mexican grade in the marginal refining configuration.

Notwithstanding these apparent drawbacks, public pricing formulae have become the cornerstone of PEMEX's commercial success. This is because a seller who credibly and unilaterally grants a customer the sort of guarantees delineated above in effect establishes a 'sequential authority relationship' between himself and the buyer, which reduces the latter’s incentive for bargaining, on the one hand, and for engaging in strategic misrepresentation, on the other hand. Sequential authority relationships are characterised by the fact that "one party has the authority to choose the price and the other party has only the authority over the trade decision"[28] (although in this particular case, the sequential authority relationship is best understood as being attenuated, since the seller has the liberty to define the parameters of the formula and change the

adjustment factor, but not to set the price of the crude). The mere existence of a formula is a clear signal to clients that a seller wishes to apply a uniform open price in a given geographical area and that, in consequence, any haggling or lying on their part with a view to obtaining casuistic discounts will be a waste of time. Thus, the microeconomic properties of pricing formulae are similar to those of the GSP mechanism, *à propos* of which Mabro observed:

> Buyers and sellers, when brought face to face, are always tempted to bargain. When the market tightens up sellers begin to seek a bit more for their oil and try to improve in their favour the terms of the sales contracts; when the market is slack buyers begin to indicate that they have opportunities for shopping around to obtain a price discount or some other advantage. *'The need to abide by the official price' will always be used as a convenient argument against change by the side which is being asked to concede a price discount or to pay a premium.*[29]

This irresistible temptation to bargain, very often at the expense of a counterpart's commercial good will, is tempered by a similar “need to abide by the formula price”. Formula prices, however, are even better than GSPs at this: because they change more often (daily, in fact, with monthly revisions to the adjustment factors), they reflect changes in market conditions more quickly and accurately. Among other things, this means that even particularly unhappy customers will only have to wait a limited amount of time for the next revision of the constant in order to see whether their grievances are being addressed or not. To put it another way (using the terminology that Albert Hirschman introduced in his seminal *Exit, Voice and Loyalty*), a pricing formula inhibits a buyer's natural temptation to use his "voice" indiscriminately in an attempt to alter a commercial relationship in his favour without dwelling on the potential damage that such behaviour can cause to the good will on which this relationship is built.[30] This does not mean, of course, that pricing formulae effectively close communication channels between commercial counterparts: if a buyer feels that the situation merits it, he can communicate to the seller his displeasure with the behaviour of a formula over a given period, and expect an improvement for the next period. The seller is not legally bound to give satisfaction to these complaints, but there is no doubt that, were he to ignore such complaints consistently, he would soon find himself without clients (because their frustration will lead them to choose the "exit" option). However, so long as seller and buyers concur that formulae are well constructed, the seller can expect clients to go for the "loyalty" option (a qualified sort of loyalty, perhaps, but loyalty in the end). Moreover, when formulae are working as

advertised, discussions between seller and buyers tend to be limited to how much the adjustment factor should move in a forthcoming period. The scope for commercial disagreement between parties is restricted, because what is under discussion is a residual magnitude that will make only a small contribution to the final price of every barrel of oil priced with the formula.

An NOC will only be able to reap this loyalty dividend fully if its clients are genuinely convinced of the futility of angling for discounts behind closed doors (in such cases, the prices generated by formulae assume a merely indicative character).[31] PEMEX, however, has been able to establish a reputation for never resorting to company-specific discounts to shift volume. Its credibility in this regard has been bolstered by a flat refusal to sell to brokers, traders or any other type of intermediary,[32] by a refusal in principle to sell under anything other than contractual terms (even to non-contractual customers), and by constant and unequivocal declarations in the sense that it prefers to sell crude within the framework of long-term contractual relationships. Given the great similarities which exist between PEMEX and PDVSA (in terms of the type of crude they have to sell, the profile of their ideal client, and so on), it seems quite extraordinary that the Venezuelan company should have chosen not to follow PEMEX's lead in terms of pricing methods (particularly since PDVSA would have had no trouble in establishing a commercial reputation similar to PEMEX's *vis-à-vis* the issue of discounts). At one point, such a decision might have been attributed to understandable caution on the part of the Venezuelan company (since the concept of formulae was new and untested). However, this is clearly no longer the case.

Various reasons have been proffered by PDVSA managers to explain this opposition to pricing formulae. One of them is that formula pricing would be too complex to handle for a company that exports around 30 different crude blends. Granted, having to market so many blends does make PDVSA's life more difficult than that of PEMEX, but it should be borne in mind that PDVSA could easily reduce the number of blends it markets in a drastic fashion, but has chosen not to do so. Moreover, the internal benchmarking system based on four crudes — Tía Juana Light, BCF-24, Bachaquero BCF-17 and Tía Juana Heavy — that PDVSA has used to calculate royalties due on its exports of all light, medium, heavy and extra-heavy streams

(respectively) since 1986[33] could just as easily be transformed into a fully fledged public formula pricing system. In any case, the claim that the day-to-day administration of a Venezuelan formula pricing system is too complex and unwieldy overlooks the fact that PDVSA prices its heavy blends through bargaining with individual clients over variable discounts from the PEMEX Maya formula. Thus, under this negotiation-oriented system, the sort of analysis and calculations that would have to be undertaken to change the adjustment factors for all the Venezuelan export blends on a monthly basis still have to be carried out, albeit on a daily basis, by traders and analysis staff who will often be under great pressure to close deals.

5.6 Sequential Authority Mechanisms and the Effective Length of Contractual Relationships

In practical terms, PEMEX's emphasis on long-term relationships is meant to forestall commercial opportunism and *revanchisme* by both parties to a supply agreement: the prices generated by formulae cannot track marginal refining yields exactly, but within the context of a long-term commercial relationship this is not a major problem, since positive and negative distortions in the formula price will tend to even out over time. Notice, however, that it is the relationships and not the contracts themselves that have a long-term character. PEMEX's supply contracts are evergreen, but have a nominal duration of a year and a short phase-out period of three months (standard throughout the oil industry). Thus, for all their apparent rigidity, these evergreen contracts offer a reasonable compromise — for both buyer and seller — between spot deals and multi-year long-term contracts (of the type that is characteristic of the coal market, for instance).

The type of arrangement underlying PEMEX's supply contracts is fairly typical of buyers' markets, and reflects the fact that

> a limitation of long-run relationships may be due to the fact that a short-term relationship is generally more advantageous to a party who knows that he will have good outside opportunities in the future. Because good outside opportunities tomorrow are related to his general ability to perform well and thus improve his bargaining position today, this party has an incentive to signal them through the signature of a short-term contract (possibly disguised as a long-term contract).[34]

An evergreen contract with a short phase-out period is indeed a short-term contract disguised as a long-term contract, giving customers a good deal of commercial leeway to find better supply options but also tangible volumetric security (at a small cost in short-term flexibility). But such a characterisation passes over the important distinction that Aghion and Bolton draw between "the *nominal length* of contracts (the length that is specified in the contract) and their *effective length* (the actual length that the parties expect the relationship to last at the time of signing)".[35] According to these authors, "looking only at the length of a contract is misleading", because "what is important is to what extent a contract of a given length locks the parties into a relationship".[36] This is because, under certain conditions of informational asymmetry, buyers will accept contracts simultaneously offered them by a monopolistic seller, even though the payoff they receive in such a situation will be lower than the one they would have received had they all held out and rejected the seller's offer. Rational buyers will be thus willing to lock themselves into relationships (and thus perpetuate the monopoly position of the seller) because of a paradoxical "free rider situation in reverse"; namely, that "contracts are valued by each buyer individually even while they create an external cost to all other buyers".[37] Indeed, the more buyers there are under contract to a given seller, the higher the external costs that non-contractual buyers will face.

Aghion and Bolton's model seems to suggest that a seller who manages to put together a "critical mass" of *effectively very long duration* contracts will place himself in a good position to get away with all sorts of anti-competitive practices. This insight appears pregnant with implications for the heavy sour crude market in the USGC. After all, the Maya contracts that PEMEX has subscribed with its most important arm's-length customers lock the two parties to a significant extent, if only because of the problems inherent in substituting large volumes of this crude for another one of broadly similar quality within an acceptable time frame. Aghion and Bolton say that their "analysis provides a rationale for [anticompetitive] practices … and explains why rational customers [will] cooperate with firms" at implementing them, so they would probably think that the fact that PEMEX manages to shift so much volume through term contracts reflects the magnitude of the negative externalities that its non-contractual customers have to face.

The successful contractual dimension to PEMEX's commercial policy clearly does not stem from the company's ability to force customers into shotgun marriages, however. After all, not all contracts seek to eliminate competition since, as Posner explains (and Aghion and Bolton explicitly accept), "customers would be unlikely to participate in a campaign to strengthen [a seller's] monopoly position without insisting on being compensated for the loss of alternative and less costly (because competitive) sources of supply".[38] Rather, we would posit that PEMEX has been able to sign contracts for very large volumes of Maya with refiners that have high reservation prices for this type of crude (and are therefore willing to pay a slight premium for the privilege of maintaining this relationship flowing smoothly) because of the company's *explicit acknowledgement* of the problematic nature of this market, on the one hand, and the *explicit renunciation* of its market power (through the adoption of contractual limitations to this power), on the other. This has been complemented by a scrupulous observance of contractual terms and volumes, and a policy of extending the same treatment to all customers (regardless of the magnitude of their liftings). Deep conversion refiners in the USGC have found the signalling devices embedded in PEMEX's term contracts sufficiently attractive and convincing to make PEMEX their supplier of choice for the majority of the base load requirements of their plants. PDVSA's clients, for their part, have availed themselves of the flexibility offered them by this company to shave peaks, balance loads, and supply a much smaller proportion of their respective base loads with Venezuelan crude. This is because in tangible terms, the advantages for customers implicit in PDVSA's highly flexible contractual approach pale into insignificance when set against its drawbacks (notably the lack of volumetric security, and the fact that refiners run the risk of paying significantly more for their crude supplies than their competitors).

In contrast to what has happened to PEMEX, PDVSA's most important commercial relationships have come to be mediated by frame contracts with effective lengths measured perhaps in months rather than years. This fact, which would go a long way towards explaining the contrasting fortunes of PDVSA and PEMEX in the deep conversion market segment, is clearly connected with the commercial reputations of these companies. A very good and recent example of this can be found in the way in which both firms went about the business of reducing their export volumes in order to comply with the supply restriction agreements that Saudi Arabia, Mexico and

Venezuela concluded in Riyadh and The Hague during March and June 1998, respectively.

Argus reported the Venezuelan cutbacks in the following terms: “US buyers complain that PDVSA is switching grades among customers. They say PDVSA claims that grades specified in contracts are not available, while it shows the same oil to other refiners on a spot basis. This allows PDVSA to capitalise on a stronger spot market".[39] PDVSA challenged this interpretation, and explained that the confusion arose "from the complexities involved in implementing output cuts. [The company] decided which grades to cut and told customers about substitutes. But as cuts were further evaluated by upstream officials, they were changed and a different slate of alternatives was proposed to buyers".[40] PDVSA also said its goal was

> to cut heavy grades and spread the pain equally among its clients. But buyers are crying foul, saying the behaviour amounts to breach of contract. One large US customer is so unhappy that it may cut term volumes once its deal expires. The refiner estimates that PDVSA's cargo shuffle will cost an extra 0.85 USD/B … Other refiners say [the] changes are upsetting finely balanced systems.[41]

On the whole, though, PDVSA's actions spoke louder than its conciliatory words to its customers. *Argus* reported, for instance, that "PDVSA's claim that it has shut Merey production to comply with its … promised output cuts is being met with scepticism, as Leona - a blend of Merey and Mesa - is unaffected". Nor was this the only indication of commercial opportunism that these customers could perceive: for instance, Petrobrás was told "not to expect its 30 MBD of Merey crude and … [was] offered Menemota crude … or the new Zuata crude as a replacement for Merey", while "another customer buying Menemota on a term basis was denied the crude … and forced to take two other grades", while a third major "was told that no Zuata would be available".[42] *Argus* contrasted the treatment meted out to Venezuelan customers with the fact that PEMEX had "consistently rebuffed requests for more crude, and is maintaining an across-the-board 3.5 percent cut for heavy sour lifters", and reported that PEMEX was "aware of the tension between PDVSA and its buyers … 'That is the difference between us and them', another PEMEX executive says of PDVSA's crude switches, emphasising that Mexico holds its contract terms in high regard".[43] Some smugness is detectable in this statement, but it is undeniable that US refiners not only tended to agree with this assessment of the situation but also

believed that PEMEX had exercised restraint in its monthly movements to the Maya adjustment factor.

5.7 Sequential Authority Mechanisms, Reputation and Prices

There are many markets – the one for heavy sour crude being one of them – in which prices are less than perfect repositories of information. In these markets where it is only possible to see through a glass darkly, economic actors have had to find ways to both amplify and project the information contained in prices. The necessity to overcome the opacity of the media through which price information is conveyed has led to the incorporation of devices that signal commitment in the legal machinery that binds commercial counterparts together.

Sequential authority mechanisms are one such device. If adequately designed and implemented, they can have a stabilising effect on commercial relationships, particularly those characterised by a high degree of closure. Contractual relationships can clearly be destabilised by the fact that "you can only take profit on a contract once",[44] since the temptations to take that profit are ever present. But by substituting rules for discretion and hence reducing the threat of extortionate pricing, sequential authority mechanisms actually make it possible for commercial counterparts in the oil market to take profits on their contracts repeatedly and not necessarily in equal measures (at least over short periods of time). Thus, in transactionally disadvantaged markets where these conditions hold, a non-committed seller may actually be worse off than a committed — hence inflexible — one. This probably explains why many other major oil producers have clearly found it in their interest to banish haggling from their commercial *modus operandi* through the adoption of public pricing formulae, thus preventing a variant of Gresham's law of adverse selection from ruling (and ruining) their commercial relationships.

The success of PEMEX's sequential authority mechanism is also a function of the role that a seller's commercial reputation (and its complement, consumer loyalty) plays in markets as thin as the one for heavy sour crude, on the one hand, and with the path dependence that prices in such markets exhibit, on the other hand. The lack of a credible supply of large volumes of heavy sour crude oil on a spot basis means that

the mechanisms of commercial competition (i.e. refiners turning to atmospheric residue or straight-run fuel oil as coker feeds, for instance) can palliate but rarely eliminate pricing distortions in the market for heavy sour crudes. If such distortions arise through opportunistic extortionate pricing on the part of one specific seller, buyers can be expected to react by reducing the term exposure that they have with that seller, on the one hand, and by discounting the price of the crude sold by the opportunistic party relative to those of its competitors, on the other. The magnitude of the discount would at least cover realised switching costs as well as those additional costs that would be generated if the buyer were to switch away once again from the competitor that displaced the overpriced feedstock. Moreover, this short-term effect on both the quantity and price preferences of buyers will be cumulative; in other words, repeated instances of opportunistic behaviour on the part of a seller will lead to repeated adjustments by the buyers, which in turn will give rise to premia not reflective of quality differentials attached to certain term supplies. This assertion will be demonstrated in the following chapter.

The path dependence of prices poses a conundrum for sellers in that the prices they may expect to receive for their oil will depend on their respective reputations. Akerlof's work on the microeconomics of loyalty convincingly demonstrates that in markets that are particularly vulnerable to opportunism, moral hazard and the like, "it pays persons to bond themselves by acquiring traits that cause them to appear to be honest. And the cheapest way to acquire such traits … is, in fact, to be honest!"[45] The problem with this is that, in most fields of commercial endeavour, obtaining a reputation is almost by definition a lengthy affair. This means that, during the time it takes to build one, a seller in a reputation-sensitive market can expect to receive lower prices than if he already had it. In turn, if the seller's performance is evaluated by customers solely in terms of pricing behaviour (as opposed to qualitative parameters), and if the reputation-related discount is large enough (as it would be if the market in question were one with high switching costs), then sellers facing a long reputation-building period will have an incentive to behave opportunistically in the short term, effectively jeopardising their chances of ever acquiring a good reputation (and of ever being able to charge higher prices for their wares). This perverse incentive for myopic behaviour will be all the stronger in the presence of opportunistic competitors, whose predatory actions will only come to haunt them at some date far into the future,

by which time they may have substantially enhanced their competitive position on the back of short-term gains. The Nash outcome to such a situation is that all sellers will behave opportunistically, and that all customers will adjust their reservation prices accordingly. No seller will exercise restraint during the reputation-building period, because to do so would carry unacceptable penalties. The fact that honesty is so complicated means that reputation in such a setting is conceivable basically if it arises through a process of spontaneous generation!

Sequential authority mechanisms of the type embodied in public pricing formulae offer a way out of this impasse to a seller who is conscious of the existence of path dependence, and who wants to maximise the reservation prices that its customers will be willing to pay (which is equivalent to minimising the length of the reputation-building period). The main problem that such a seller will face lies in convincing *any one of its customers* that it harbours fundamentally good intentions towards the buying firm, and that the latter will not become the target of predatory practices at some future date. Individually, a customer will not care one iota whether others become the targets of such practices (in fact, it might relish the prospect) but collectively, all of the customers will want individual tangible assurances that it will not happen to *them*. Hence, if a seller is to make a *truly credible* commitment to an individual customer, he will necessarily have to make it to all its other customers as well. However, so long as any one customer has any reason to question this commitment, all others will tend to harbour similar doubts, and the seller will find the effort of establishing a reputation too costly. What such a seller needs, in a way, is the practical equivalent of the academic sleight of hand that Tadelis detects in most formalised treatments of reputation: "the simplest standard reputation model has only two types, ordinary and Stackelberg. In that setting there is no reputation building. Rather than being built gradually, reputations [good or bad] spring to life." Tadelis rightly complains that this approach "fails to illuminate the process by which names with no initial value become valuable after good performance, a process that is well documented in reality".[46] By the same token, however, he does not examine the conditions under which reputation can be — indeed, may have to be — built after only a brief gestation period. Such conditions do not obtain in the restaurant trade (the main focus of Tadelis' attention) but are characteristic of the market for oil and, more specifically of the market for heavy sour crudes. In these markets, some very

important sellers (like PEMEX or Saudi Aramco) have found it possible to overcome their credibility problems and to acquire a valuable reputation quickly, mainly through the device of making credible price commitments in public.

A good way of understanding this point is to examine the competitive mechanism known as the most-favoured-customer clause, which "guarantees a firm's current customers that they will be reimbursed the difference between the current price and the lowest price offered in the future (up to some specified date)".[47] A firm derives benefit from this mechanism essentially by making future price cuts costly (i.e. committing to a high price) and hence diminishing the incentives of its rivals to cut their own prices. But as Tirole observes, "despite its strategic attractiveness, the most favoured customer clause is not widespread … [since] rebates to other customers must be made observable to each buyer, because unrecorded rebates would benefit (*ex post* but not *ex ante*) a manufacturer who had offered price protection in the past. That is, discount secrecy removes the credibility of the price protection policy".[48] The Achilles' heel of this mechanism, then, is that customers will never be sure that one of their rivals is getting a rebate under the table, while they are being made to pay over the odds.

Committing efficiently in public can be less difficult, just as long as the seller explicitly assumes the risk that all of its customers will update their beliefs (and their reservation prices) downwards as soon as any of them perceives behaviour that deviates from the norm promised out by the seller, even if the behaviour is beneficial to the customer in question. This enables the seller to bypass the inconvenience posed by the verifiability of his public commitment. After all, even promises made in public can be broken, so a seller who tries to commit publicly will still face a long and costly reputation-building period, unless he can give a cast-iron guarantee of good conduct from day one. And an efficient way for a firm to achieve this is to make itself the hostage of the good will of its customers. In the case of a price protection scheme (in line with the sort of behavioural rules set out by Kreps and Wilson for markets where situations of incomplete information are the norm and actors' strategies are best responses relative only to their beliefs[49]), any buyer who receives a secret rebate will automatically assume that its competitors will benefit from similar backhanders, with the result that the scheme will unravel and the seller will be unable to enjoy its

benefits. This comes across quite clearly if one looks at the dynamics behind the resounding failure of arm's-length netback pricing, for instance.

At first glance, it would seem logical to expect netback contracts to foster stronger and more stable commercial relationships between a crude seller and his clients than those achievable through public pricing formulae. After all, unlike pricing formulae, netbacks guarantee a positive margin for every barrel of crude processed (and one would think that refiners would hesitate to jeopardise such a cosy arrangement by behaving mercenarily for the sake of small temporary gains[50]). In practice, though, this assumption has not held. Specifically, during 1986, netback contracts became non-binding, because crude buyers subjected them to successive and frequent amendments in their favour.[51] So opportunistic was the behaviour of refiners on that occasion that Saudi Arabia (the producer that unleashed the "netback crisis") not only decided to substitute them for a less self-destructive pricing method — public pricing formulae — but also was sworn off them for good.

The dynamics behind the abrupt death spiral that obtained once most oil exporters climbed on the netback bandwagon were a direct consequence of the opacity and secrecy of netback contracts. These characteristics gave crude buyers every incentive to renegotiate and/or desert supply accords more often than would have been the case had most producers been selling their crude on some other basis[52] and, hence, probably destabilised the market *more* and caused the price of oil to fall *further* than would have been the case had a different pricing mechanism been the oil producers' weapon of choice during the 1986 price war. These two counterfactual assertions seem impossible to prove,[53] but consider the following: once netbacks were publicly abandoned by various OPEC countries, the price of oil experienced a rapid and significant recovery (the spot price of Brent went from under 9 USD/B to around 15 USD/B in under a month) in spite of the fact that the OPEC quota accord of August 1986 did not take a significant volume of crude off the market and, moreover, was repudiated by Iraq. On the strength of the above one would think that, given the amount of crude produced by OPEC in 1986, the market could very well have considered Brent crude at 14—15 USD/B a fair deal, had netbacks not come into the picture at all. Such a price would still have represented a calamitous fall from earlier

price levels, but at least producers would have been spared from having to sell their crude for less than 10 USD/B.

5.8 Conclusions

Because of their high-power signalling properties, to say nothing of the simplicity with which they can be supervised and monitored, public pricing formulae offer large crude oil sellers and their customers an ideal vehicle for economising on bounded rationality while at the same time safeguarding against the hazards of opportunism. Through the use of a pricing formula, a seller effectively gives all its customers the same yardstick with which to measure his performance, while at the same time acknowledging and advertising the fact that any transgression on its part against any one of them will adversely affect the future prices it is to receive from all of them for a long time to come. This recognition of path dependence commits the seller to ride out market distortions, as opposed to taking advantage of them, even when — indeed, especially when — the prices of term and spot volumes are not in harmony (such divergences tend to be both more marked and longer lived in the market for heavy sour crude than those which occur from time to time in the market for light and medium crudes).

Credible commitments of the kind embedded in public pricing formulae not only impose sacrifices, however. A seller's margin of manoeuvre in certain commercial matters can be enhanced — paradoxically — by their very inflexibility. For instance, a committed seller can easily add new customers to its books, or greatly increase the volume lifted by one particular customer, without its other customers immediately coming to the conclusion that discounts may be behind these changes. Having said that, the administration of a formula pricing system for various crudes and markets does place a burden on sellers in terms of its requirements for consistency (a virtue that is often at odds with commercial expediency or necessity). This is because departures from the stated rules in any one market can generate spillovers that may affect the seller's operations in other markets or for other crudes (not least because its customers will not necessarily lift only one type of crude, or take it to only one location). Nevertheless, there is also a positive aspect to this; namely, customers will

tend to feel reassured by the fact that these potential spillover effects will serve as a further deterrent against unacceptable behaviour on the part of a seller.

On the whole, a sequential authority mechanism like the one that lies at the heart of PEMEX's commercial policy enables a seller to stake his future welfare on his reputation by making this reputation especially difficult to maintain. In other words, the circle can be squared by taking advantage of the fact that "the power of reputation seems positively related to its fragility".[54] This sort of public commitment can conceivably be rationalised in terms of the restriction of competition. For instance, the Aghion and Bolton model also assumes that all contracts are publicly observable. These authors admit "this is a strong assumption. In practice, not all contracts are observable. As a result, one can never be certain when a contract is observed, whether there does exist a hidden contract which cancels the effects of the observed contract". Their model is structured in such a way that any selling firm has "an incentive to publicise all of his contracts … Thus, hidden contracts are not a problem".[55] Indeed, PEMEX's example shows that the incentive for publicity in a market like that for heavy sour crude is real enough, even if there is no scope for engaging in monopolistic practices.

NOTES

[1] Geroski, Ulph and Ulph 1987: 77.
[2] See in particular Horsnell and Mabro, *op. cit.*; Horsnell 1997; Barrera-Rey and Seymour 1996.
[3] See Barrera-Rey and Seymour, *ibid.*
[4] *PIW* calls these optional contracts "frame contracts"; (24 May 1993, special supplement: 2).
[5] PDVSA Finance 1997: A-43.
[6] Affiliates in which PDVSA is not the sole shareholder do enjoy volumetric security, because their supply contracts state that "if their supplies are interrupted, PDVSA is required to compensate the affected affiliate for any additional costs incurred in securing crude oil or other feedstocks" (PDVSA Finance, *ibid.*).
[7] See Port Arthur Finance 1999: 66.
[8] Karl Llewellyn, quoted by Williamson 1996: 255.
[9] "A spot transaction … is a once-and-for-all deal for a given amount of oil available in one batch at a specified location" (Mabro 1984: 59). In contrast, "a deal involving offtake deliveries over a period of time is a term contract, however short or long the stipulated period is" (*ibid.*: 75).
[10] *ICOMH*, *op. cit.*: F36.
[11] *PIW*, 30 November, 1992: 3.
[12] *PIW*, 24 May, 1993, special supplement: 1. PDVSA has also negotiated a number of longer-term frame contracts (with lifetimes between two and ten years) for the sale of heavy crudes with a number of oil majors (PDVSA Finance 1997: A-44).
[13] In 1976, PDVSA came into being and PEMEX started to export significant volumes of crude once again.

[14] The directive that Mexico should not provide any country with more than 20 per cent of its crude requirements has never been relaxed, though. During the 1980s, there were a couple of years in which Spanish imports of Mexican crude exceeded this threshold. However, the Mexican government did not see this as a cause of major geopolitical concern.
[15] This figure was in line with the fees that other OPEC NOCs had to pay to their own ex-concessionaires.
[16] In any given quarter, buyers could vary their liftings by up to 20 per cent of stipulated volumes, so long as the variation in their liftings at the end of the year did not exceed 20 per cent of the stipulated volumes.
[17] Maza Zavala and Malavé Mata 1981: 180.
[18] Calderón Berti 1983: 68. This clause was exceptionally favourable for the ex-concessionaires, because the notification and negotiation periods generally lasted fifteen days each. This meant that up to thirty days could elapse before a price modification went into force and, during this period, the buyer could still lift crude at the old price and resell it at the new price.
[19] If buyers became displeased with Venezuelan prices, they could phase out their purchases of Venezuelan crude over a whole year (25 per cent of their volume per quarter). Official Venezuelan prices were not applied to the cargoes lifted during the phase-out period (prices for these cargoes were determined by averaging the "new" official price with the price prevailing before the disagreement between the counterparts occurred; in no case could this average exceed the "old" price by more than 50 per cent).
[20] See "PDVSA has Edge in Renegotiating with Majors", *PIW*, 19 November 1979: 5.
[21] CEPET, *op. cit.*, v. II: 158.
[22] One example suffices to illustrate just how favourable these formulae were: while the Aruba refinery posted annual profits of 25—75 MMUSD while the old formulae were in force, Exxon forecast that it would lose about 50 MMUSD a year with the new formulae.
[23] *ICOMH, op. cit.*: F36.
[24] Bacon and Mabro, *op. cit.*: 21. If a refiner with access to preferentially-priced crude has no excess capacity at his disposal he can achieve more profits, but not at the detriment of other refiners.
[25] *Ibid.*: 32.
[26] *Ibid.*: 20.
[27] Thus *PIW*: "Buyers of Mexican crude … face the most complex crude-pricing formula system in the world (*ICOMH, op. cit.*: D-21). Why refiners should be daunted by this is not at all clear. Admittedly, the fuel oil element makes hedging more difficult, but the Mexican formulae are designed to limit the price exposure of contractual buyers by having pricing periods close to the day of arrival of cargoes. Moreover, while PEMEX will not entertain requests for price discounts, it is quite willing to accommodate reasonable requests from clients as to the specific time periods over which they want their cargoes to be priced.
[28] Tirole, *op. cit.*: 23.
[29] Mabro 1984: 56.
[30] Hirschman 1970.
[31] That is why, as Adelman says, any small, local discount has the potential of becoming a generalised discount (1995: 6).
[32] The companies whose formulae serve purely for indicative purposes can be identified by the large number of traders that they have as clients (it goes without saying that, if traders were not able to get discounted crude they would not be able to resell it at a profit).
[33] *PIW*, 13 October, 1986: 3.
[34] Tirole, *op. cit.*: 27.
[35] Aghion and Bolton 1987: 389.
[36] *Ibid.*
[37] Steven Salop, quoted in *ibid.*: 402.
[38] Posner 1976: 203. Aghion and Bolton recognise that it is entirely right and logical to think "that the buyer is better off when there is entry and that [therefore] he (she) will tend to reject exclusive dealing contracts that reduce the likelihood of entry unless the seller compensates him (her) by offering and advantageous deal" (*op. cit.*: 393).
[39] *WPA*, 1 February 1999: 3. Preceding quotations come from this article.
[40] *Ibid.*
[41] *Ibid.*
[42] *Ibid.*
[43] *Ibid.*

[44] Kay 1993: 275.
[45] Akerlof 1983: 56.
[46] Tadelis 1999: 559.
[47] Tirole, *op. cit.*: 330.
[48] *Ibid.:* 332.
[49] Kreps and Wilson 1982a.
[50] As the head of an independent European refiner put it to *PIW* in the midst of the netback crisis: "my board of directors wants a sure refining margin and is willing to forgo the possibility of the bigger profits aggressive trading might bring" (*PIWK* 1986: 3).
[51] Mabro 1987: 41.
[52] Mabro (1987: 43) says that "netback contracts are no different from other commercial relationships: they come unstuck as soon as one party shopping around for better terms decides to go elsewhere". This is undoubtedly true, but the incentive for buyers to shop around *in the first place* is greater when there are large volumes of crude being sold on a netback basis.
[53] However, according to Kreps and Wilson (1982a: 884), "the formulation in terms of players' beliefs gives the analyst a tool for choosing *among* sequential equilibria. In some cases one can predict that one equilibrium among several will prevail because only the beliefs that sustain the one are intuitively possible". Our assertions are predicated on assumed beliefs of oil market actors that make a lot of intuitive sense (in this case, we assume that refiners believe that their competitors will always attempt to drive as hard a bargain as they themselves would).
[54] Kreps and Wilson 1982b: 276.
[55] Aghion and Bolton, *op. cit.*: 397.

6. THE BEHAVIOUR AND DETERMINATION OF PRICES

Realised prices are perhaps the ultimate indicator of the strength of the competitive position of companies and, therefore, of the soundness or weakness of their commercial strategies. Prices compress nearly all the information about a commodity, and are more visible than the quantities to which they correspond, so winners and losers in a given market can be quickly identified on the basis of the prices that they receive for their products. However, the synthetic character of prices means that their analysis cannot be used as a tool to diagnose the pathology of a particular commercial strategy or, indeed, to explain why one particular actor gained the upper hand in a market. This is the reason why the focus of the previous chapters has been on identifying non-price dimensions of the competition between PDVSA and PEMEX in the USGC market for heavy sour crude, on the one hand, and on advancing hypotheses that can account for the outcomes that this competition has produced, on the other. In particular, we have stressed that deep conversion refiners appear to prefer to obtain most of their baseload supplies from PEMEX rather than PDVSA, essentially because they perceive the former to be a better supply risk. In other words, we contend that PEMEX has apparently attracted to its orbit most of the intramarginal volumes in the market, while PDVSA has been cast in the role of supplier of the marginal barrels. Of course, if a division of the market along these lines had really taken place, this would necessarily be reflected in the realised prices obtained by both companies. Hence, we will now undertake a detailed analysis of price outcomes in the market, in order to prove that this hypothesis is, in fact, correct.

6.1 Price Outcomes of Competition in the USGC Duopoly for Heavy Sour Crude

The history of the market for heavy sour crude in the USGC after 1986 — as reflected in the relative price behaviour of individual Mexican and Venezuelan crude blends and the price of these countries' respective export baskets to the USA — is a record of the progressive deterioration in the long-term quality of PDVSA's fairly constant market share. The effects of PDVSA's commercial policy have eroded the bases of the company's commercial relationships and provoked a discernible and markedly negative effect on the prices that Venezuelan crudes are able to command in the

market during normal or slack years. These, in turn, have led to the appearance of a persistent differential between Mexican and Venezuelan prices that cannot be accounted for in quality terms.

The problematic commercial dynamics inherent in PDVSA's new post-1986 *modus operandi* became apparent to its customers only gradually, in a learning process replete with incident and mutual recrimination. The advantages of PEMEX's public pricing formulae also took some time to become manifest, not least because the introduction of this pricing mechanism was not an altogether smooth affair. Moreover, immediately after 1986, PDVSA's commercial expertise was still very much superior to the one that had been cultivated within PEMEX during the chaotic Díaz Serrano administration. The conjunction of these factors meant that, for some time, Venezuelan heavy sour crudes continued to command prices in line with their quality (and on occasion, even premium prices).

As the 1980s drew to a close, however, PEMEX succeeded in moving up the learning curve and closing the expertise gap that had made PDVSA a more effective force in international marketing. In addition, after the Iraqi invasion of Kuwait, the Venezuelan company began to expand both its output and exports of heavy sour crudes in a significant manner. This increase in volume terms both highlighted and magnified the contradictions of the company's commercial policy, with the result that its position at the high value end of the market for heavy sour crude was severely compromised. Thanks to the near-parallel growth in heavy crude exports from Mexico and Venezuela, dissatisfied PDVSA customers were able to meet their appetite for foreign heavy sour crude by increasing their Maya term commitments while using the "dependable access that buyers ... had to Venezuelan spot cargoes" to restrict their term exposure to Venezuelan volumes.[1]

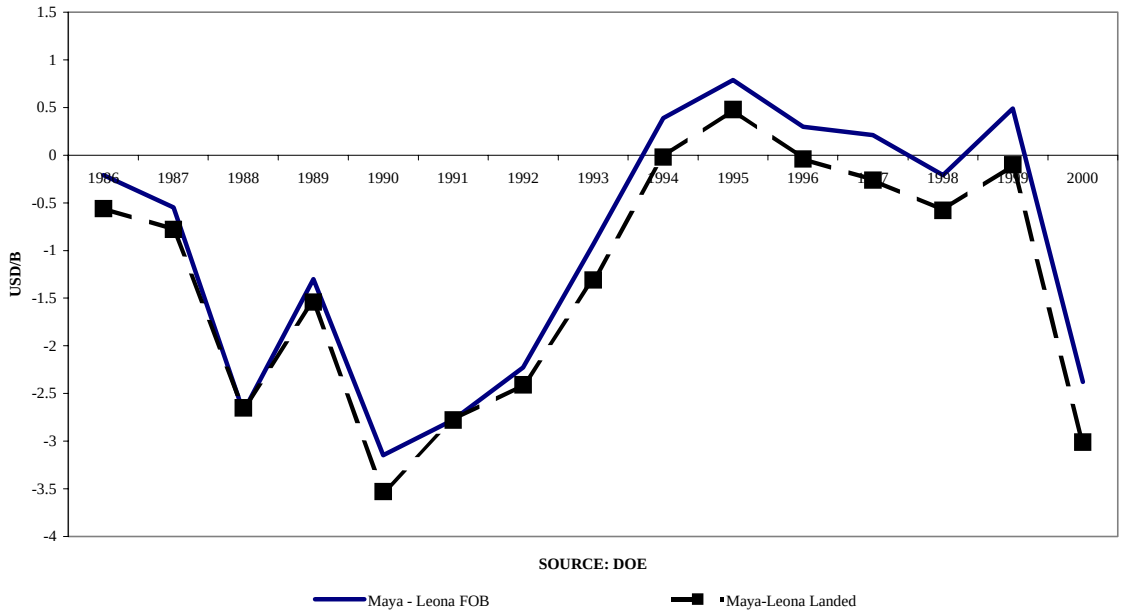
PDVSA was not pleased with this situation and, from time to time, it tried to tighten the screws and "push buyers back towards term purchases".[2] Its efforts in this direction proved of little avail, largely because the company's stated objective to make customers compete for supplies in tight markets meant that these same customers expected Venezuelan barrels to compete against all comers in slack markets. The full extent and implications of the adversarial stance assumed by

PDVSA's customers can best be gauged by recounting the way in which they forced the company not only to compete against all comers but also against itself. Between 1992 and 1994, *PIW* reported on a number of occasions that buyers of Venezuelan spot cargoes found that its "three operating divisions ... [were] so aggressive in their independent marketing that they sometimes undercut each other on the sale of the same spot cargo" because, even though "each division [was] technically in charge of selling its own allotments, [in practice] they [placed] each others' supplies from time to time"[3] and often tried to "lure customers [away] from the others".[4] Unsurprisingly, many refiners (especially the larger ones) ended up by becoming "proficient at lowering acquisition costs by negotiating the same spot cargo with all three [PDVSA] units".[5] Those refiners who lacked the leverage to do so, largely because of their small size or unfavourable financial situation, were the ones who ended up by signing term contracts with PDVSA. Thus, and in consonance with the other adverse selection traits of its commercial policy, the Venezuelan company tended to attract to its contractual orbit customers characterised by a lower credit-worthiness, by less complex and technologically advanced refining installations, and, in general, by a lower long-term viability. By the same token, PDVSA's dealings with its larger unaffiliated customers revolved around the tacit threat by the latter to take their custom elsewhere on any given month whenever Venezuelan barrels stopped being the most attractive alternative in the market, day in and day out.

PDVSA's relegation to the status of supplier of choice for marginal heavy sour crude barrels to deep conversion refiners in the USGC has naturally had an impact on Venezuelan crude prices, which is readily apparent in Figure F6.1. This figure plots the evolution of the Maya-Leona differential since 1986.[6] It shows that, starting in 1990, this differential tightened inexorably, to the extent that in recent years the Mexican crude has consistently traded at a premium over the Venezuelan crude on an FOB basis, in spite of the much higher quality of the latter.[7] Figure F6.2 offers an even better illustration of the progressive deterioration of the quality of PDVSA's market share. The landed price of Leona relative to the landed price of all US imports in its gravity range (20.1°-25° API) plummeted after the Gulf war, and only recovered in 2000, a year when the penalty for sulphur content in crude reached extraordinary levels. In contrast, the price differential of Maya relative to this basket of imports has stayed within a relatively narrow price band determined by its quality. More or less

the same thing can be said for Canadian crudes (these crudes display a slightly more erratic behaviour than that of Maya, but this can be ascribed to their being both landlocked and subject to pipeline constraints). Indeed, the contrast between the relatively stable behaviour of the price of pipeline Canadian crudes and Leona's spectacular falls and rises in value appears to underscore the point that some peculiar dynamics seriously affect the position of Venezuelan crudes (and Venezuelan crudes only) in the heavy sour market.

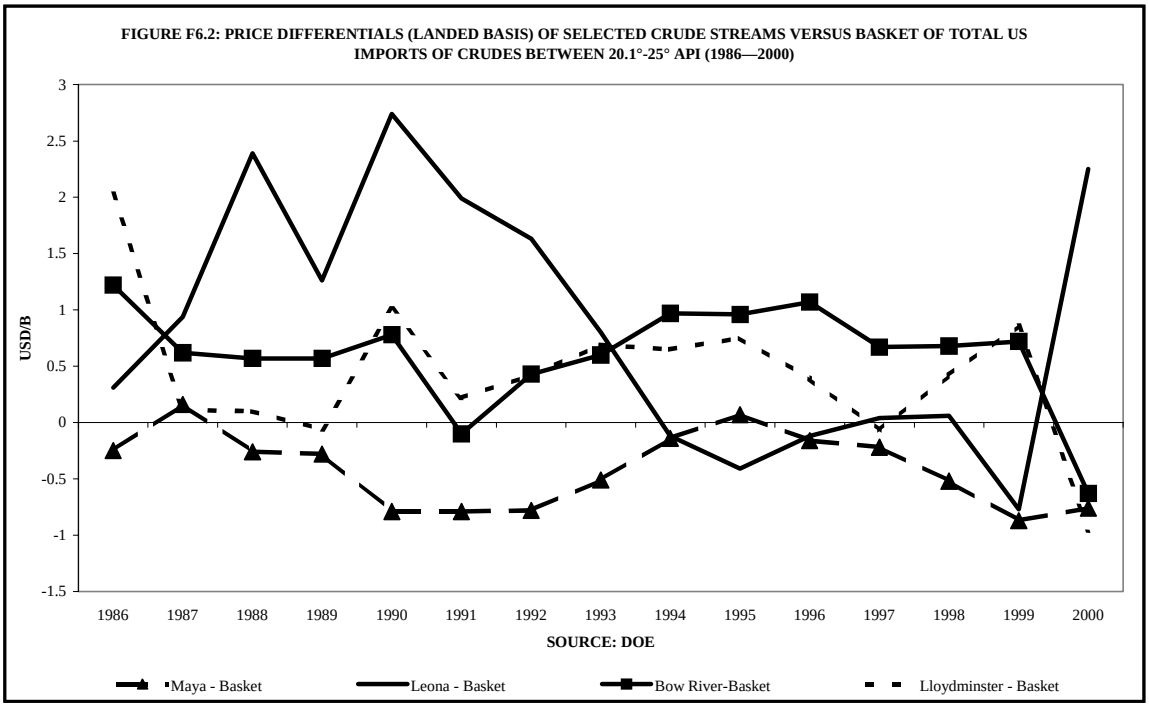
FIGURE F6.1: PRICE DIFFERENTIALS BETWEEN SELECTED CRUDE STREAMS IMPORTED INTO THE USA (1986—2000)



On the whole, the price of Leona and other Venezuelan heavy sour crudes sold to third parties relative to that of Maya benefits significantly from any generalised tightening in the oil market. These tight market spells are taken by PDVSA as a chance to claw back foregone pennies (or even dollars). However, even under the favourable circumstances of 1996—7, PDVSA was unable to demand premia for Leona cargoes on a consistent basis. In 2000, however, the company was far more successful in this endeavour. Firstly, spare production capacity within OPEC countries descended to levels not recorded since the First Oil Shock, and this prompted the temporary appearance of a sellers' market in oil, the likes of which had not been seen for a decade. Secondly, gasoline shortages in the Midcontinent region

forced the premium attached to crudes with low sulphur contents to very high levels. Nevertheless, the considerable strengthening of Venezuelan prices during tight market spells does not translate into a consolidation of its long-term competitive position in the USGC market for heavy sour crude. The comparative complexity and average volume figures discussed beforehand suggest that, during such spells, most of the deep conversion refiners in the USGC continue to find the signalling devices embedded in PEMEX's term contracts sufficiently attractive and convincing to make PEMEX their supplier of choice for the majority of the base load requirements of their plants. In contrast, the aggressive pricing of the Venezuelan NOC means that, in very bullish markets, PDVSA's regular clients are even more reluctant than normal to let Venezuelan crudes form a large part of their base loads. However, under these market conditions, the Venezuelan NOC is able to extract appreciable premia from those refiners who either buy from it only on occasion or from regular customers who have an urgent need for additional volume. In doing so, however, PDVSA only increases the imponderable supply costs faced by refiners without a Mexican term contract and, hence, the company also increases the value that its customers (or potential customers) give to a contractual relationship with PEMEX. The effect that this has had on Venezuelan prices over the long term has been far from beneficial.

FIGURE F6.2: PRICE DIFFERENTIALS (LANDED BASIS) OF SELECTED CRUDE STREAMS VERSUS BASKET OF TOTAL US IMPORTS OF CRUDES BETWEEN 20.1°-25° API (1986—2000)

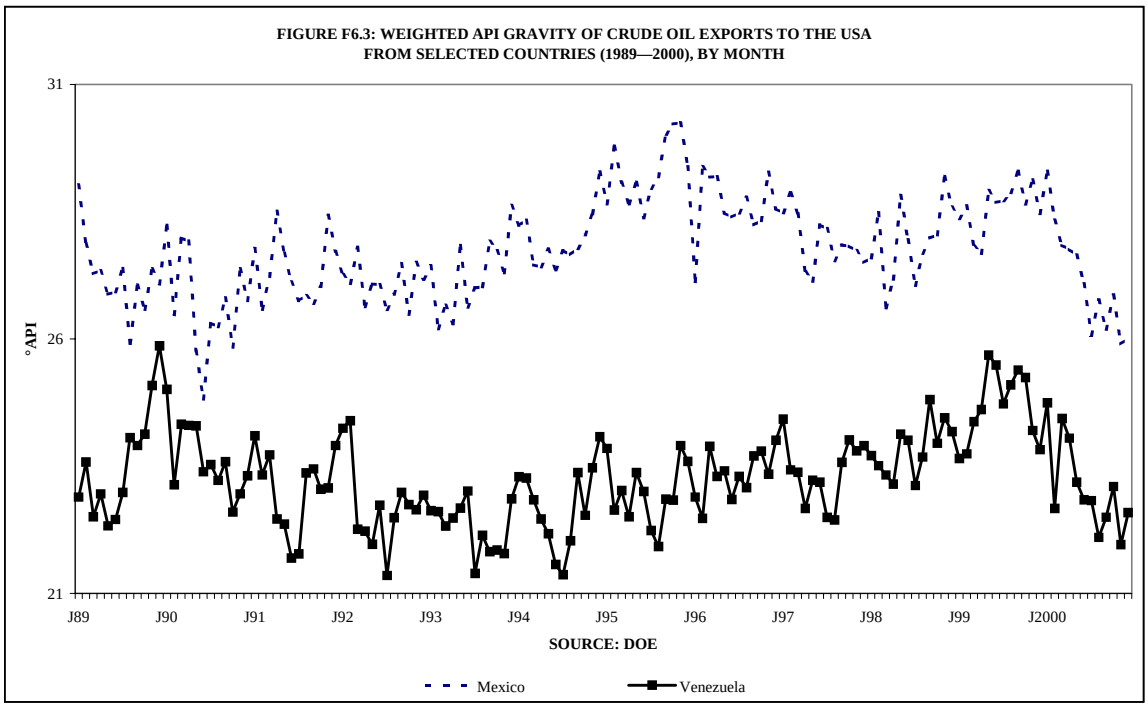


6.2 A Statistical Analysis of the Price of Heavy Sour Crude in the USGC

The analysis of Mexican and Venezuelan realised prices presented so far fully supports the supposition that PEMEX has a stronger competitive position in the USGC market than PDVSA. However, the differences in quality between Mexican and Venezuelan crudes, as well as the volatility of the price that the market puts on some of these quality parameters (particularly sulphur content), make it difficult to gauge exactly how much stronger the Mexican position is solely on the basis of graphic differential analysis. Take, for instance, the significant appreciation that Leona crude underwent in 2000. Did its price go up by as much as it should have, given the significant penalty that the market attached to high sulphur content in that year? This type of question can be tackled by subjecting the prices that PEMEX and PDVSA have charged their customers in the USA (as reported by the DOE) to statistical time series analysis. In the light of the thrust of the hypothesis that underlies the whole of this study – the strength (or lack thereof) of the respective competitive positions of PDVSA and PEMEX, as expressed in their realised prices, derives from the very different transaction costs that US refiners have to face when dealing with one or the other – we have to undertake this type of analysis if we are to quantify the effects of these transaction costs, rather than just deducing their existence *a priori*. Such quantification is desirable because, as Stanley Fischer has pointed out, "transaction costs have a well-deserved bad name as a theoretical device ... [partly] because there is a suspicion that almost anything can be rationalized by invoking suitably specified transaction costs".[8]

Through the EIA, the DOE publishes the monthly weighted average FOB and delivered prices of all the crude oil imported from both Mexico and Venezuela. These DOE series provide the only reliable and continuous information on realised Venezuelan crude prices (to any region of the world) that can be found in the public domain. The series include the prices of cargoes of light, medium and heavy Mexican and Venezuelan imports to the USA, so their suitability for modelling the behaviour of the heavy sour crude oil market might be open to question. However, carrying out this analysis on the basis of these series is justifiable from a physical point of view: the proportion of heavy sour crude oil exports to total US exports for both of these countries is sufficiently high (upwards of 60 per cent) for their respective export

baskets not to be considered anything other than low in quality (see Figures F6.3 and F6.4). The Mexican export basket comes in a bit on the light side at an average of 27.92°API for the period under consideration (around the gravity of Arab Heavy), but it compensates for this fact by its very high sulphur content (2.44 per cent). The Venezuelan export basket, on the other hand, is rather heavier (23.22°API) but it also has significantly less sulphur (1.72 per cent). Therefore, the prices of these baskets can serve as adequate proxies for the prices of Mexican and Venezuelan heavy sour crudes (for the sake of consistency, and in order to compare like with like, it is advisable to use the DOE series for all Mexican imports as well).



As can be seen in Figures F6.5 and F6.6, the evolution of the relative prices of both baskets baskets from the moment when both countries officially abandoned GSPs in 1986 can be divided into two main periods: the first one lasts until April 1992, while the second one goes from May 1992 to 2000. During the former period, the price of the Mexican export basket is generally higher, but there are a few episodes when the Venezuelan crude basket commands a higher price than the Mexican. During the latter period, in contrast, the prices of the Venezuelan export basket to the US have been consistently lower than those of the Mexican export basket with the exception of

two months during 2000. We shall now show, on the basis a statistical model that compensates for quality differentials between both baskets, that this price differential reflects the higher quality of PEMEX's portfolio of arm's-length clients.

FIGURE F6.4: WEIGHTED SULPHUR CONTENT OF CRUDE OIL EXPORTS TO THE USA FROM SELECTED COUNTRIES (1989—2000), BY MONTH

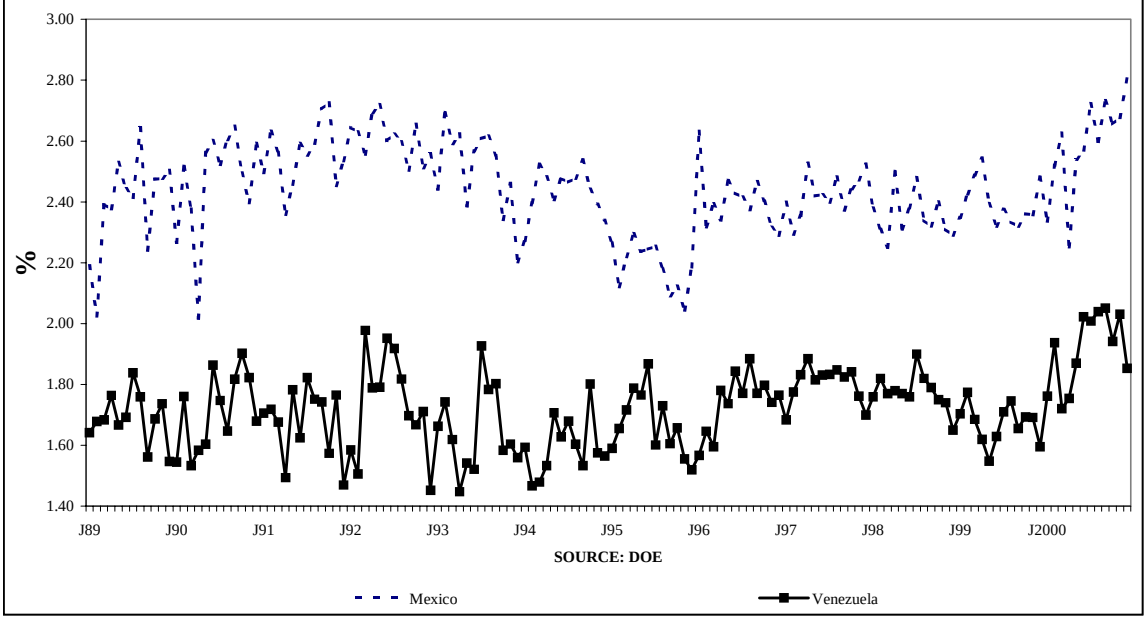


FIGURE F6.5: COMPARISON OF WEIGHTED FOB PRICES OF CRUDE EXPORTS FROM SELECTED COUNTRIES TO THE USA (1975—2000)

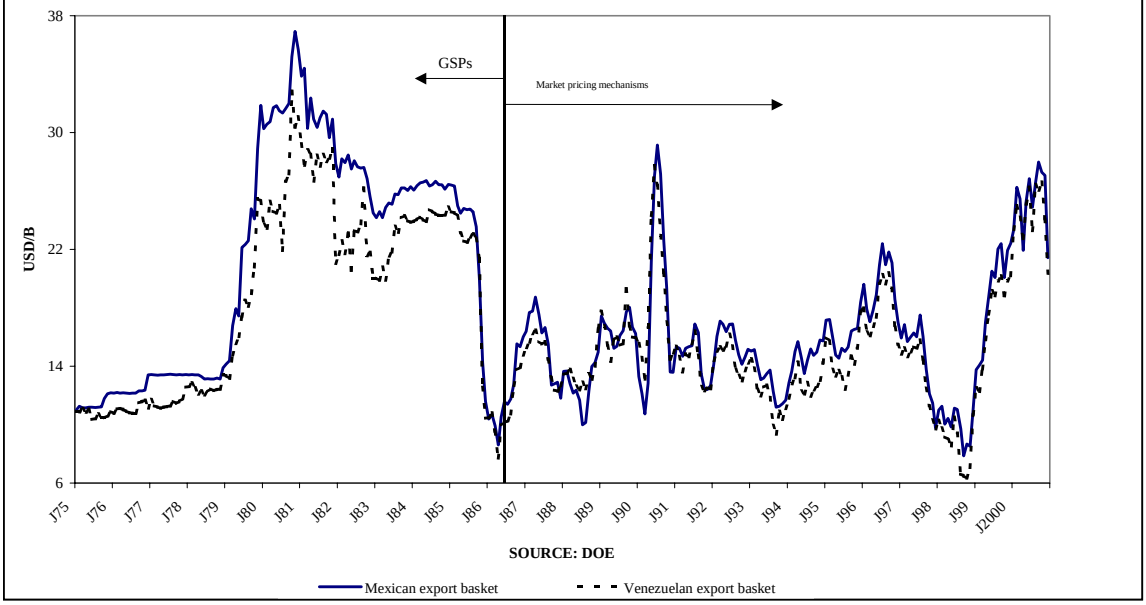
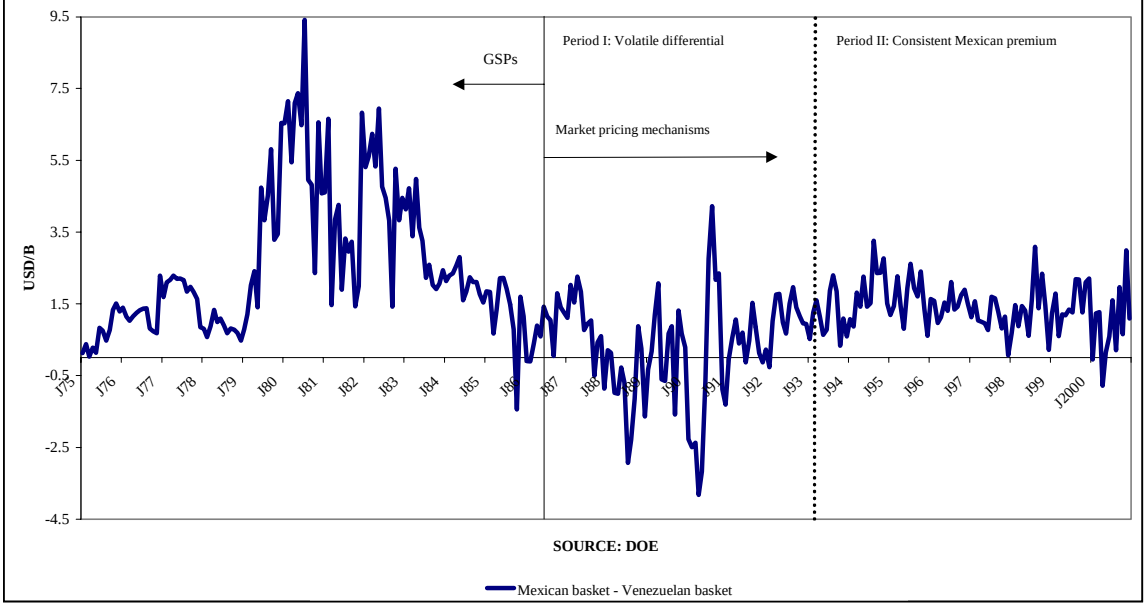


FIGURE F6.6: FOB PRICE DIFFERENTIALS BETWEEN CRUDE EXPORTS FROM MEXICO AND VENEZUELA TO THE USA (1975—2000)



SOURCE: DOE

The main idea behind the statistical crude quality model is to express the price of any given crude in the USGC in terms of the price of a sour crude marker for the region (WTS), plus or minus an adjustment in this price calculated on the basis of quality and transportation cost differentials. In a nutshell, the model assumes that price differentials between crude streams are solely attributable to interaction between these factors, and not to the relative abundance or scarcity of a particular crude stream. There is a certain loss in the informational value of the model because of this simplifying assumption, but it is small. In any case, the model is not divorced from demand and supply considerations, because the price of the reference crude (WTS), which is the anchor of the whole model, reflects not only the overall price trend of the international oil market at large, but also the relative value of sulphur in the crude oil balance in the USGC. Both in its overall conception and in its ultimate purpose and application, then, the model is similar to so-called hedonic price indices, which adjust for quality differences as measured by the observed physical characteristics of goods, and which can be used to ascertain whether there are systematic price differences across national markets, for instance.[9]

This statistical method of accounting for quality differentials was chosen in preference to the widely used — and better known — method of deriving equilibrium prices for

crudes on the basis of their netback margin differentials relative to a reference crude in a representative refining configuration at a certain location, because the latter method would have posed insurmountable informational obstacles. Firstly, it would have been necessary to obtain detailed crude oil assays for all the Venezuelan export blends, in order to determine both GPW and equilibrium price for each one of them. Secondly, on the basis of the DOE import statistics, one would have had to ascertain the exact volume of each blend imported into the USA. Finally, in order to compare the equilibrium prices with the DOE price series — which would still have been the only available open market price reference for Venezuela — one would have had to construct an equilibrium price for the Venezuelan export basket as a whole, by weighing the equilibrium price of each export blend by its share in total imports.

The quality adjustment model presented here was constructed using the Dynamic Linear Model Theory, as formulated by Harrison and West,[10] as its cornerstone. The statistical analysis of the behaviour of price series clearly had to be dynamic, in order to reflect the ebb and flow of differentials (analysing the time series used in the exercise within a static framework would have been tantamount to assuming that the relationships between the different variables remain constant through time). Moreover, given the dynamic nature of the analysis, there was an additional advantage in expressing it in Bayesian terms, thus incorporating the capability of economic actors to observe the outcomes of their actions, on the one hand, and to update their beliefs in a probabilistic fashion, on the other. However, non-Bayesian statisticians might have misgivings about the setting of actors' a priori beliefs in an apparently arbitrary and subjective fashion. Hence, the a priori value of the parameters underlying the model were set on the basis of results derived from a classical — in the statistical sense — time series model (see Appendix IIII).

The crudes used for purposes of estimation of the parameters in this classical model were waterborne medium sour crudes imported into the USGC region, whose pricing is seen as being both reasonably transparent and consistent. These crudes are: Maya, Isthmus, Vasconia, Caño Limón, Arab Heavy and Arab Medium. Venezuelan official posted prices were excluded from the estimation process, because they are not good indicators of the levels at which deals are actually being done. The most important result generated by the classical model was that the price of a crude in the USGC is

more severely penalised when such a crude has a high sulphur content relative to some other crude and the API gravities of both are similar, than when it has a lower API gravity and the sulphur contents of both crudes are similar. The USGC market, in other words, has increasingly become a market for *sulphur*.

The results shown in Table T6.1 were obtained when the prices of both baskets were evaluated using the dynamic linear quality adjustment model. As can be appreciated, Venezuelan observed prices are significantly lower than estimated prices. The regression parameters that generate this result, moreover, do not generate similar anomalies when applied to the price series of a control group of crudes, constituted by key crude streams competing in the US market (Mexican, Nigerian, Colombian, Saudi, North Sea, even US domestic grades).

Table T6.1: Observed and Estimated Prices for Crude Oil Exports to the USA (1992—2000)

	Estimated price - observed price (USD/B)	
Year	*PEMEX*	*PDVSA*
1992	0.44	1.79
1993	0.09	1.55
1994	0.06	1.78
1995	-0.06	1.58
1996	-0.04	1.38
1997	-0.03	1.30
1998	-0.05	1.14
1999	0.03	0.84
2000	-0.07	-0.40
AVERAGE	**0.04**	**1.22**

SOURCE: DOE price data

The model indicates that the price differential between both baskets over this period should have been around 0.13 USD/B, whereas in reality the differential was a much higher 1.32 USD/B. In other words, on average and relative to the Mexican export basket, the Venezuelan basket to the USA was sold on a delivered basis with a far greater discount (nearly 1.20 USD/B) than would have been necessary in order to reflect adequately the differences in the quality of both crude baskets. The figures in

Appendix IV plot the dynamic behaviour of the influence of the international price of crude, API gravity, sulphur content and transportation costs on the price of both baskets. The price of the Venezuelan basket is more adversely affected by sulphur content and transportation costs than the Mexican basket. In other words, an increase in sulphur content or in transportation costs translates into a greater discount on the FOB price if the crude is Venezuelan than if it is Mexican. By the same token, any decrease in API gravity translates into a greater discount if the crude is Venezuelan than if it is Mexican. Finally, the price of Venezuelan crude increases less than the price of Mexican crude when the price of WTS increases (and vice versa). The quality differences between the Mexican and Venezuelan baskets are not restricted to API, sulphur and transportation costs, but even if one makes generous allowances for the more adverse characteristics of Venezuelan crudes in terms of metals content and acidity, it is clear that the Venezuelan basket has been underpriced by a very considerable margin.

The results of the model also confirm that PDVSA is serious in its stated intention to make its customers pay the maximum price that the market will bear,[11] while highlighting this as the reason why the Venezuelan NOC has been cast in the role of residual supplier by its wary customers. This comes across well in Figure F6.7, which plots the relationship between observed prices for the Venezuelan export basket to the USA and the estimated equilibrium prices for the basket derived from the quality adjustment model. Venezuelan observed prices exhibit a tendency to exceed the equilibrium prices whenever the market begins to give off symptoms of tightness. Unfortunately, in times of market weakness, customers reward this mercenary behaviour through an immediate widening in the differential between observed and estimated prices, in favour of the latter. One could think that this may be symptomatic of the very significant growth that Venezuelan exports have experienced over the 1990s. However, Figure F6.8 (which plots the same variables for the Mexican export basket) disproves that hypothesis. Mexican exports to the US have also increased considerably over the 1992—2000 period, but this has not affected the relationship between the observed and estimated prices for the Mexican export basket. This is not unrelated to the fact that Mexican observed prices track estimated prices closely even during bull market spells.

FIGURE F6.7: OBSERVED AND ESTIMATED PRICES FOR THE VENEZUELAN CRUDE EXPORT BASKET TO THE USA, (1992—2000)

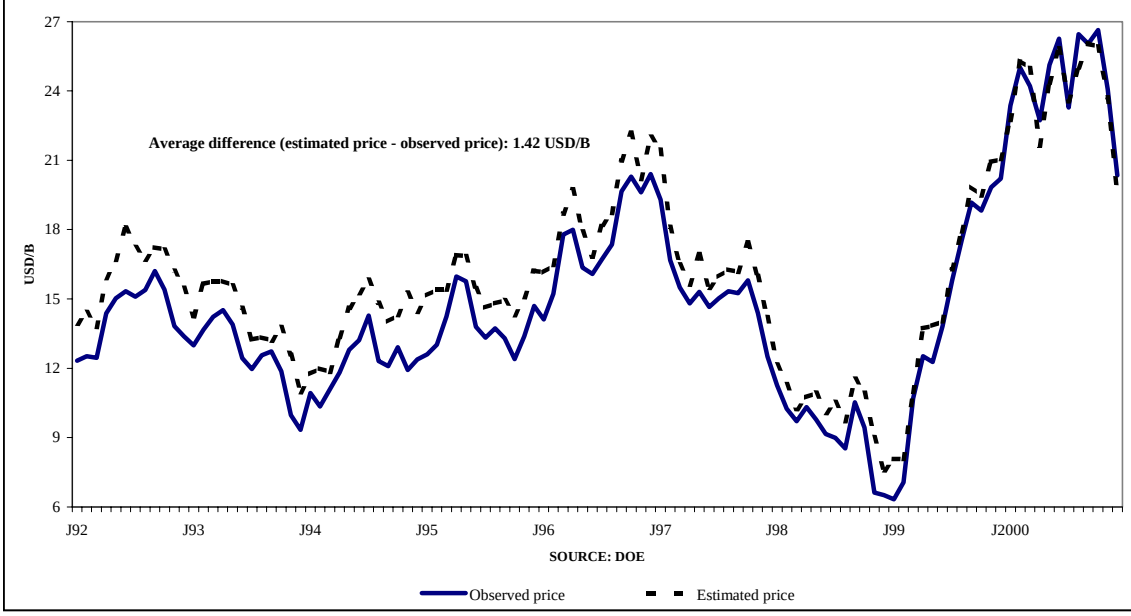
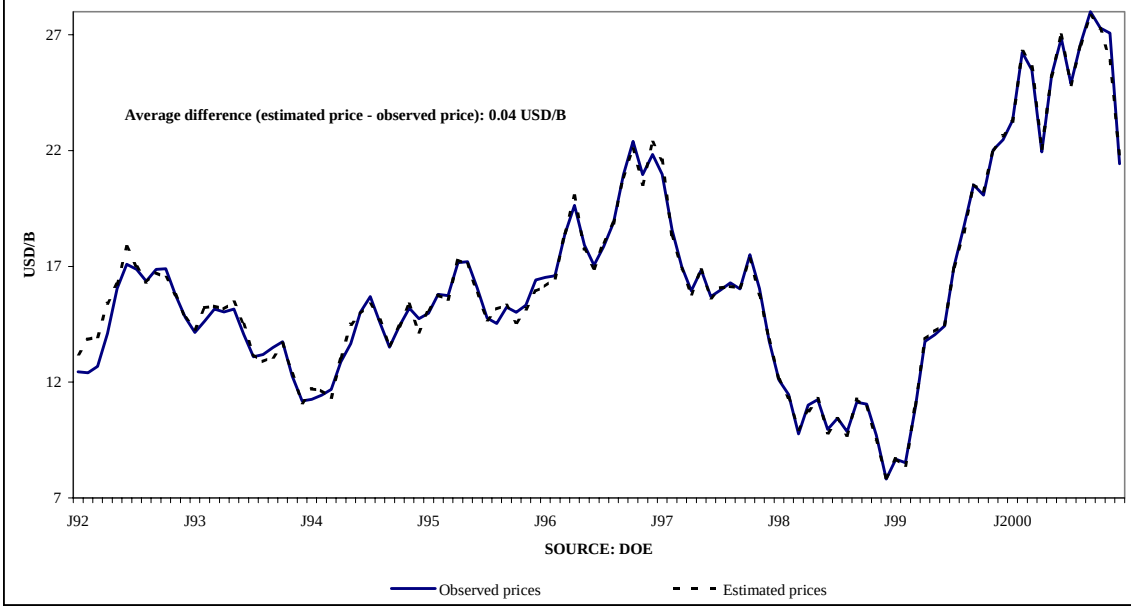


FIGURE F6.8: OBSERVED AND ESTIMATED PRICES FOR THE MEXICAN CRUDE EXPORT BASKET TO THE USA (1992—2000)



The results obtained from the statistical analysis of the DOE price series are quite problematic. After all, it would be logical to expect enduring discounts such as these to entice customers away from PEMEX, thus forcing it to lower its own prices and at the same time pushing PDVSA's prices upwards at a point where both would tend to converge. In other words, the pursuit of self-interest by these companies' clients

should, in principle, ensure that these discounts are competed away, mainly because PEMEX's customers might be expected to refuse to buy its crude if its prices are not in line with those of its main competitor. Indeed, the competitive structure of the USGC market for heavy sour crude begs one crucial question: why would any customer — let alone a large number of them — choose to remain loyal to a supplier who is known to charge consistently higher prices than his competitor, when changing suppliers is a course of action that promises generating savings that would exceed generously any switching costs arising from this change? "In such situations", Mabro explains, "the economic theorist always expects prices to equalise. But oil prices seem to remain stubbornly unequalised. To express surprise at this lack of homogeneity does not necessarily reflect a naive belief in theoretical truths, but rather a desire to seek an explanation".[12]

6.3 Effects of Vertical Integration on Venezuelan Crude Oil Prices

The search for an explanation for these apparent discounts leads, in the first instance, to PDVSA's internationalisation programme and the influence that its very large sales of crude to affiliated refining subsidiaries in the USA might have on the average Venezuelan export prices to this market. PVDSA's transfer prices to its affiliates are determined either through individually tailored netback formulae[13] or (in the case of its more recent downstream acquisitions), through slightly less onerous "formula[e] indexed to the [delivered] market price of Maya crude oil ... adjusted for quality and commercial factors and less a fixed competitive allowance".[14] These transfer prices do not reflect the true refining value of Venezuelan crudes, and incorporate large discounts unwarranted by quality considerations. Although the company's supply contracts with affiliates are not in the public domain (for obvious reasons of commercial confidentiality), there is plenty of evidence available to verify this assertion indirectly. For instance, before 1997 (when PDVSA acquired the 50 per cent of Uno-Ven that it did not already own, and incorporated the accounts of this affiliate into its consolidated balance sheet), PDV America's 10-K form reported some very interesting figures for Uno-Ven's (now called PDV Midwest) crude acquisition costs. As Table T6.2 shows, the prices at which PDVSA transferred crude to this affiliate during the period 1993—6 were appreciably lower than the prices it charged to all its US clients (including its other affiliates), notwithstanding the fact

that Uno-Ven's crude supplies were markedly superior in quality. Likewise, Citgo's 2000 10-K laconically stated that, in order to comply with Venezuela's OPEC commitments, PDVSA had exercised the *force majeure* clauses included in its supply contracts, and that "the exercise of these clauses require[d] that the Company [Citgo] locate alternative sources of supply for its crude oil requirements, and such action resulted in ... crude oil costs ... for the year ended December 31, 1999 ... [that were higher by] $55 million from what would have otherwise been the case".[15] Dividing this sum by the contractual volume affected by the *force majeure* (19.71 MMB) shows that the market prices that Citgo had to pay exceeded the price of transferred barrels by a handsome 2.79 USD/B (Table T6.3).[16] Finally, on a more anecdotal plane, PDVSA itself has given ample indication of the magnitude of the discounts implicit in its transfer prices. For instance, in the days following the filing of a petition for the imposition of anti-dumping tariffs on crude oil imports from Iraq, Mexico, Saudi Arabia and Venezuela by a group of small US oil producers, some PDVSA officials publicly declared that being found guilty of dumping could give PDVSA a welcome opportunity to get rid of the more onerous netback clauses in its long-term supply contracts.[17] More recently, PDVSA has allegedly been trying to renegotiate the netback formulae of some of these contracts with its joint-venture partners, in order to reduce discounts that are said to run as high as 4—5 USD/B for some crude streams.[18]

TABLE T6.2: PDVSA. Delivered Crude Prices and Qualities to the USA, by Type of Client (1994-6)

	Prices (USD/B)		*Quality*			
			Uno-Ven Lemont		All Other US Clients*	
			°API	Sulphur	°API	Sulphur
	Uno-Ven Lemont	All Other US Clients*				
1994	11.66	13.12	28.68	1.40	22.72	1.60
1995	13.88	14.84	28.68	13.80	22.98	1.67
1996	18.47	18.54	29.69	1.33	23.39	1.75

* Includes all other PDVSA affiliates in the USA

Sources: PSA, DOE, PDV América 1993

Clearly, PDVSA's transfer price structure goes a long way towards explaining the anomalous relationship between Mexican and Venezuelan prices. Given the magnitude of the volumes it sells to affiliates, the discounts implicit in PDVSA's netback formulae are large enough to depress the average price of the Venezuelan

export basket to the USA by a significant margin. Moreover, this difference in prices has a structural nature (i.e. it is resistant to arbitrage), because the only way in which a refiner can get access to these discounts is by establishing some sort of formal association with PDVSA.

TABLE T6.3: Citgo. Unit Value of PDVSA Supply Contract, Derived from 1999 Declaration of Force Majeure

Refinery	*Contractual volume (MBD)*	*Volume Affected by Force Majeure (MMB)*	*Additional Supply Costs (MMUSD)*
Lake Charles	120	8.36	17.0
Corpus Christi	130	9.09	18.4
Paulsboro	30	1.79	3.6
Savannah	12	0.47	1.0
			0.0
TOTAL	**292**	**19.71**	**55**

Average Implicit Discount = 2.79 USD/B

Note: Lyondell-Citgo Refining Company not included because compensation mechanism is in operation

SOURCE: Citgo 10-K, 2000

There are those who would explain such behaviour by pointing out that, "for national oil companies ... in major producing nations, the issues of size and integration go beyond economics and include national security" and, therefore, "these cases may be appropriately exempt from the strictly financial evaluation applied to private oil companies".[19] Such a line of thought, if taken at face value, would justify even irrational vertical integration strategies. However, not one of the analysts who hold this view has seriously suggested that considerations of profitability be completely ignored when evaluating such strategies, "lest integration in the name of national security simply becomes an inefficient and expensive government subsidy",[20] as appears to be true in PDVSA's case. Furthermore, the soundness of the fundamental premiss behind the company's internationalisation programme (i.e. vertical integration equals security of outlet) appears shaky when one considers that PEMEX has not found it necessary to include either netback pricing clauses or so-called competitive allowances in its sole joint venture supply contract, even though its partner in this venture is Shell USA (a company whose size and financial solidity give it a vastly superior bargaining power to the one which PDVSA's partners enjoyed when they negotiated their respective deals). Indeed, the operations of the Mexican NOC prove that it is possible for a crude-long company to enjoy a reasonable degree of volumetric security for exports even if it is not highly integrated and does not

discount its cargoes. In marked contrast to PEMEX, PDVSA appears to have renounced the option of selling sizeable volumes of its crude at anything resembling true market prices and, in exchange, has only attained a shaky security of placement during bear market spells (while it is true that roughly half of Venezuela's crude exports have a secure home abroad, considerable uncertainty continues to plague the rest, to the extent that PDVSA has alleged that it was forced to acquire storage capacity in the Caribbean in order "to stop distant competitors from gaining quick access to US markets"[21]).

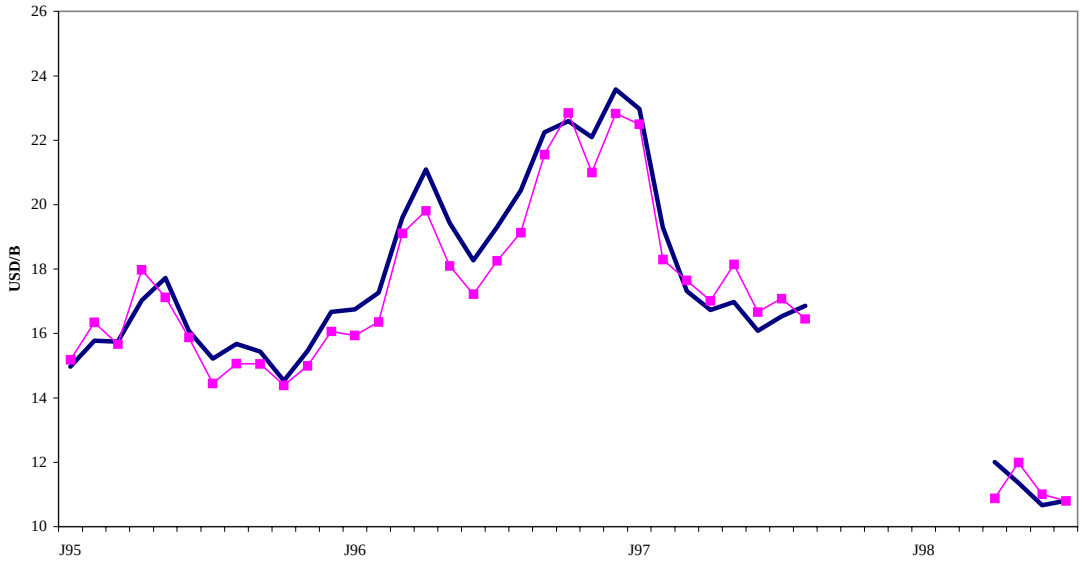
6.4 Distortions Affecting Venezuelan Arm's-length Prices

Distortions arising from PDVSA's transfer price system clearly account for the lion's share of the difference between realised Venezuelan prices and the prices estimated by the quality adjustment model. However, one can assume that the prices that PDVSA obtains from arm's-length transactions must also be distorted by the effects that the company's commercial policy induces in its customers. Quantifying these distortions is difficult, owing to the opacity of Venezuelan pricing, but they can nevertheless be highlighted through the statistical analysis of other DOE price series that are either less complete or somewhat less accurate indicators of Venezuelan prices than the ones used in the preceding section.

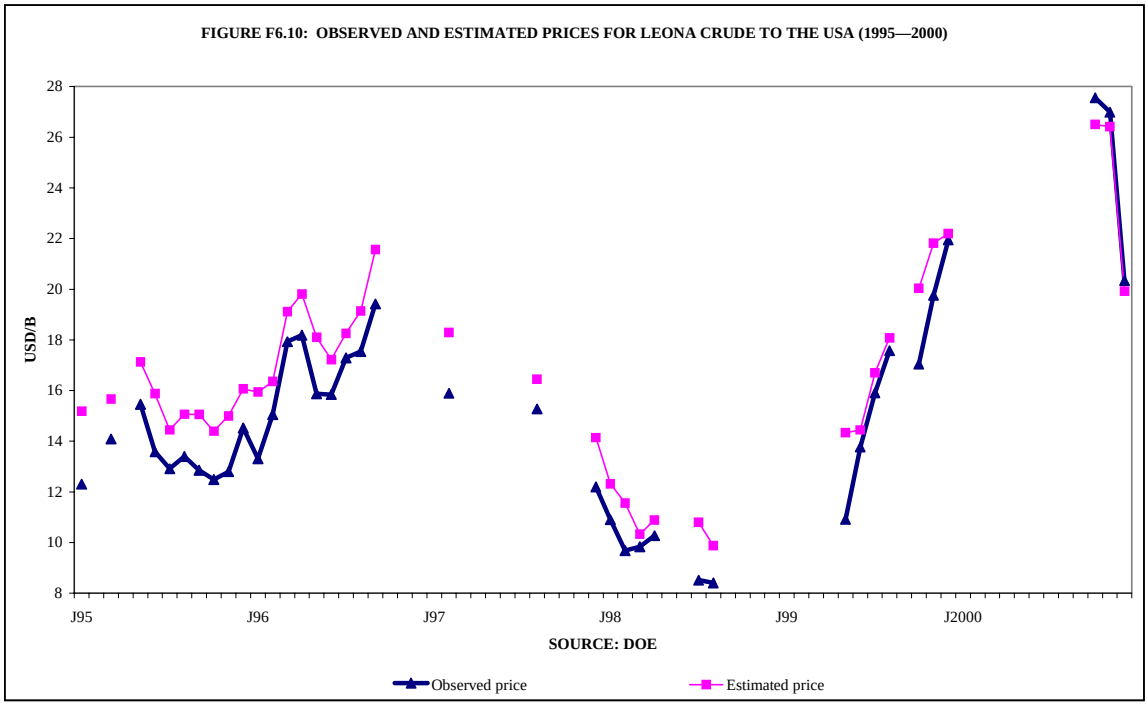
As was discussed above, PDVSA's pricing becomes quite aggressive when markets tighten, with the result that the gap between observed and estimated prices for Venezuelan crudes narrows considerably or even becomes inverted. The deemed tolling fees, competitive allowances and volume charges included in the company's transfer formulae, however, mean that the prices charged to affiliates are more stable than those charged to third parties. Thus, it follows that whenever the differential between PDVSA's estimated and observed prices begins to narrow, it is the company's unaffiliated customers who feel the full brunt of PDVSA's projection of market power. The prices of the light and medium crudes that PDVSA places in the open market are not negatively affected by this behaviour, thanks to their fungibility. The opposite seems to be true as far as the prices of Venezuelan heavy sour blends are concerned, however. This point can be best appreciated by comparing the average monthly prices for Furrial (28.5° API, 1.2% sulphur content) and Leona crudes in the

USA, which the DOE has published since 1995.[22] Even though these series are rather patchy, their analytical usefulness is at least not compromised by the effects of inter-affiliate transfers because large volumes of both are — or were, until recently[23] — sold to arm's-length customers (the DOE will publish prices only if at least three different buyers — including affiliates — have bought cargoes during a given period). Figure F6.9 shows that Furrial volumes sent to the USA during the period 1995—8 realised a small premium of 0.38 USD/B (on the whole, the observed prices for Furrial tend to coincide with estimated prices even during 1998, a time of exceptional market weakness). In contrast, the observed prices of Leona were inferior to estimated prices by 1.49 USD/B on average and, as Figure F6.10 shows, the differential between these series narrowed considerably in times of rising prices but ballooned during bearish spells. The same sort of trend is detectable in the evolution of the weighted price for all US crude imports with an API gravity of 20° or less (Figure F6.11). This series is an excellent proxy for the prices of some of PDVSA's heavier blends, since Venezuela supplied, on average, 88 per cent of US imports of such crudes in the period 1992—2000.[24] Estimated prices for this series over this period exceeded realised prices by 1.51 USD/B on average.

FIGURE F6.9: OBSERVED AND ESTIMATED PRICES FOR FURRIAL CRUDE TO THE USA (1995—98)



SOURCE: DOE



The story repeats itself in Figure F6.12, which plots the evolution of the weighted price of US crude imports with gravity between 20.1-25° API once the volume and price contributions made to the series by Mexican and Canadian crudes have been subtracted. Venezuelan crudes accounted for 74 per cent of the composition of this residual basket in the period 1992—2000[25], and the estimated prices for this basket exceeded realised prices by an average of 1.40 USD/B over this period. Interestingly, the observed prices of the US import basket for crudes with an API gravity of 20° or less follow the prices estimated by the model more closely than those of the reconstructed Venezuelan basket for crudes between 20.1-25° API, particularly in times of falling prices. This is a logical result, because asphalt refineries account for a significant proportion of the crudes under 20° API gravity imported into the USA. On average, these refineries belong to companies that are small in comparison to those that own deep conversion refiners, and their financial clout and degree of market power is therefore much smaller as well. Thus, when the market slackens, the lifters of Venezuelan asphaltic grades are in a weaker position to retaliate against PDVSA than deep conversion refineries, which absorb the bulk of US imports of Venezuelan crudes with a gravity of 20.1°-25° API.

FIGURE F6.11: OBSERVED AND ESTIMATED PRICES FOR US CRUDE IMPORTS WITH AN API GRAVITY OF 20° OR LESS (1992—2000)

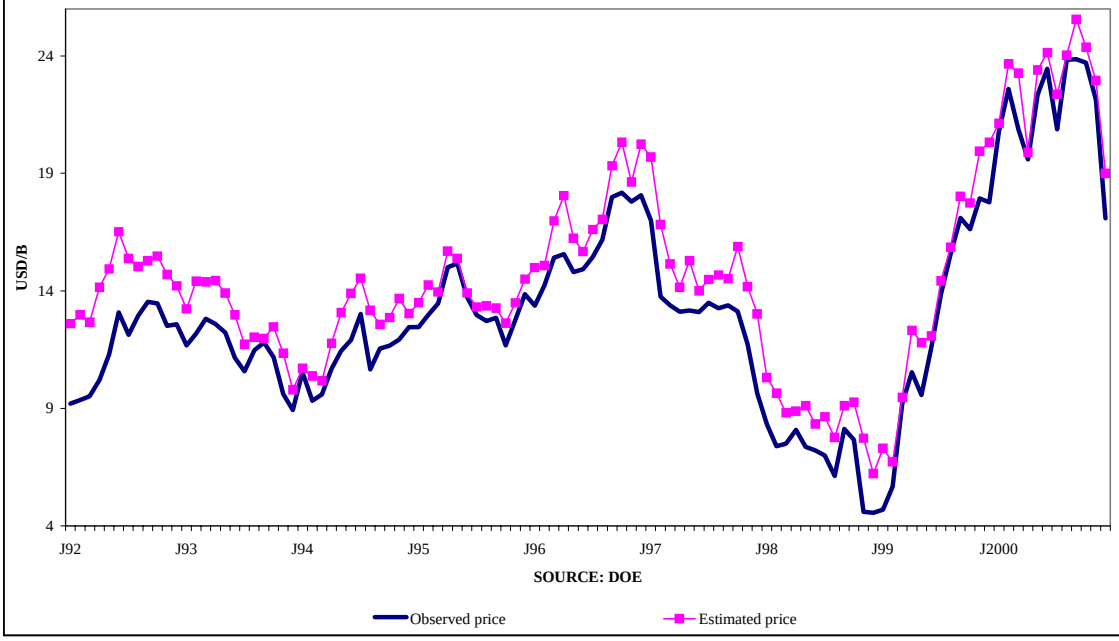
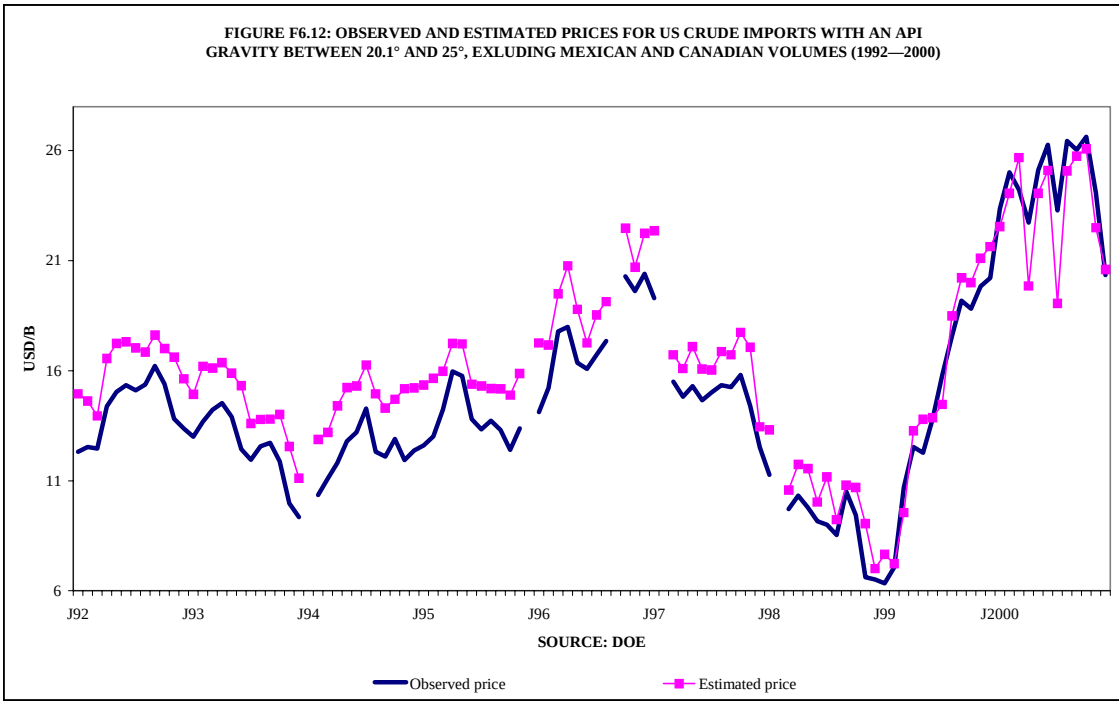


FIGURE F6.12: OBSERVED AND ESTIMATED PRICES FOR US CRUDE IMPORTS WITH AN API GRAVITY BETWEEN 20.1° AND 25°, EXLUDING MEXICAN AND CANADIAN VOLUMES (1992—2000)



The inference to be drawn from these results is that PDVSA's sales of heavy sour crudes to arm's-length customers also take place at price levels that do not reflect fully the quality of these crudes, albeit less markedly so than in the case of its transfers to affiliates. Given the almost perfect duopolistic setup of the USGC market for heavy sour crude, and the zero-sum character that competitive interaction between the

duopolists has assumed over time, we can attribute this to the higher quality of PEMEX's portfolio of arm's-length clients. This in turn, reflects the fact that PDVSA has been cast as the supplier of marginal heavy sour barrels into the deep conversion market in the USGC and, in consequence, it is only able to obtain genuinely marginal prices for its crudes.

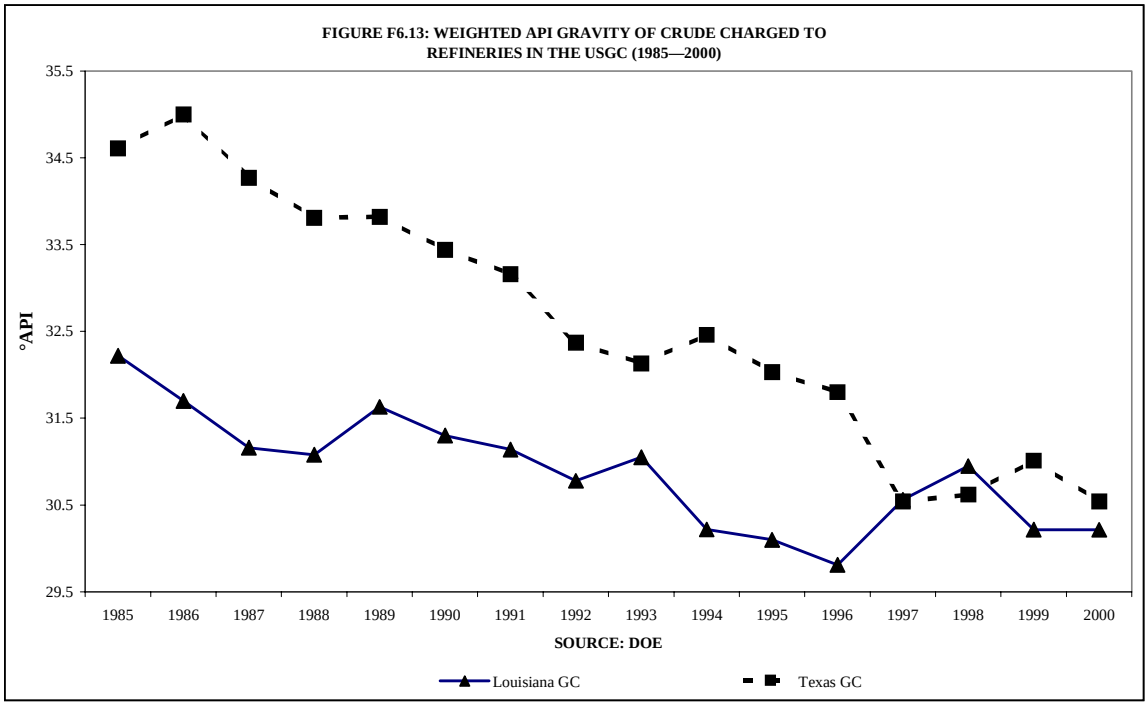
6.5 The Link between Market Structure and Sub-optimised Deep Conversion Capacity

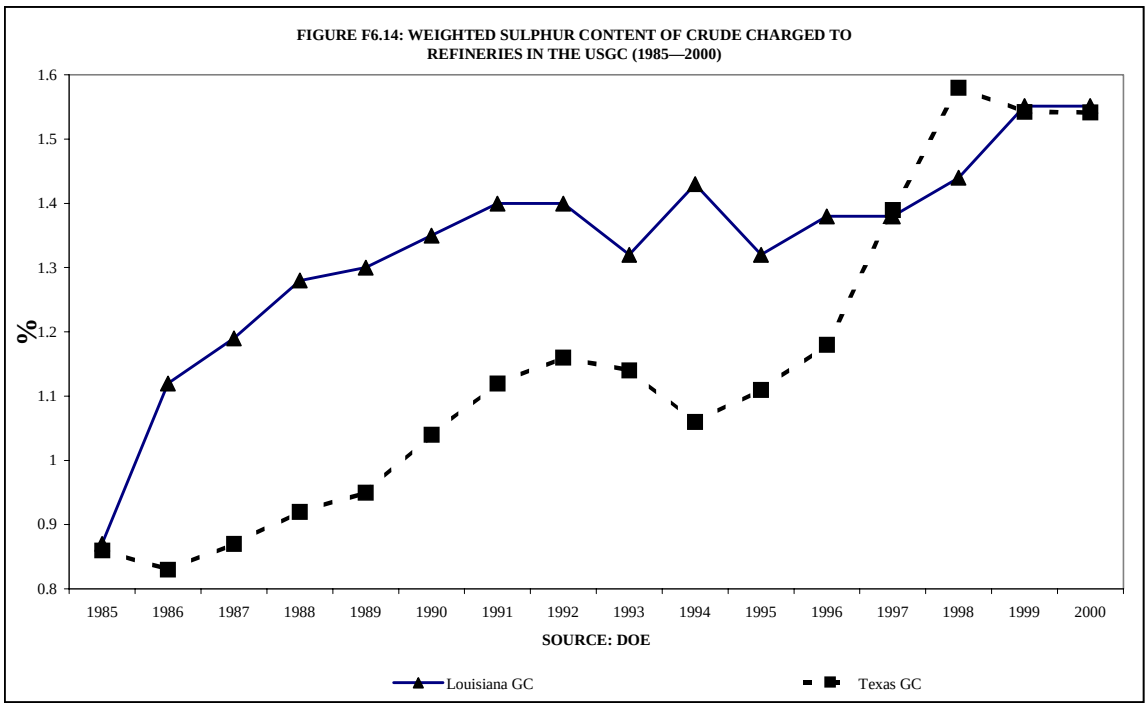
The rise and perpetuation of the competitive structure that is characteristic of the duopoly for heavy sour crudes in the USGC stems largely from the adoption and implementation of different commercial policies by PEMEX and PDVSA from 1986 onwards. Significant as the differences between the *modus operandi* of both companies are, however, they are not sufficient in themselves to account *in full* for the remarkable stability in market shares observed in this market since the early 1990s or, for that matter, for PDVSA's inability to shed the undesirable role of marginal supplier.

It is clear that, in comparison to PDVSA, PEMEX has received a premium from buyers of its heavy sour volume throughout much of the 1990s. The "contracts as barriers to entry" model proposed by Aghion and Bolton explains the existence of a contractual premium that does not seem to respond to competitive pressure in terms of a "free rider situation in reverse", whereby individual buyers will attach value to supply contracts even though these contracts create a negative externality - expressed as a non-competitive acquisition price - that reduces the payoff to the each buyer in comparison to the one he could have received had he chosen not to lock himself into a contractual relationship. Aghion and Bolton posit that rational buyers may be entirely willing to perpetuate the monopoly position of a seller in this way so long as the external costs that non-contractual buyers face are high enough; in the absence of such costs, attempts to impose contractual premia by the seller will be resisted by buyers. These theoretical insights are important for the case of the USGC market for heavy sour crudes, since it would appear that refiners in the area have perceived that paying such a premium to PEMEX made more sense than facing the potential costs associated to the volumetric and price uncertainty inherent in lifting Venezuelan

volumes. Crucially, this perception was grounded in an empirical fact that affected all of them; namely, the total supply of imported heavy sour crude oil to deep conversion and asphalt refineries located in the USGC and its Midcontinent hinterland over much of this period was not sufficient to cover the optimal baseload requirements of these plants. Thus, the average base slate of these refineries was slightly lighter and sweeter than would have been optimal, and the existence of this small amount of unsatisfied demand prompted deep conversion refiners to confer such a high value on Mexican term contracts. In other words, deep conversion plants were not processing as much heavy sour crude as they would ideally have wanted, and their collective inability to put together an optimal heavy sour base slate increased their individual aversion to Venezuelan volumetric and price risk in a way that made it rational for many of them to term out a high percentage of their Mexican crude liftings, and to buy more oil under spot conditions from PDVSA.

Sub-optimised deep conversion processing capacity has been the glue that has held the two-tiered market together, except in exceptional circumstances like those that materialised in 1998. Between 1990 and 1997, sub-optimised conversion capacity grew, in the wake of important additions to coking capacity in the USGC. These additions, together with the debottlenecking of existing plants, translated into a marked decrease in the average quality of the crude processed in USGC refineries (Figures F6.13 and F6.14). During this period, the average API gravity of crude processed in Louisiana and Texas fell by 1.59° and 2.62° degrees, respectively, while the average sulphur content increased by a tenth of a percentage point in Louisiana and one half of 1 per cent in Texas. These figures slightly underestimate the quality decrease in the *incremental* barrel supplied to the area, because crude runs increased during this period by 22 per cent in Louisiana and 6 per cent in Texas. It should alos be noted that there was a marked decline in onshore domestic US production in the region over this period, and that the average quality of the crude that disappeared from the market was quite high.





To a significant extent, the persistence of sub-optimised heavy sour capacity in the USA throughout the 1990s was a product of PEMEX's export diversification strategy. During the decade following 1986, PEMEX reshuffled its sales portfolio between its two most important export markets for heavy sour crude oil in order to take advantage of historically higher US prices, all the while keeping its total exported volume

constant (except for a small increase following the Iraqi invasion of Kuwait) and utilising its production capacity to the full. PEMEX kept abreast of the healthy growth in demand for heavy sour crudes (maintaining its market share in the USA as a whole, and increasing its market share in the USGC area), while carefully avoiding the role of residual supplier to the American market (which would have had adverse price implications for it). Indeed, PEMEX managed to do more than simply avoid this undesirable role: the volumetric increase in Mexican exports to the USA was complemented by a successful drive to reduce the amount of Maya crude sold to either asphalt refiners or plants located outside the USGC.

A good indication of the magnitude of the sub-optimised heavy sour processing capacity up to 1997 can be found in the market analysis carried out by Purvin and Gertz on behalf of the underwriters of the first PDVSA Finance bond issue. According to this consultancy firm, during 1995, the utilisation rate of nameplate refining capacity for heavy sour crudes in PADDs I, II and III averaged 65, 72 and 90 per cent, respectively, for an overall average of 82 per cent (the comparable figures for 1996 were 86, 82 and 87 per cent, for an overall average of 82 per cent).[26] This analysis slightly overstated the amount of uncommitted refining capacity by considering mothballed capacity of landlocked and/or asphalt plants, as well as the theoretical heavy sour capacity of some large PADD I refineries which have been run in sweet mode for some time now. Nevertheless, the study did identify sub-optimised heavy sour processing capacity at a number of important plants, although it made clear that much of this uncommitted capacity was located in either PADD II or the northern reaches of PADD III, which meant that supplying these refineries would translate into lower netbacks for waterborne volumes coming from either Mexico or Venezuela. The study did not spell out the way in which this sub-optimised processing capacity foundation effectively underpinned the market for heavy sour crude, and neither did it convey a sense of how fragile these foundations were. But both of these things would become shockingly clear to market participants and observers in 1998.

During late 1997, sub-optimised deep conversion capacity in the USGC and its environs dwindled to almost nothing. According to Purvin and Gertz, the only uncommitted heavy sour refining capacity to be found in the whole of PADDs I, II,

and III from 1997 onwards was in Orion's Good Hope refinery, a troubled project whose prospects were far from brilliant at that point.[27] Thus, for the first time since 1986, the security premium attached to Mexico's short-haul Maya crude almost disappeared, as the incremental flows of heavy sour crudes from all origins (see Table T6.4) were seen to be far in excess of high conversion demand in the foreseeable time horizon (up to at least 2005). Mexico and Venezuela alone were expected to increase the volume of heavy sour crude entering the international market by 1.1 MMBD by 2000, and 1.4 MMBD by 2005 (compared to 1996 figures). As far as Canada went, the simultaneous expansion of pipeline infrastructure and heavy crude production capacity in this country from 1997 onwards was seen to herald the displacement of the Canadian versus Latin American arbitrage point for imported heavy crude from Chicago down to the Wood River area, with significant amounts of waterborne imports being backed up from PADD II to PADD III (pipeline expansions increased cross-border crude capacity by 460 MBD, while capacity to move Canadian volume south to Wood River increased by 270 MBD, with the effects shown in Figure F6.15 below).

Table T6.4: Production Capacity of Heavy Sour Crude Oil, by Region (MBD)

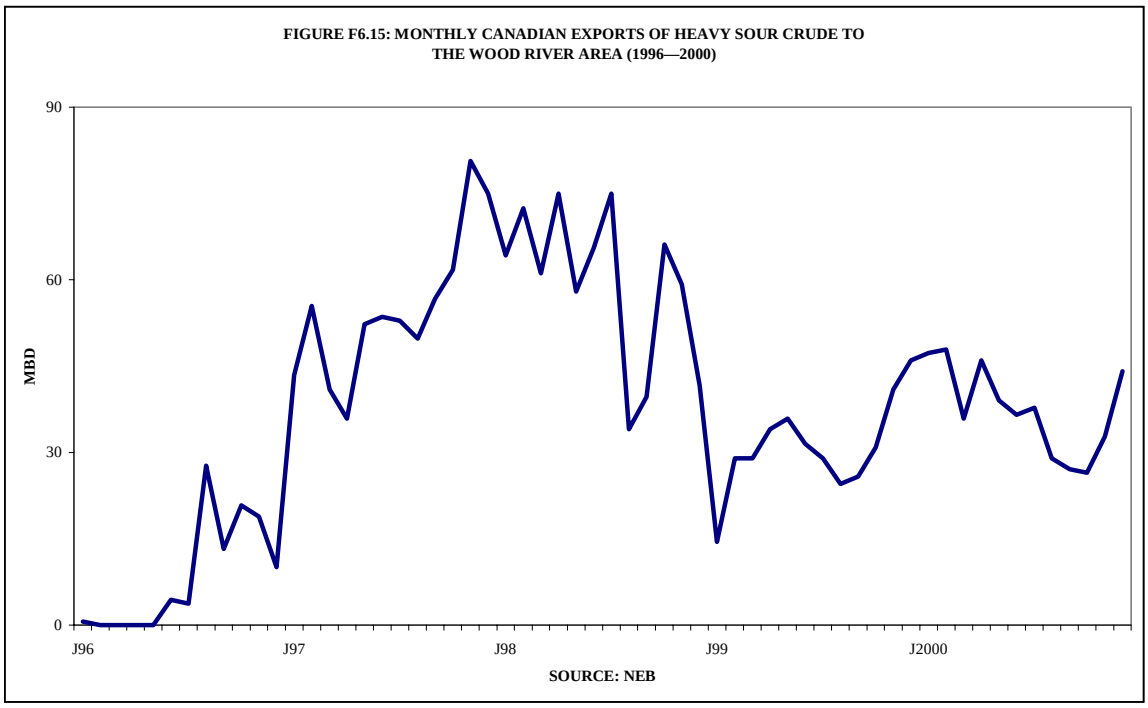
Region	*1985*	*1990*	*1998*
California Offshore Continental Shelf	80	80	131
Mexico	1,178	1,265	1,659
Middle East	970	1,670	2,035
Venezuela	1,090	1,200	1,935
Western Canada*	300	450	818
TOTAL	3,618	4,665	6,578

*Does not include mined tar sands output upgraded to syncrude

SOURCES: HOVENSA, MEM, NEB, PEMEX

In sum, the stable two-tier duopoly outcome observable throughout most of the 1990s in the market for heavy sour crudes in the USGC broke down for a while in late 1997, in the wake of the disappearance of sub-optimised deep conversion capacity and under the strain posed by the very large supplies of this type of crude that refiners thought they saw on the immediate horizon. However, just as they were settling in to

enjoy a period of windfall gains by playing the main sellers of heavy sour crude off against one another, refiners with hugely expensive conversion facilities discovered once again, as the output restrictions agreed upon by Mexico, Saudi Arabia and Venezuela began to be felt, that their supply security was not something that could be taken wholly for granted. The main beneficiary of their concerns in this regard appears to have been PEMEX, and the two-tiered duopolistic outcome has reasserted itself over 2000—2001, even though this period has also witnessed a significant increase in the economic penalty that the market attaches to crudes with a high sulphur content.



6.6 Contestability in the USGC Market for Heavy Sour Crudes: the Role of Arab Heavy and Offshore Gulf of Mexico Crudes

The USGC market for heavy sour crude is a two-tiered duopoly characterised by a rather restrained price competition between a firm that functions as a price leader (PEMEX) and one that is a price follower (PDVSA).[28] This peculiar arrangement has been underpinned by the existence of sub-optimised deep conversion, which has made refiners more willing to pay a premium for reliable Mexican supplies than if

they had been able to optimise their base load requirements to the full. This situation, coupled with the lack of direct substitutes for Mexican and Venezuelan heavy sour crudes in large enough volumes, might be thought to offer plenty of scope for the potential abuse of market power by the leading firm in the duopoly. Nevertheless, pricing has been kept honest by the fact that, traditionally, the largest lifters of Arab Heavy crude have also been amongst the most important customers for Mexican and Venezuelan heavy sour blends. Thus, even at times when the market presence of Arab Heavy has bordered on the marginal, the potential threat posed by incremental supplies of this crude has ensured that PEMEX, in particular, would not succumb to the temptation of leading the quiet life of a monopolist.

From the early 1980s onwards, Arab Heavy has not been a baseload feedstock of choice for deep conversion refineries in the USGC, which can achieve better margins running crudes of an even poorer quality. On the whole, Arab Heavy (like Arab Medium) is better suited for refineries that rely on less severe processes for upgrading purposes (complex refineries in Northwest Europe or Japan would be a case in point). In most of the very complex USGC refineries, therefore, Arab Heavy tends to be used mainly in conjunction with less tractable crudes. Moreover, the presence of Arab Heavy in the US market has been limited by the fact that, after the Second Gulf War (an event that put Saudi finances under great strain), "additional growth in export volumes without impacting severely on prices proved difficult [for Saudi Aramco to achieve] ... [so] the emphasis was then put on revenue maximisation on the basis of existing volumes, given that revenue growth through export growth had been precluded".[29] This emphasis had two complementary facets: firstly, Saudi Aramco decided "to bias development expenditure and the pattern of exports more towards the higher value grades, and to bias the unutilised production capacity toward the lower value grades, i.e. to maximise light production at the expense of heavy"; secondly, the company decided "to attempt to charge what the market would bear in different regions", and to increase the flow of oil to those regions where higher prices prevailed.[30] These policy initiatives led to a substantial increase in Saudi sales to markets to the East of Suez, at the expense of sales elsewhere, as well as cuts in Arab Heavy volumes for all markets (with the reduction being especially marked in the USA). As a result of the latter, the percentage of Arab Heavy liftings accounted for by the ex-Aramco partners and Saudi Aramco's US affiliate (Star Enterprise) became

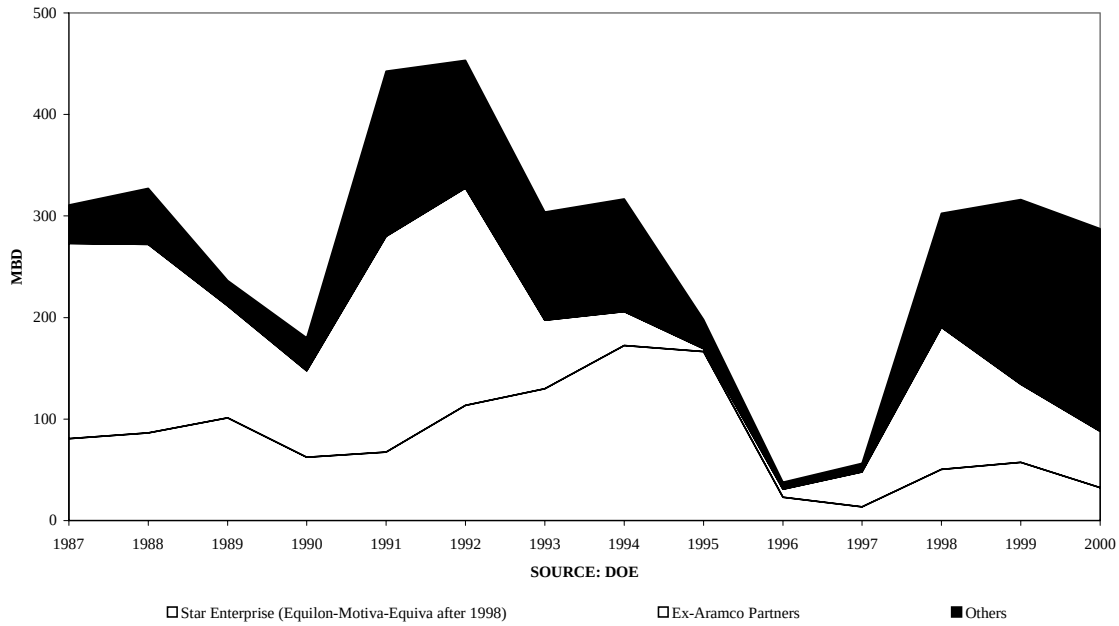
even more pronounced than it had been in the past (Figure F6.16), and the volume of Arab Heavy sold under genuinely arm's-length pricing conditions declined proportionately. Thus, throughout much of the 1990s, the option of lifting Arab Heavy to arbitrage distortions in the pricing of Mexican or Venezuelan heavy sour crudes was, for practical purposes, closed to the majority of PDVSA and PEMEX customers, whose only credible supply alternatives were more expensive medium sour grades (like Arab Medium).

Regardless of the drastic reduction in the market presence of Arab Heavy in the USGC after the Second Gulf War, PEMEX (the barometric market leader in the USGC[31]) has continued to price Maya crude with an eye on the formidable might of Saudi Aramco. This has prevented the Arab Heavy/Maya differential from narrowing too much. In other words, the continued — albeit very modest at times — presence of Arab Heavy crude, has made this market duopolistic contestable (if not strictly competitive) and has therefore prevented monopolistic pricing,[32] even though PEMEX is aware that in very complex refining configurations, Arab Heavy represents a sub-optimal substitute for Mexican and Venezuelan heavy sour blends. Nevertheless, the fact that some of PEMEX's and PDVSA's key customers (notably the former Aramco partners but also Shell) in the USGC and elsewhere have always had a potential access to large Saudi heavy volumes through their special relationships with Saudi Arabia meant that PEMEX has not tried (or has not dared) to set the price of Maya (and, by association, of all the Venezuelan volumes sold with reference to it) at Arab Heavy parity.

The role that Arab Heavy developed for itself in the US heavy sour market has changed significantly as a consequence of the 1998 Asian crisis, and the oil price crisis that followed it. The collapse of Asian oil demand forced Aramco to pick up the sales slack elsewhere, notably the USA. Furthermore, Arab Heavy was precisely the Saudi crude that was most affected by events in Asia, and the withdrawal of Mexican and Venezuelan volume in line with the supply restriction agreements gave Saudi Aramco a ready opportunity to market this displaced volume in the USA (the fact that the company could sell out of storage facilities located in the Caribbean effectively eliminated the competitive handicap derived from the reluctance of high conversion refiners to rely for their supplies on very long-haul crudes). Hence,

refiners in the USA turned to Arab Heavy to fill up their upgrading plants, chiefly for want of anything better. In line with the expansion of its market share, Arab Heavy became a face-to-face competitor for both Maya and Venezuelan heavy sour grades, rather than a guarantor of their fair pricing. Whether this situation will continue in the future, or whether Arab Heavy will revert to its previous role is, at the moment, highly uncertain. Much will depend on the role that Saudi Arabia will elect to play once the dust kicked up by the 1998 storm in the international oil market has finally settled. There are as yet very few indications as to what route exactly the Kingdom is prepared to take. On the one hand, Saudi policy makers have made it clear that they would prefer not to allow Saudi Aramco to be marginalised from this important market, and this would appear to imply that they intend to hold on to the market share gained after 1998. On the other hand, this stated objective might prove to be quite flexible once economic growth in the Far East gives Saudi Aramco the possibility of realising higher netback values for Arab Heavy crude sold in Asia.

FIGURE F6.16: IMPORTS OF ARAB HEAVY CRUDE TO PADD'S I, II AND III, BY TYPE OF CUSTOMER (1987—2000)

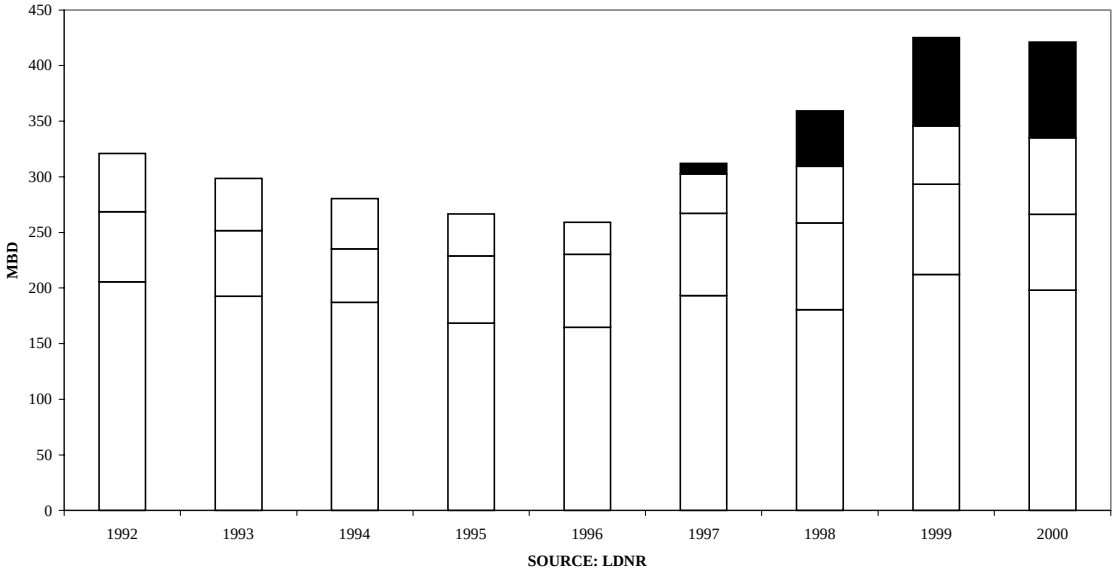


SOURCE: DOE

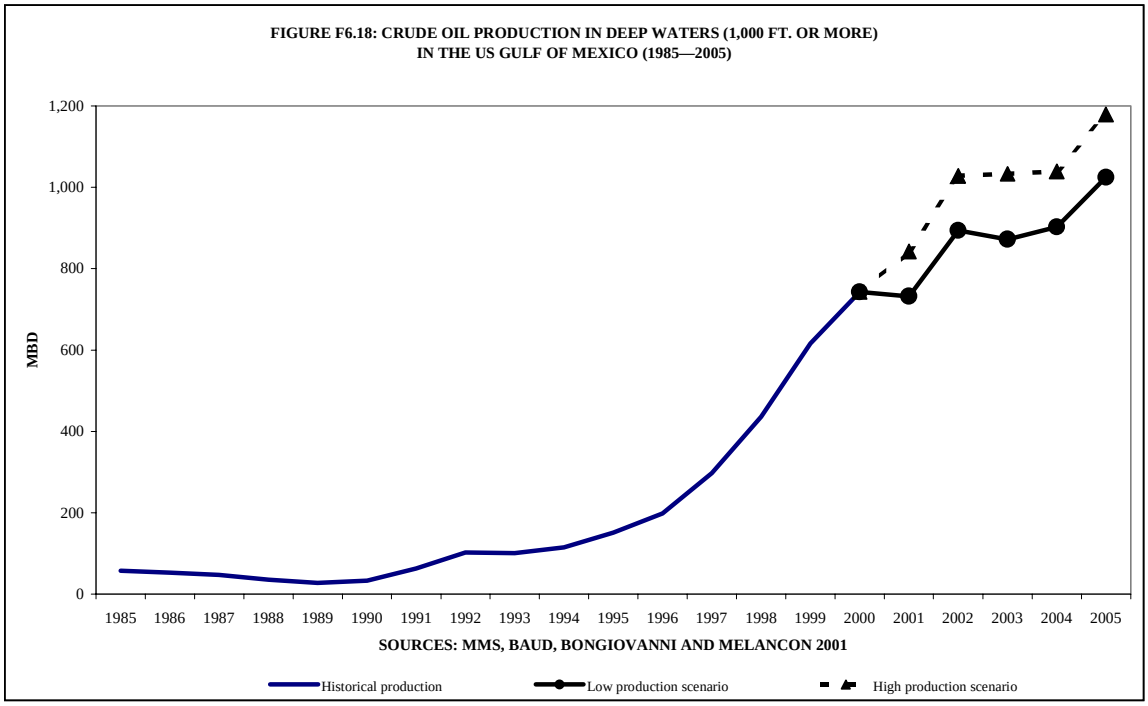
In recent years, crudes produced in deep waters in the Gulf of Mexico Offshore Continental Shelf (GOMOCS) have also played a dual role as competitors and guarantors of the contestability of USGC market for heavy sour crude. Thanks to

quantum advances in upstream technology, the prolific oilfields in this zone have made — and will continue to make — a major contribution to US oil reserves and, more importantly, to US production. For instance, between 1994 and 1998, overall US oil production declined by 410 MBD, but deep water GOMOCS production increased by 320 MBD over the same period (in 1999, deep water GOMOCS output surpassed shallow water output for the first time in history, and accounted for about 12 per cent of total US production).[33] GOMOCS output consists in the main of medium gravity, high sulphur crudes like Mars and Poseidon. Their physical characteristics render them adequate for upgrading purposes, but their attractiveness in this regard is enhanced by an important logistical consideration; namely, that the arrangement of pipeline infrastructure onshore in Louisiana limits their main market to refineries located along the Louisiana Gulf Coast. The dearth of other outlets for these crudes has forced equity producers to price them very keenly, so as to ensure the custom of these refiners. As a result, and especially during the glutted market of late 1997 and 1998, imported waterborne heavy sour crudes found themselves competing head to head with deep water GOMOCS streams, especially in those refineries that are logistically advantaged to lift deep water GOMOCS volume (Figure F6.17).

FIGURE F6.17: LIFTINGS OF GULF OF MEXICO OCS CRUDES BY SELECTED LOUISIANA REFINERIES (1992—2000)



This situation changed somewhat between 1998 and 2000, because the supply restrictions that affected the market for heavy sour crudes during this period lessened competition between GOMOCS crudes and imported heavy sour streams, since the former were able to move painlessly into spaces vacated or not filled by the latter. However, the peaceful coexistence between GOMOCS crudes and heavy sour imports will probably not last for very long. After all, even the less optimistic production scenarios see the availability of deepwater GOMOCS crudes increasing sharply in coming years (Figure F6.18). The steep rise in output could result in local surpluses of heavy and medium sour crudes in the Louisiana Gulf coast, unless pipeline infrastructure is built to transport large volumes of these crudes to the Texas Gulf Coast and beyond. A couple of pipeline projects along these lines have been mooted, but nothing definite has come of these proposals as yet, and the long lead times for such projects probably make it difficult for GOMOCS producers to prevent some kind of glut from developing in Louisiana after 2001. This situation will probably be of limited duration, largely because it would ensure that expansions in pipeline capacity to the Houston area would in fact be built at some point. Once this happens, deepwater GOMOCS crudes will be in direct competition with medium sour crudes all over the USGC, and their pricing will become rather more peripheral to the market for genuine deep conversion grades. However, their ready availability and convenience for USGC refiners can be expected to continue to inhibit any tendency for Mexican and Venezuelan pricing to get out of line.



6.7 A Stable Two-tiered Duopoly? A Theoretical Exercise

The market for heavy sour crude oil in the USGC appears to be an asymmetrical, or two-tiered, duopoly. Using technical terms, one would say that, throughout the 1990s, this market has been in a state of stable Stackelberg equilibrium. Stackelberg equilibria are characterised by the fact that a firm in an oligopolistic market will choose an output that maximises its profits, and the following firm (or firms) will then choose its (or their) own output accordingly. However, the sort of two-tiered outcome that this formulation proposes is rare in the extreme because, as Hay and Morris observe, "follower profits will be [always] less than those obtainable at the Nash-Cournot equlibrium point. So no firm will willingly accept the follower's role. An attempt by both firms to lead would lead to very poor profit outcomes for both firms as output was expanded".[34] Two-tiered (Stackelberg) outcomes are somewhat more likely to appear "if there are fundamental asymmetries between the competitors".[35] However, as far as the USGC market for heavy sour crude goes, this only complicates the picture further, since PEMEX and PDVSA are nothing if not evenly matched on a commercial level. However, Hay and Morris point out that Stackelberg outcomes may also arise if several periods are considered so that a leader may emerge from a learning process.[36] In other words, the sort of learning process that deep conversion

refiners in the USGC have undergone may lead to the appearance of first- and second-class sellers. Once buyers have started to differentiate between sellers in this way, the two-tiered equilibrium can consolidate and become stable (so long as certain conditions are satisfied), as we shall now show by applying a model of price leadership based on consumer loyalty — originally developed by Deneckere, Kovenock and Lee[37] — in a duopolistic setting.

The model assumes the existence of a duopoly with no possibility of market entry for further sellers. Production costs are zero, and output is totally perishable and cannot be stored. In each period, clients will buy a maximum of one unit from either of the companies. These assumptions are restrictive but, for the case at hand, they are not entirely lacking in realism. For instance, short- and medium-term production decisions in both Mexico and Venezuela are essentially independent of variable crude production costs, because the latter are so low. By the same token, the large reserves-to-production ratio of these two producers means that, even at a very low discount rate, the value of crude whose production is foregone today is lost (because its net present value is calculated on the basis of the barrel being produced on the last day of life of the reservoir). This characteristic makes their oil a perishable good in a financial sense.

The model requires a disparity in the sizes of the client bases for each company and, given the asymmetries identified in a previous section, we assume that PEMEX's client base is the largest. Seven importers of heavy crude oil in the USGC (BP Amoco, Chevron, Premcor, Conoco, Deer Park, Marathon-Ashland and the ExxonMobil Beaumont refinery) are considered to be loyal to PEMEX; Citgo, Chalmette and Lyondell are considered to be loyal to PDVSA. Four other importers (Coastal, ExxonMobil Baytown and Baton Rouge, Hunt and Koch) are considered as lifters with no preference. Together, these companies accounted for about 90 per cent of all imports of crudes with a gravity of 25° API or less into the USGC for the period under consideration. Clients were not allocated to one company or the other arbitrarily: the main assignation criterion was the difference between their purchases of crude from both companies over the years ("neutral" companies tended to buy similar volumes from both over time). Clients in which either of the sellers has a shareholding stake were assumed to be loyal to that seller, regardless of their

purchasing track record before their acquisition. Interestingly, PDVSA's loyal customers are all refineries in which it has an ownership stake.

The results obtained from running the model with the parameters discussed in Appendix V show that, in the presence of an exogenously determined price leader, the company with the large client base will always obtain the same profits, while the one with the smaller client base will obtain a larger profit when it acts purely as a price follower. In principle, this could explain why PDVSA might be content with letting PEMEX function as the trendsetter (i.e. the first mover) in the market for heavy sour crudes. However, things are more complicated than that, because even though in theory PDVSA has the possibility of setting its prices at *r*, in reality the company sells its crude by granting discounts which are not reflective of quality differentials, *vis-à-vis* Maya prices which are clearly considered by clients to be reasonable. This puzzling facet of PDVSA's commercial policy, though, is consistent with a duopolistic setting where client loyalty exists, and pricing moves by the duopolists are simultaneous (in other words, there is no price leadership as such). Upon examination of the prices set by both companies under equilibrium conditions in such a setting, one can observe that the company with the largest client base always sets the price at the highest level acceptable to its clients (this is broadly consonant with PEMEX's long-term observed pricing behaviour). Moreover, the prices set by the company with the smaller client base are proportional to the price level, but not only are they always lower than the reference price *r*, they also depend entirely on the number of clients loyal to the leading firm and the number of uncommitted clients (variables n_1 and *m*, respectively). In other words, prices for this company are not a function of the size of its customer base (variable n_2), which means that the company can only increase its prices in the long term by transforming a neutral client into one that is loyal to it (and thus reduce the magnitude *m*). This sort of behaviour is not unlike that which one can discern at the heart of PDVSA's vertical integration policy, although we have shown that, on the whole, PDVSA's downstream acquisitions have had a deleterious effect on the average realised price of Venezuelan crude exports to the USA.

The results generated by the model fit best within a setting characterised by simultaneous price moves (a situation in which, by definition, there can be no price leadership).[38] The fact that we have said that PEMEX is the barometric price leader

in the market for heavy sour crude in the USGC does not invalidate them, however. Recall that, since PEMEX sells crude with formulae linked to the prices of other crudes, it only has the liberty to define the parameters of the formulae and change the adjustment factors, but not to set the absolute price of the crude. PEMEX's price leadership in this market manifests itself in that every month, when a review of its adjustment factor is due, the other sellers wait for the announcement of changes in this factor, and then use these as an *input* in their own pricing decisions and negotiations with clients (be they for spot or term volumes). In this sense, then, PEMEX is always a first mover. However, neither PEMEX nor anybody else sells all non-committed volume for a given month only on the day when a change in the adjustment factor has taken place. This means that, as a rule, both PEMEX and its competitors are simply taking as given the prices generated by the formula for any day when a transaction is concluded[39] and, in this sense at least, it is possible to speak of simultaneous pricing (i.e. the prices used as references by follower companies are being generated exogenously by the market, at the same time that transactions are taking place).

6.8 Conclusions

A recount of the most salient features of the duopolistic interaction between PEMEX and PDVSA reads as follows. Firstly, PEMEX appears to have achieved commercial primacy at the high-value end of the USGC market for heavy sour crudes, while the placement of PDVSA's export volumes hinges to a crucial extent on its ownership of captive outlets. Secondly, PEMEX plays the role of barometric price leader in this market, with PDVSA negotiating the pricing for both individual cargoes and term contracts on the basis of straight discounts off the Maya crude formula.[40] Thirdly, PEMEX's realised prices have been consistently higher (on a quality-adjusted basis) than those of PDVSA, which would imply that the market for heavy sour crude oil in the USGC appears to be a two-tiered duopoly (the market has been in a state of stable Stackelberg equilibrium).

On the basis of a price leadership model incorporating consumer loyalty, we have shown that these apparent price imbalances can be sustainable in the long run, even in the absence of vertical integration on the part of the company that charges structurally lower prices (although such vertical integration makes it even easier for such

imbalances to persist through time). The model shows that, in a market with high consumer switching costs, a duopolist may be able to sell his output at a considerably higher price than his competitor so long as he can count on having a portfolio of loyal clients (as defined by Deneckere, Kovenock and Lee) that is sufficiently large relative to that of his competitor, and to the total size of the market. However, the model was not developed to predict the behaviour of economic agents so much as to show that it is possible to explain in theoretical terms how a company can obtain premium prices consistently without suffering a loss in market share. This approach might be seen as problematic by those who think that "a hypothesis of this sort is most persuasively supported through successful ex ante predictions, not ex post explanations ... [since] any post hoc explanation risks being too pat".[41] Ellickson, for instance, questions in these terms the findings of his own — very good — investigation into the informal regulation of the nineteenth century American whaling industry. This criticism misses the point that "the inability to predict the precise whaling norms that would develop in a particular fishery", or even to "identify a large set of norms that would *not* be observed",[42] in Ellickson's case, is not so much symptomatic of lack of rigour as of the degree of contingency that is inherent to all social institutions that go through a process of historical development. Indeed, Kuenne would probably see in Ellickson's unnecessary self-criticism a reminder of how pervasive is the "misconceived allegiance to the notion that empirically derived results incapable of being expressed numerically are deficient, even if data limitations or the crudeness of techniques in the face of complex interdependence argue strongly for the inability to derive such measures".[43] It is hard to disagree with Kuenne when he says that "realistic restraint on such unattainable ambitions would conduce to an acceptance of qualitative results, and the acceptance of such multivariate methods as factor analysis and – horror of horrors – historical analysis".[44]

The empirical and statistical findings presented throughout this study make no sense if abstracted from the events that constitute their historical context: the decision by PDVSA to take advantage of the 1986 price crisis to buy more refineries overseas, or PEMEX's inability to adopt commercial practices which permitted the exercise of individual managerial discretion, say. This goes to show that historical analysis is probably the most valuable aid in understanding how concrete markets function, even if by its very nature this type of analysis makes it enormously difficult for the analyst

'to advance successful *ex ante* predictions'. Consider the case of the way the international diamond trade worked until very recently. *Ex post*, it is quite easy to rationalise the economic efficiency of the very unorthodox marketing practices followed by De Beers (notably, the famous system of 'sights'). But could anyone seriously have suggested, *ex ante*, that the market for this most expensive of luxury goods would function very well for decades, on the basis of the customers buying clutches of diamonds from a single seller, on a take-it-now-or-leave-it-forever basis, sight unseen? This rhetorical question is equally applicable to the market for heavy sour crude in the USGC. After all, regardless of how well informed an analyst might have been back in 1981, it is quite improbable that she could have predicted the very different conventions and procedures that have come to prevail in the Mexican side of the market, on the one hand, and on the Venezuelan side, on the other. It is even less probable that anybody looking at the similarities in size and heavy sour crude reserves and availabilities of PDVSA and PEMEX could have predicted that this market would end up by becoming a stable two-tiered duopoly. But however unlikely this outcome might have struck a theoretician, the empirical evidence that shows that this was precisely the way in which the market evolved appears overwhelming.

NOTES

[1] *PIW*, 28 February 28 1994: 3. Trade journals completely misread the situation, claiming that "incremental demand for sour crude in the US [was] increasingly being taken up by [Venezuelan] barrels, leaving less room for added term sales" (*PIW*, 30 November 1992: 3).
[2] *Ibid.*
[3] *PIW*, 30 November 1992: 3.
[4] "PDV Restructures in Effort to Get More Term Deals", *PIW*, 18 July 1994: 4.
[5] "PDV's Downstream Model Tarnished by US Sales Woes", *PIW*, 28 February 1994: 3.
[6] From 1998 onwards, the average US Maya price published by the DOE also includes the prices of Maya cargoes bound for the US West Coast. The prices of these cargoes, calculated on the basis of a formula incorporating West Coast crudes, have generally been lower than USGC prices.
[7] The Maya-Leona differential on a delivered basis is actually l*ower* than on an FOB basis. This would imply that the Venezuelan crude enjoys a transportation advantage over the Mexican crude, which is certainly not the case. Moreover, the way in which the DOE compiles its price series data rules out the possibility of erroneous price reporting. Thus, this apparent anomaly remains unresolved.
[8] Quoted in Williamson 1979: 233.
[9] Verboven 1998: 198.
[10] Harrison and West 1997; see also Harrison and Reed 1999; and Appendix IV.
[11] PDVSA claims that its very flexible pricing policy enables it to extract price premia from its customers on a regular basis (*PIW*, November 30, 1992: 3). This means that, in tight markets, PDVSA behaves like an Arrovian monopolist, raising the price until the excess demand for its crude grades is eliminated.
[12] Mabro 1984: 68.

[13] The 20-F reports that PDVSA files with the SEC state that all these contracts are structured around pricing formulae based on the spot market value of a slate of refined products assumed to be produced from each crude (or feedstock) at each refinery under typical conditions. This value is adjusted downwards by subtracting certain inflation-indexed deemed refining costs, transportation costs, import duties, taxes, a deemed refining margin and a so-called volume charge (these two elements are calculated to assure the refinery of a profitable level of activity) for each sort of crude. In the oil industry, this pricing mechanism is generally referred to by the tautological name of *market related pricing* (nowadays, there are no internationally-traded crudes or products whose price is not related in some way to either the major spot or paper markets). But the term is actually an euphemism for discounted prices that are *inferior* to true spot prices, as the following lines make abundantly clear: "in 1987, Tamoil [Italian arm of the Libyan state oil company] ... was the only major Italian marketer to make a profit: none of the conventional [*sic.*] refiners is able to stay in the black in a market where prices are controlled at the average of product prices in five other European countries ... The reason [behind this] is simple ... Over 80% of the crude refined by Tamoil ... came from Libya, and, although [Tamoil's annual] report does not say so, the Libyans *must have invoiced Tamoil at market related prices*"(*The Barrel*, 30 May, 1988: 1; italics ours).

[14] HOVENSA 1999: 84. Besides HOVENSA, this type of formula also applies to its Chalmette Refining and Merey Sweeny partnerships. PDVSA incorporated a formula of this type into the supply contract for its wholly owned affiliate PDV Midwest after the company bought out Unocal from the Uno-Ven partnership in 1997.

[15] Citgo 10-K 2000: 8.

[16] Volume cuts for the Lyondell-Citgo refinery did not contribute to these losses because PDVSA has had to indemnify Lyondell in "compensation for such reductions" (Lyondell 10-K 2000: 26).

[17] "PDVSA Officials See Possible Advantage to Application of Anti-dumping Rule to Oil", *The Oil Daily*, 3 May 1999: 1.

[18] *PIW*, 28 February 2000: 3-4. General Oswaldo Contreras Maza, appointed as Citgo's CEO in 2000, has recognised that the company's netback supply agreements with PDVSA yield discounts that average about 3 USD/B in times of high oil prices (*PIW*, 22 January 2001: 8). This acknowledgement marks quite a departure from the company's previous stand on the matter, which involved not only denying the existence of such discounts but actually claiming that the company's transfer prices were higher than open market prices (see, for instance, *PIW*, 2 June 1986: 10).

[19] Mlotok 1994: D3.

[20] *Ibid.*

[21] *PIW*, 31 July 1995: 3. Paradoxically, PDVSA's downstream presence has sometimes been a liability even during times of healthy oil demand (there have been occasions when the company has found itself either having to buy crude in the spot market to meet its commitments or, worse, having to trim the crude entitlements of some of its term customers; *PON* 5 and 8 June and 29 September 1987; *PIW*, 9 March 1987).

[22] Both series contain lacunae, due to the withholding of data to avoid disclosure of individual company information. Monthly price data for Furrial have almost always been been witheld since 1998. Both of these series are also available on an annual basis from 1986 onwards.

[23] Up to 1998, PDVSA used to place very large volumes of Furrial on a purely spot basis in the US market, with very little being sold to affiliated refiners under long-term supply contracts. Affiliated refiners could and did buy cargoes of this crude, of course, but they did so under the same conditions as the rest of PDVSA's American clients.

[24] The percentage figures for each of the nine years during this period are as follows: 98, 97, 99, 92, 93, 90, 80, 79, 83.

[25] The percentage figures for each of the nine years during this period are as follows: 80, 78, 81, 76, 77, 75, 74, 53, 57, 74. The prices used to subtract the contribution of Canadian volumes to this price series were the ones reported by the DOE for Bow River Heavy and Lloydminster.

[26] PDVSA Finance 1997: C14-7.

[27] PEMEX Finance 1998: B-28; 1999: B-30.

[28] As Roberts (1984: 5) notes, "a price leader is not necessarily the producer which changes its price first" so much as the one who "is able to enforce [price changes] in the long run and have a direct influence on the decisions of other producers".

[29] Horsnell, *op. cit.*: 299.

[30] *Ibid.*

[31] A barometric price leader "commands adherence of rivals to his price only because, and to the extent that, his price reflects market conditions with reasonable promptness" (Stigler 1947: 432). PEMEX does not exercise a "dominant firm" type of leadership, which is characterised by the fact that the leader ensures "that all producers follow his price decisions by threatening to use aggressive pricing and production policies to drive them out of the market if they do not conform" (Roberts 1984: 5).
[32] A contestable market is one “subject to potential entry by firms that have no disadvantage relative to incumbents, and that assess the profitability of entry on the supposition that incumbents’ prices are fixed for a sufficiently-long period of time” (Baumol, Panzar, Willig 1986: 342).
[33] As the MMS puts it, "with 30 fields on production at the end of 1999, the deep water of the Gulf of Mexico can rightly claim to be America's new frontier and has truly emerged as a world class hydrocarbon province. Its future looks bright, as many new geologic trends are only now seeing the first exploratory drilling" (Baud, Doyle, Peterson and Richardson 2000: ix).
[34] Hay and Morris, *op. cit.*: 61.
[35] *Ibid.*
[36] *Ibid.*
[37] This model was elaborated by Deneckere, Kovenock and Lee (1992).
[38] A price leader cannot have a direct influence on the decisions of other producers when pricing decisions are simultaneous.
[39] Even spot deals are generally done at least a month in advance from the date when lifting is supposed to take place.
[40] Indeed, PDVSA takes the price of Maya as a key input for most of its investment decisions concerning heavy crudes. Clear examples of this can be found in Petrozuata 1997, Cerro Negro 1998 and especially HOVENSA 1999.
[41] Ellickson 1996: 41.
[42] *Ibid.*
[43] Kuenne, *op. cit.*: 147.
[44] *Ibid.*

7. CONCLUSIONS AND OUTLOOK

The market for heavy crude oil for deep conversion purposes in the USGC has only existed for about twenty years. Before 1980, heavy sour streams could still be used as general purpose feedstocks, so few — if any — refineries in the region geared their operations to the destruction of bottoms produced from such streams. However, the deep conversion market grew quickly, on the heels of tightening environmental legislation, a plummeting demand for residuals in the USA, and a massive overall increase in the supply of heavy sour crude. From 1986 onwards (and especially after 1990), this market evolved into an asymmetrical duopoly underpinned by a peculiar competitive arrangement that is out of kilter with the conventional wisdom about how oligopolistic markets should behave. It is a market riddled with transactional problems, but where a high degree of vertical integration by one of the duopolists appears to be a symptom of commercial failure more than a safeguard against these problems. It is a highly concentrated market where price-sensitive customers consistently commit themselves to buying very large volumes from the supplier that consistently charges higher prices and gives them the least operational flexibility. It is also a market where the negative value of sulphur is relentlessly increasing (as product specifications and emission restrictions get tighter and tighter), but where the lower sulphur content of Venezuelan crudes does not reflect in their prices except during periods of extreme market tightness.

The two-tiered structure that characterises the market for heavy sour crude in the USGC is, in great measure, an outcome of the competitive strategies followed by PEMEX and PDVSA since the netback crisis. PEMEX's "economic value to the customer" has been magnified by PDVSA's commercial strategy because, between 1986 and 1990, the Venezuelan company unwittingly succeeded in "redefining the way in which the buyer thinks about the product's function, even if the product and service offering itself is the same".[1] As Porter explains:

> if the buyer can be convinced that ... the cost or value of the product to him is not only the initial purchase but involves additional factors ... that enter into the actual total cost or value of the product, then the firm has the potential opportunity of demonstrating

> that its product has a superior performance along these dimensions and thereby justifies a price premium and buyer loyalty.[2]

PEMEX was indeed presented with such an opportunity by PDVSA's commercial policy, which reduced the price-sensitivity of deep conversion customers in the USA to volumes that were perceived to be commercially more secure. The Mexican NOC took this opportunity well, through the introduction of public pricing formulae.

The competitive advantage that PEMEX has been able to build over the years has clearly been based upon architecture ("a system of relationships within the firm, or between the firm and its suppliers and customers, or both"[3]) rather than on its ownership of strategic assets of greater quality than those of PDVSA (strategic assets are those that give firms "an advantage over their potential competitors even though there is nothing they can do which these other firms, if equally placed, could not do equally well"[4]). In this sense, Kay comments:

> competitive advantages based on architecture can be sustained over long periods, but not easily. Organizational knowledge needs to be refreshed and replenished … [and in any case] architecture is very easily destroyed … [not least because] organizational knowledge can often be conservative, and fail to see … market shifts occurring, or refuse to acknowledge their relevance when they have occurred.[5]

PEMEX's success at perpetuating its competitive advantage owes a lot to the continuity of its commercial policy (since 1982, the only one of the key constituents of this policy to have changed significantly is the export diversification strategy). In turn, this can be directly linked to the fact that PEMEX's international crude marketing has been in the hands of the same technocratic group since that date (and from 1989 onwards, it has been the province of a separate and small marketing company which has served as a buffer, isolating PEMEX's customers from some of the effects of the company's well-attested problems in its other areas of activities). Given the complexity and peculiar characteristics of the international oil business, this has been an abiding — albeit potentially fragile — source of competitive strength. As Kay observes,

> more than any other distinct capability, the sustainability of architecture rests on the skills of senior managers at … recognizing the nature of the company's architecture and the function it plays in the markets the firm serves … [and] the degree to which architecture must grow with, and from, the organisation.[6]

Therefore, it will be interesting to see whether recent changes in the Mexican political system have any effect on PEMEX's international marketing activities. In the past, there would have been no reason to suppose that any alteration in its commercial policy might be in the offing, in the short, medium or long term. However, the recent state of political flux in Mexico could conceivably translate into a wholesale redefinition of PEMEX's entrepreneurial practices, which in turn could have a great impact on governance structures in the USGC market. Common sense, allied to the fact that Mexico stands to lose a lot if PEMEX's international oil marketing activities were to fail to perform as they have in the past, suggest the wisdom of a conservative approach to these issues on the part of the government. However, the notion that tinkering with this delicate and successful commercial machinery could be potentially disastrous is not yet widely appreciated, so only time will tell whether the complexion of the USGC heavy sour market might yet be changed by Mexican domestic politics. If this proved the case, then the whole question of the patterns of oligopolistic competition in the USGC market for heavy sour crude would have to be reassessed.

The unfavourable strategic position that PDVSA currently occupies in the USGC is really that market's way of penalising the company for selling its heavy sour crudes in a manner that ignores the problems derived from bilateral monopoly and asset specificity. PDVSA's persistence in its commercial ways, in the face of such heavy penalisation, surely does not stem from its lack of appreciation that "the goal of competitive strategy for a business unit in an industry is to find a position in the industry where the company can best defend itself against ... competitive forces or can influence them in their favour".[7] Rather, it reflects the benefits that the company has reaped from its transfer pricing system with overseas refining affiliates. The opacity of PDVSA's commercial policy has made it possible for the company to reduce its taxable income through the simultaneous transfer of rent to a low tax environment and the importation of costs to a high tax environment. Indeed, PDVSA's integrated operations are mainly responsible for the staggering differences in its fiscal burden relative to that of its closest peer company, PEMEX. For instance, in 2000, PEMEX's gross revenues (excluding excise taxes) came to USD 50.3 billion, and its fiscal contributions to the Mexican government (excluding excise taxes) amounted to USD 29 billion.[8] In the same year, PDVSA's gross revenues reached USD 53.6 billion, but is fiscal contributions amounted to only USD 11.23 billion.

The latter figure represents only 41 per cent of the record oil export revenues (USD 27.3 billion) that PDVSA obtained during that year. The previous peak in Venezuelan oil export revenues had occurred during 1981 (i.e. *before* PDVSA's internationalisation policy began), and during that year the USD 19.1 billion of export sales generated USD 13.9 billion in royalties and income taxes for the Venezuelan government, a figure equivalent to 73 percent of gross export revenues. Indeed, by collating the geographic and sector figures that PDVSA files with the SEC with data published in PDVSA's internal statistical annual and MEM's annual reports on the Venezuelan oil industry (Table T7.1), one can put together a very revealing picture of the contribution that the company's international refining and marketing assets make to its balance sheet.[9]

TABLE T7.1: PDVSA. Balance Sheet Contribution of International Refining and Marketing Assets (1992—7)

	Total Assets	*Variable Operational Costs*	*Total Costs**	*Taxable Income*
1990	17%	44%	71%	2%
1991	17%	33%	66%	3%
1992	16%	35%	65%	3%
1993	18%	38%	70%	7%
1994	18%	39%	72%	5%
1995	20%	35%	69%	3%
1996	19%	35%	76%	2%
1997	19%	23%	72%	3%
Average	**18%**	**35%**	**70%**	**4%**

* Includes financial costs, and the cost of purchasing crude and products in the international market

SOURCES: PDVSA, MEM

The main beneficiaries of PDVSA's vertical integration appear to have been the company's refining partners and wholly-owned overseas subsidiaries. Association with the Venezuelan NOC has multiplied their downstream earnings, shored up their financial position and considerably simplified their logistical and operational requirements. It is no exaggeration to say that the internationalisation programme has fulfilled these refiners' most sanguine expectations. To appreciate why, one need only consider the response which John Hall, CEO of Ashland Oil, gave when asked about

the possible problems that might obstruct or complicate associations between US refiners and crude-long NOCs:

> the price of raw material is a critical issue for … refiners. Perhaps the best of [all] worlds for a refiner [is] to have some type of margin guaranteed or protected [but] this type of arrangement is not … attractive to producers...[Since] the price of the raw material is the one issue on which the interest of each partner [in a downstream joint venture] is different … [it] could be the biggest source of conflict in the partnership.[10]

This source of conflict, though, has not affected PDVSA's foreign ventures, if only because the Venezuelan NOC has consented to set the price of its crude at a level that makes it very attractive for its partners and subsidiaries to process it.

PDVSA's downstream vertical integration agreements have thus been very favourable for its partners and affiliates, even though the dire financial situation of the former at the time the company's joint venture agreements were signed should have made it easy for the Venezuelan company to extract concessions from *them*, rather than the other way around.[11] The explanation for this lies in the fact that, by means of some very complex and clever financial engineering, PDVSA has been able to use the transfer price system underpinning the profitability of its overseas refining assets in order to increase its discretionary cash flows abroad. PDVSA has invested these cash flows — amounting to approximately USD 10 billion — in yet more overseas refining capacity, with the result that the company has become one of the five largest refining companies in the world. The money used for these acquisitions would otherwise have ended up in the coffers of the Venezuelan government, and there are reasons to believe that the administration of President Chávez may no longer be willing to countenance this situation. For instance, the appointment of general Contreras Maza to the helm of Citgo carried with it the brief of increasing that company's fiscal contributions to Venezuela. PDVSA's most recent refinery acquisitions, as well as its attempts to renegotiate some of its supply contracts, make it quite clear that the company has assumed a more rigid stance towards inter-affiliate discounts than the one it had under previous administrations.[12] The renegotiation of most of PDVSA's contracts to bring them in line with the provisions of the recent HOVENSA contract would undoubtedly result in a narrowing of the price differential between the Mexican and Venezuelan export baskets. However, it is too early to tell whether the initiative of restructuring PDVSA's crude oil supply agreements with its affiliates will be

successful (if it is ever attempted), not least because these agreements are intimately tied up with the debt securities that the company has placed in international financial markets since 1993. Also, there has been no sign of any real change in the problematic nature of the relationship between PDVSA and the Venezuelan government, which is what lies behind the company's predilection for vertical integration and opaque pricing practices.

If PDVSA were to adopt a commercial policy that recognized the great worth of reputation in the deep conversion market segment, the effect of such a change on the general price level in the market would not be very large. In many markets, downstream vertical integration by players seeking a way of achieving security of outlet has often had a very negative effect on price levels because, as McBride found in his investigation of the American cement industry during the 1960s, the integrated manufacturers in effect export low-capacity utilisation rates to non-integrated firms, who can only respond by dropping their prices (thus depressing prices in the whole market).[13] However, even though PDVSA's transfer pricing system certainly induces its affiliates to run more crude and produce more gasoline than if they were buying their feedstock in the open market, the complexity of the company's deep conversion assets in the USGC limits the extent to which they can export large amounts of excess capacity to other refiners in the region anyway.[14] However, the absence of any tangible mobility barriers between the two tiers that constitute the USGC market for heavy sour crude would probably lead, in a reasonably short term, to a substantial improvement in Venezuelan realised prices. In 2000, such an improvement materialised without any change in PDVSA's commercial policy taking place, due to overall market tightness and an increase in the sulphur content penalty. However, if past history is anything to go by, this situation is unlikely to endure for very long. Revamping its commercial policy appears to offer PDVSA the best means to improve its ratio of one good year price-wise in exchange for nine bad ones.

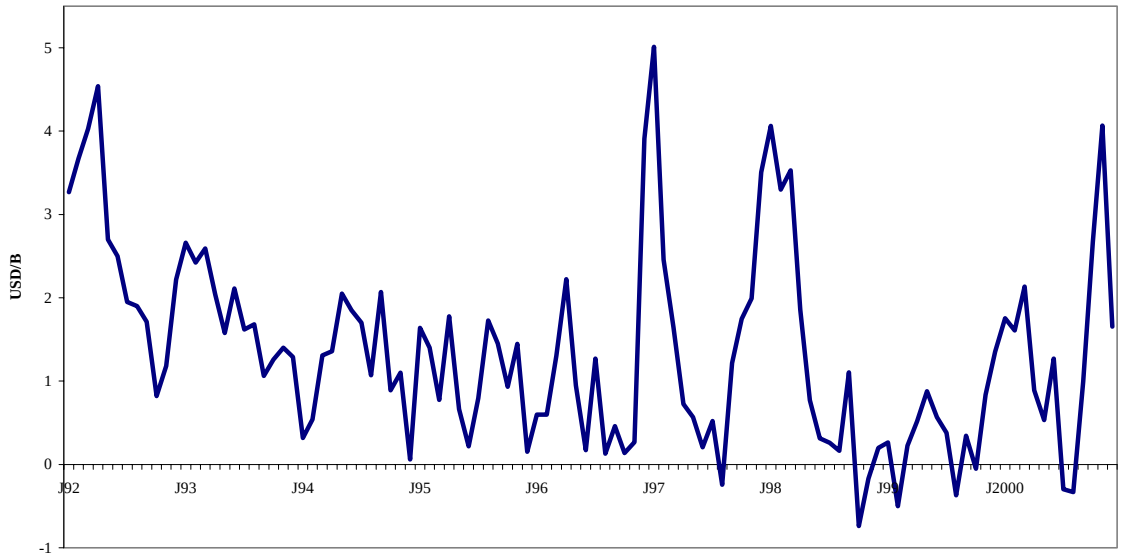
The adoption of more transparent commercial mechanisms by PDVSA would undoubtedly affect PEMEX negatively, because the Mexican NOC would henceforth be forced to share with PDVSA the burden of being a residual supplier to the US market for heavy sour crudes. Nevertheless, in the medium run, this change would probably end up by being beneficial to PEMEX as well, because such a development

would foster the appearance of better signalling mechanisms and channels of communication between the companies, and would also inhibit aggressive undercutting practices. Even though restrained competition appears to be the normal outcome of strategic interaction between duopolists,[15] the ever-present threat posed by heavy volumes originating in the Persian Gulf makes it highly unlikely that PDVSA and PEMEX would be able to engage in explicit price-fixing to the detriment of deep conversion refiners for any length of time. However, the fact that they would be speaking a similar commercial language would certainly make it easier to communicate their intentions and resources unequivocally not only to their customers but also to each other. The latter dimension to the communication process has, for the most part, been lacking in the USGC heavy sour crude market. This is important in a negative sort of way because, as Porter rightly observes, "communicating commitment reduces the uncertainty and causes the players to calculate their rational strategies from new assumption, which avoids warfare".[16] Efficient communication channels and signalling mechanisms to a considerable extent obviate the need for competitors to engage in unsettling moves and countermoves in pursuit of their corporate goals, partly by making it very clear "what moves or events are such that they will provoke a retaliation … even though retaliation may be costly and lead to marginal financial performance".[17] In a word, a repeat performance of the catastrophic form of competition that occurred at the end of 1997 would be made far less likely if there was *mutual recognition* by these companies of their respective *hot buttons* (i.e. "areas of business where a threat will lead to disproportionate response … [because] they reflect strongly held goals, emotional commitments and the like"[18]) as well as the market's *focal points* (i.e. "prominent resting place[s] on which the competitive process can converge its expectations … [and which serve as] natural sticking place[s]"[19] in moments of adjustment).

The years 1999 witnessed some very tight (even inverted) Arab Heavy/Maya price differentials in the USA, as a result of the drive for market share of the Saudi crude (Figure F7.1). Whether this situation will arise once again is possibly one of the most important questions one can ask about the immediate future of heavy sour crude supplies in the USGC area. If it did, it would mean that the PEMEX-PDVSA duopoly would be forced to accommodate an additional member. This could be problematic, not least because as John Kay observes, competitive structures characterised by the

presence of three players of comparable strength are both chronically and acutely unstable.[20] Also, if Saudi Aramco were to adopt a much higher profile role in the deep conversion market, the two incumbent duopolists as well as the Saudi company would be faced with the problem that the behaviour of the entrant will not necessarily conform to the behavioural patterns that have prevailed in this market for the past ten — or more — years, mainly because the entrant may not be aware either of the "well understood conventions of competitive behaviour" or the "simple rule structures in non—verbal communication" (however inefficient) that are characteristic of oligopolies where "competitors have co—existed for any length of time".[21]

FIGURE F7.1: MONTHLY PRICE DIFFERENTIAL BETWEEN ARAB HEAVY AND MAYA CRUDES, DELIVERED IN THE USA (1992—2000)



SOURCES: DOE, PEMEX, MEES

In sum, since 1986, the competitive arrangement in the USGC market for heavy sour crudes has been underpinned by the existence of relatively small amounts of sub-optimised heavy sour processing capacity in the USGC and its area of influence. The apparent stability of this arrangement belies a fragility underscored by the events of 1997—8, when the whole edifice threatened to crumble as deep conversion refiners saw the announced increases in the future supply of heavy sour crude from Mexico, Canada, Venezuela and other sources as heralding a new stage in the evolution of the heavy sour crude market, characterised by ample supplies, very low prices for heavy

products and attractive conversion differentials. Deep conversion refiners, confident that there would be no conjunctural or chronic scarcity of heavy sour grades, took steps to limit their term commitments in order to allow competition between the main sellers to drive the price relentlessly downwards. In the end, the combination of ruinous prices and supply restriction agreements between oil producers ensured that the expected glut did not materialise. In fact, as a result of separate efforts by PDVSA and PEMEX to promote investments in upgrading capacity through their shouldering of the light/heavy differential risk attached to this type of project, demand growth in the deep conversion market segment kept abreast of the effective growth in the supply of heavy sour crude.

PEMEX and PDVSA had an important incentive to overcome the reticence by refiners to commit to further upgrading investment, because the profitability of their own investments in additional heavy sour crude capacity is lower in the absence of an expansion in the aggregate demand for this type of crude. This reticence was due to the poor returns of projects undertaken during the 1980s and early 1990s. Characteristically, the two companies went about solving this problem in diametrically different ways. PVDSA stayed true to its tradition of vertical integration by acquiring shareholding stakes in three US refineries (two of which were to receive grassroots coking plants), for a total outlay of USD 1.7—1.9 billion.[22] PEMEX, for its part, considered that buying refineries abroad would tie up its scarce investment capital (which had alternative uses in more urgent and profitable projects in Mexico), and was thus unwilling and unable to offer refiners equity contributions. However, the company was the only party who knew what the expected Cantarell production profile would look like, and it used this proprietary information to its advantage by offering refiners long-term Maya crude oil supply agreements that incorporated "certain support mechanisms that will protect, under certain adverse market conditions, the investments the purchasers have to undertake in accordance with the agreements".[23] These margin-protection mechanisms, based on the accrual of credits and debits by the parties to the contract (rather than on cash payments by one party to the other), enabled PEMEX to "further [its] strategy to support the export value of Maya crude oil in relation to the value of other grades … by creating incentives for refiners to invest in new high conversion refineries that will be capable of upgrading the relatively large proportion of residue produced from processing

Maya … in less efficient refining configurations".[24] These innovative contracts granted PEMEX exclusive access to the conversion facilities, in a way that gave the company the chance to match the customers' individual margin support requirements with its own production plans, so as to minimise the expected costs of the protection mechanism over the life of the contracts.[25] In other words, by shouldering the risks associated with unfavourable light/heavy differentials, and forfeiting any claim on the profits associated with favourable conversion margins, PEMEX put in place long-term synthetic tolling agreements[26] with these plants (the duration of these contracts is five to eight years, compared to 20 years for the typical PDVSA supply contract with a refining affiliate).[27] Aside from their relatively low expected cost for PEMEX, these contracts also held the attraction that the upgrading plants have been designed *ex-proffesso* to process Maya, a feature that will give the Mexican crude a head start over any potential competitor once the contracts expire.

The efforts by PDVSA and PEMEX to promote the expansion of deep conversion capacity in the USGC crystallised in five projects, intended to add about 750 MBD to heavy sour demand in the USGC upon completion (Table T7.2). The projects were undertaken under the aegis of either traditional joint ventures (as at Deer Park LP and the Merey Sweeny LP) or of long-term supply contracts linked to the construction of new upgrading plants (as at Exxon Baytown, Marathon Garyville and Premcor Port Arthur). Both types of agreements incorporated quite tight construction schedules, financial penalties for unjustifiable delays and onerous exit clauses. PDVSA and PEMEX were also behind a number of coking projects located in the vicinity of the USGC, which will have a significant impact on the supply/demand balance in this refining centre. Coastal's project at the former Exxon refinery in Aruba was promoted by PEMEX through a long-term contract similar in conception and operation to those for the Baytown, Garyville and Port Arthur refineries. The HOVENSA project, in turn, was underwritten by PDVSA and Amerada Hess, who constituted a partnership to own and operate the latter's huge refinery in the US Virgin Islands. Finally, PEMEX undertook the reconfiguration of two of its refineries in Mexico with coking plants with the threefold objective of reducing imports of petroleum products, enhancing the quality for diesel and gasoline to meet new environmental standards, and ramping up domestic processing of heavy sour crudes without substantial increases in distillation capacity.

Table T7.2: Additions to Heavy Sour Crude Deep Conversion Capacity in the USGC and its Area of Influence, 2000—2002 (MBD)

Company	Location	Additional Heavy Sour Crude Capacity		Start-up date
		Coking	Distillation	
USGC				
Deer Park Refining LP	Deer Park, Texas	25	70	July 2001
Exxon Mobil Corp.	Baytown, Texas	40	109	July 2001
Marathon Ashland LLC	Garyville, Louisiana	35	90	October 2001
Phillips 66 Co.	Sweeny, Texas	58	165	December 2000
Premcor Inc.	Port Arthur, Texas	80	170	January 2001
Non-USGC				
Coastal Aruba Refining Co. N.V.	San Nicolás, Aruba	30	100	May 2000
HOVENSA LLC	St. Croix, US Virgin Islands	58	115	April 2002
Petróleos Mexicanos	Cadereyta, Mexico	50	100	June 2000*
	Ciudad Madero, Mexico	46	100	December 2001*

* Both of these projects have suffered very significant delays

In coming years, the USGC market may yet witness a far greater degree of informal cooperation between PDVSA and PEMEX and possibly other NOCs — Saudi Aramco and KPC — regardless of whether there is convergence in the commercial policies of all these companies. The uncertainties regarding future production of heavy sour crudes are still seen by refiners as being too high. Therefore, it is safe to assume that demand in the deep conversion market segment will only continue to grow if producing country interests are willing to absorb a substantial part of the risk attached to upgrading projects, in order to leverage the profitability of their own upstream investments. Large NOCs are in a favourable position to shoulder this type of risk on their own, because their possession of confidential information related to their future production profiles translates into significant economies in observing and forecasting the behaviour of the light/heavy price differential.[28] However, the costs associated with the absorption of these risks will be much lower for all NOCs involved if they act in unison, rather than in isolation. Such cooperation goes against the "every oil exporting country for itself" ethos that has prevailed in the oil market between 1986 and 1998. However, one can only hope that the catastrophic collapse of 1998 and the surprising recovery of 1999-2001 have shown major producers, once

again, that there is far more to be gained than lost in cooperation. After all, the history of the oil industry teaches that, if oil rent is not to be dissipated as consumer surplus, some form of cooperation between producers is not only desirable but inevitable. All oil exporting countries ignore this lesson at their peril but, relatively speaking, the potential losses attached to non-cooperative outcomes are even more serious for those whose production consists mainly of heavy sour crudes.

NOTES

[1] Porter 1980: 121.
[2] *Ibid.*
[3] Kay 1993: 14.
[4] *Ibid.*: 113. The overwhelming competitive advantage of PDVSA and PEMEX relative to smaller producers of heavy sour crude is based upon strategic assets; namely, very prolific oilfields.
[5] *Ibid.*: 163—4
[6] *Ibid.*: 164. Polanyi (1962: 51—5) can be profitably consulted to appreciate the importance not only of the idiosyncratic capabilities and knowledge that firms build through time but also of the communication codes and routines that it employs in its dealings with customers.
[7] Porter, *ibid.*: 4.
[8] PDVSA data from its 2000 20-F form submitted to the SEC. PEMEX data from the company's 2001 *Statistical Annual*.
[9] This cross-referencing exercise can only cover up to 1997, because some of the figures necessary to carry it out ceased to be available after this date as aresult of changes in PDVSA's statistical reporting procedures.
[10] *IPF*, 17 October 1988: 4—5.
[11] For instance, when Southland entered into its joint venture agreement with PDVSA, it exchanged its existing Citgo shares for 1000 shares of common stock Class A and 1000 shares of common stock Class B, and then sold to PDVSA all the Class A common stock. Surprisingly, only Class B stock could vote "on disputes related to a crude supply agreement" (disputes which were of great concern for PDVSA), while Class A stock only voted "on disputes related to [the] product purchase agreement" (Citgo 1986: 20).
[12] For instance, the price of Merey crude oil for the HOVENSA joint venture is to be "set according to a pricing formula indexed to the market price of Maya crude oil, adjusted for quality and commercial factors, less a fixed competitive allowance of $0.20 per barrel". Through the euphemisms, one can see that this formula still incorporates a discount, but it is smaller by an order of magnitude than the one in the company's previous inter—affiliate supply agreements. See HOVENSA 1999: 10.
[13] McBride 1983: 1021.
[14] This has not been the case in the asphalt segment, however, where PVDSA's generous transfer pricing has had a disastrous effect on competitors of Citgo Asphalt.
[15] For an interesting example of this see Rees 1998: 249—65.
[16] Porter, *ibid.*: 100.
[17] *Ibid.*: 68.
[18] *Ibid.*
[19] *Ibid.*: 106.
[20] Kay notes that such a competitive structure gives rise to games "which [have] no Nash equilibria", which means that players "are condemned to endless, indecisive jockeying for position". Kay also says that, "intriguingly, instability is particularly a problem of threesomes. As the number of players increases, so does the probability of a stable outcome" (Kay, *op. cit.*: 244).

[21] *Ibid.*: 236. As Porter remarks, “a problem leading to instability in oligopoly is in coordinating the expectations of competitors about what the eventual market outcome will be. To the extent that competitors have divergent expectations, jockeying will … occur and the prospect of outbreaks of warfar is likely” (*op. cit.*: 105—6). This sort of problem may also arise, incidentally, if KPC manages to increase its market share in the USGC segment for deep conversion crudes in a significant fashion.

[22] PDVSA paid Mobil USD 270 million for a 50 per cent stake in the Chalmette refinery. PDVSA will also defray half the cost (269 MMUSD) of building a coker at Phillips' Sweeny refinery. Additionally, in exchange for a 50 per cent stake in the St. Croix refinery, the Venezuelan company agreed to pay Amerada Hess USD 62.5 million in cash, plus a USD 562.5 million secured note payable with interest over ten years, plus a USD 125 million note whose payment is contingent on the refinery's future cash flows. Finally, through HOVENSA, PDVSA will also need to contribute about USD 500 million for the construction and financing of the new coker at the St. Croix refinery.

[23] PEMEX 20-F 1999: 25. In the case of the Port Arthur project, for instance, PEMEX offered Premcor a mechanism "designed to moderate the fluctuations of [Port Arthur's] coker gross margin, which is the differential between the price for intermediate refined products from [the project's] coking operations and the cost of coker feedstocks. This mechanism is based on a formula that is intended to be an approximation for coker gross margin and is designed to provide for a minimum average coker gross margin over the first eight years following completion of the Refinery Upgrade Project" (Port Arthur 1999: 3, and 65—74 for the formula in question and other aspects of the long-term supply contract). It should also be mentioned that, *in addition* to PDVSA's equity contributions to HOVENSA LLC and Merey Sweeny LP, the crude supply contracts for both of these joint ventures also include similar protection provisions.

[24] PEMEX 20-F 1999: 25.

[25] See Port Arthur 1999: B-20.

[26] In financial terms, synthetic positions are created by buying and selling instruments in a way that their joint profit and loss profile mimics that of another instrument. For instance, purchasing a call option and selling a put option with the same strike prices is equivalent to going long a futures contract (but generating income, instead of an expenditure). In the same way, the long-term PEMEX contracts mimic the claims on a refiner’s capacity that a tolling agreement gives to the party that wants to run crude through a given plant, but in a way that does not involve the payment of a tolling fee for every barrel processed.

[27] As the independent engineering auditors to the Port Arthur project put it, "the parties to the [PEMEX] Contract have chosen an appropriate level for the margin protection which should not put unfair pressure on [PEMEX] over an extended period of time … [since] the basic intent of the [PEMEX] Contract is only to minimize adverse cycle risk to secure adequate cash flow for debt service obligations. It is not structured as a permanent subsidy for oil purchases" (*ibid.*: B-21), unlike the contracts that support the operations of PDVSA's overseas refining affiliates.

[28] In Canada, for instance, the upstream sector is very atomised in comparison to that of Mexico or Venezuela, so producers of heavy sour crude and bitumen in this country have les of an advantage in forecasting the behaviour of the light/heavy price differential than NOCs of major exporting countries. This could be counteracted if they were to pool their production and market it as a single consortium. Such a consortium would be able to offer margin protection mechanisms similar to those embedded in the contracts that PEMEX and PDVSA struck with USGC refiners. This would be a way of fostering the growth of aggregate demand for bitumen-based Canadian heavy sour crudes in PADD II that would not involve the construction of upgraders in Canada. In addition, it would probably be an effective instrument to counteract the considerable market power of some buyers of Canadian heavy sour crude (notably Koch and BP). However, it is unclear whether the establishment of such a consortium would run afoul of antitrust legislation.

APPENDIX I: APPLICATION OF COMPETITIVE EQUIVALENCE PRINCIPLE TO DESIGN A PRICING FORMULA

The following is an example of the economic rationale behind public pricing formulae. It shows how a formula for Maya crude could be designed on the basis of three crudes (one Nigerian, one Iraqi and one Egyptian) chosen at random. As can be appreciated, if one were to refine .1925 barrels of each one of these crudes in a hydroskimming configuration (according to the yields obtainable in the Mediterranean area), and then add .4036 barrels of residual fuel oil to the resulting mix, the product yield of this synthetic barrel would be reasonably similar to that which would be obtained by processing one barrel of Maya at this refining centre. The only significant difference in product quality and yield would lie in the sulphur content of the residual fuel oil yield. In order to compensate for this factor, the hypothetical formula would have to incorporate a sulphur penalty (whose value would be determined by the price of the diluent that one would have to add to the Maya fuel oil to reduce its sulphur content to a level comparable to that of the fuel oil produced from the synthetic barrel).

TABLE TAI.1: Hypothetical Pricing Formula for Maya Crude

	Product yields (in percentages)						
Product	*Bonny Light*	*Kirkuk*	*Suez Blend*	*Low sulphur fuel oil*	***Basket***		***Maya***
LPG	1.70	1.06	1.06		0.74		0.61
Premium gasoline	16.23	9.41	6.83		6.25		5.09
Regular gasoline	7.00	9.29	6.72		4.43		5.84
Naphtha	4.17	7.43	5.00		3.20		4.50
Jet	7.50	10.43	7.00		4.80		0.67
Diesel	29.05	23.50	27.00		15.32		18.02
Fuel oil	31.97	35.34	42.75	40.36	61.55		61.55
Weight in formula	0.1925	0.1925	0.1925				
Fuel oil sulphur content	0.22	2.20	2.40	1.00	1.35	≠	4.37

Yields in a hydroskimming configuration in the Mediterranean

APPENDIX II: MAYA PRICING FORMULAE FOR THE USGC

Since the introduction of public pricing formulae by PEMEX in 1986, there have been a total of four formulae for Maya sales to the USA (excluding the West Coast). These formulae are as follows:

From 15/02/1986 to 31/07/1989

MAYA = 0.21(WTI+WTS+ANS) + 0.37(FO6 3%) - 0.28(FO6 1% - FO6 3%) + K

From 01/08/1989 to 30/04/1990

MAYA = 0.33 (WTS + ANS) + 0.335 (F.O.6 3%) + K

From 01/05/1990 to 31/03/1996

MAYA = 0.246 WTS + 0.147 ANS + 0.099 (LLS + BRENT) + 0.394 F.O.6 3% + K

From 01/04/1996 to date

MAYA = 0.40(WTS+FO No.6 3%) + 0.10(LLS+BRENT) + K

WHERE:

ANS: Alaska North Slope 1st Month, CIF Gulf
BRENT: Dated Brent Blend, FOB Sullom Voe
LLS: Light Lousiana Sweet, FOB St. James (La.)
WTI: West Texas Intermediate, First Month, at Cushing (Okla.)
WTS: West Texas Sour, First Month, Midland (Tx.)
FO6 1%: Low Sulphur Fuel Oil, Waterborne USGC
FO6 3%: High Sulphur Fuel Oil, Waterborne USGC
K: Monthly adjustment factor, as determined by PEMEX
Platt's Crude Oil Market Wire price data are used to compute these formulae.

The decision to eliminate WTI from the Maya pricing formula was taken in response to concerns expressed by clients in the sense that this crude had a great propensity to become de-linked from the world oil market at large, mainly due to infrastructural constraints in the pipeline systems linking the USGC with the US Midcontinent. Dated Brent was added to the formula to pick up the interactions between US domestic crudes and transatlantic imports, while the inclusion of LLS was prompted by its suitability to serve as a proxy for a number of imported waterborne crudes. The elimination of ANS came as a result of *Platt's* decision to suspend the quote for ANS in the Gulf Coast, itself the product of the effective disappearance of the spot market for this crude outside of California in the wake of the lifting of the export ban on this crude.

APPENDIX III: DERIVATION OF *A PRIORI* INPUTS FOR A BAYESIAN QUALITY ADJUSTMENT MODEL

Liliana Figueroa

This model seeks to identify the influence of certain regressors (notably quality indicators and transportation costs) on the price of individual crude oils. The parameters thus obtained were used as *a priori* inputs for the Dynamic Linear Quality Adjustment Model (see below), as were the variances obtained from running this classical time series analysis model. The crudes used in the estimation of the parameters of the model were waterborne sour crudes imported into the USGC region, whose pricing is seen as being reasonably transparent and consistent. These crudes are: Maya, Isthmus, Vasconia, Caño Limón, Arab Heavy (ARH) and Arab Medium (ARM). The following set of equations was constructed:

$$
\begin{cases}
\mathbf{Vasconia}_t = \alpha \times \mathbf{WTS}_t + \beta \times 27.29 + \gamma \times \mathbf{0.64} + \psi \times \mathbf{LH}_t + \lambda \times \mathbf{TVasconia}_t + Z_{1t} \\
\mathbf{Caño\,L}_t = \alpha \times \mathbf{WTS}_t + \beta \times 29.70 + \gamma \times \mathbf{0.50} + \psi \times \mathbf{LH}_t + \lambda \times \mathbf{TCaño\,L}_t + Z_{2t} \\
\mathbf{Maya}_t = \alpha \times \mathbf{WTS}_t + \beta \times 21.80 + \gamma \times 3.33 + \psi \times \mathbf{LH}_t + \lambda \times \mathbf{TMaya}_t + Z_{3t} \\
\mathbf{Isthmus}_t = \alpha \times \mathbf{WTS}_t + \beta \times 33.40 + \gamma \times \mathbf{1}.25 + \psi \times \mathbf{LH}_t + \lambda \times \mathbf{TIsthmus}_t + Z_{4t} \\
\mathbf{ARH}_t = \alpha \times \mathbf{WTS}_t + \beta \times 27.40 + \gamma \times \mathbf{2}.80 + \psi \times \mathbf{LH}_t + \lambda \times \mathbf{TARH}_t + Z_{5t} \\
\mathbf{ARM}_t = \alpha \times \mathbf{WTS}_t + \beta \times 28.60 + \gamma \times \mathbf{2}.81 + \psi \times \mathbf{LH}_t + \lambda \times \mathbf{TARM}_t + Z_{6t} \\
Z_{it} = \rho_i \times Z_{i(t-1)} + e_t; \qquad i = 1,...,6
\end{cases}
$$

WHERE:

β and γ are the parameters that weigh the main determinants of quality (API gravity and sulphur content, respectively) for each crude and

λ is the parameter which adjusts for transportation costs.

The estimation was carried out through the method of three stage least squares, so as to adjust for possible correlations between the explanatory variables and the error terms. The instrumental variables used were the price quotes for various qualities of motor gasoline, heating oil/diesel and residual fuel oil in the USGC. The results of the estimation are expressed in the following pair of equations:

$$\begin{cases} 1. \\ p_t = \underset{(19.69)}{0.97} \times WTS_t + \underset{(3.11)}{0.10} \times API - \underset{(-5.88)}{1.15} \times \%S - \underset{(-2.31)}{0.16} \times LH_t - \underset{(-2.88)}{1.19} \times Transport_t + Z_t \\ \\ 2. \\ Z_t = 1.07 \times Z_{t-1} + e_t; \end{cases}$$

The model is estimated in such a way that each equation can correct for auto-correlation in a slightly different way, but the differences in the estimation of the parameters ρ_i were not large. The average of the estimates of these parameters (ρ=1.07) is shown in equation 2, above. The variability explained by the model for the crudes used in the estimation process was 98 per cent. The degree of fit of the classical model, without taking into consideration corrections for auto-correlation, was 96 per cent.

APPENDIX IV: A DYNAMIC LINEAR QUALITY ADJUSTMENT MODEL FOR CRUDE OIL PRICES IN THE USGC

Liliana Figueroa

The Bayesian analysis of time series approach was chosen to study the different pricing mechanisms of PEMEX and PDVSA because of its theoretical foundations (beliefs and the uncertainty surrounding them can be represented by probability distributions), and its dynamic nature. Under this method, and given all the available information, an individual represents his views about the present by a subjective probability model, observes certain outcomes or data, and is then able to update his beliefs under the laws of probability (Bayesian paradigm) and make inferences about the future. Represented mathematically, this is:

- $(Y \mid \theta)$ ~ is the probability distribution of the random quantity Y given a vector parameter θ
- $\theta \sim p(\theta)$ is the prior distribution of the vector parameter θ, which represents our prior knowledge (beliefs) about the parameter
- $p(y, \theta) = p(y \mid \theta)\, p(\theta)$ is the joint distribution
- $p(y) = \int_{\Theta} p(y \mid \theta)\, p(\theta)\, d\theta$, $\theta \in \Theta$ is the forecasting distribution of Y
- $p(\theta \mid Y=y) = p(y, \theta) / p(\theta)$ is the updated (posterior) distribution of θ.

A strong feature of the family of Dynamic Linear Models is that forecasting and updating results for the Normal model are valid under weak assumptions, i.e. when no distributional form is assumed, and only the first 2 moments (mean and variance) of the probability distribution have to be established. Therefore, the lack of knowledge about the distributional form of crude oil prices or parameters considered in the model does not limit the analysis.

The model used to compare the pricing mechanisms of PEMEX and PDVSA is a Simple Regression Discount Dynamic Linear Model or DDLM $\{\mathbf{F}_t, \mathbf{I}, V_t, \boldsymbol{\delta}\}$ with unknown variance V_t. The form of the model is:

observation equation: $Y_t = \mathbf{F}_t'\boldsymbol{\theta}_t + \nu_t, \quad \nu_t \sim (0, V_t)$

system equation: $\boldsymbol{\theta}_t = \boldsymbol{\theta}_{t-1} + \mathbf{w}_t, \quad \mathbf{w}_t \sim (\mathbf{0}, \mathbf{W}_t)$

information: $(\boldsymbol{\theta}_{t-1} \mid D_{t-1}) \sim (\mathbf{m}_{t-1}, \mathbf{C}_{t-1})$

with

Y_t the crude price at time *t*,

$\mathbf{F}_t'=(WTS_t, API_t, \%S_t, transport_t)$ - a known regression vector at time *t*,

$\boldsymbol{\theta}_t'=(\theta_{1,t}, \theta_{2,t}, \theta_{3,t}, \theta_{4,t})$ - the parameter vector at time *t*,

ν_t the observation noise, with mean zero and unknown variance V_t,

$\mathbf{w}_t$ the system noise vector, with mean $\mathbf{0}$ and system variance $\mathbf{W}_t$,

D_{t-1} is all the available information (or knowlegde) up to time *t-1*

The observation equation represents the influence each of the quantities in $\mathbf{F}_t$ has on the expected price $E(Y_t \mid \mathbf{F}_t'\boldsymbol{\theta}_t) = \mathbf{F}_t'\boldsymbol{\theta}_t$. It includes a random noise term that affects only the observation. Therefore, the observation equation is of the form

$$Y_t = WTS_t \times \theta_{1,t} + API_t \times \theta_{2,t} + \%S_t \times \theta_{3,t} + transport_t \times \theta_{4,t} + \nu_t, \quad \nu_t \sim (0, V_t)$$

The unknown variance V_t is estimated through a discount dynamic model with point estimate $S_0=4$, $n_0=2$ degrees of freedom (as a measure of precision of the estimate) and a discount $\delta_v=0.9$.

The system equation represents the way in which the parameters evolve, i.e. the dynamic behaviour of the influence of the benchmark WTS, the gravity, sulphur content and transportation costs on the FOB price. In this case it is assumed that these parameters follow the simple process of behaving as they did in the previous month but with some random perturbation. The system variance matrix $\mathbf{W}_t$ is specified

through its discount characterisation. A constant discount of δ=0.95 is chosen for the regression components, indicating a great durability for the quantitative model.

To complete the specification of the model, the priors for the parameters were set as:

$$(\theta_{1,0} \mid D_0) \sim (0.96, 0.04^2)$$
$$(\theta_{2,0} \mid D_0) \sim (0.06, 0.04^2)$$
$$(\theta_{3,0} \mid D_0) \sim (-1.15, 0.20^2)$$
$$(\theta_{4,0} \mid D_0) \sim (-1.00, 0.20^2)$$

The prior means were set according to the results generated by the classical model described in Appendix III above. The variances represent the uncertainty surrounding these estimates: a small variance indicates a precise estimate, while a large variance indicates either ignorance or lack of confidence in the estimate.

With this setting, the prices of both the Mexican and Venezuelan export baskets to the USA were dynamically fit, in a retrospective fashion (this method uses all the available information for the whole period under consideration - except for the observation estimate at each time *t* – and should be distinguished from the so-called on-line method, which only uses information available *before* each time *t*). Figures FAIV.1 and FAIV.2 show the price estimates for both baskets, and their relationship with observed prices, using the Mexican retrospective regression coefficients. Figures FAIV.3 and FAIV.4 show the price estimates for both baskets, and their relationship with observed prices, using the Venezuelan retrospective regression coefficients. It is important to note that the fit is good for both baskets, as the algorithms are actually designed to learn from the data. This can be more clearly observed in the price estimates for the Venezuelan basket, which show a poor fit in the first months (due to the prior settings) but then gradually adapt to the behaviour of the system.

Figures FAIV.5 through FAIV.12 show the retrospective regression coefficients for both the Mexican and Venezuelan baskets. It is clear from these graphs that the price of the Venezuelan basket is more strongly penalised on account of its sulphur content and transportation cost than the Mexican basket. By the same token, every additional API degree translates into a 0.06USD/B price increase for the Mexican basket, but

only 0.03USD/B for the Venezuelan one. Finally, the price of Venezuelan crude increases less than the price of Mexican crude when the price of WTS increases (and viceversa).

FIGURE FAIV.1: OBSERVED AND ESTIMATED PRICES FOR THE MEXICAN CRUDE EXPORT BASKET TO THE USA, CALCULATED WITH MEXICAN RETROSPECTIVE REGRESSION PARAMETERS (1992—2000)

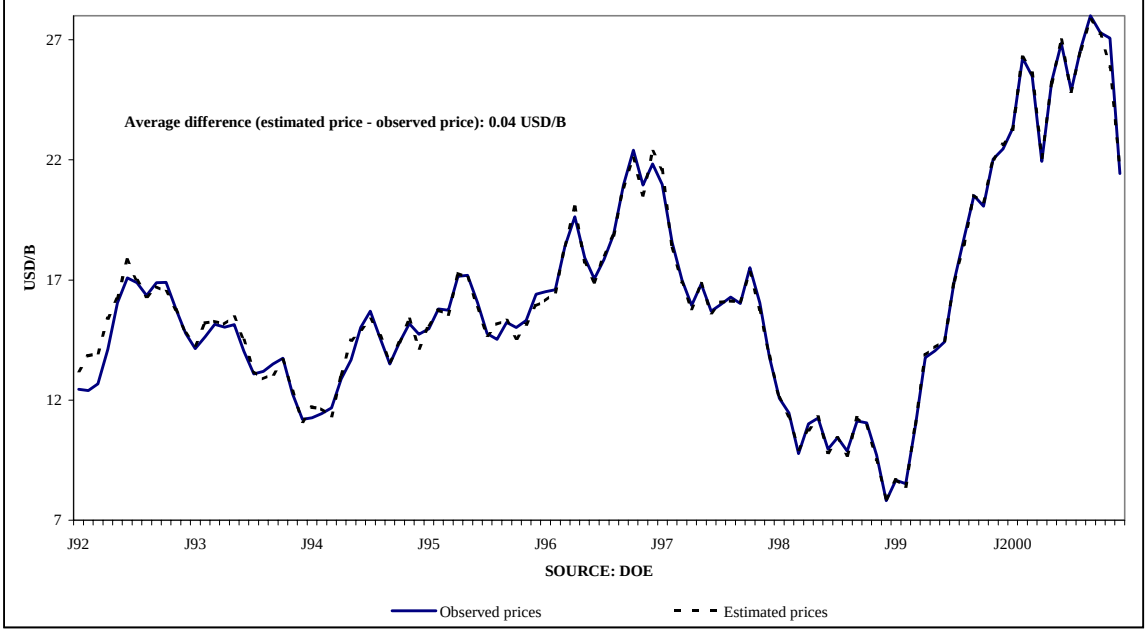


FIGURE FAIV.2: OBSERVED AND ESTIMATED PRICES FOR THE VENEZUELAN CRUDE EXPORT BASKET TO THE USA, CALCULATED WITH MEXICAN RETROSPECTIVE REGRESSION PARAMETERS (1992—2000)

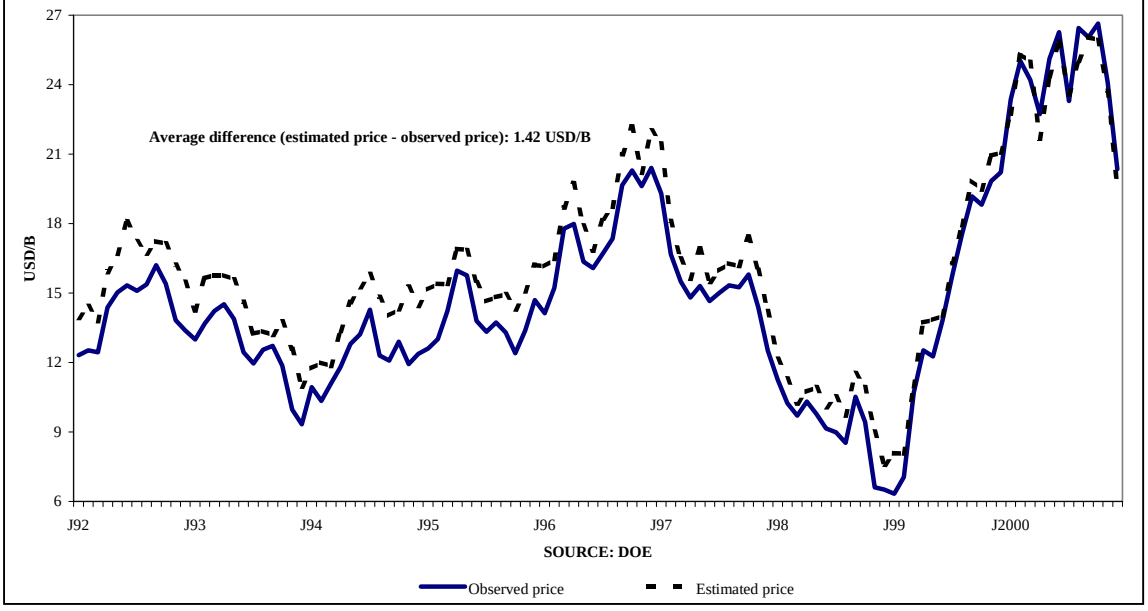


FIGURE FAIV.3: OBSERVED AND ESTIMATED PRICES FOR THE MEXICAN CRUDE EXPORT BASKET TO THE USA, CALCULATED WITH VENEZUELAN RETROSPECTIVE REGRESSION PARAMETERS (1992—2000).

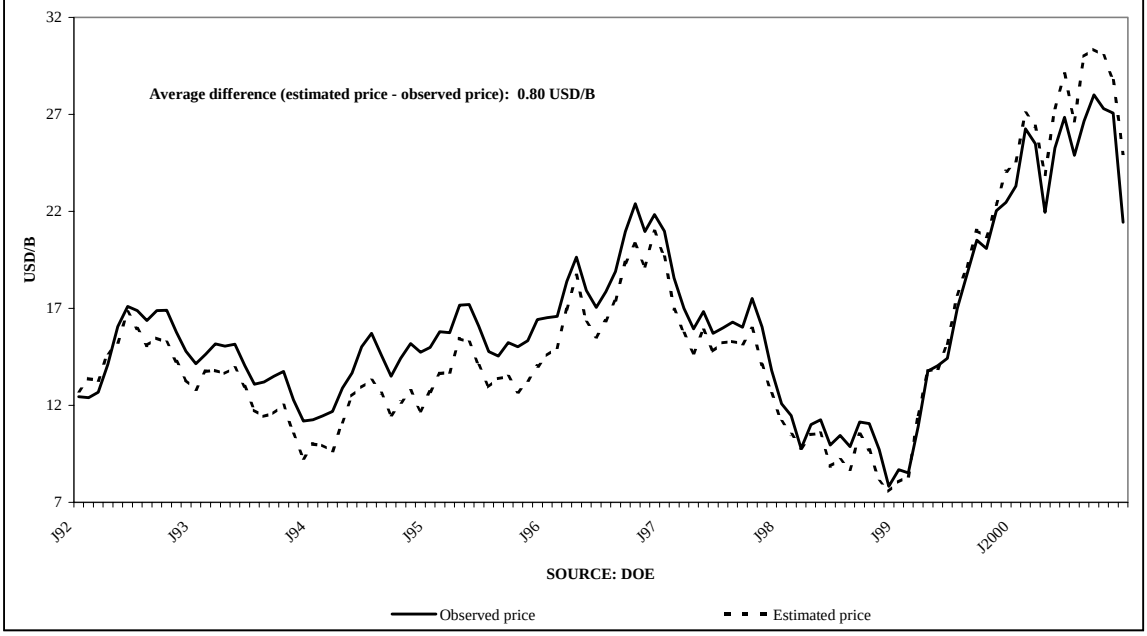


FIGURE FAIV.4: OBSERVED AND ESTIMATED PRICES FOR THE VENEZUELAN CRUDE EXPORT BASKET TO THE USA, CALCULATED WITH VENEZUELAN RETROSPECTIVE REGRESSION PARAMETERS (1992—2000).

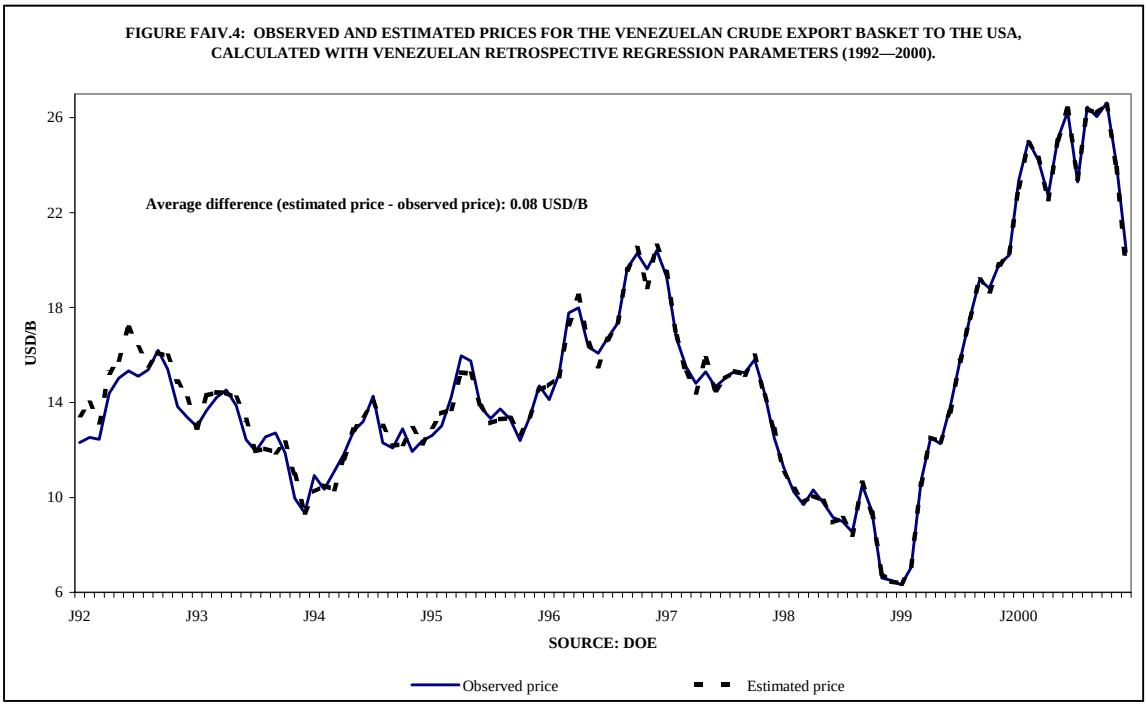


FIGURE FAIV.5: EVOLUTION OF THE MEXICAN RETROSPECTIVE REGRESSION PARAMETER FOR WTS PRICE (1992—2000).

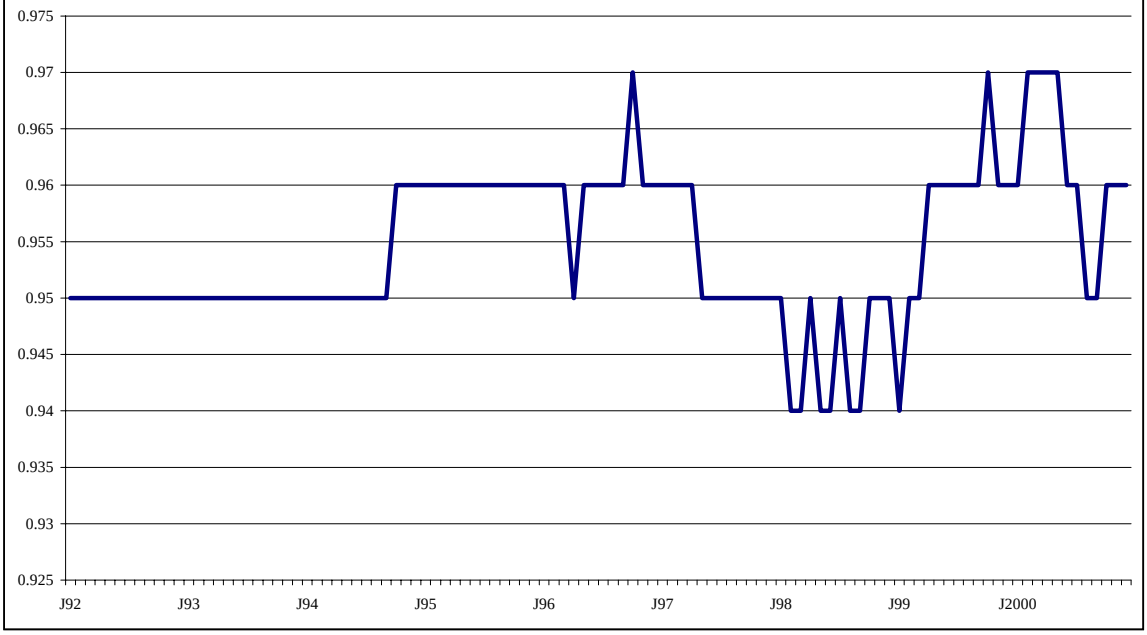


FIGURE FAIV.6: EVOLUTION OF THE MEXICAN RETROSPECTIVE REGRESSION PARAMETER FOR API GRAVITY (1992—2000).

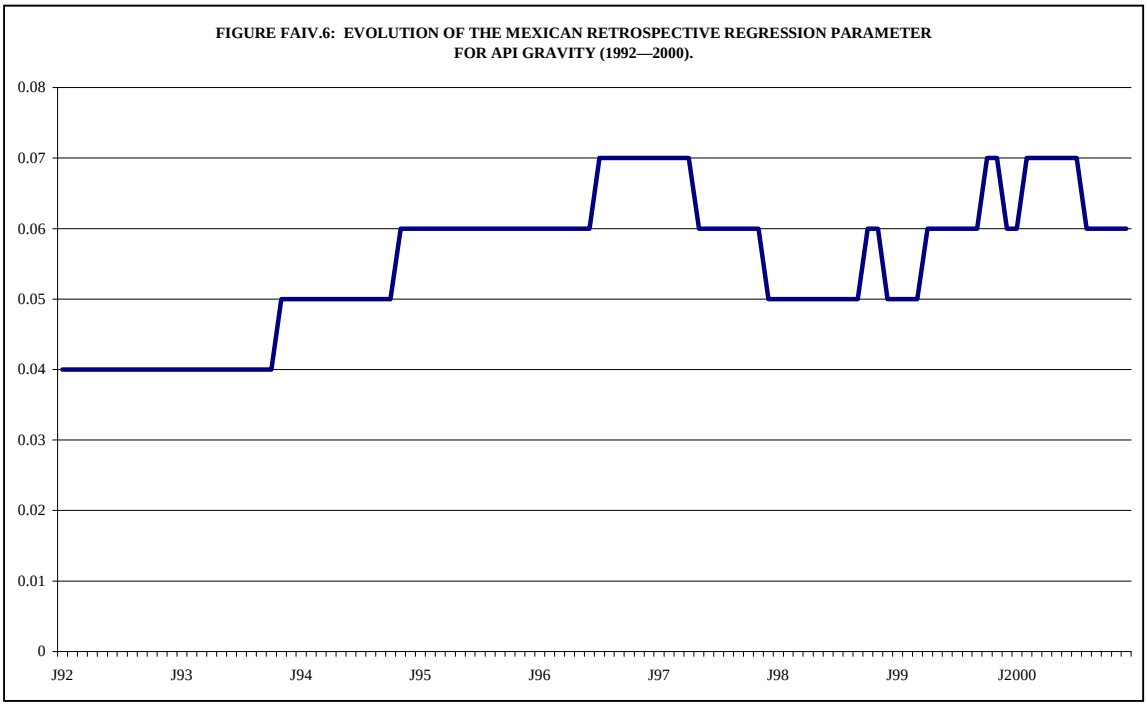


FIGURE FAIV.7: EVOLUTION OF THE MEXICAN RETROSPECTIVE REGRESSION PARAMETER FOR SULPHUR CONTENT (1992—2000).

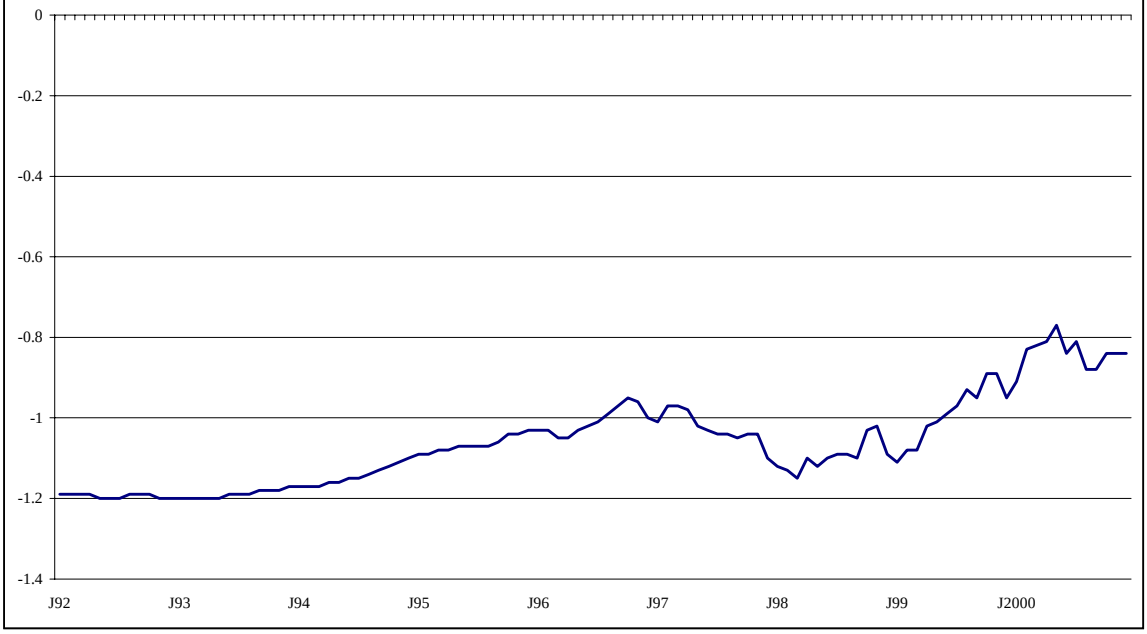


FIGURE FAIV.8: EVOLUTION OF THE MEXICAN RETROSPECTIVE REGRESSION PARAMETER FOR TRANSPORTATION COSTS (1992—2000).

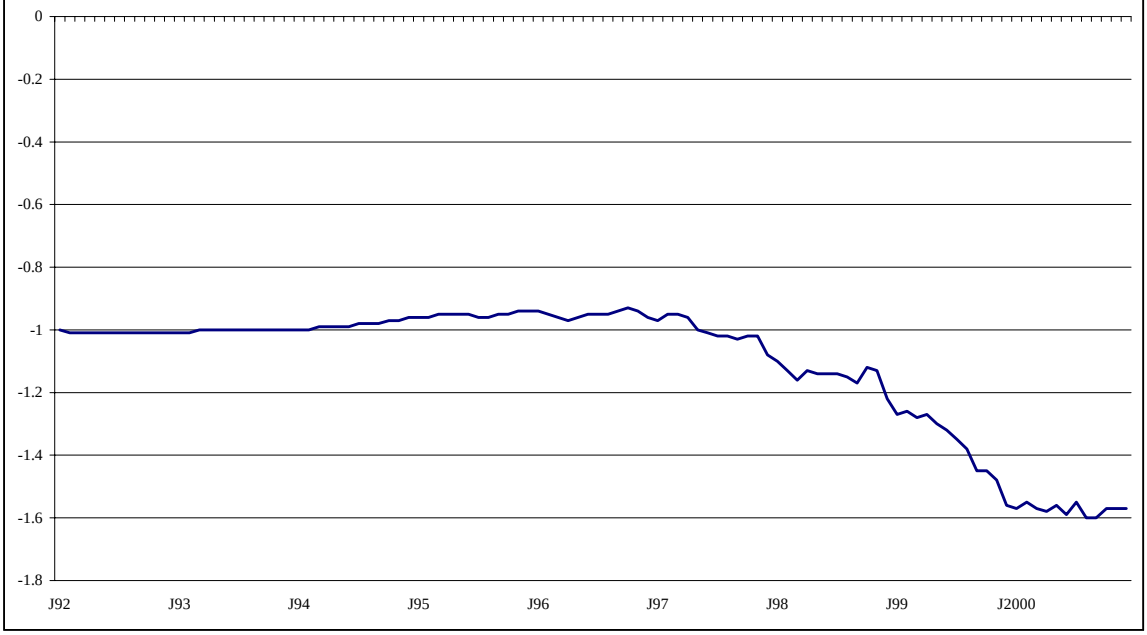


FIGURE FAIV.9: EVOLUTION OF THE VENEZUELAN RETROSPECTIVE REGRESSION PARAMETER FOR WTS PRICE (1992—2000).

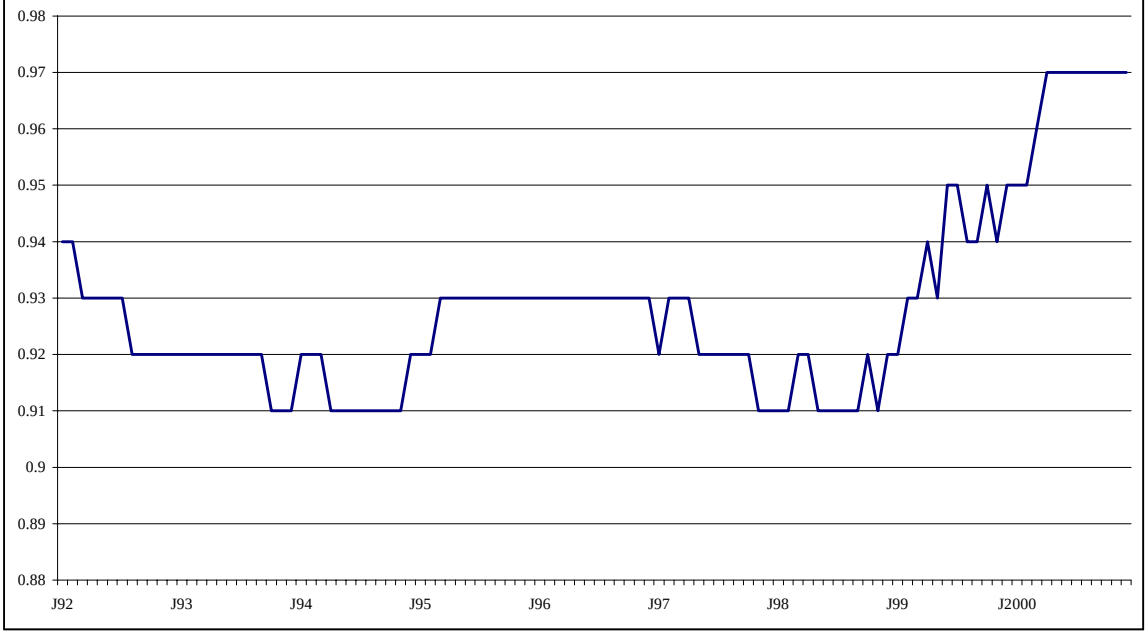


FIGURE FAIV.10: EVOLUTION OF THE VENEZUELAN RETROSPECTIVE REGRESSION PARAMETER FOR API GRAVITY (1992—2000).

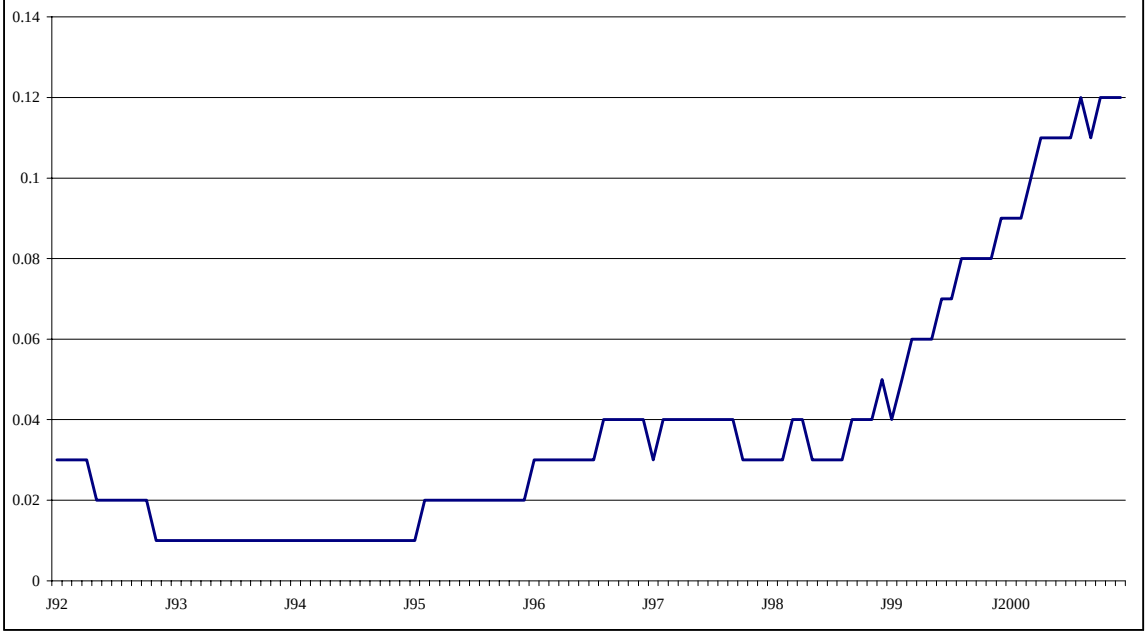


FIGURE FAIV.11: EVOLUTION OF THE VENEZUELAN RETROSPECTIVE REGRESSION PARAMETER FOR SULPHUR CONTENT (1992—2000).

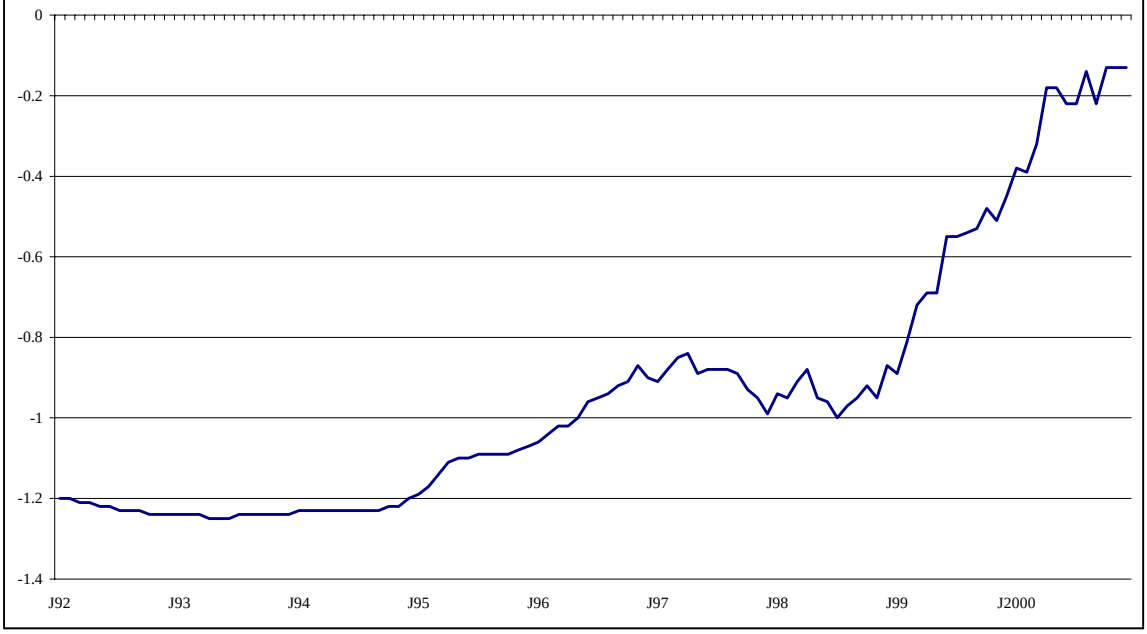
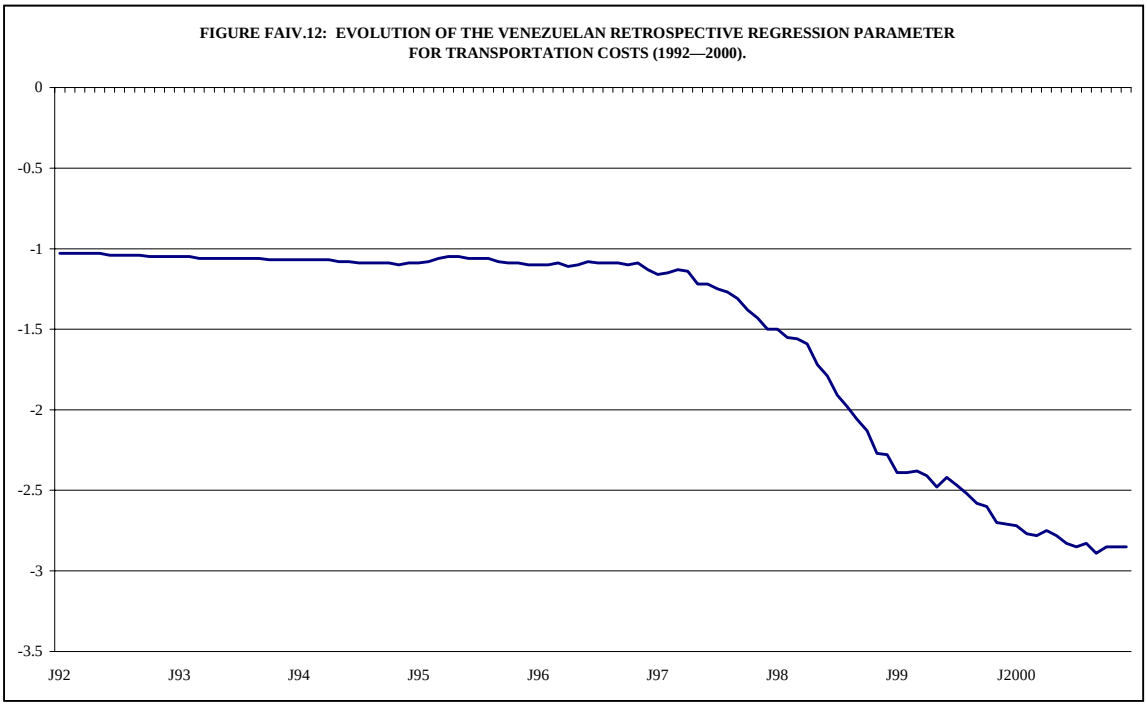


FIGURE FAIV.12: EVOLUTION OF THE VENEZUELAN RETROSPECTIVE REGRESSION PARAMETER FOR TRANSPORTATION COSTS (1992—2000).



In order to check for the soundness of these findings, dynamic fits for a number of other crude grades (LLS, WTS, the Nigerian export basket to the USA, ARH, ARM, Maya, Isthmus) were performed, using both the Mexican and the Venezuelan coefficients. Table TAIV.1 shows the results of this exercise for a selection of this

control group: LLS and the Nigerian export basket to the USA. As can be appreciated, the estimation of prices under the dynamic models with the Venezuelan coefficients leads to this control group of crudes being discounted to a significant degree relative to their observed prices. In contrast, when the prices of these control crudes are estimated with the Mexican coefficients, estimated prices coincide far more closely with observed prices. These results strongly confirm the finding that Venezuelan crude oil exports to the USA have been consistently underpriced, and by a considerable margin.

Table TAIV.1: Results of Dynamic Fits for the Prices of Selected Crudes (1992—2000)

	Crude	***A*** *Observed price (USD/B)*	***B*** *Estimated price (USD/B)*	*Difference (A-B)*
Mexican coefficients	LLS, FOB St. James	20.20	19.83	0.37
	Nigerian export basket to the USA	18.88	18.29	0.59
Venezuelan coefficients	LLS, FOB St. James	20.20	18.74	1.46
	Nigerian export basket to the USA	18.88	16.82	2.06

SOURCES: DOE, *Platt's*

APPENDIX V: MODEL OF PRICE LEADERSHIP BASED ON CONSUMER LOYALTY IN A DUOPOLISTIC SETTING

Liliana Figueroa

The model assumes the existence of a duopoly with no possibility of market entry for further sellers. Production costs are zero, output is totally perishable and cannot be stored. The model also assumes that there are only three types of clients: n_1 clients who are loyal to the first duopolist, n_2 clients who are loyal to the second duopolist and m clients who have no discernible preference for either. In terms of the clients' preferences, the first set of clients will buy a unit from the first duopolist if the selling price is equal to or less than a price r; if the selling price is higher than r, these clients will not buy from any other company. The behaviour of the second set of clients goes along the same lines but with purchases from the second duopolist. Finally, the third set of clients will buy from whomever offers the lowest price, as long as this price is equal or less than r. The model assumed that companies only need to consume one barrel of crude and that the sole determinant behind their purchasing decision was not quality, but the commercial relationships that they maintained with the sellers.

In the model, the profits of company i are determined thus:

$$\pi_i(p_i, p_j) = \begin{cases} L_i(p_i) = (n_i + m)p_i; & p_i < p_j \\ T_i(p_i) = (n_i + I_f^i)p_i; & p_i = p_j \\ H_i(p_i) = n_i p_i; & p_i > p_j \end{cases}$$

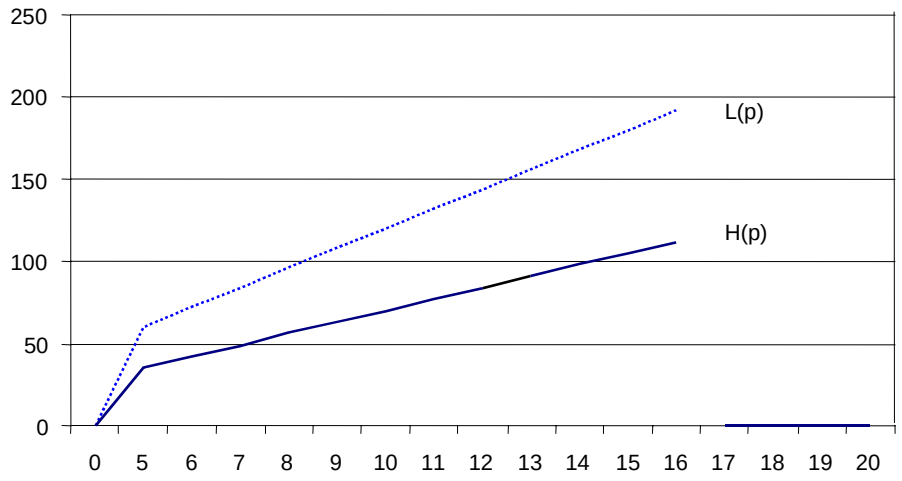
where I_f^I is a variable that will take a value of 1 if company i is a market follower, and 0 if the company is a market leader.

The reference price for heavy crude r was determined with reference to the price of WTI, on the basis of a reasonable WTI-Maya differential of 5 USD/B (the average

value for the period under consideration). The reference price used for WTI was 19.60 USD/B and, hence, *r* equals 14.60 USD/B.

Figure FAV.1 plots the functions L(p) and H(p) for PEMEX, using the reference case outlined above with the additional following parameters: n_1=7, n_2=3, m=5.

FIGURE FAV.1: COMPARATIVE BEHAVIOUR OF SELECTED FUNCTIONS FOR REFERENCE CASE



The Nash solution for strategic interaction with simultaneous pricing movements is the following:

$$\pi_1 = n_1 r$$

$$\pi_2 = \left(\frac{n_1}{n_1 + m} \right) (n_2 + m) r$$

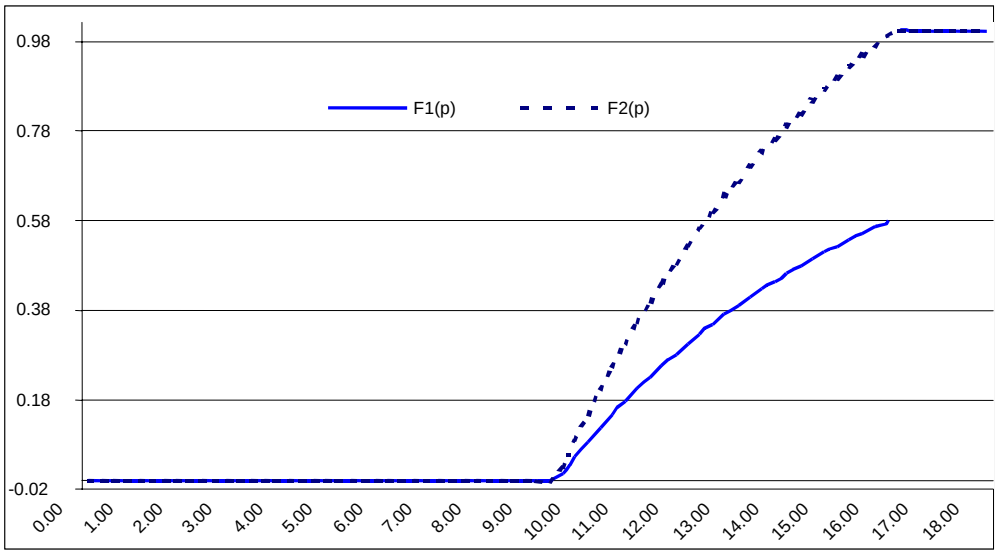
The price set by PEMEX is the maximum value which will be accepted by its loyal clients (that is, *r*). PDVSA's profits are lower than those of PEMEX, even though it manages to supply all the requirements of "neutral" clients, as well as its own loyal clients. The functions determining the distribution of price equilibria clearly indicate

PDVSA's propensity for lower prices. This point is further illustrated by Figure FAV.2, which plots the distribution of price equilibria.

$$F_1(p) = \begin{cases} 0 & ; p < \dfrac{n_1 r}{n_1 + m} \\ 1 + \dfrac{n_2}{m} - \dfrac{(n_2 + m) n_1 r}{(n_1 + m) m p} & ; \dfrac{n_1 r}{n_1 + m} \le p < r \\ 1 & ; p \ge r \end{cases}$$

$$F_2(p) = \begin{cases} 0 & ; p < \dfrac{n_1 r}{n_1 + m} \\ 1 + \dfrac{n_1}{m}\left(1 - \dfrac{r}{p}\right) & ; \dfrac{n_1 r}{n_1 + m} \le p < r \\ 1 & ; p \ge r \end{cases}$$

FIGURE FAV.2: DISTRIBUTION OF PRICE EQUILIBRIA



In this particular application of the model, PEMEX was assumed to be the price leader on the basis of the anecdotal evidence discussed throughout the study. This assumption can be relaxed, with no detriment to the outcomes generated by the model. Deneckere, Kovenock and Lee show that, if the price leader is chosen exogenously, so long as one holds to the assumption that the follower firm gets the customers without preferences if its price is equal or lower than that of the leader, then the following results obtain:

1. If the leader is the firm with the largest portfolio of loyal clients, it will set the price at *r*, and the follower will react by setting prices at the same level. Profits in this case will be determined by:

$$\pi_1 = n_1 r$$

$$\pi_2 = (n_2 + m) r$$

2. If the price leader is the firm with the smallest portfolio of loyal clients, then profits will be determined by:

$$\pi_1 = n_1 r$$

$$\pi_2 = \left(\frac{n_2 + m}{n_1 + m} \right) n_1 r$$

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