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UNLOCKING THE ASSETS: ENERGY AND THE FUTURE OF CENTRAL ASIA AND THE CAUCASUS

THE ECONOMICS OF PIPELINE ROUTES: THE CONUNDRUM OF OIL EXPORTS FROM THE CASPIAN BASIN

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I Introduction

Over the past five to six years, considerable international attention has been given to the issue of transporting oil from the Caspian Basin with discussion of potential routes through Russia, Georgia, Turkey, China, Afghanistan and Iran. The relative merits of proposed options rest on both economic and political factors. Many arguments have been advanced for favoring one route over others. These include concerns about the security of routes, worries over the use of monopoly power by either privately owned pipelines or by governments and, of course, the underlying economic cost and efficiency of various proposals.

While the debate is framed in these terms, an underlying motivation that drives the positions taken by various participants is the division of the rents (the difference between the market value of the oil and the cost of developing, producing and transporting it to market). Hence much of the public discussion may reflect the strategic use of information by various parties to gain an advantage over another in the competition for these rents. For example, countries in the region are in favor of routes which will transit their territory and hence will allow them to earn income from transit tariffs. At the same time, pipeline builders wish to negotiate low tariffs and have an incentive to propose many alternative routes to diminish the bargaining power of any one country.

In this paper, we focus on the economic dimensions of proposed oil pipeline routes. Our purpose is to raise and illustrate various issues that will lead to a better understanding of the factors which are relevant in determining the comparative efficiencies of alternative oil pipeline choices. While our focus is on the economic dimension of the choice, reference will be made to the constraints that non-economic factors may impose on pipeline route choice. Other papers in this series focus in more detail on the political, religious and cultural factors.

While we focus exclusively on oil routes, we recognize the interdependence between oil and gas markets and the potential competition between them where both are available. However, the conditions where oil and gas become direct competitors are extremely complex. Several constraints can influence this relationship, including the availability of each resource in a particular geographic market and the available infrastructure to convert each commodity into usable energy. Our analysis avoids this complexity. We compare competing oil pipeline routes to other oil pipeline routes.

To begin our study, we initially ignore political and strategic considerations that affect decisions of pricing and oil flows and stress purely economic issues. From there, we add in other factors that influence oil markets as they operate today to illustrate the extent and nature of inefficiency in oil markets and to examine the impact of Central Asia and Caucasus oil on the flow patterns of oil from the region. In this way, we are able to highlight how Saudi Arabia's oil marketing strategies will affect new oil exporters like Kazakhstan and Azerbaijan and how the entry of Kazakhstan and Azerbaijan oil will likely affect Saudi Arabia and other Gulf producers. Our main conclusions are as follows:

i) Limitations on drilling infrastructure and recent disappointing finds suggest that the region will not be able to generate sufficient export volume to support large-scale export lines in the near and perhaps even intermediate term. As a result, reliance will be on make-shift solutions, such as using existing lines which can be refurbished and expanded or the use of oil swaps, as has been proposed with Iran.

ii) Given reasonable expectations for economic growth, neighboring countries such as the Ukraine, Romania, Bulgaria and Turkey can absorb much of the projected export surplus of Caspian oil over the next decade. This could leave as little as 1-1.5 million barrels of Caspian oil that would have to be exported by way of the Mediterranean or the Persian Gulf and Arabian Sea.

iii) There are significant scale economies to pipeline throughput. Scale economies are sacrificed when several smaller lines are built instead of one larger line. The benefits of multiple routes as a means of reducing the financial risk of temporary closures of pipelines must be weighed against this cost. For reasonable assumptions about the frequency and severity of disruptions, the certain costs of higher transport costs exceed the expected value of such losses.

iv) Given economies of scale and the likely magnitude of increases in the volume of Caspian oil (including Russia) that will be exported via the Mediterranean, there is only need for one large capacity export pipeline from each of the major producing countries, Azerbaijan and Khazakstan, at least until 2010.

v) Of the routes to the Mediterranean that are designed to bypass the Turkish Straits, the pipeline from Baku to Ceyhan has the highest cost/b of the routes investigated - at least one dollar per barrel more than a bypass route through Turkish Thrace

vi) Routes involving a large capacity pipeline from Samsun to Ceyhan have a higher transport cost than the bypass routes through Thrace but are less expensive than for the Baku-Ceyhan.

vii) All routes involving pipelines that are designed to bypass the Turkish Straits have higher transport costs than using tankers to transit the Straits. A short, high capacity bypass through Turkish Thrace adds roughly 60 cents/b to the cost of moving oil from the Black Sea to the Mediterranean. The Baku-Ceyhan pipeline adds $1.20. Some of this cost differential is offset by the lower costs of using large tankers, available in the Mediterranean but not able to transit the Turkish Straits.

viii) A large capacity pipeline that bypasses the Turkish Straits should be considered as a means of transporting projected increases in oil exports from the Caspian region. The economic viability of a bypass would be greater if shippers had to bear the true social cost of transiting the Turkish Straits (that is the expected value of damages borne by the residents of Istanbul to their person and property as well as the cost of delays due to congestion. Measuring the true cost of tanker passage is very difficult since it requires the placement of a value on such "goods" as the integrity of historical buildings and locations

ix) In an environment of efficient oil markets, Azeri and Kazak oil would generate a higher net revenue if exported to Europe rather than to Asia. This reflects a combination of factors including relative transport costs for Azeri and Kazak oil compared to the costs of competing suppliers. But, if Saudi Arabia insists on maintaining a significant presence in the European market, the option for Kazakhstan to export its oil to Pakistan by pipeline (CAOPP) might, in that case, provide a higher net revenue than to Europe. This would not be the case for Azeri oil which is geographically closer to the European market.

x) There is evidence that the Saudis subsidize sales of their oil to European markets. Prices of Saudi crude in Europe are found to be 72 cents lower than in Asia. The average differential between European and Asian prices observed during the last decade is not sufficient to offset the cost of moving Caspian oil to ports in the Gulf or the Arabian Sea for export to Asia.

II Background to the problem of transport

The sudden independence of the oil and gas-rich republics following the break-up of the Soviet Union in 1991 created a unique opportunity for international oil and gas companies. A new region, boasting a potential of between 15 and 31 billion barrels of proven oil reserves and 230 to 360 trillion cubic feet of natural gas was suddenly open to investment. The stakes were high since the newly independent states had giant known oil fields that needed foreign technology and capital to exploit. The reserves were extremely attractive to private Western oil companies who were hunting for major fields to add to their balance sheets. Many of the deals that have been signed have high rates of return. For a list of Western oil companies who have signed joint ventures or exploration deals in recent years, see Appendix A.

III Constraints on Caspian Basin Potential

In 1997, regional production averaged around 800-900 b/d of which a third was exported, according to the Economist Intelligence Unit. Taking logistical and political constraints into consideration, the agreements that have already been signed by international oil companies should result in the export of an incremental 500,000 to 600,000 b/d of oil from the region by 2000. Total regional production could reach around 3.5 million b/d by 2010. This assumes that the optimistic assessments, that the Caspian shelf concession in the shallow waters of the Kazakh offshore sector contains 20 to 30 billion barrels, are correct. Such a production level would imply an increase in exports to around 2.5 to 2.8 million b/d by 2010.

Individual forecasts are as follows:

* Edinburgh, UK-based Wood Mackenzie Consultants forecasts oil production to reach 1.7 million b/d by 2000, rising to 3.4 million b/d by 2010, primarily from Kazakhstan and Azerbaijan.

* The International Energy Agency (IEA) expects oil production from Kazakhstan, Turkmenistan, Azerbaijan and Uzbekistan to rise from 858,000 b/d in 1996 to 1.5 million b/d in 2000 and 2.9 million b/d in 2010. The IEA suggests exports will reach 900,000 b/d in 2000, up from 300,000 b/d in 1996, and 2 million b/d by 2010.

* The Center for Strategic and International Studies (CSIS) of Washington, DC expects Kazakhstan, Azerbaijan, and Turkmenistan to reach a peak oil production level of about 3.5 million b/d sometime around 2010. In particular, CSIS expects Kazakh production to reach 1.9 million b/d from three main areas: the Tengiz field, the offshore Caspian shelf concession and the Karachaganak field.

* Some US government analysts suggest total Central Asian and Caucasus oil production could reach as high as 4.5 million b/d by 2010, were political barriers to be removed.

In some cases, such as the Tengiz field in Khazakhstan and Chiraq, Guneshli and Azeri fields in Azerbaijan, oil production can meet projections if stable transportation arrangements can be made. In other cases, such as Azerbaijan’s Karabakh field and the Ashrafi field, geologic projections may be overly optimistic.

As in other regions in the world, oil and gas development in Central Asia and the Caucasus will be affected by constraints in readily available drilling rigs or floating platform systems that are needed to finish well completions. These constraints on infrastructure, drilling equipment and rigs are more severe in the region than in other parts of the world.

Geography plays a big role in the problem. There are only two assembly yards equipped for manufacturing or refurbishing offshore drilling rigs for the region: one at Astrakhan in Russia along the northern Caspian and one in Primorsk, near Baku. This has limited local supply. To bring additional semi-submersible rigs into the landlocked region is an onerous and expensive task. To reach the offshore regions of most oil-rich countries, oil companies can tow huge drilling rigs by sea to production areas or employ drilling ships. To reach the landlocked Caspian Sea, by contrast, rigs must be cut apart and floated down the Volga river and then reconstructed. AIOC is using the one operational semi-submersible platform in the region. Refurbishment costs for that platform were $38 million. Two other platforms are under refurbishment, one by BP, rumored to cost $200 million plus to upgrade, and a floating drilling rig brought from the Persian Gulf by Lukoil. There is also a limited number of jack-up rigs available in the region as well though onshore and coastal exploration is less constrained. Companies are starting to cooperate by forming drilling clubs. Given the high number of contracts signed however, firms may still have difficulty meeting contractual drilling deadlines. Several of the production sharing agreements for exploration in the region require completion of appraisal and the start of production within the next six years.

The constraints on available drilling equipment and the difficulty in scheduling the use of limited rigs means that a disappointing first effort can have a major impact on development schedules for any particular field. In the event that more drilling is required, say, in the case of a dry hole or unexpected gas find, the exploring company may have to wait before a second rig can be acquired to drill elsewhere in the concession area. So in the case of Azerbaijan's Karabakh field, initial failure to find oil may mean that schedules to produce oil by 2001 may no longer be feasible.

The region also suffers from a wide array of political and physical obstacles to the construction of oil and gas export pipelines to major consuming markets. There are political barriers that have so far inhibited major exports via Russia or Iran. Security concerns have plagued various routes through the Caucasus and eastern routes to Pakistan via Afghanistan. Meanwhile, physical, environmental and political constraints on tanker transit via the Black Sea through Turkey's Bosporus Straits remain a wild card in developing Black Sea options. Other, lengthier on-land routes through Turkey or from Kazakhstan to China may face difficulties obtaining commercial financing. Given the drilling constraints mentioned above, it may take several years before large enough export volumes exist to promote even a single, large-scale pipeline project across Turkey or China.

Transportation problems have restricted the flow of available oil production from Kazakhstan and Azerbaijan. Since the early 1990s, the two countries, combined with international oil companies involved in oil and gas fields in the region, have been holding negotiations to eliminate barriers to various alternate export routes with varying success.

Some routes are subject to intractable political obstacles. US economic sanctions against Iran have so far inhibited investment in an Iranian route, but these sanctions may not be effective against investors such as Malaysia’s Petronas or China’s CNPC in the future. The territorial dispute among Azerbaijan, Armenia and the region of Nagorno-Karabakh shows no signs of abating, and hostilities remain a major risk. Some commentators believe armed Armenian or Karabakh militants might also try to prevent completion of a pipeline from Baku to Ceyhan

Routes that involve entry into sections of Russia’s vast pipeline network have required complex, time-consuming negotiations. Bureaucratic chaos, lack of formalized legal structures, corruption and the center’s lack of administrative control over the regions contribute a unique but random factor of confusion and complexity to Russian transport negotiations.

However, political and economic forces may be at work as well. Some elements within Russia’s Foreign Ministry are antipathetic to any significant exports from Kazakhstan or Azerbaijan. On one level, Caspian exports represent competition for Russia’s own production both inside the Russian transport system and on international markets. But there are also reasons for Russia to put forward export routes. Nationalists argue that access to Russia’s pipeline system preserves Moscow’s preeminent role in its geographic periphery. Still others may have more limited economic motives, to create obstacles to the resolution of the pipeline route dilemma as a bargaining strategy to gain Moscow its "rightful" share in the vast resources that were partially developed prior to the breakup of the Soviet Union.

IV Pipeline Route Developments in early 1998

The landscape for Caspian pipeline negotiations has changed over the past seven years, mainly due to shifting political factors. It will continue to change long after this study is published. For this reason, we include several proposed routes, including those which do not at present seem feasible for political reasons.

Starting in late 1997, the AIOC consortium began shipping a limited volume of oil (40,000b/d) from its Chiraq field in Azerbaijan through the so-called Northern route that extends from Baku to the Russian cities of Grozny and Tikhorestsk, Russia to the Russian Black Sea port of Novorossiysk. This route required both construction on the Azerbaijan side by AIOC and refurbishment by Russian pipeline company Transneft on the Russian portion of the route. Initial capacity is 120,000 b/d but could be expanded to 300,000 b/d with an additional $600 million investment. The tariff on this route has been set at $2.16/b for ten years.

AIOC is also refurbishing a western route from Baku to Tbilisi to the Georgian port of Supsa. The project involves some new construction along the route as well as port construction and rehabilitation of a refined products line inside Azerbaijan. AIOC expects the western line to be ready by late 1998 or early 1999 and will eventually be able to carry about 200,000 b/d. The tariff on this route has been set at 40 cents/bl.

Regional leaders have called upon Western consortia members to declare a final plan for a long-term route for transport of over 1 million b/d by October 1998. The US and Turkish governments are pushing for the development of a major route from Baku to the Turkish Mediterranean port of Ceyhan. Exact routing is still under debate though companies are anxious to avoid Turkish areas under control of Kurdish rebels. Moscow has declared its opposition to subsea Caspian routes because of environmental risks and high seismic activity in the area.

The Caspian Pipeline Consortium (CPC) which groups Russia, Kazakhstan, Oman, Chevron, Lukoil, Rosneft-Shell, Mobil, Agip, British Gas, Kazak Munaigaas and Oryx is trying to finalize plans for a private 1.34 million b/d pipeline from the Tengiz field in Western Kazakhstan to Tikhorestsk to the Russian Black Sea port of Novorossiysk, utilizing an existing Russian line from Tengiz to Grozny. It was hoped that construction of the line would begin following a definitive agreement with Moscow in May 1997 but CPC has had difficulty finalizing land right arrangements with local authorities. Some questions also remain about the legal structure of the company's ownership. CPC members are now planning to begin the project this summer. The CPC pipeline, if finalized, would permit the export of around 200,000 b/d of Tengiz crude during initial operations.

The development of the CPC line to Novorossiysk, coupled with lines to Supsa or other Black Sea ports, will put additional pressure on Turkey's Bosporus Strait which now handles 1.2 million b/d of oil transport. Turkey has objected to any sizable increase of oil traffic through the already congested Straits on safety and environmental grounds. The matter is being investigated by several world bodies including the International Marine Organization (IMO). As a result, several Western oil consortium members are investigating construction of a bypass of the Bosporus Strait. Several routes have been considered. One would begin at either the Turkish Black Sea port of Samsun or the coal port of Zonguldak and extend across Turkey to the Mediterranean port of Ceyhan, utilizing a mixture of old and new pipelines connecting to the Kirikkale refinery near Ankara. Other possible bypasses include a route in Turkish Thrace from Kiyikoy to Ibrikbana on the Aegean and pipelines from the Bulgarian port of Bourgas to Alexandroupolis in Greece or Vlore in Albania.

Iran has proposed that Azerbaijan and Turkmenistan export their oil to Iran's northern refining centers at Tabriz, Tehran and Arak and "swap" it for exports of Iranian oil from Iran's main Persian Gulf terminal at Kharg Island. The plan has the advantage of the existence of substantial Iranian pipeline capacity that could be reversed. However, US government objections are an important obstacle. Iran is also demanding a swap fee of $2-3 a barrel to make investments to enable its refineries to handle Caspian crude.

The maximum amount of oil that could be swapped would be 400,000 to 500,000 b/d. It is likely that only smaller volumes would be practical. However, industry and local officials report that Malaysia's Petronas or China's CNPC might be willing to invest in an Iranian route that would transport their own future Caspian production while at the same time generating transit fees from other producers once US sanctions are lifted.

China's CNPC has also proposed building a $3.5 billion pipeline from Kazakhstan to China's that might connect to future oil facilities in China's Tarim Basin. That project, along with Unocal's proposed oil and gas pipeline that would connect an existing line at Charjou, Turkmenistan through Afghanistan to Pakistan (CAOPP), is considered a long-range program that won't be implemented until the next decade. Exxon, Mitsubishi and CNPC are also studying a natural gas line from Turkmenistan to China.

V Alternative Transport Options For Caspian Oil

Given the difficulties and cost of developing Caspian oil as well as the continuing delays in resolving the issue of transit routes, it is unlikely that exports from the region will exceed 1.5 million b/d by 2005 and 2.8 million b/d by 2010. Indeed the IEA is projecting an export surplus of only 1.1 mmb/d by 2005 and 2.3 mmb/d by 2010.

These relatively limited export surpluses raise the question of how many of the proposed routes will be economically desirable. The current focus of AIOC and CPC is to bring Caspian oil to the Black Sea where it can then be transported to other markets. The countries that ring the Black Sea provide a good potential market. These countries import crude, some from Russia and some through the Bosporus from the Middle East and other sources. While these countries have recently experienced enormous declines in GDP and energy usage, they can be expected to increase their consumption and imports of crude over the next 7 to 12 years.

Planecon, a Washington based consultancy specializing in oil affairs of the Former Soviet Union, projects that, given expected growth rates, the countries bordering the Black Sea, combined with swaps with Iran, could absorb from 1 million b/d to 1.5 million b/d by 2010. Furthermore, by building a pipeline from Zonguldak or Samsum to the Kirikkale refinery near Ankara to supply that refinery with Caspian crude, the existing pipeline from Ceyhan to Kirikkale could be reversed and some 113,000 b/d could be exported from Ceyhan. The capacity of this pipeline could probably be increased by adding extra pump stations. Table 1 gives some possible absorption levels of Caspian oil by Iran and countries bordering the Black Sea This would leave only 1 to 1.5 million b/d which would be exported outside of the region.

With the construction of the AIOC line to Supsa with a capacity of 200,000 b/d, in combination with the "northern" route to Novorrossiysk, it is unlikely that there will be sufficient additional Azeri exports to Iran beyond the 300 to 400 mb/d to supply the refineries at Tabriz, Tehran and Arak in the near term.

Russia is currently exporting some 1.2 million b/d through the Bosporus and will undoubtedly increase those exports over the next 5-10 years. Combined with Kazak and Azeri oil, there will be enough volume to support a large capacity line through Bulgaria or Turkey to the Aegean.

VI The Comparative Economics of Individual Oil Transport Routes

The importance of scale economies in pipeline transport is evident in the calculations shown in Appendix Table C. In Table 2 below, we have abstracted some comparisons from this table. The cost of transporting oil from Baku to Supsa over a pipeline with capacity of 900 mb/d would be 68 cents/b whereas the cost would drop to 50 cents/b with a pipeline having a capacity of 1.5 mmb/d. Costs for the smaller throughput are 36% higher than for the larger one. On the Bosporus bypass route from Kikikoy to Ibrikabana, costs would be 55 cents/b for a 500,000 b/d line and only 35 cents/b for a 1.5 million b/d line. Costs for the lower throughput are 57% higher in this case.

The importance of scale economies for transporting Caspian oil calls into question the wisdom of multiple pipeline routing that has been advocated as the cost effective solution to the threat of disruption of oil exports from the region. These disruptions could result from either to acts of terrorism or from government actions of a transit country. However, given the expected level of exports to points outside the Black Sea, perhaps as little as 1.5 million b/d by 2010, the use of several pipelines will result in substantially higher transport costs. There is clearly a trade-off between lower transport costs and security risk.

As an example, consider the cost of transporting 1.5 million b/d from Baku to the Black Sea using two alternatives. Based on calculations shown in Appendix Table C, costs using a 1.5 mmb/d pipeline from Baku to Supsa are roughly half those using two 750 mb/d pipelines; one to Supsa and the other to Novorossyisk. The differential cost of using two 750,000 b/d pipelines would be $750 thousand each day or roughly $274 million each year.

Table 2: Scale Economies in Pipeline Transport. Cost of Capital 15%.

Route				% increase
	Length miles	Capacity mb/d	Cost/b	in Cost
Baku-Supsa	510	900	0.68	36.0%
	510	1500	0.50	
Baku-Ceyhan	1200	600	2.52	3.3%
	1200	800	2.44	
Samsun-Ceyhan	534	800	1.21	37.5%
	534	1880	0.88	
Kiyikoy-Ibrikbana	114	500	0.55	57.1%

	114	1500	0.35					

Whether it is worthwhile to buy insurance against an undesirable event depends on the probability of occurrence of the event and the value of the loss incurred when the event occurs. Risks associated with the Baku-Supsa and Baku-Novorossiysk lines are disruptions of oil flow due to terrorist acts or closures by the Russian or Georgian governments resulting from tariff or politically motivated disputes. The loss from a pipeline closure is the discounted value of the oil revenue lost, which depends not only on the length of closure but also on how quickly the lost throughput can be "made up". Experience in Colombia suggests that pipelines can be repaired and the flow of oil resumed quickly. The use of drag reduction agents will permit a larger throughput once flow is restored to replace lost sales if necessary.

Let us assume for illustrative purposes, that there is a two week closure and that the lost throughput can be made up within one year of its delay. At an oil price of $15/b, the loss of revenue is equal to $22.5 million per day. If this revenue is recaptured within one year, the loss will be reduced to the time cost of $22.5 million. At a cost of capital of 10%, the loss would at most $2.25 million per day, or $31.5 million for the two week period. Having two routes will not, of course, eliminate losses due to pipeline closures. If we assume that the total number of disruptions is the same each year regardless of the number of routes, the losses under the two route regime would be one half the losses with one larger pipeline. Hence the differential cost of disruption for one large line is only $1.6 million per day. Of course, the existence of two routes will give terrorist groups more than one pipeline to target. Thus, the number of disruptions could actually be higher for the two pipelines scenario. In this event, the loss differential between the two alternatives would be even smaller that $1.6 million per day of closure. It is clear that one could have many such disruptions each year before the losses would add up to the certain cost of $260-$330 million per year of losing the benefits of scale. These calculations suggest that, unless pipeline operators are extremely risk averse it would not be efficient to give up the benefits of scale economies for security from short term disruptions. The benefits of scale economies would be greater than the expected benefits of multiple routes.

Since Caspian oil is costly to develop and produce and is distant from markets, the sacrifice of scale economies will represent a large fraction of potential profits. It is a cost that must be borne by one or more of the parties involved in the extraction and transport of the oil.

If the risks involve not the acts of terrorists but acts of governments, the existence of multiple routes will reduce the bargaining power of governments of transit countries to squeeze post contract concessions from pipeline operators. The question remains. Is it worth paying an additional $274 million a year to avoid this risk?

Scale economies are also important in determining the timing of pipeline investments. The first route which is built will have an advantage over later ones since it will already have some throughput which could be combined with any additional exports that become available to lower average costs. Pipeline firms have an incentive to construct large diameter lines with initial excess capacity, (which can be offset for low initial throughputs by having less pump capacity) both to provide space for future increments to exports as well as an entry barrier to other routes. The excess capacity, which means that the incremental cost for additional throughput is very low, will signal promoters of other routes that they will face fierce competition for incremental exports.

VI Pipeline Proposals for Late Oil

Table 3 refers to routes which have been proposed for what might be called late oil, i.e. oil that will be produced when fields in Azerbaijan and Kazakstan are more fully developed. Early oil, the low volumes that are currently being produced as well as the increases expected in the next few years before any major new pipelines are developed, will be shipped using, by and large, existing or upgraded facilities. Pipeline transport costs for this "early" production will be different from the "long run" costs, which is our focus here and which require major investments in new facilities. Our calculations are based on costs of building new pipelines. Recent experience by AIOC with attempts to refurbish Soviet era pipelines is that refurbishing costs are higher than the cost of laying new pipe, suggesting that laying new pipe is more cost effective, except possibly in terms of acquiring right of way rights.

The characteristics and capital costs of the routes chosen are those which have been examined by CSIS, Wood Mackenzie , the IEA and other published sources, indicated in all tables as IEA.. We have also attempted our own estimates for the CPC and Bosporus bypass, indicated by SJ. Total capital costs include the cost of the pipe and its installation, cost of pumping stations, storage, loading platforms and monomoorings at the point(s) where oil is transferred from pipeline to tanker. Right of way costs are not included in these estimates. Per barrel transport costs are calculated for 15% cost of capital and assuming a 30 year economic life for the project. Operating costs are assumed to be 2% of capital costs. Appendices B and C discuss our methodology more extensively. Appendix Table C compares calculations for a 10%,15% and 20% cost of capital and for 20 and 30 year service lives.

Table 3: Pipeline Costs for Alternative Routes. Cost of Capital 15%

Route	Length Kilometers	Diameter Inches	Capacity m/b/d	Total Cost US $ bill	Cost $/b	Source
Northern AIOC	1,100	40	300	1.04	$1.64	IEA
Baku-Novorossyisk	1,595	40	800	2.28	$1.35	CSIS
Baku-Tbilisi-Supsa	850	40	900	1.30	$0.68	IEA
Baku-Tbilisi-Supsa	850	40	1,500	1.60	$0.50	IEA
Baku-Ceyhan/ Armenia	1,950	40	600	3.50	$2.75	IEA
Baku-Ceyhan/ Georgia	2,170	40	600	3.20	$2.52	IEA

Baku-Ceyhan/ Iran	2,070	40	800	3.93	$2.32	CSIS
Baku-Ceyhan/Georgia	2,170	40	800	4.14	$2.44	CSIS
Samsun-Ceyhan	890	40	800	2.05	$1.21	CSIS
Samsun-Ceyhan	890	48	1,880	3.50	$0.88	CSIS
Burgas-Alexandroupolis	317	40	600	0.70	$0.55	CSIS
Burgas-Alexandroupolis	317	40	600	0.70	$0.55	IEA
Burgas-Vlore	915	36	750	0.80	$0.50	CSIS
Azerb/Turkmen/Kharg	2,150	40	1,500	3.00	$0.94	IEA
Azerb/Turkmen/Kharg	2,150	40	900	3.00	$1.57	IEA
CPC First Phase	1,500	42	560	2.50	$2.11	IEA
CPC Second Phase	1,500	42	1,500	4.50	$1.42	IEA
CPC	1,500	42	1,500	1.90	$0.60	WOOD
CPC	1,580	42	1,340	2.00	$0.70	CSIS

CPC	1,500	42	800	1.87	$1.10	SJM
CAOPP	1,673	42	1,000	5.00	$2.36	WOOD
CAOPP/Pakistan	1,667	42	1,000	2.70	$1.27	CSIS
CAOPP	1,667	42	1,000	2.70	$1.27	IEA
Kiyikoy-Ibrikbana	190	42	500	0.58	$0.55	IEA
Kiyikoy-Ibrikbana	190	42	1,500	1.11	$0.35	IEA
Kiyikoy-Ibrikbana	190	42	1,000	1.00	$0.47	SJM
CNPC to China	3,000	40	1,000	3.50	$1.65	Wood
CNPC to Iran	1,200	28	250	1.10	$2.08	Wood

Our estimates attempt to measure the economic costs of transporting oil. The tariff ultimately levied will reflect, in addition, other factors such as tax laws, right of way costs and transit tariffs. Since counties will attempt to collect as much of the "surplus" as possible, they would want to raise tariffs up to the point where producers would be indifferent, as to available transport corridors. Because tariff negotiations will be undertaken in the context of what alternative routes are available, pipeline consortia will have an interest in proposing alternative routes, as a bargaining tool to negotiate the tariff on the route they favor. Of course, this "gaming" requires that their preferred route not be revealed. Transit countries with lower actual transport costs will generally have an advantage. In a perfect world of zero transactions costs, no strategic behavior and perfect information and where all routes were equally risky, the lowest cost route would be the route selected. In the imperfect world we live in, many other considerations will influence, and perhaps even, determine the choice.

Tanker transport also exhibits economies of scale which however, may not be accurately reflected in current freight rates because of short term market conditions. Tanker rates are extremely volatile in the short run and are also subject to longer term cycles, reflecting the limited capacity to add to the stock of tankers and their long service lives. Table 4 gives tanker rates between various ports that are used throughout this study. Appendix E discusses the tanker market, how the rates in Table 4 were derived and the effect of different assumptions about tanker rates on our conclusions.

Table 4: Tanker Rates.				
To /From	Ras Tanura	Ras Tanura	Novorossyisk	Sidi Kerir
VLCC	via Cape	via Suez $1.30		
Italy LR-2 VLCC		$1.31	$.64	$.45
VLCC	$2.22			$.32

Rotterdam LR-2 VLCC		$1.97	$1.23	$1.04
VLCC	$2.32			$.76

Rates for the LR-2 are included despite being higher than VLCC rates, because the LR-2 is, for all practical purposes, the largest tanker that can pass through the Turkish Straits. So, while the Straits make it possible to ship oil by tanker all the way from Black Sea ports to European destinations, this advantage

is offset to some extent by the fact that the largest tankers that can used for the voyage are not the cheapest. In fact, oil is also exported through the Bosporus using smaller Aframax vessels of 60-100 thousand DWT. Rates for these vessels will be even higher than for the LR-2.

VII Azeri Oil

Calculations shown in Table 3 include only the cost of transporting oil from the field to a shipping port. To compare the economic efficiency of alternative routes, it is necessary to compute total transport costs, including tanker costs, to a given delivery point, say Rotterdam or one of the ports in Italy. Otherwise we would be comparing routes of different lengths. Shorter pipelines will require longer trips by tanker to the final destination and longer pipelines will imply less time in tankers. Since the cost of shipping oil by tanker is lower than the cost by pipeline (for equivalent distance and the same size tanker), routes which favor tanker transport for a greater proportion of the distance from field to market will be cheaper than those which rely more heavily on pipeline transport for the foreseeable future.

Appendix Tables D-1 through D-4 compare the total transport costs of Azeri oil delivered to Rotterdam and Italy for various pipeline routes using a cost of capital of 10% and 15%. Total costs are calculated by adding the pipeline costs to the tanker costs given in Table 4. For the bypass routes, costs must include the cost of transporting the oil from one Black Sea port to another as well as the cost of off loading and reloading the cargo at Black Sea ports. We have assumed these costs to be 40 cents/b, equal to approximately five days of daily hire of an LR-2, to reflect the fact that an additional three days are required to offload and then reload tankers in order to use a bypass pipeline. Quantitative, but not qualitative results, are sensitive to the magnitude of this cost. The effects of assuming different costs can be easily seen by simply adding or subtracting any change in this cost to the total transport costs of all routes which rely on a bypass of the Turkish Straits.

While it would seem obvious that Caspian oil should be shipped to the closer Mediterranean markets and not to the more distant Rotterdam, where Azeri oil is physically shipped will depend on a number of factors: the growth of demand for oil in Europe, capacity constraints on refineries and pipelines in Europe, future changes in those constraints and the reaction of other suppliers to shipments of Caspian oil to Europe.

Europe will continue to import oil from outside the region even after it has absorbed expected Caspian exports. If Caspian oil is shipped only to Mediterranean ports then, holding all else constant, prices in the Mediterranean will fall relative to those in other European markets. When this differential becomes greater than the cost of shipping to other markets, oil will flow to those other markets. In other words, one cannot assume that the Mediterranean is the only market in Europe for Caspian crude. We include calculations for two European markets, Augusta, Italy and Rotterdam to highlight an interesting aspect of tanker economies of scale.

To simplify our exposition, Table 5 extracts data from Tables D-1 and D-2 and shows the total transport cost of Azeri oil to Rotterdam and Augusta for three important routes: i) a 900,000 b/d pipeline to Supsa, then by LR-2 tanker to the final destination, ii) a 900,000 b/d pipeline to Supsa, then by tanker to the Turkish port of Kiyikoy, then by a 1.5 million b/d pipeline to Ibrikbana, and finally by VLCC to the destination port, and iii) an 800,000 b/d pipeline from Ceyhan to Baku and then by VLCC to its final destination. The large capacity bypass route is chosen for these comparisons on the assumption that it would carry Russian and/or Kazak oil as well.

Table 5 captures the main conclusions that can be drawn from Tables D-1 to D-4. These are as follows.

i) of all the pipeline options that would avoid tanker passage through the Bosporus, a large capacity pipeline of 1.5 million b/d that bypasses the Bosporus through Turkish Thrace (from Kiyikoy to Ibrikbana) has the lowest cost/b in terms of total transport cost from Baku to the destination port.

ii) for comparable throughputs, transport costs involving the pipeline from Baku to Ceyhan are the highest of all alternatives considered, at least one dollar per barrel more than the bypass through Thrace.

iii) routes using a large capacity pipeline from Samsun to Ceyhan (1.9 million b/d) have a lower transport cost than the Baku-Ceyhan pipeline but the difference is small relative to the cost of the large capacity bypass route through Thrace.

Table 5: Transport Cost Comparisons For Azeri Oil			
Delivered to Europe. Assuming a Cost of Capital of 15%			
Destination-Route	Cost/b	Cost as a % of	Cost Minus Cost
Baku-Rotterdam:		Bypass Route	of Bypass Route
Tanker From Supsa	$1.91	87%	-0.28

Supsa-Turkish Bypass	$2.19	100%	+
Supsa-Samsun-Ceyhan	$2.72	124%	0.53
Baku-Ceyhan	$3.20	146%	1.01
Italy			
Tanker From Supsa	$1.41	80%	-0.36
Supsa-Turkish Bypass	$1.77	100%	0.00
Supsa-Samsun-Ceyhan	$2.30	130%	0.53
Baku-Ceyhan	$2.78	157%	1.01

iv) using an LR-2 tanker for the entire trip to either Augusta or Rotterdam is cheaper than all of the routes that use a pipeline to bypass the Turkish Straits . The additional cost of using a Baku-Ceyhan pipeline in place of an LR-2 tanker from Novorossyisk or Supsa, is $1.44/b for Augusta and $1.29/b for Rotterdam. This issue discussed more fully in section IX below.

v) a conclusion from Tables D-1 to D-4, not noted in Table 5, is that a large capacity pipeline to Supsa is much less costly than a similar pipeline to Novorossyisk for Azeri oil. The Supsa port will require greater investments than Novorossyisk to handle large quantities of oil but this factor is more than offset by the fact that the route to Supsa is much shorter than to Novorossyisk.

Arguments in favor the Baku-Ceyhan route include: i) it is the only route, other than the route through the Bosporus, that minimizes the number of times that oil is handled. Routes that require oil to be shipped across the Black Sea and then off-loaded into another pipeline may result in additional oil spills and increase the already considerable pollution in the Black Sea. ii) the Baku-Ceyhan route avoids crossing Chechnya, and the risks that region poses for the Baku-Novorossiysk route. iii) the Baku-Ceyhan route potentially provides Khazakhstan an alternative route to connect to international markets. and iv) as compared with the route through Iran, it avoids the Strait of Hormuz. A very large proportion of the world's crude already flows through these Straits.

Carrying Kazak oil would require increasing the capacity of the Baku-Ceyhan pipeline and that would also lower the cost/b for transit making it more competitive with other routes. Nonetheless, given the current relationship between tanker and pipeline transport costs, the Baku-Ceyhan route will always be more expensive than alternatives which make less use pipelines and substitute transit by tanker. So key issues are: how much are the benefits of the Baku-Ceyhan pipeline worth in terms of higher transport costs and who will bear these costs.

Another option for Azeri oil is to move it through Iran to Kharg Island (either directly or through a swap with Iranian oil) or through Afghanistan and Pakistan to Gwadar on the Arabian Sea and then to East Asia.

From the point of view of efficiency, one must take into account the effect of choosing one route or the other on the pattern of world oil flows. To see this, assume that world demand and supply of oil remains constant and that Saudi Arabia played a role as swing producer by reducing its output to accommodate increased exports of Azeri oil. In this case, each barrel of Azeri oil that is shipped to Europe would, holding European consumption constant, reduce Gulf shipments to Europe by one barrel. Similarly, each barrel of Azeri oil shipped to Asia would reduce Saudi shipments to Asia by one barrel.

Transport costs of Azeri oil to Italy, by way of a 1.5 million b/d bypass pipeline through Turkish Thrace, are probably going to be in the neighborhood of $1.75/b. Freight rates from the Gulf to the Mediterranean via the Cape are roughly $2.22. Thus, each barrel of Azeri oil shipped to Europe that displaces a barrel of Gulf oil will reduce transport costs to the Mediterranean by 45 cents/b.

On the other hand, each barrel shipped to Asia that displaces a barrel of Gulf crude increases transport costs by $1.27 to $1.57, the cost of transporting Azeri oil to ports in the Gulf or Arabian Sea. Clearly, overall transport costs are reduced by having Azeri oil go to the European market and Gulf oil shipped to the Asian market. If markets are efficient, Azeri oil will flow to Europe and, if necessary, displace potential Persian Gulf sales. Incremental Gulf oil would be more competitive in the Asian market.

However, there is evidence that Persian Gulf suppliers, most notably Saudi Arabia might not be willing to be pushed out of the European market. Instead, for several years, Saudi Arabia has taken steps to ensure that its oil remains competitive in distant markets by subsidizing buyers' transportation costs.

Data which have been calculated by Petroleum Intelligence Weekly (PIW) suggests that, in general, sales prices for Saudi oil are lower in Europe than in the Far East, despite the higher transport costs from the Gulf to Europe. An examination of price data for Arab Light - 34 crude in Table 6 shows that prices in the Far East tend to be above European prices when the latter are falling and above European prices when the latter are rising. This pattern is consistent with Saudi pricing formulae whereby Far East buyers pay a price (FOB, the Gulf) equal to the average spot price of Dubai and Oman crude, adjusted for differences in quality, prevailing in the month in which the oil is loaded onto a tanker, while European buyers pay a price equal to the average spot price of Brent crude (adjusted for quality differences) over a ten day period prevailing at the time of delivery, roughly 40 days after the crude is loaded and shipped. In the absence of a trend in crude prices, the differences introduced in prices by these formulae will cancel each other over time and on average neither market would have a higher price.

Table 6 shows that prices for Far East markets over the ten year period were, on the average, 72 cents per barrel higher than for European buyers. In Figure 1, we have plotted monthly Saudi FOB prices as computed by PIW for European and Asian delivery. To allow for the lag inherent in the Saudi pricing formula, we have plotted the Far East price for a given month against the European price for one month later. The price gap is especially visible for the post Gulf War period.

Table 6: FOB Price of Arab Light - 34

				Far East -	Percent
Year	Europe	US	Far East	Europe	Difference
1988	13.22	13.06	14.16	0.94	107.1%
1989	16.63	16.91	16.23	-0.4	97.6%
1990	21.47	20.31	21.13	-0.34	98.4%
1991	16.78	16.49	17.35	0.57	103.4%
1992	17.19	17.30	17.78	0.59	103.4%
1993	14.21	14.53	15.63	1.42	110.0%
1994	14.64	14.68	15.39	0.75	105.1%
1995	15.67	15.66	16.71	1.04	106.6%
1996	19.44	19.73	19.39	-0.05	99.7%
1997	16.06	15.99	18.74	2.68	116.7%
Average	16.53			0.72	

Source: PIW

The price anomaly between the two markets would suggest that some Persian Gulf suppliers are price discriminating, charging European buyers a lower price than Far East buyers. Since most Persian Gulf suppliers are producing close to capacity and presumably would sell as much as possible in the higher priced market, it is Saudi Arabia, which does have spare capacity and is viewed as the swing (or marginal) supplier, that has an incentive to price discriminate if it is possible to do so.

The existence of such price discrimination is important to the issue of pipeline routes because to the extent that a barrel of oil is "worth more" in the Persian Gulf than in the Mediterranean, the profitability of shipping Azeri oil south and then to the Far East, would be enhanced.

At current freight rates, this 72c premium is not sufficient to compensate for the transport penalty of $1.27 to $1.57 that Azeri oil carries for Asian delivery. But, increases in the European -Asian price differential or changes in tanker rates could upset this calculation and result in Azeri oil being more profitable in the Asian market.

The European-Asian price differential may in fact widen over the next ten years. European oil production is expected to climb significantly between 2000 and 2010 generally keeping pace with growth in demand for the region. Demand for imported supplies from outside the region will not change very much from current levels (see table G-3).

By contrast, Asian oil demand is expected to rise considerably between 2000 and 2010 despite recent problems with Asian economies. At the same time, Asian local oil production will make few, if any, gains. This means that Asia will have to import an increasing amount of oil from other world regions. This oil "deficit" in Asia, that is the difference between the amount that will be consumed and the amount produced, is expected to grow by approximately 8 mmb/d by 2005 over the deficit that prevailed in 1995 and by 11-13 mmb/d over 1995 levels, by 2010. This large gap means that Asian buyers will have to pay prices that will attract surplus oil from other regions in the world.

It is beyond the scope of this paper to determine whether, and by how much, the premium for oil in Asia will change. That will depend on an extremely complex set of factors including not only the relative transportation economics for oil production in different regions in the world but also the relative properties (API gravity, sulfur content etc.) of the world's incremental oil supplies over the next ten years; the marketing policies of Persian Gulf producers with spare capacity; and the changing configurations of refinery capacity in both Europe and Asia over the same period. This calculation would make an excellent topic for future modeling research.

But, it can be noted that there will be many oil producers who will be able to meet that Asian demand at transportation and production costs considerably below those producers of the Caspian Basin while Caspian producers will have a reasonable cost advantage toward many of the same producers who might otherwise supply Europe's smaller but still significant supply deficit. It should be noted that forecasts in Table G-3 already include Central Asia and the Caucasus in the figures for European and FSU supply. Thus, the 5 to 7 million b/d supply deficit projected for Europe and the FSU by the year 2010 will likely be made up from rising supplies from Africa and the Middle East.

Another interesting aspect of the cost figures in Table 5 is that the difference in costs of using tankers to transit the Turkish Straits rather than a bypass pipeline is larger for Augusta than for Rotterdam. The reason for this is that LR-2s are used if tankers go through the Straits while oil is loaded onto VLCCs for the final leg of the voyage when the bypass pipeline is used. The lower cost/b of VLCC tankers over the LR-2 offsets some of the additional cost of using a bypass pipeline. The longer the voyage, the greater will be this offset.

This can be seen more easily in figure 2. The intercept OA represents the cost/b of transiting the Straits in a LR-2 tanker. The slope of the line AC represents the cost/b/mile on an LR-2. (We are assuming that this cost is proportional to distance). The height of OC gives the total transport cost/b of moving crude from the north end of the Bosporus as a function of distance to market.

The intercept OB measures the pipeline cost/b of crossing from the Black Sea to the Aegean. OB is realistically assumed to be greater than OA. The slope of the line BD is the cost/b/mile of shipping oil from an Aegean port in a VLCC. As discussed above, the cost/b will be lower for a VLCC than for a LR-2. For short distances AC will be below BD indicating that the higher cost of getting from the Black Sea to the Mediterranean by pipeline is not significantly offset by the lower rates that are offered by VLCC transport. However, as distance increases the two curves will get closer indicating a smaller cost penalty for using the bypass pipeline.

VIII Tengiz Oil

Appendix Tables D-5 to D-8 compare the total transport costs of Kazak oil delivered to Rotterdam and Italy for various pipeline route for alternative values of cost of capital.

To simplify our exposition Table 7 extracts data from Tables D-5 and D-6 and shows the total transport cost of Kazak oil to Rotterdam and Italian markets for three alternative routes, each assuming a CPC pipeline to Novorossyisk with a throughput of 800,000 b/d. The three alternatives are: i) a large capacity Bosporus bypass of 1.5 million b/d throughput , ii) a large capacity pipeline from Samsun to Ceyhan, and iii) use of LR-2s from Novorossyisk which transit the Bosporus.

Our main conclusions are: i) of all the routes designed to bypass the Turkish Straits, a large capacity pipeline of 1.5 million b/d through Turkish Thrace has the lowest cost and ii) all pipelines are more costly than using tankers to transit the Straits. The Baku-Ceyhan pipeline would add 81 to 99 cents/b while the lowest cost bypass adds 28 to 53 cents/b, depending on destination and size of tanker used.

Table 7: Transport Cost Comparisons for Kazak Oil From Novorossyisk	
to Europe. Assuming a Cost of Capital of 15%	

Destination-Route	Cost/b	Cost as a % of	Cost Minus Cost
Baku-Rotterdam:		Bypass Route	of Bypass Route
Tanker From Novorossyisk	$2.33	89%	-0.28
Novorossyisk-Turkish Bypass	$2.61	100%	0.00
Novorossyisk-Samsun-Ceyhan	$3.14	120%	0.53
Italy			
Tanker From Novorossyisk	$1.74	79%	-0.46
Novorossyisk-Turkish Bypass	$2.20	100%	0.00
Novorossyisk-Samsun-Ceyhan	$2.73	124%	0.53

Table 6 does not include as an option an extension of the Baku-Ceyhan pipeline to feed Kazak oil into it, since no cost estimates for a Trans-Caspian pipeline are currently public. However, given the high cost of the Baku-Ceyhan line, discussed in the context of Azeri oil adding the cost of a Trans Caspian line will make this option for Kazak oil very expensive.

To compare the relative merits of delivering Kazak oil to the Persian Gulf instead of the Mediterranean, we follow the argument developed above in our discussion of Azeri oil. With transport costs to Mediterranean markets at $2.22 for Saudi oil and $2.20 for Kazak oil, by way of the lowest cost bypass pipeline, transport costs for Kazak oil are comparable those facing Gulf suppliers

For Asian markets, transport costs for Kazak oil will be $1.27 to $1.57 higher than for Gulf oil, the cost of transporting the oil to ports in the Gulf and Arabian Sea.

In an efficient market, routes through Iran to Kharg Island or through Afghanistan and Pakistan to Gwadar will have lower net revenue for Kazak producers than routes to Europe. However, if Saudi Arabia insists on maintaining a significant presence in the European market, the option for Kazakhstan to export its oil to Pakistan by pipeline (CAOPP) might provide a higher net revenue than to Europe.

IX The Bosporus

As Tables 5 and 7 clearly show, delivering Caspian oil to market with tankers from Novorrosysk and Supsa which then transit the Bosphorus is significantly the lowest cost option. Other routes are being considered in part because of strong Turkish objections to increasing the quantities of oil and other "dangerous" cargoes that pass through the Bosporus. Russia is currently exporting approximately 1.2 mmb/d through the Bosporus. Caspian oil plus possible increases in Russian exports could possibly add another 2-3 million b/d by the year 2010. The Turkish government has argued that if 3 million b/d are shipped through the Bosporus using large 150,000 DWT tankers, the Straits would have to be closed for 300 days each year.

The Turkish government stresses the environmental, safety and congestion problems of increased tanker traffic. Other countries, the Russian Federation in particular, have argued that improved management, regulations such as requiring pilots for large ships and specific separation rules, and investment in modern traffic control systems, in particular a vessel tracking system (VTS), would permit the safe passage of projected oil exports from Azerbaijan and Kazakhstan. Russia correctly argues that the additional traffic generated by Caspian oil exports will account for a very small proportion of the total traffic through the Bosporus, adding from one to four additional tanker trips per day depending on the level of exports and the size of the tankers used. On average, there are currently 136 ships that transit the Bosporus each day.

Ship size is important because ships over 80,000 DWT require that the Bosporus be closed to two way traffic in order to permit the vessel to cross over into the oncoming traffic lane. This requirement for large vessels is necessary because the configuration of the Bosporus is such that ships are required to make at least twelve course corrections in a distance of only 31 kilometers. The average width of the Strait is 1.5 km but is only 700 meters at its narrowest point. At this point (Kandilli) ships are required to make a 45 degree course correction and cannot see oncoming traffic. It must make this maneuver at a point where the current could be as high as 7-8 knots. A second 45 degree course change is also required.

As traffic has increased, the number of accidents, some very serious, has also increased. During the period 1982 to 1994, there were 201 major accidents in the Turkish Straits. In one incident in 1994, an oil tanker collided with a freighter and burst into flames killing 30 people. The fire took several days to be extinguished.

The Montreux Convention of 1936, which guarantees free passage of all vessels through the Straits, is a barrier to development of a efficient use of this congested route. While Turkey is assigned the rights to manage the Straits, its flexibility to pursue this right is constrained by the Convention. With tariffs limited to covering administrative costs, the Turkish authorities must rely on the use of regulations to manage traffic in an orderly and safe way. The Turkish government announced a new set of regulations governing transit through the Straits in 1994. After some objections from other States, the proposed regulations were amended. The new Turkish Regulations for Navigation went into effect in 1995. These regulations include a speed limit of 10 knots per hour, the closure of one traffic lane for all vessels over 250 meters and the closure of the waterway to all shipping when vessels over 300 meters in length transit. Ships over 200 meters in length can transit only during daylight hours. The effect of the Regulations has been a marked reduction in the number of accidents. However, these benefits have come at the cost of increasing delays for transit.

A rational policy for dealing with congestion and environmental costs from tanker traffic through the Bosporus cannot be resolved without a revision of the Montreux Convention or at least a change in its interpretation. Efficient use involves a mechanism by which ship owners bear the cost of the externalities of using the Turkish Straits as a transit route**.** In this way, they can balance the benefits of using the Straits against the cost of alternative ways to move cargoes between the Black Sea and the Mediterranean.

Such mechanisms could include tolls and/or a requirement that ship owners carry comprehensive insurance against all damage to people and property. These solutions require the consent of many countries including Russia. Negotiations will be very difficult as many parties will have to decide on how to share the surplus created by reducing congestion and the costs of bearing the negative environmental externalities.

Turkey has argued that when the Montreux Convention was signed in 1936, traffic through the Straits as well as the size of Istanbul were much smaller than today. For example, in 1938 an average of only 15 ships with an average weight of 13 tons passed through the Bosporus. In 1995, the average was approximately 126 per day with an average weight of 200,000 tons. The increase in traffic increases the probability of accidents and the larger city increases the possible cost in terms of damages to persons and property of an accident. These are real costs which are currently not been borne by users of the Straits. It is reasonable to assume that the signers of the treaty did not intend that the clause which gives "free" passage to all vessels, should be interpreted to mean that Turkey would be required to subsidize use of the Straits by assuming the cost of shipping accidents that fall on Turkish property and residents. The treaty permits the collection of tolls to pay for the administration of the Straits. These other costs are just as real.

In the case of tolls, an efficient use of the Bosporus would require that tolls reflect the costs imposed on other ships through delays as well as costs imposed on residents and property owners in Istanbul, by collisions, explosions or other incidents in the Bosporus. Since not all ships will impose the same level of externalities, a schedule of tolls would be required for ships according to the externalities they create. Large tankers which require the closure of the waterway to other traffic would pay higher tolls than ships which do not; ships carrying hazardous cargoes would also pay higher tolls than those that do not. Needless to say, the establishment and administration of appropriate tolls would be complicated and difficult given both the number of different sized ships and possible cargoes and the number of countries that would have to agree to them.

An alternative solution to the problem is to require that all ships have liability insurance to cover any damage inflicted on the people and property of the surrounding area. One political advantage of this approach is that it requires shippers to absorb the costs of environmental and other damage inherent in transiting the Bosporus, but avoids the charge that Turkey wishes to profit from the Straits by charging tolls. This requirement would not, however, address the issue of congestion. Furthermore, insurance for the contingencies involved may not be available. Such insurance would require that insurance companies calculate the appropriate schedule of premiums. Again, this will be difficult to do with any precision.

A serious problem inherent in any of these solutions is how to place a value on the esthetics of a clear and clean waterway, tanker free vistas and the historical treasures of Istanbul which are vulnerable to serious accidents in the Bosporus. While economists can provide techniques for valuing these "commodities", these will typically only place a lower bound to the true value. In any case, the valuation of these assets will likely be determined in the political arena where factors other than economics dominate.

One way to look at the pipeline proposals is that they are one alternative way of dealing with the congestion and environmental externalities created by the transit of oil tankers through the Bosporus. Thus, the cost of pipeline transport is the cost of eliminating those environmental externalities associated with tankers.

The incremental cost to using a bypass through Turkish Thrace in place of transiting the Turkish Straits in tankers is less than 55 cents/b. However, the incremental costs to total transport costs may be lower, as shown in Tables 5 and 7, because of the ability to use lower cost VLCC vessels in the Mediterranean. For example, a large capacity bypass with a throughput of 1.5 million b/d would add less than $650,000 per day to the cost of transporting that quantity of oil from the Black Sea to Augusta. On the other hand, the cost of the Baku-Ceyhan pipeline is $1.44 /b higher than shipping oil through the Straits on a tanker. At 800,000 b/d, the largest proposed Baku-Ceyhan pipeline for which we have cost data, the additional cost would be $1.2 million per day.

The preceding costs have been calculated assuming a cost of capital of 15% but one could argue that the social opportunity cost of capital is closer to 10%. At a rate of return of 10%, the additional costs of the pipelines would be only $270,000 and $352,000 per day, respectively. For the 1.5 million b/d throughput Bosporus bypass, the additional costs for oil shipments to Augusta are less than $9 per year for each resident of Istanbul.

To determine whether $9 per capita per year is greater or less than the benefits that Istanbul residents receive from diverting 1.5 million b/d of oil away from the Bosporus would require that we measure these benefits. We have not attempted to do so in this paper.

The Turkish position of the Bosporus is somewhat inconsistent. On the one hand, they have argued that increased tanker traffic will lead to increased congestion and environmental risks and have taken the position that the only acceptable solution is the construction of the Baku-Ceyhan route. On the other hand, they have already indicated that they will collect a tariff on that pipeline, adding to the cost of bypassing the Straits. In addition, it is not at all clear that diverting 800,000 b/d of oil to Ceyhan will have any significant effect on the externality problem in the Straits which is used to justify the pipeline. After all, diverting 800,000 b/d will mean that only one less tanker a day would transit the Straits. Not only will this have an insignificant effect on congestion, it will also have an insignificant effect on the environmental risks of Bosporus traffic, since there will still be many other tankers carrying much more volatile and otherwise hazardous cargoes that would still transit the Bosporus. These arguments apply also to any bypass route.

The construction of a pipeline to divert some of the Caspian oil away from transiting the Bosporus will have to be borne by someone. Buyers of oil will not pay since the market is competitive. If the Turkish Government insists on collecting tariffs on any line built, the producing countries and/or companies will have to bear, not only the pipeline costs but also the Turkish tariff. This raises a number of interesting issues that are beyond the scope of this study.

X The Effect of Central Asia Supplies: Forecasting the Market

From the energy security point of view, consuming countries benefit when global oil production comes from as diverse a base as possible. Such diversity reduces reliance on any particular geographic country or center, thereby reducing the effect on world supplies and prices from major disruptions in any one area. Experience has shown that maintenance of moderate prices is more easily achieved when there is reasonable market competition within and outside of the Organization of Petroleum Exporting Countries (OPEC).

Many options exist to enhance the diversity of the world's oil productive base. There are still significant oil and gas deposits to be exploited outside the Middle East in many places around the globe. The oil and gas potential of Central Asia and the Caucasus has received intensely focused attention in recent years as a possible substitute or alternative to the Middle East as a major energy supplier. This emphasis, though well-intentioned, may be misguided.

In the short-term, Central Asia and the Caucasus' energy potential will be quite limited due to a wide variety of constraints to rapid development. Longer term, the region may provide a steady flow of oil and gas, but is unlikely to compare favorably with other major provinces like the North Sea or Latin America in the speed and efficiency with which large reserves can be translated into peak production rates. Output from the region may never match its geological potential as logistical and political obstacles hold back the number of oil companies that can bring finds on line at any one time.

Forecasts for the year 2005 and 2010 reveal that if production from non-OPEC provinces continues to grow at a rate commensurate with expansion seen over the past decade, the amount of oil from the Middle East needed to meet rising world oil demand requirements could be significantly reduced. Non-OPEC production has expanded by 1%-1.5% per annum on average since 1988 through a combination of technological advances in drilling systems and unearthing of new basins in South America, in deep water and elsewhere. Should this trend continue, non-OPEC production would likely reach 54 million b/d by 2005 and 58 million b/d by 2010 including rising Caspian Basin production.

Under this moderate non-OPEC expansion scenario, oil markets could be expected to be oversupplied by 2005-2010 under both high and low demand growth cases. The period is likely to witness a substantial increase in the amount of production capacity that will have to be shut in by the Organization of Petroleum Exporting Countries (OPEC) or other producers to defend even moderate price levels. Under this scenario, Caspian Basin oil production will not be critical for maintaining moderate oil prices for at least another decade assuming as seems reasonable that historically-persistent competition continues within OPEC.

The above conclusion is illustrated in Table G-1 which projects anticipated production levels for various players in the international oil market under a moderate production growth scenario that matches historical trends for price and rate of capacity expansion. The non-OPEC figures assume that non-OPEC growth will continue at the historical rate of the past ten years of 1.4% per annum and provide a forecast of non-OPEC production of 54 million b/d in 2005 and 58 million b/d in 2010. By adding the output for OPEC countries that are projected by these governments, it is possible to illustrate the overall surplus between what OPEC would like to produce and what would be needed from OPEC to balance supply with demand. The discrepancy between the two, as expressed in the line for the residual share left for Saudi Arabia, serves as a measure of market oversupply. It can be assumed that Saudi Arabia will want to produce at levels similar to the 1997 base case or some amount above that level. In many cases shown, Saudi Arabia's residual share is indicated as a negative number or a number substantially below the 8.7 million b/d that the kingdom is producing today. This result implies that under many scenarios, Saudi Arabia and other Persian Gulf producers will have to shut in significant volumes of production capacity to balance with supply with demand to defend oil price levels.

However, in a high demand scenario where oil use rises by 3% per annum between 2000 and 2010, subtracting Caspian oil would lead to a significant tightening of oil markets from current levels. In other words, rising exports from the Caspian Basin could play a significant role as a marginal supplier in arresting a jump in the price of oil under conditions of strong oil demand and high growth.

In a paper forecasting future world oil demand by assuming that, as countries develop, their pattern of energy use will converge toward that of the developed countries, Sickles suggests that neither the moderate (2%) or the high growth (3%) scenarios are the most likely to develop. This model predicts that global oil demand will reach 80 million b/d by 2005 and 89 million b/d by 2010. This forecast is considerably below moderate growth scenarios or high growth scenarios which predict global oil demand will reach 94 million b/d and 103 million b/d respectively by 2010.

The implications of this forecast for oil producers seeking to raise output between 2005 and 2010 are relatively pessimistic. Under a scenario where oil demand growth reaches 80 million b/d in 2005 and 89 million b/d in 2010, oil markets could wind up to be oversupplied by a wide margin. For example, the residual share for Saudi Arabia is negative in all scenarios, including those where increases in production from the Caspian Basin are assumed to be zero. Such an outcome will obviously not occur. However, the analysis suggests that Saudi Arabia and other members of OPEC will have to shut in significant volumes of productive capacity --ranging from 12 million b/d to 15 million b/d-- to balance supply with demand in 2005 and 2010 under a moderate non-OPEC growth scenario. By comparison, OPEC only has around 1 to 2 million b/d a day of production capacity shut in at present.

Under a low non-OPEC growth scenario forecast by the US Department of Energy, OPEC would have to shut in between 5 to 7 million b/d of capacity except under the high growth scenario for 2010 where emerging production from the Caspian Basin is set to zero. Under this high growth scenario, OPEC can get by shutting in an incremental 2 million b/d. This forecast also indicates that maintenance of moderate prices is feasible for the period between 2005 and 2010 even if a major non-OPEC province is removed. In other words, under the convergence forecast scenario and other scenarios, Caspian Basin production will not be critical for maintaining moderate oil prices for at least another decade assuming, as seems reasonable, that historically persistent competition continues within OPEC.

Although it is difficult to assess which of the many scenarios is most likely to come to pass, the exercise does seem to illustrate the limited contribution of Central Asian and Caucasian production to the global supply-demand balance for the next decade or so. Its contribution will meet only 3-4% of world oil use. The relative importance of this supply is far smaller than output from Venezuela which is expected to account for as much as 7 to 8% of total world oil demand or the Middle East, which could still dominate within 25-35% share, depending on other market conditions. And, in fact, it could be argued that its contribution –standing at something between 3-4% of projected world oil demand --remains only as significant as a margin of calculated error in forecast planning.

XI Conclusions

In this paper we have focused on the economic aspects of Caspian export pipelines. We have calculated the costs of exporting oil through a number of proposed lines, including those that are designed to bypass the Turkish Straits. Our conclusions are as follows:

i) Limitations on drilling infrastructure and recent disappointing finds suggest that the region will not be able to generate sufficient export volume to support large-scale export lines in the near and perhaps even intermediate term. As a result, reliance will be on make-shift solutions, such as using existing lines which can be refurbished and expanded or the use of oil swaps, as has been proposed with Iran.

ii) Given reasonable expectations for economic growth, neighboring countries such as the Ukraine, Romania, Bulgaria and Turkey can absorb much of the projected export surplus of Caspian oil over the next decade. Projected increases in oil demand from these countries, combined with exports to supply refineries in Grozny, Russia and northern Iran could absorb 1 million barrels to 1.5 million barrels of oil a day by 2010. While total regional production could reach 3.5 million b/d by 2010, this projection depends on optimistic assessments of the quantity of reserves that lie in the shallow waters of the Kazak offshore sector. If these expectations are borne out, exports could total 2.5 to 2.8 million b/d by 2010. However, given the difficulties of developing Caspian oil, it is unlikely that production will support exports of more than 2.8

million b/d by 2010. This could leave as little as 1-1.5 million barrels of Caspian oil that would have to be exported beyond the littoral states of the Black Sea or Iran.

iii) There are significant scale economies to pipeline throughput which are sacrificed when several smaller lines are built instead of one larger one. The benefits of multiple routes as a means of reducing the financial risk of temporary closures of pipelines must be weighed against this cost. For reasonable assumptions about the frequency and severity of disruptions, the certain costs of higher transport costs exceed the expected value of such losses. On the other hand, if risks involve, not the acts of terrorists, but acts of governments, the existence of multiple routes will reduce the bargaining power of governments of transit countries to squeeze post contract concessions from pipeline operators

iv) Given economies of scale and the likely magnitude of increases in the volume of Caspian oil (including Russia) that will be exported via the Mediterranean, it is likely that only one large capacity export pipeline from each of the major producing countries, Azerbaijan and Khazakstan will be needed, at least until 2010.

v) Of the routes to the Mediterranean that are designed to bypass the Turkish Straits, the pipeline from Baku to Ceyhan has the highest cost/b of the routes investigated, at least one dollar per barrel more than a bypass route through Turkish Thrace. Extending the Baku-Ceyhan line to carry Russian or Kazak crude would permit a larger capacity pipeline to be built and would lower transport costs. Nonetheless, given the relationship, between tanker and pipeline costs, the Baku-Ceyhan route will still always be more expensive than alternatives involving shorter pipelines and more reliance on tanker transport.

vi) Routes involving a large capacity pipeline from Samsun to Ceyhan have a higher transport cost than the bypass routes through Thrace but are less expensive than for the Baku-Ceyhan.

vii) The largest tanker that can transit the Bosporus is an LR-2 which carries approximately 1 million barrels of oil. However, because of economies of scale in tanker transport as well as past over building of large tankers, freight costs per barrel/mile are lower for the VLCC tankers carrying 1.5 - 2 million barrels of oil. For shorter trips such as Supsa-Italy, transport costs using the LR-2 for the entire trip are lower than the cost of a route which includes a large capacity pipeline through Turkish Thrace. For longer trips such as to Rotterdam, the lower cost of VLCC transport from eastern Mediterranean ports offsets some of the added cost of handling oil in, and across the Black Sea, and shipping to a Mediterranean port through a Bypass pipeline.

viii) Depending on where Caspian oil is finally shipped, a large capacity bypass pipeline could be a relatively inexpensive substitute to transit through the Turkish Straits and should be considered as a means of transporting projected increases in oil exports from the Caspian region. The economic viability of a bypass would be increased if shippers had to bear the true social cost of transiting the Turkish Straits, that is, the expected value of damages borne by the residents of Istanbul to their person and property as well as the cost of delays due to congestion. It is the Montreux Treaty, which allows all ships to transit the Straits without bearing these costs, that makes transiting the Turkish Straits so attractive to shippers. Revision of the Montreux Convention will be difficult, since it will require that countries using the Turkish Straits agree on how to share both, the benefits of reduced congestion and the costs of environmental externalities.

ix) In an environment of efficient oil markets, Azeri and Kazak oil would generate a higher net revenue if exported to Europe rather than to Asia. This reflects a combination of factors including relative transport costs for Azeri and Kazak oil compared to the costs of competing suppliers. But, if Saudi Arabia insists on maintaining a significant presence in the European market, the option for Kazakhstan to export its oil to Pakistan by pipeline (CAOPP) might, in that case, provide a higher net revenue than to Europe. This would not be the case for Azeri oil which is geographically closer to the European market.

x) There is evidence that the Saudis subsidize sales of their oil to European markets. Prices of Saudi crude in Europe are found to be 72 cents lower than in Asia. The average differential between European and Asian prices observed during the last decade is not sufficient to offset the cost of moving Caspian oil to ports in the Gulf or the Arabian Sea for export to Asia.

Appendix A

Major International Activities in Exploration and Development in the Caspian Basin.

Kazakhstan

The first oil field deal with a newly independent republics came in 1993 when Chevron formed the Tengizchevroil joint venture with the Kazakh government. In 1996 and 1997, Mobil and Russia's Lukoil entered the deal in an effort to diversify risk and to broker a workable transport arrangement for the field's output. Plans to construct a pipeline connection between Tengiz and the Russian port of Novorossiysk have progressed but are not yet finalized. A small amount of output from the field moves through the Russian pipeline system and by railcars to various ports in the region. Production is running at about 170,000 b/d. The venture hopes to finish its transport arrangement for a line to Novorossiysk that will allow additional exports of 200,000 b/d by 1999 and between 700,000 –800,000 b/d by 2010.

In 1995, British Gas, Italy's Agip and Russia's Gazprom agreed to finance work to boost output at the Karachaganak gas and condensate field. Gazprom dropped out of the deal in Mid-1996 and Texaco joined the deal in 1997.

A consortium of international oil companies, including Italy's Agip, BP/Statoil, British Gas, Mobil, Royal Dutch Shell, French Total and KSC, a Kazakh partner company, completed a seismic study of Kazakhstan's Caspian Sea shelf in 1996. The group took its pick of two of 12 exploration blocks. Limited production is expected no sooner than 2004 but sizable output of over 1 million b/d might be possible beyond 2010, assuming geological theories about the area pan out.

China's China National Petroleum Corp. (CNPC) has invested in a 60% stake in oil and gas producer Aktobemunaygas and plans to take a 51% stake in a joint venture to upgrade the Uzen field.

Lukoil and Hurricane Hydrocarbons of the US are investing to upgrade the Kumkol field in southern Kazakhstan. Production at the field is expected to rise from 12,000 b/d to 50,000 b/d by 2000.

A Japanese consortium led by Japan National Oil Corp. (JNOC) is exploring in the Aktyubinsk province. JNOC has reportedly discovered three commercially viable fields in Kazakhstan since 1994.

Other smaller joint ventures include the 20,000 b/d Arman field –Oryx Energy and local partners—TPAO of Turkey and a local partner in the Aktyubinsk, Atyrau and Mangustau oblasts; Anglo-Dutch and Naphta Israel in the Tenge field; Mobil and local partners in the Tulpar region; and Union Texas and Oman Oil Co. in the Atyrau region. Exxon and Oryx Energy are teamed to explore the Metvyi Kultuk region.

Amoco is negotiating an exploration deal for the South Emba field while Spain's Repsol and UK Enterprise Oil is negotiating for the Baiganin block in he Aktyubinsk region.

Azerbaijan

In 1993, the AIOC consortium which now groups Amoco, BP, Exxon, Pennzoil, Lukoil, Delta-Nimir, Statoil, Itochu, Unocal, Ramco, Turkish Petroleum Co. (TPAO) and Azeri state Socar finalized plans to develop the Chiraq, Guneshli and Azeri fields. Oil flows of approximately 40,000b/d began this year from the Chiraq field and tentative exports through Russia have begun. Volumes of up to 100,000 b/d are scheduled to be exported through Georgia by the end of this year. Production is programmed to hit 800,000 b/d by 2010 if and when the consortium is able to line up export outlets for all of its production. A decision on a Main Export Pipeline is slated for October. An all land route from Baku to Ceyhan, Turkey or an expansion of facilities to Supsa, Georgia are currently favored.

Karabakh field is under exploration by a consortium grouping Pennzoil, Lukoil, Agip, and Socar. Hopes for a 200,000 b/d of oil production have been called into question with recent exploration setbacks.

Socar signed an exploration agreement with France's Elf Aquitaine and Total for the Lenkoran Deniz and Talysh Deniz fields in 1997. Other partners include OIEC of Iran, Germany's Deminex, Italy's Elf and Belgian Petrofina. It is believed that the fields have the potential to produce 300,000 b/d.

Lukoil signed a production sharing agreement (PSA) with Socar last year for the Yalama field.

Amoco, Unocal, Delta-Nimir, Itochu, and Socar will develop the Dan Ulduzu and Ashrafi fields. The companies hope production will hit 145,000 b/d by 2007.

Mobil signed a PSA for the Oguz field in 1997.

Chevron signed a PSA for the Apsheron field in 1997.

Exxon signed a PSA for the Nachichivan field in 1997.

BP, Statoil, Elf Aquitaine, Lukoil, Turkish Petroleum Corp. and OIEC of Iran and Socar formed a consortium to develop of Shakh Deniz field.

Other offshore oil field deals under negotiation include the Inam field (Amoco), the South Caspian Archipelago (Mobil, Ramco and Total), Shallow Guneshli (Conoco), the Yanan tava-3, Atashgah and Muga Deniz (JNOC), and Umid fields. Azerbaijan is also working on an international tender for several other offshore fields. The Kyapaz field remains in dispute with Turkmenistan.

Turkmenistan

There are several international companies working in Turkmenistan under joint venture arrangements including Argentina's Bridas (the Keymir oil field and Yashlar prospect); Ireland's Dragon and Holland's Larmag (offshore block near Cheleken); Malaysia's Petronas (Gubkin, Barimov, and Livanov fields); Monument Oil (Burun, Nebit Bag, Kamdag and Monzhukly fields, the latter three with Mobil); and Mobil (Karaboggazgol gas field). Russia's gas monopoly Gasprom, Shell, Itochu, and China National Petroleum Corp. have also shown interest in

Turkmen projects, among others. The Turkmens have also begun the tendering process for offshore acreage. The Turkmen government has also signed bilateral protocols of intent for the development of major natural gas pipeline projects with China, Pakistan, and Turkey.

Unocal, which signed an agreement with the government of Turkmenistan in October 1995, continues to pursue a major project for the construction of a gas pipeline from the Dauletabad gas field in southern Turkmenistan to Pakistan via Afghanistan. Shell, which maintains a "strategic alliance" with Gazprom, was recently appointed to conduct a feasibility study of the Iran-Turkey gas grid for Turkmenistan. Turkmenistan and Gazprom remain, however, at a deadlock over gas sales to the Ukraine via Russia, an arrangement that was disbanded last year.

Source: Petroleum Intelligence Weekly, IEA, US Department of State Caspian Region Development Report, Industry sources.

Appendix B

Estimating Capital Expenditures for the CPC and Bosporus Bypass Pipelines

In this appendix we discuss our assumptions and method used to calculate the investment cost of the CPC and the Bosporus bypass pipelines. We also discuss the method by which we compute per barrel transport costs from these estimates of capital expenditures as well as those that have been made for the same and alternative routes by others. Industry estimates could be biased downwards if they are to be used strategically to affect the routes that will ultimately be chosen.

In our calculations of capital (investment) costs, we assume pipe costs (installed) at $32,500 per mile (length) inch (diameter); Storage (tank farms) at $12/b and pump stations at $1,000/HP. Monomoorings are assumed to cost $10 million each. All other facilities including measuring and loading lines are estimated at $250 million. We assume a flat terrain. To the extent that actual terrain deviates significantly from this assumption our estimates will underestimate the horsepower required for these two routes. These calculations do not include right-of-way costs.

The CPC Route

Assumptions: Estimated Cost

Route length of 900 miles (1500 kilometers)

Diameter of pipe is 42 inches

Throughput is 800,000b/d

Pipe cost (installed) $1,229 million

Total tank storage at field is 3.75 mmb/d 45

Thirteen pump stations 260

Additional storage at Novorossiysk is 4.7 mmb/d 56

Monomoorings (3 @ $10 million) 30

All other facilities (measuring and loading lines,

suction and booster pumps, etc.) 250

Total Capital Cost $1,870 million

Bosporus Bypass

Assumptions: Estimated Cost

Route length of 114 miles (190 kilometers)

Diameter of pipe is 42 inches

Throughput is 1 mmb/d b/d

Pipe cost (installed) $155.6 million

Total tank storage (10 mmb at each end) 240

Pump stations 43

Monomoorings (3 at each end @ $10 million) 60

All other facilities (measuring and loading lines,

spill recovery, etc.) 500

Total Capital Cost $998.6 million

Appendix C

Computing Per Barrel Pipeline Transport Costs

Total costs of transporting a given quantity of oil, C, can be expressed in terms of two components:

C = (capital cost) + (operating cost)

where r is the rate of return used to calculate the cost of capital. To compute the total cost of each pipeline option we have assumed a pre-tax cost of capital of 10% 15% and 20%. The discussion in the paper has used the cost figures for a 15% cost of capital since private investors may require a substantial risk premium for investing in the Caspian area. From a social point of view, risks will be lower and a 10% rate may be appropriate. The length of life for all projects was assumed to be 30 years and all capital investment was amortized over this period. Operating costs are set at 2% of total capital investment. This is a rough figure but a reasonable "rule of thumb".

To compute average cost per barrel that uses each pipeline, we found the annual payment that would amortize the capital cost in 30 years, added the annual operating cost and divided this sum by the annual throughput..

Table C -1 shows the cost per barrel for various pipelines based on the estimates of capital cost provided by the IEA, CSIS and Woodmac and ourselves (see appendix B). Calculations are shown for a 10%, 15% and 20% capital cost and for service lives of 20 and 30 years. The higher costs for a 20 year amortization is generally only a few cents per barrel. Costs are very sensitive to the rate of discount used.

These calculations are clearly, only rough approximations. However, since our interest in per barrel costs is primarily to compare costs of alternative routes, biases which affect all routes equally will not affect the relative standing of each route.

Table C-1

Table C: Pipeline Costs for Alternative Routes. Cost of Capital 10%-20%, Length of Life 20-30yrs.

Route	Length Kilometer	Diameter Inches	Capacity mb/d	Total Cost US$bill	Cost/b 10%/20yr	Cost/b 10%/30yr	Cost/b 15%/20yr	Cost/b 15%/30yr	Cost/b 20%/20yr	Cost/b 20%/30yr	Source 0
Northern AIOC	1100	40	300	$1.04	$1.31	$1.20	$1.71	$1.64	$2.14	$2.10	IEA
Baku-Novorossiisk	1595	40	800	$2.28	$1.07	$0.98	$1.40	$1.35	$1.76	$1.72	CSIS
Baku-Tbilisi-Supsa	850	40	900	$1.30	$0.54	$0.50	$0.71	$0.68	$0.89	$0.87	IEA
Baku-Tbilisi-Supsa	850	40	1500	$1.60	$0.40	$0.37	$0.53	$0.50	$0.66	$0.65	IEA
Baku-Ceyhan/ Armenia	1950	40	600	$3.50	$2.20	$2.01	$2.87	$2.75	$3.60	$3.53	IEA
Baku-Ceyhan/ Georgia	1700	40	600	$3.20	$2.01	$1.84	$2.63	$2.52	$3.29	$3.23	IEA
Baku-Ceyhan/ Iran	2070	40	800	$3.93	$1.85	$1.70	$2.42	$2.32	$3.03	$2.97	CSIS
Baku-Ceyhan/Georgia	2170	40	800	$4.14	$1.95	$1.79	$2.55	$2.44	$3.20	$3.13	CSIS
Samsun-Ceyhan	1450	40	600	$1.16	$0.73	$0.67	$0.95	$0.91	$1.19	$1.17	IEA
Samsun-Ceyhan	890	40	800	$2.05	$0.97	$0.89	$1.26	$1.21	$1.58	$1.55	CSIS
Samsun-Ceyhan	890	48	1880	$3.50	$0.70	$0.64	$0.92	$0.88	$1.15	$1.13	CSIS
Burgas-Alexandroupolis	317	40	600	$0.70	$0.44	$0.40	$0.57	$0.55	$0.72	$0.71	CSIS
Burgas-Alexandroupolis	317	40	600	$0.70	$0.44	$0.40	$0.57	$0.55	$0.72	$0.71	IEA
Burgas-Vlore	915	36	750	$0.80	$0.40	$0.37	$0.53	$0.50	$0.66	$0.65	CSIS
Azerb/Turkmen/Kharg	2150	40	1500	$3.00	$0.75	$0.69	$0.98	$0.94	$1.23	$1.21	IEA
Azerb/Turkmen/Kharg	2150	40	900	$3.00	$1.26	$1.15	$1.64	$1.57	$2.06	$2.02	IEA
CPC First Phase	1500	42	560	$2.50	$1.68	$1.54	$2.20	$2.11	$2.76	$2.70	IEA
CPC Second Phase	1500	42	1500	$4.50	$1.13	$1.04	$1.48	$1.42	$1.85	$1.82	IEA
CPC	1500	42	1500	$1.90	$0.48	$0.44	$0.62	$0.60	$0.78	$0.77	WOOD
CPC	1580	42	1340	$2.00	$0.56	$0.52	$0.74	$0.70	$0.92	$0.90	CSIS
CPC	1500	42	800	$1.87	$0.88	$0.81	$1.15	$1.10	$1.44	$1.41	SJM
CAOPP	1673	42	1000	$5.00	$1.88	$1.73	$2.46	$2.36	$3.09	$3.03	WOOD
CAOPP/Pakistan	1667	42	1000	$2.70	$1.02	$0.93	$1.33	$1.27	$1.67	$1.63	CSIS
CAOPP	1667	42	1000	$2.70	$1.02	$0.93	$1.33	$1.27	$1.67	$1.63	IEA
Kiyikoy-Ibrikbana	190	42	500	$0.58	$0.44	$0.40	$0.57	$0.55	$0.72	$0.70	IEA
Kiyikoy-Ibrikbana	190	42	1500	$1.11	$0.28	$0.26	$0.36	$0.35	$0.46	$0.45	IEA
Kiyikoy-Ibrikbana	190	42	1000	$1.00	$0.38	$0.35	$0.49	$0.47	$0.62	$0.61	SJM
CNPC to China	3000	40	1000	$3.50	$1.32	$1.21	$1.72	$1.65	$2.16	$2.12	Wood
CNPC to Iran	1200	28	250	$1.10	$1.66	$1.52	$2.17	$2.08	$2.72	$2.66	Wood

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Appendix D

In this appendix we show calculations of total transport costs for Azeri and Kazak oil delivered to Rotterdam and Italian ports using cost of capital equal to 10% and 15% and Black Sea transfer costs, the cost of loading and unloading oil in Black Sea ports as well as the cost of transiting the Black Sea of 40 cents a barrel.

Our calculations of Black Sea transfer Costs put these at 31 cents/b calculated as the cost of transiting the Black Sea in an LR-2, plus an additional 3 days in ports for loading and offloading and additional port charges. We have used 40 cents in the tables in this appendix and in the text in order to be on the conservative side. The cost differential between using the Turkish Straits for tankers versus a bypass pipeline will be sensitive to assumptions about Black Sea transfer costs. A cost of 60 cents for example (a number which has been suggested by industry analysts) will increase the cost penalty of trips to Augusta by almost a third.

TABLE D-1: Comparison of Transport Costs For Azeri OIL , Cost of Capital 15%, Length of Life 30 years

	Capacity	Cost/b To	Blk Sea	Second	Tanker to	Total Cost
Routes to Rotterdam	mb/d	First Port	Transfer Cost	Pipeline	Destination	$/b
Northern AIOC, LR-2 Tanker	300	$1.64			$1.23	$2.87
Baku-Novorossyisk, LR-2 Tanker	800	$1.35			$1.23	$2.58
Baku-Tbilisi-Supsa, LR-2 Tanker	900	$0.68			$1.23	$1.91

Baku-Tbilisi-Supsa, LR-2 Tanker	1500	$0.50			$1.23	$1.73
Baku-Ceyhan via Armenia, VLCC	600	$2.75			$0.76	$3.51
Baku-Ceyhan via Georgia VLCC	600	$2.52			$0.76	$3.28
Baku-Ceyhan via Iran VLCC	800	$2.32			$0.76	$3.08
Baku-Ceyhan via Georgia VLCC	800	$2.44			$0.76	$3.20
Baku-Supsa-Samsun-Ceyhan	900/600	$0.68	$0.40	$0.91	$0.76	$2.75
Baku-Supsa-Samsun-Ceyhan	900/800	$0.68	$0.40	$1.21	$0.76	$3.05
Baku-Supsa-Samsun-Ceyhan	900/1880	$0.68	$0.40	$0.88	$0.76	$2.72
Baku-Burgas-Alexandroupolis	900/600	$0.68	$0.40	$0.55	$0.76	$2.39
Baku-Burgas-Alexandroupolis	900/600	$0.68	$0.40	$0.55	$0.76	$2.39
Baku-Supsa-Burgas-Vlore	900/750	$0.68	$0.40	$0.50	$0.76	$2.35

Baku-Kiyikoy-Ibrikbana.	900/500	$0.68	$0.40	$0.55	$0.76	$2.39
Baku-Kiyikoy-Ibrikbana	900/1500	$0.68	$0.40	$0.35	$0.76	$2.19
Baku-Kiyikoy-Ibrikbana	900/1000	$0.68	$0.40	$0.47	$0.76	$2.31
Routes to Osaka						
Turkmenistan-Kharg	900	$1.57			$0.93	$2.50
CAOPP	1000	$2.36			$0.93	$3.29
CAOPP	1000	$1.27			$0.93	$2.20
CAOPP	1000	$1.27			$0.93	$2.20
CNPC-Iran	250	$2.08			$0.93	$3.01

TABLE D-2: Comparison of Transport Costs for Azeri Oil, Cost of Capital 15%, Length of Life 30 years						

	Capacity	Cost/b	Blk Sea	Second	Tanker to	Total Cost
Routes To Italy	mb/d	to Port	Transfer Cost	Pipeline	Italy	$/b
Northern AIOC	300	$1.64			$0.64	$2.28
Baku-Novorossyisk	800	$1.35			$0.64	$1.99
Baku-Tbilisi-Supsa	900	$0.68			$0.64	$1.32
Baku-Tbilisi-Supsa	1,500	$0.50			$0.64	$1.14
Baku-Ceyhan via Armenia	600	$2.75			$0.32	$3.07
Baku-Ceyhan via Georgia	600	$2.52			$0.32	$2.84
Baku-Ceyhan via Iran	800	$2.32			$0.32	$2.64
Baku-Ceyhan via Georgia	800	$2.44			$0.32	$2.76

Baku-Supsa-Samsun-Ceyhan	900/600	$0.68	$0.40	$0.91	$0.32	$2.31
Baku-Supsa-Samsun-Ceyhan	900/800	$0.68	$0.40	$1.21	$0.32	$2.61
Baku-Supsa-Samsun-Ceyhan	900/1880	$0.68	$0.40	$0.88	$0.32	$2.28
Baku-Burgas-Alexandroupolis	900/600	$0.68	$0.40	$0.55	$0.32	$1.95
Baku-Burgas-Alexandroupolis	900/600	$0.68	$0.40	$0.55	$0.32	$1.95
Baku-Supsa-Burgas-Vlore	900/750	$0.68	$0.40	$0.50	$0.32	$1.91
Baku-Kiyikoy-Ibrikbana.	900/500	$0.68	$0.40	$0.55	$0.32	$1.95
Baku-Kiyikoy-Ibrikbana	900/1500	$0.68	$0.40	$0.35	$0.32	$1.75
Baku-Kiyikoy-Ibrikbana	900/1000	$0.68	$0.40	$0.47	$0.32	$1.87
Routes to Osaka						

Turkmenistan-Kharg	900	$1.57			$0.93	$2.50
CAOPP	1000	$2.36			$0.93	$3.29
CAOPP	1000	$1.27			$0.93	$2.20
CAOPP	1000	$1.27			$0.93	$2.20
CNPC-Iran	250	$2.08			$0.93	$3.01

TABLE D-3: Comparison of Transport Costs For Azeri Oil. Cost of Capital is 10%, Length of Life 30 years

Routes to	Capacity	Cost/b	Blk Sea	Second	Tanker to	Total Cost
Rotterdam	Mb/d	to Port	Tanker	Pipeline	Destination	
Northern AIOC	300	$1.20			$1.23	$2.43
Baku-Novorossyisk	800	$0.98			$1.23	$2.21
Baku-Tbilisi-Supsa	900	$0.50			$1.23	$1.73

Baku-Tbilisi-Supsa	1500	$0.37			$1.23	$1.60
Baku-Ceyhan via Armenia	600	$2.01			$0.76	$2.77
Baku-Ceyhan via Georgia	600	$1.84			$0.76	$2.60
Baku-Ceyhan via Iran	800	$1.70			$0.76	$2.46
Baku-Ceyhan via Georgia	800	$1.79			$0.76	$2.55
Baku-Supsa-Samsun-Ceyhan	900/600	$0.50	$0.50	$0.67	$0.76	$2.43
Baku-Supsa-Samsun-Ceyhan	900/800	$0.50	$0.50	$0.89	$0.76	$2.64
Baku-Supsa-Samsun-Ceyhan	900/1880	$0.50	$0.50	$0.64	$0.76	$2.40
Baku-Burgas-Alexandroupolis	900/600	$0.50	$0.50	$0.40	$0.76	$2.16
Baku-Burgas-Alexandroupolis	900/600	$0.50	$0.50	$0.40	$0.76	$2.16
Baku-Supsa-Burgas-Vlore	900/750	$0.50	$0.50	$0.37	$0.76	$2.13

Baku-Kiyikoy-Ibrikbana.	900/500	$0.50	$0.50	$0.40	$0.76	$2.16
Baku-Kiyikoy-Ibrikbana	900/1500	$0.50	$0.50	$0.26	$0.76	$2.01
Baku-Bosphorus Bypass	900/1000	$0.50	$0.50	$0.35	$0.76	$2.10
Routes to Osaka						
Turkmenistan-Kharg	900	1.15			$1.45	$2.60
CAOPP	1,000	1.73			$1.45	$3.18
CAOPP	1,000	0.93			$1.45	$2.38
CAOPP	1,000	0.93			$1.45	$2.38
CNPC-Iran	250	1.52			$1.45	$2.97

TABLE D-4: Comparison of Transport Costs for Azeri Oil, Cost of Capital 10%, Length of Life 30 years

	Capacity	Cost/b	Blk Sea	Second	Tanker to	Total Cost
Routes To Italy	Mb/d	to Port	Transfer Cost	Pipeline	Italy	$/b
Northern AIOC	300	$1.20			$0.64	$1.84
Baku-Novorossyisk	800	$0.98			$0.64	$1.62
Baku-Tbilisi-Supsa	900	$0.50			$0.64	$1.14
Baku-Tbilisi-Supsa	1,500	$0.37			$0.64	$1.01
Baku-Ceyhan via Armenia	600	$2.01			$0.35	$2.36
Baku-Ceyhan via Georgia	600	$1.84			$0.35	$2.19
Baku-Ceyhan via Iran	800	$1.70			$0.35	$2.05
Baku-Ceyhan via Georgia	800	$1.79			$0.35	$2.14
Baku-Supsa-Samsun-Ceyhan	900/600	$0.50	$0.50	$0.67	$0.35	$2.02

Baku-Supsa-Samsun-Ceyhan	900/800	$0.50	$0.50	$0.89	$0.35	$2.23
Baku-Supsa-Samsun-Ceyhan	900/1880	$0.50	$0.50	$0.64	$0.35	$1.99
Baku-Burgas-Alexandroupolis	900/600	$0.50	$0.50	$0.40	$0.35	$1.75
Baku-Burgas-Alexandroupolis	900/600	$0.50	$0.50	$0.40	$0.35	$1.75
Baku-Supsa-Burgas-Vlore	900/750	$0.50	$0.50	$0.37	$0.35	$1.72
Baku-Kiyikoy-Ibrikbana.	900/500	$0.50	$0.50	$0.40	$0.35	$1.75
Baku-Kiyikoy-Ibrikbana	900/1500	$0.50	$0.50	$0.26	$0.35	$1.60
Baku-Kiyikoy-Ibrikbana	900/1000	$0.50	$0.50	$0.35	$0.35	$1.69
Routes to Osaka						
Turkmenistan-Kharg	900	$1.15			$1.45	$2.60

CAOPP	1000	$1.73			$1.45	$3.18
CAOPP	1000	$0.93			$1.45	$2.38
CAOPP	1000	$0.93			$1.45	$2.38
CNPC-Iran	250	$1.52			$1.45	$2.97

TABLE D-5: Comparisons of Total Transport Costs For Kazak Oil, Cost of Capital 15%, Length of Life 30 years

	Capacity	Tengiz to	Black Sea	Second Pipe	Final	Total
ROUTE	mb/d	Black Sea	Tanker	Line Cost	Tanker	Cost
CPC: Routes to Rotterdam						
Tengiz-Novorossyisk	560	$2.11			$1.23	$3.34

Tengiz-Novorossyisk	1,500	$0.60			$1.23	$1.83
Tengiz-Novorossyisk	1,340	$0.70			$1.23	$1.93
Tengiz-Novorossyisk	800	$1.10			$1.23	$2.33
Samsun-Ceyan	800/800	$1.10	$0.40	$1.21	$0.76	$3.47
Samsun-Ceyan	800/1500	$1.10	$0.40	$0.88	$0.76	$3.14
Burgas-Alexandroupolis	800/600	$1.10	$0.40	$0.55	$0.76	$2.81
Burgas-Vlore	800/750	$1.10	$0.40	$0.50	$0.76	$2.77
Kiyikoy-Ibrikbana	800/500	$1.10	$0.40	$0.55	$0.76	$2.81
Kiyikoy-Ibrikbana	800/1500	$1.10	$0.40	$0.35	$0.76	$2.61
Bosporous Bypass	800/1000	$0.70	$0.40	$0.59	$0.76	$2.45

Routes to Osaka						
Turkmenistan-Kharg	900	$1.57			$0.93	$2.50
CAOPP	1000	$2.36			$0.93	$3.29
CAOPP	1000	$1.27			$0.93	$2.20
CAOPP	1000	$1.27			$0.93	$2.20
CNPC-Iran	250	$2.08			$0.93	$3.01

Table D-6: Comparisons of Total Transport Costs For Kazak Oil, Cost of Capital 15%, Length of Life 30 years						
ROUTE	Capacity	Tengiz to	Black Sea	Second Pipe	Final	Total
CPC Routes to Italy	mb/d	Black Sea	Tanker	Line Cost	Tanker	Cost
Tengiz-Novorossyisk	1500	$0.60			$0.64	$1.24

Tengiz-Novorossyisk	1340	$0.70			$0.64	$1.34
Tengiz-Novorossyisk	800	$1.10			$0.64	$1.74
Samsun-Ceyan	800/800	$1.10	$0.40	$1.21	$0.32	$3.03
Samsun-Ceyan	800/1500	$1.10	$0.40	$0.88	$0.32	$2.70
Burgas-Alexandroupolis	800/600	$1.10	$0.40	$0.55	$0.32	$2.37
Burgas-Vlore	800/750	$1.10	$0.40	$0.50	$0.32	$2.33
Kiyikoy-Ibrikbana	800/500	$1.10	$0.40	$0.55	$0.32	$2.37
Kiyikoy-Ibrikbana	800/1500	$1.10	$0.40	$0.35	$0.32	$2.17
Bosporous Bypass	800/1000	$1.10	$0.40	$0.59	$0.32	$2.41
Routes to Osaka						

Turkmenistan-Kharg	900	$1.57			$0.93	$2.50
CAOPP	1000	$2.36			$0.93	$3.29
CAOPP	1000	$1.27			$0.93	$2.20
CAOPP	1000	$1.27			$0.93	$2.20
CNPC-Iran	250	$2.08			$0.93	$3.01

TABLE D-7: Comparisons of Total Transport Costs For Kazak Oil, Cost of Capital 10%, Length of Life 30 years						
	Capacity	Tengiz to	Black Sea	Second Pipe	Final	Total
ROUTE	Mb/d	Black Sea	Tanker	Line Cost	Tanker	Cost
CPC: Routes to Rotterdam						

Tengiz-Novorossyisk	560	$1.54			$1.23	$2.77
Tengiz-Novorossyisk	1,500	$0.44			$1.23	$1.67
Tengiz-Novorossyisk	1,340	$0.52			$1.23	$1.75
Tengiz-Novorossyisk	800	$0.81			$1.23	$2.04
Samsun-Ceyan	800/800	$0.81	$0.50	$0.89	$0.76	$2.95
Samsun-Ceyan	800/1500	$0.81	$0.50	$0.64	$0.76	$2.71
Burgas-Alexandroupolis	800/600	$0.81	$0.50	$0.40	$0.76	$2.47
Burgas-Vlore	800/750	$0.81	$0.50	$0.37	$0.76	$2.44
Kiyikoy-Ibrikbana	800/500	$0.81	$0.50	$0.40	$0.76	$2.47
Kiyikoy-Ibrikbana	800/1500	$0.81	$0.50	$0.26	$0.76	$2.32
Bosporous Bypass	800/1000	$0.81	$0.50	$0.46	$0.76	$2.53

Routes to Osaka						
Turkmenistan-Kharg	900	$1.15			$1.45	$2.60
CAOPP	1000	$1.73			$1.45	$3.18
CAOPP	1000	$0.93			$1.45	$2.38
CAOPP	1000	$0.93			$1.45	$2.38
CNPC-Iran	250	$1.52			$1.45	$2.97

Table D-8: Comparisons of Total Transport Costs For Kazak Oil, Cost of Capital 10%, Length of Life 30

ROUTE	Capacity	Tengiz to	Black Sea	Second Pipe	Final	Total
CPC Routes to Italy	Mb/d	Black Sea	Tanker	Line Cost	Tanker	Cost
Tengiz-Novorossyisk	1,500	$0.44			$0.64	$1.08

Tengiz-Novorossyisk	1,340	$0.52			$0.64	$1.16
Tengiz-Novorossyisk	800	$0.81			$0.64	$1.45
Samsun-Ceyan	800/800	$0.81	$0.50	$0.89	$0.35	$2.54
Samsun-Ceyan	800/1500	$0.81	$0.50	$0.64	$0.35	$2.30
Burgas-Alexandroupolis	800/600	$0.81	$0.50	$0.40	$0.35	$2.06
Burgas-Vlore	800/750	$0.81	$0.50	$0.37	$0.35	$2.03
Kiyikoy-Ibrikbana	800/500	$0.81	$0.50	$0.40	$0.35	$2.06
Kiyikoy-Ibrikbana	800/1500	$0.81	$0.50	$0.26	$0.35	$1.91
Bosporous Bypass	800/1000	$0.81	$0.50	$0.46	$0.35	$2.12
Routes to Osaka						

Turkmenistan-Kharg	900	$1.15			$1.45	$2.60
CAOPP	1000	$1.73			$1.45	$3.18
CAOPP	1000	$0.93			$1.45	$2.38
CAOPP	1000	$0.93			$1.45	$2.38
CNPC-Iran	250	$1.52			$1.45	$2.97

Appendix E

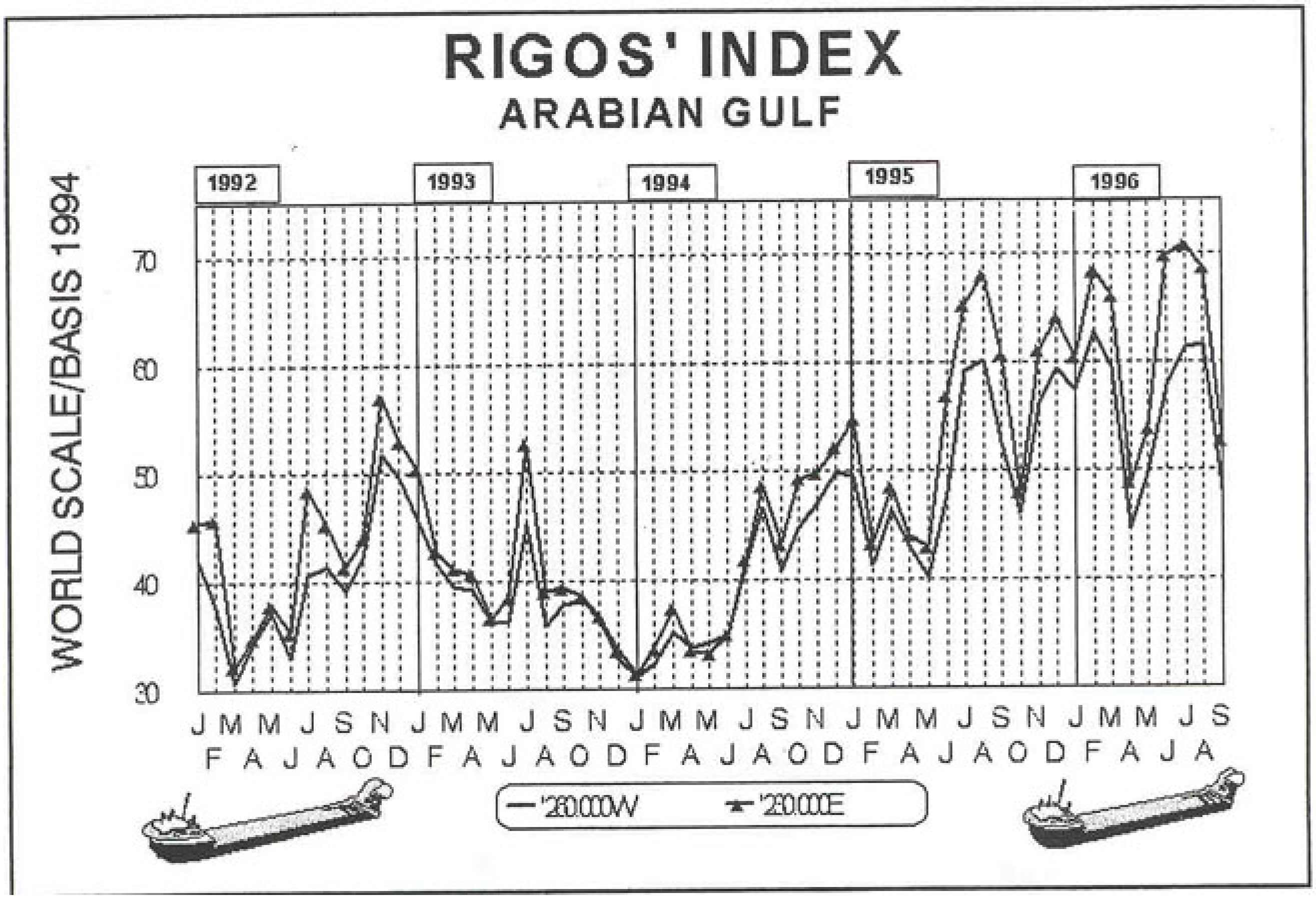
The Tanker Market

Much of the discussion in this paper and some of the conclusions are dependent on what assumptions we have made for tanker rates between various ports. We have mentioned in several places that tanker rates can be quite volatile. Indeed over the period October-December 1997 World Scale rates in the Middle East have moved from W100 down to W50 and then back up to W68 in February and then to W70-W80 in March. Figure E-1 shows the monthly fluctuations in tanker rates from the Gulf for the period 1992-1996. As one might expect, these fluctuations have an enormous effect on the earnings of tanker owners. For example, income of a VLCC declined in the two month period October-December 1997 from $42,400 to $26,000 per day.

There can also be periodic swings over a period of a decade or more produced by investment cycles in tankers. Since tankers have a fairly long service life and the capacity to build new tankers limited, the adjustment of the stock of tankers to its desired level is quite slow. The 1970s and the period following the Gulf War were periods of large scale investments in oil tankers leading to "excess capacity" and exceptionally low prices over the last 20 years or so. Table E-1 shows the average annual spot rates for VLCC tankers over the 1992-1997 period from Ras Tanura to several ports. Rates have risen dramatically in the last three years reflecting a tightening of the market. Current rates to Rotterdam, for example, are $1.91.

As a result of the low rate of construction of VLCC tankers since the 1970s, with the exception of the early 1990s, the average age of the VLCC fleet as of the end of 1997 was 23 years with more than 43% of the fleet being older than 20 years. With VLCCs accounting for 45% of total available DWT, the rapidly aging fleet combined with

Figure E1



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increasing demands for requiring tankers to be double hulled for environmental reasons, will mean that new construction will have difficulty matching retirements. The implication is that tanker rates will be still higher in the future. However, Drewry Shipping Consultants Ltd. projects tanker rates for 1999 to be more than a third higher than 1996 prices. That would imply 1999 prices of at least $1.83 in the Ras Tanura - Rotterdam market, a price that has already been exceeded.

Table E-1 Average Annual Spot Tanker Rates From Ras Tanura			
	Rotterdam	Beaumont	Singapore
Year		per barrel	
1992	$0.98	$1.02	$0.00
1993	$1.07	$1.10	$0.38
1994	$0.89	$0.89	$0.32
1995	$1.17	$1.19	$0.42
1996	$1.37	$1.31	$0.49
1997	$1.49	$1.59	$0.60

Ideally one would like to calculate what long run average tanker rates would be. This should be the rate used for long term planning purposes although, as suggested by the discussion above, the long run in the tanker market may be many years away and would thus be an inappropriate measure for the intermediate term. In addition, if the cyclical pattern of investments in new tankers continues in the future, long costs may not be the relevant except as a price at which a tanker investment boom is initiated.

Nonetheless, in terms of planning and comparing potential pipeline routes which will be in operation within the next five to ten years, prudence would suggest that rates be used that are higher than those currently prevailing, assuming that the Asian economy and its demand for oil recovers. This is especially important for the VLCC tankers in which overbuilding has been focused in the past and which are employed in the oil trade to Asia.

The transport rates used in this study are based on calculations, made by Tusiani, of the daily rental rate which would be sufficient to earn a 15% rate of return on a new tanker. His rates include the daily capital and operating cost for each of three different sized ships. Following his methodology, we calculate the number of days that each vessel would take to travel between two specific ports and add bunker costs, port charges and the opportunity cost of time in port. These rates are reported in Table 4 in the text. In general, these rates are higher than current rates (as of April 1998). The only exception was for the Novorossyisk-Italy run where our calculations for the LR-2 rate is 17 cents lower than current rates.

Tables E-1 and E-2 replicate Tables 5 and 7 in the text using current freight rates. None of our results is significantly altered by using current, rather than our calculated, tanker rates. The cost difference between using tankers to transit the Turkish Straits and using a bypass through Thrace are slightly smaller in Tables E-1 and E-2 than shown in Tables 5 and 7 in the text. In other words, our calculated rates, compared with current rates, generates a larger cost of bypassing the Turkish Straits. The reason for this is that current LR-2 rates for Novorossyisk/Supsa to Augusta are higher than the calculated "long run" rates in Table 4. The effect of higher LR-2 rates is to make tanker transport through the Turkish Straits relatively more costly.

Table E-2: Transport Cost Comparisons For Azeri Oil			
Delivered to Europe. Assuming a Cost of Capital of 15%			
Destination-Route	Cost/b	Cost as a % of	Cost Minus Cost
Baku-Rotterdam:		Bypass Route	of Bypass Route
Tanker From Supsa	$1.83	91%	-0.18
Supsa-Turkish Bypass	$2.01	100%	0.00
Supsa-Samsun-Ceyhan	$2.54	126%	0.53
Baku-Ceyhan	$3.02	150%	1.01
Italy			
Tanker From Supsa	$1.41	80%	-0.36
Supsa-Turkish Bypass	$1.77	100%	0.00
Supsa-Samsun-Ceyhan	$2.30	130%	0.53

Baku-Ceyhan	$2.78	157%	1.01

Table E-3: Transport Cost Comparisons for Kazak Oil From Novorossyisk			
to Europe. Assuming a Cost of Capital of 15%			
Destination-Route	Cost/b	Cost as a % of	Cost Minus Cost
Baku-Rotterdam:		Bypass Route	of Bypass Route
Tanker From Novorossyisk	$2.25	93%	-0.18
Novorossyisk-Turkish Bypass	$2.43	100%	0.00
Novorossyisk-Samsun-Ceyhan	$2.96	122%	0.53
Italy			
Tanker From Novorossyisk	$1.83	84%	-0.36
Novorossyisk-Turkish Bypass	$2.19	100%	0.00
Novorossyisk-Samsun-Ceyhan	$2.72	124%	0.53

Appendix F

Figure 1 in the text shows a plot of monthly data of Saudi prices for European and Far East delivery. In order to take account of the pricing formulae where Far East prices lag European prices by roughly one month, the European prices for one month (say April) are plotted against the Far East price for the following month (May). This procedure, allows us to compare the FOB Saudi prices leaving the Gulf at approximately the same time for the two markets. The data shows that there has been some price differential paid for Saudi oil by the Far East over the price paid by European buyers.

Economic theory can be used to suggest whether it could be in the interest of the Saudis to price discriminate between these two markets. The necessary conditions for price discrimination to be successful and raise profits are that the seller must be able to segment his market into two separate markets each of which has a different elasticity of demand. In addition, the seller must be able to prevent buyers from purchasing the product in the low price market and reselling it in the high price market. For the Saudis to charge a lower price in Europe that in the Far East, the elasticity of demand that the Saudis face in Europe must be higher than in the Far East.

The elasticity of demand for Saudi oil in Europe is given by:

$$E_{se} = (Q_e/Q_s) (E_e) + (Q_{oe}/Q_s)(E_{oe})$$

where

E_{se} is the elasticity of demand for Saudi oil in Europe;

E_e is the elasticity of demand for oil in Europe,

Q_e is equal to the quantity of oil consumed in Europe

Q_s is the quantity of Saudi oil consumed in Europe

$E_{oe}$is the elasticity of supply of oil, other than Saudi, to the European market

Q_{oe} is the quantity of oil, other than Saudi, consumed in Europe.

A similar equation for the Far East would determine the elasticity of demand for Saudi oil in that market.

To get some sense of the relative values of these elasticity's note that the elasticity of demand for Saudi oil in each market is a weighted average of the overall elasticity of demand for oil and the elasticity of supply of non Saudi oil where the weights are respectively, the inverse of the share of Saudi oil in total consumption and the ratio of non-Saudi to Saudi oil consumed in that market. Hence, for example, the elasticity of demand for Saudi oil in Europe is greater, the smaller is the Saudi share in the European market.

An examination of oil flows suggests that the share of Saudi oil in Europe is approximately 5%; one half that in the Far East (roughly 10%)). Applying the equation above, the elasticity of demand for Saudi oil in Europe would be equal to

$E_{se} = (20)(E_e) + (1.05)(E_{ofe})$

whereas the elasticity in the Far East (E_{sfe}) would be

$E_{sfe} = (10)(E_{fe}) + (1.25)(E_{ofe})$

where E_{ofe} is the elasticity of supply of oil, other than Saudi, to the Far East market.

To simplify let us assume that the elasticity of demand for crude as well as the elasticity of non-Saudi supply in Europe and the Far East are the same. Given that the elasticity of supply of non-Saudi oil is likely to be quite small (at least in the short run), since most producers have little or no spare capacity, it will not have much effect in determining the demand elasticity's for Saudi oil. Under these assumptions, the most important determinant of the demand elasticity that the Saudis face in each market will be the overall elasticity of demand for oil and the share of Saudi oil in each market. Given that this share in Europe is half that in the Far East, the elasticity for Saudi oil in the European market will roughly be twice that in the far east.

Saudis will maximize the income from oil sales if they set prices so as to equate the marginal revenue in each market. Marginal revenue is a function of the demand elasticity and is given by:

$MR = p$ times$(1-[1/E_d])$

where E_d is the demand elasticity for Saudi oil and p is the price of oil.

If the marginal revenue is equalized in both markets, this equation implies that the ratio of prices in the two markets which maximizes revenue will be:

$$\frac{p_{fe}}{p_e} = \frac{\left(1 - \frac{1}{\varepsilon_{sfe}}\right)}{\left(1 - \frac{1}{\varepsilon_{se}}\right)}.$$

.

Thus, for example, if the demand elasticity for oil in Europe and the Far East is .5, E_{se} will be equal to 20 while E_{sfe} will be equal to 50. The ratio of the FOB price for the Far East to that for Europe would then be 1.125. That is , price for the Far East would be 12.5% higher than for Europe. If E_e were equal unity, then the Saudi FOB price for the Far East would be only 5.5% higher than the price for European delivery. Since the overall elasticity is likely to fall between these two values, the price for Far East buyers should be in the neighborhood of 5.5%-12% higher than for European buyers.

As indicated in Table 6, prices for Far East buyers were, on average, 72 cents, or roughly 4% higher than for buyers in Europe. The Far East price was higher than the European price in seven of the ten years for which we have data. And in three of these years the FOB price for Far East buyers was above 90 cents per barrel more than for European buyers, equivalent to 5-17 %

higher that prices to European buyers. This evidence is consistent with the theory and lends strong support that there is some degree of price discrimination present.

Price discrimination cannot succeed in the long run if arbitrageurs can buy in the lower priced market and resell in the higher priced one. The 6-12.5% price difference generated by our theoretical analysis above does not take into account problems of preventing resale. The need to discourage arbitrage behavior places an additional constraint on the extent to which the Saudis can price discriminate. Saudi oil contracts understandably prohibit resale of their oil without their permission. Major oil companies that buy Saudi oil have an incentive to honor these contracts since they expect to be in a long term relationship with the Saudis. Individual oil traders who do not have access to the low priced Saudi oil in the Gulf will find it difficult to arbitrage the price difference away. Once that oil reaches its European destination, transport costs make it unprofitable to reship the oil back to Asia. The maintenance of the differential price depends on the willingness of the majors to honor their contracts.

It is likely that Saudi price discrimination will continue. They have had a policy of diversifying their markets by selling in all markets (North America, Europe, and Asia) and have been willing to subsidize sales if necessary to maintain a share in each of these markets. To the extent that their share of the European market declines, the elasticity of demand for their oil in Europe will increase and provide continuing incentive to price discriminate.

Appendix G

TABLE G-1 Global Oil Demand and Supply Balance for 2005 and 2010: Moderate Non-OPEC Growth

	1997 Base			2005				2005				2010				2010	
		With Caspian				Without Caspian					With Caspian				Without Caspian		
		Low	Sickles	Moderate	High	Low	Sickles	Moderate	High	Low	Sickles	Moderate	High	Low	Sickles	Moderate	High
Rate of Increase in Demand		1.0%		2.0%	3.0%	1.0%		2.0%	3.0%	1.0%		2.0%	3.0%	1.0%		2.0%	3.0%
Global Demand	73.50	79.50	80.00	85.00	89.50	79.50	80.00	85.00	89.50	83.50	89.00	94.00	103.00	83.50	89.00	94.00	103.00
Global Supply	73.00	79.50	80.00	85.00	89.50	79.50	80.00	85.00	89.50	83.50	89.00	94.00	103.00	83.50	89.00	94.00	103.00
Other Non-OPEC	42.00	51.50	51.50	51.50	51.50	51.50	51.50	51.50	51.50	54.50	54.50	54.50	54.50	54.50	54.50	54.50	54.50
Caspian	0.80	2.50	2.50	2.50	2.50	1.00	1.00	1.00	1.00	3.50	3.50	3.50	3.50	1.00	1.00	1.00	1.00
OPEC Total	30.30	25.50	26.00	31.00	35.50	27.00	27.50	32.50	37.00	25.50	31.00	36.00	45.00	28.00	33.50	38.50	47.50
OPEC Liquids	2.50	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Iran	3.65	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.50	5.00	5.00	5.00	4.50	5.00	5.00	5.00
Iraq	1.20	4.00	4.50	4.50	4.50	4.50	4.50	4.50	4.50	5.00	6.00	6.00	6.00	5.00	6.00	6.00	6.00
Kuwait	2.00	2.50	3.00	3.00	3.00	2.50	3.00	3.00	3.00	3.50	4.00	4.00	4.00	3.50	4.00	4.00	4.00
UAE	2.30	2.50	3.00	3.00	3.00	2.50	3.00	3.00	3.00	3.00	3.50	3.50	3.50	3.00	3.50	3.50	3.50
Venezuela	3.40	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	7.00	7.00	7.00	6.00	7.00	7.00	7.00
Other OPEC	6.60	7.50	8.00	8.00	8.00	7.50	8.00	8.00	8.00	7.50	8.00	8.00	8.00	7.50	8.00	8.00	8.00
Residual Saudi	8.70	-4.00	-5.50	-0.50	4.00	-2.50	-4.00	1.00	5.50	-7.00	-6.00	-1.00	8.00	-5.00	-3.50	1.50	10.50

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TABLE G-2: Global Oil Demand and Supply Balance for 2005 and 2010: Low Non-OPEC Growth

	1997 Base			2005				2005				2010				2010	
		With Caspian					Without Caspian				With Caspian				Without Caspian		
		Low	Sickles	Moderate	High	Low	Sickles	Moderate	High	Low	Sickles	Moderate	High	Low	Sickles	Moderate	High
Rate of Increase in Demand		1.0%		2.0%	3.0%	1.0%		2.0%	3.0%	1.0%		2.0%	3.0%	1.0%		2.0%	3.0%
Global Demand	73.50	79.50	80.00	85.00	89.50	79.50	80.00	85.00	89.50	83.50	89.00	94.00	103.00	83.50	89.00	94.00	103.00
Global Supply	73.00	79.50	80.00	85.00	89.50	79.50	80.00	85.00	89.50	83.50	89.00	94.00	103.00	83.50	89.00	94.00	103.00
Other Non-OPEC	42.00	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50	44.50
Caspian	0.80	2.50	2.50	2.50	2.50	1.00	1.00	1.00	1.00	3.50	3.50	3.50	3.50	1.00	1.00	1.00	1.00
OPEC	30.30	32.50	33.00	38.00	42.50	34.00	34.50	39.50	44.00	35.50	41.00	46.00	55.00	38.00	43.50	48.50	57.50
OPEC Liquids	2.50	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Iran	3.65	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.50	5.00	5.00	5.00	4.50	5.00	5.00	5.00
Iraq	1.20	4.50	5.00	5.00	5.00	4.50	5.00	5.00	5.00	5.00	6.00	6.00	6.00	5.00	6.00	6.00	6.00
Kuwait	2.00	3.00	3.50	3.50	3.50	3.00	3.50	3.50	3.50	3.50	4.00	4.00	4.00	3.50	4.00	4.00	4.00
UAE	2.30	2.50	3.00	3.00	3.00	2.50	3.00	3.00	3.00	3.00	3.50	3.50	3.50	3.00	3.50	3.50	3.50
Venezuela	3.40	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.50	7.00	7.00	7.00	6.50	7.00	7.00	7.00
Other OPEC	6.60	7.50	8.00	8.00	8.00	7.50	8.00	8.00	8.00	7.50	8.00	8.00	8.00	7.50	8.00	8.00	8.00
Residual Saudi	8.70	2.00	0.50	5.50	10.00	3.50	2.00	7.00	11.50	2.00	4.00	9.00	18.00	4.50	6.50	11.50	20.50

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TABLE G-3		Forecast Comparisons										
		PRC				PIRA				DOE		
Year	1995	2000	2005	2010	1995	2000	2005	2010	1995	2000	2005	2010
	Base				Base				Base			
Demand												
Western Hemisphere	25.8	29.3	32.7	35.1	25.8	29.0	31.5	33.7	24.4	28.1	30.7	34.9
Europe/FSU	20.2	21.4	22.8	24.3	20.1	21.6	23.7	25.9	20.6	20.7	22.1	21.6
Asia	16.9	20.4	25.4	30.5	17.9	22.6	27.0	31.6	16.0	21.6	25.9	29.8
Africa/Middle East	6.3	7.5	8.9	10.8	6.3	7.0	8.1	9.4	5.7	7.5	8.5	9.4
Total demand	69.1	78.5	89.8	100.7	70.1	80.2	90.3	100.6	66.7	77.9	87.2	95.7
Production												
Western Hemisphere	20.0	23.7	25.1	25.0	21.6	25.0	28.2	30.7	20.9	22.2	23.3	24.7
Europe/FSU	13.9	16.4	18.8	19.7	14.6	16.4	17.0	18.4	13.7	15.2	16.0	16.0
Asia	7.2	8.0	8.2	8.1	7.8	8.4	9.1	9.7	7.6	7.8	8.0	8.2
Africa/Middle East												
Non Opec	6.4	7.5	7.5	7.2	6.8	7.8	10.1	11.6	4.0	4.6	4.8	5.0
Opec	21.7	24.7	30.3	35.3	20.5	23.2	26.2	30.8	20.5	28.1	35.1	41.8
Total	28.1	32.1	37.9	42.5	32.4	31.0	36.3	42.4	24.5	32.7	39.9	46.8
Total Supply	69.2	80.2	89.9	95.3	71.3	80.8	90.6	101.2	66.7	77.9	87.2	95.7
Regional Balances												
Western Hemisphere	-5.8	-5.6	-7.6	-10.1	-4.2	-4.0	-3.3	-3.0	-3.5	-5.9	-7.4	-10.2
Europe/FSU	-6.3	-5.0	-4.0	-4.5	-5.5	-5.2	-6.7	-7.5	-6.9	-5.5	-6.1	-5.6
Asia	-9.7	-12.4	-17.3	-22.4	-10.1	-14.2	-17.9	-21.9	-8.4	-13.8	-17.9	-21.6
Africa/Middle East	21.8	24.7	29.0	31.7	26.1	24.0	28.2	33.0	18.8	25.2	31.4	37.4

DOE projections are the Reference Case

DOE forecast of production of all Opec members, except for Saudi Arabia, are assumed to be at capacity.

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