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**Article**

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## Energy market for Caspian Sea oil and its supply

Seyed Emad EMADI  
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### *Abstract*

*By The Caspian Sea countries present growing importance in the global energy market. The largest energy producers in the region are Azerbaijan, Kazakhstan, and Turkmenistan. In recognition of the growing importance of Caspian countries in the global energy market, this article takes a look at the internal energy markets in the region and its oil and gas supply potential. The largest energy producers in the region are Azerbaijan, Kazakhstan, and Turkmenistan. The region has significantly expanded its oil and gas exports to international markets since the beginning of the 1990s and Azerbaijan, Kazakhstan, Turkmenistan all have the potential to increase hydrocarbon production in the coming years. The increases in output so far have been associated with, and encouraged by, an emerging diversity of export routes and markets. The big question for the Caspian region countries is how to sell their oil and gas. Their large neighbor, Russia, has lots of oil and gas of its own, plus an extensive pipeline network to move that oil and gas. Russia's Gazprom gas monopoly therefore does not need Turkmenistan's gas for the Russian market nor for re-export from Russia.*

*Keywords: AHP, EIA, Supply chain, System Dynamics, Structure® and Decide 2000®, Swap*

*JEL Classification Codes: Q34, Q47*

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## Introduction

The Caspian region produced 1.9 million barrels per day (BBLS/day) of oil and natural gas liquids in 2005, or 2% of total world output. Table 1 shows oil and gas reserves and resources in this region and in table 2 gives information about oil and gas production rates in Caspian countries. Caspian Sea region oil output has been higher, but suffered during the separation of the Soviet Union and the years following. Kazakhstan, whose production has risen rapidly since the late 1990s, accounted for 67% and Azerbaijan for 22% of regional crude oil output in 2005. Based upon figures published by BP, Caspian Sea region oil production comes from proven (economically recoverable) reserves of 48 billion BBLS. This equals about 4% of total the world proven reserves, and much more than BP's figure for U.S. reserves (29 billion BBLS). EIA estimates of much larger "possible" reserves suggest a potential for much greater production. The Caspian Sea region's relative contribution to world natural gas supplies is larger than that for oil. Its gas production of 3.0 trillion cubic feet per year (TCF/year) in 2005 was 3% of world output. As with oil, gas production has been higher, but suffered during the Soviet Union's collapse and the following years. Turkmenistan is the largest producer; with production of 2.0 TCF/year, it accounts for almost two-thirds of the region's gas output.

Table 1. Estimates of Oil and Gas Reserves and Resources:

Region		Proven Reserves, BP, End of 2005		Possible Additional Oil/Gas EIA
		Oil (billions of BBLS)	Natural Gas (trillion TCF)	
Caspian Sea Region	Azerbaijan	7.0	48	32/35
	Iran	0.1	N.a.	15/11
	Kazakhstan	39.6	106	92/88
	Russia	0.3	N.a.	7/N.a.
	Turkmenistan	0.5	102	38/159
	TOTAL	47.5	256	184/293
	WORLD	1,201	6,348	N.a.

Sources: BP. BP Statistical Review of World Energy June 2006; Penwell Publishing Company. Oil & Gas Journal. December 19, 2005; Energy Information Administration. Caspian Sea Region: Survey of Key Oil and Gas Statistics and Forecasts, July 2006; U.S. Geological Survey. "National Oil & Gas Assessment, at: <http://www.energy.cr.usgs.gov/oilgas/noga/2004update.htm>], viewed March 1, 2005.

Table 2. Oil and Gas Production in the Caspian Sea

Country	Crude Oil (thousands of barrels per day)				Natural Gas (trillion cubic feet per year)		
	2001	2005	2010		1992	2005	2010
			Low	High			
Azerbaijan	317	440	900	1,290	0.28	0.18	0.70
Iran	0	0	0	0	0	0	0
Kazakhstan	804	1,293	1,900	2,400	0.29	0.84	1.24
Russia	N/A	N/A	N/A		N/A	N/A	N/A
Turkmenistan	110	196	165	450	2.02	1.97	3.50
Total Caspian	1,231	1,899	2,965	4,140	2.59	2.99	5.44
WORLD	73,935	81,088	9,1600		72.195	97.534	116.50

Sources: BP Amoco. BP Statistical Review of World Energy 2001, June 2001; BP BP Statistical Review of World Energy June 2006: Energy Information Administration. Caspian Sea Region: Survey of Key Oil and Gas Statistics and Forecasts, July 2006; EIA. International Energy Outlook 2006, June 2006, [<http://www.eia.doe.gov/oiaf/ieo/index.html>], viewed September 7, 2006.

It is estimated that an additional 184 billion barrels of crude oil reserves are possible. This would raise the total reserves to almost five times its present level. This level of proven reserves would nearly equal the amount now held by Saudi Arabia and could come to about 15% of total world reserves. If the high output projection for 2010 comes to pass, Caspian Sea region oil production would have more than doubled — to 4.1million bbls/day.

The purpose of this research is to analyze the critical issues related to the Caspian Sea Oil supply chain and the options available to oil exporting countries in the Caspian Sea region. The problem to be examined involves the system dynamics of Caspian Sea oil supply chain. The main objectives of this research are:

- Using system dynamics to analyze the critical issues related to the Caspian Sea Oil supply chain.
- Applying the analytic hierarchy process (AHP) to analyze and prioritize the options available for oil exporting countries in this region.

The methods used in this research are system dynamics and Analytic Hierarchy process (AHP). The system dynamics are general, but their implementation requires that using specific computer software. A number of different software packages are available to implement system dynamics, Structure® and Decide 2000® packages is used in this research. These packages were selected because i) it supports a compact, but informative, graphical notation, ii) are simple procedure for user, iii) These packages provides powerful tools for quickly illuminate and structuring the problem (Nezhad,

2009).

## Trends in energy production

Production from Azerbaijan, Kazakhstan, and Turkmenistan rises from an estimated 2.9 million barrels per day (MB/D) in 2009 to 4.4 MB/D in 2020 and to a peak of around 5.4 MB/D between 2025 and 2030, before falling back to 5.2 MB/D by 2035 (IEA, 2009). Although oil demand across the region continues to grow with economic expansion, total production remains much higher, freeing up oil for export. The volume of exports peaks at 4.6 MB/D soon after 2025 and falls back to about 4.3 MB/D in 2035, up from about 2.3 MB/D in 2009. Azerbaijan and Kazakhstan remain the only significant exporters of oil.

Natural gas production is also set to expand substantially over the projection period. Natural gas production in the Caspian countries in aggregate jumps from 188 billion cubic meters (BCM) in 2008 and 159 BCM in 2009 to nearly 260 BCM by 2020 and 315 BCM in 2035 (IEA, world energy outlook, 2010). As with oil, gas demand is set to grow less than production in volume terms, yielding a significant expansion of the region's net exports. By 2035, total net exports are projected to reach nearly 100 BCM in 2020 and 130 BCM in 2035, up from only 63 BCM in 2008. The biggest contributors to this increase in exports are Turkmenistan and Azerbaijan.

The oil and gas landscape of the Caspian region has been transformed in the years since 1991. From a starting position as constituent republics within a tightly integrated Soviet economic system, the Caspian resource-owners have become autonomous actors on the international energy stage, asserting national authority over management of their resources and creating new links with export markets. Diversification of routes and markets has contributed to more reliable market-based pricing of exports and, thereby, created stronger incentives to develop resources.

This process has been quicker for oil than for natural gas; although more oil-export capacity is required to accommodate future production growth, the relative ease and flexibility of transportation of oil meant that it was traded to multiple destinations and with reference to international prices quite soon after 1991. By contrast, natural gas exports from Turkmenistan, which has been the region's largest gas exporter, were characterized for much of the 1990s and early 2000s by non-cash and barter payments well below the international value of the gas. It was only after 2005 that Gazprom, the major purchaser of Central Asian gas, was ready to concede cash payments and higher export prices, reflecting the importance that Central Asian supplies had come to assume in the Russian gas balance (at least until the economic crisis in 2008-2009), as well as increased competition for Caspian gas resources from China and also from other potential consumers in Europe and southern Asia.

Aside from the distance to export markets, oil and gas exploration and production in the Caspian region has to cope with some distinctive challenges. While average upstream exploration and development costs are reasonable by international standards, developments in the Caspian Sea operate in a very difficult and fragile natural environment, with the shallower northern Caspian waters habitually freezing from November until March. The Russian Volga-Don canal system from the Black Sea is the only maritime route into the Caspian region, creating logistical difficulties for companies bringing in drilling and other large equipment. Upstream developments since 1991 have also had to deal with rapidly shifting legal and regulatory frameworks and shifting balances between state and commercial influence over the sector, as the Caspian countries established their national systems of resource management and then, in some cases, toughened the conditions for upstream operators from the mid- 2000s onwards.

For all the technical challenges associated with Caspian production, the costs of getting Caspian resources out of the ground compare favorably with those in most other regions. The actual and planned capital expenditure and estimated production profiles for the six main Caspian oil and gas fields (the Azeri-Chirag-Guneshli complex, Karachaganak, Kashagan, Shah Deniz, South Yolotan and Tengiz) show a wide variety of costs (IEA, 2010). Overall, IEA calculate that the capital cost of developing these fields averages around \$8 per barrel of oil and \$55 per thousand cubic meters of gas (around \$8.5 per barrel of oil equivalent [BOE], or \$1.5/MBTU). These are at the lower end of the estimated range of costs for the Eastern Europe/Eurasia region of \$7-19/BOE and below the global average.

These estimates, combined with the size of Caspian resources, their relative accessibility to outside investors, help to explain the continued interest of national and international oil and gas companies in the Caspian upstream sector. But these figures tell only a part of the story and need to be considered alongside a wider range of risks and costs, including regulatory and fiscal requirements, operating expenditures (lifting costs) and, most crucially for the Caspian, the distance, expense and complexity involved in bringing resources to international markets.

Foreign investment has been central to the development of oil and gas production in Azerbaijan and Kazakhstan, but much less so elsewhere in the region. Investment by privately-owned international companies was the dominant element of this story in the 1990s, but since 2000 an increasing share of foreign investment has come from national oil and gas companies in Asia, including Korea, Malaysia, India and, in particular, China. State-owned Chinese companies have become heavily involved in various upstream and mid-stream projects as investors, service providers, operators, and as purchasers of Caspian hydrocarbons.

New export infrastructure both for oil (since 2006) and gas (since late 2009) now

connects Central Asia to the fast-growing Chinese market. Both as a source of investment capital and as a major export market, China will continue to have a strong influence on trends in Caspian production and trade through the projection period and beyond. China's growing role in the region is challenging the traditional predominance of Russia in Central Asia and also provides stiff competition for other international companies seeking investment opportunities in the region — all to the benefit of the Caspian countries themselves. But, even as a greater share of Caspian resources is exported to the east, it is worth keeping China's current investment position in perspective. As of 2009, the share of Chinese companies in the oil and gas production of the four main Caspian producers at 7%, resulting largely from a 19% share in Kazakhstan oil output (Figure 1).

### Caspian oil and gas production and export

Table 3 shows the export volumes and estimated breakdown by route for oil from the Caspian Sea in 2007 - not including exports from the non-Caspian regions of Kazakhstan, Turkmenistan or Russia. The largest exporter of Caspian oil in 2007 was Kazakhstan with more than 1.04MB/Day (around 52 million ton for the year<sup>1</sup>), followed by Azerbaijan and then Russia. Russian oil exports from the Caspian region (including Russian volumes exported through the Caspian Pipeline Consortium, or CPC, pipeline) account for only around 3% of Russia's total oil export.

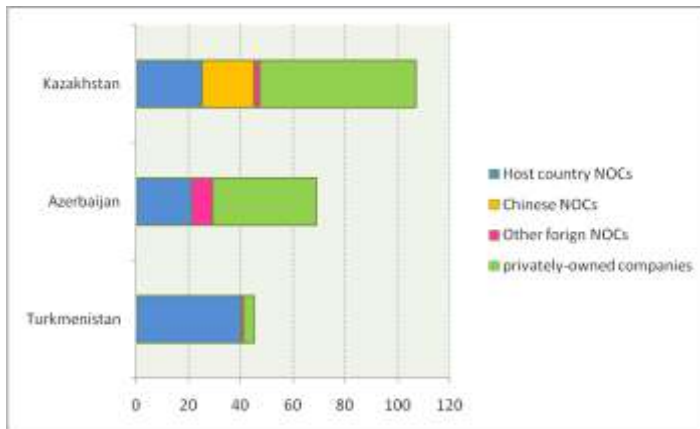


Figure 1. Estimated Caspian oil and gas production by type of companies, end of 2009.

Source: World Energy Outlook 2010

\*Note: Host country NOC refers to national oil and gas companies operating in their own country; NOCs (whether China or foreign) refers to state-owned or state-controlled companies; shares of production in projects governed by production-sharing

agreements (PSA) are allocated according to the ownership of the PSA.

Table 3. Export of oil from the Caspian Sea, estimated breakdown by route\*

Route	Export		Source of oil (in MT)
	KB/Day	MT/Y	
Tengiz-Novorossiysk (CPC Pipeline) Kazakhstan-Russia	652	32.6	Kazakhstan (25.6) Russia (7.0)
Baku-Tbilisi-Ceyhan (BTC Pipeline) Azerbaijan-Georgia-Turkey	850	42.5	Azerbaijan
Atyrau-Samara Pipeline Kazakhstan-Russia	350	17.5	Kazakhstan
Baku-Batumi Azerbaijan-Georgia: by Train	136	6.8	Azerbaijan (4.4) Kazakhstan** (2.4)
Baku- Novorossiysk Pipeline Azerbaijan-Russia	139	6.95	Azerbaijan (2.55) Kazakhstan*** (4.4)
Neka Iran: deliveries by Barge	112	5.6	Turkmenistan (3.5) Kazakhstan (2.1)
Total	2239	111.95	

Source: official website of ministry of foreign affairs of republic of Kazakhstan, <http://portal.mfa.kz/portal/page/portal/mfa/en/content/policy/cooperation/CIS/Cooperation%20of%20the%20RK%20with%20Russian%20Federation>  
BP: <http://www.bp.com/genericarticle.do?categoryId=9006615&contentId=7064976>  
And International Energy Agency Working Paper Series, Dec 2008

\* Does not cover exports from non-Caspian regions of Kazakhstan (85 KB/D [4.5 MT/Y] exported to China from central Kazakhstan), Turkmenistan or Russia

\*\* Kazakh shipments by barge to Baku

\*\*\* Kazakh shipments by barge to Makhachkala (Russia)

The CPC pipeline from Tengiz in Kazakhstan to the Russian Black Sea port of Novorossiysk was the main export pipeline for Caspian oil in 2007, followed by the Baku-Tbilisi-Ceyhan (BTC) pipeline Azerbaijan to the Turkish Mediterranean port of Ceyhan. The Atyrau-Samara line leads north from the Caspian shore and feeds into the Transneft pipeline network. For the moment, there is no quality bank for the Transneft system, which means that exports of light, sweet crude from Kazakhstan along this route is mixed with Urals blend and loses value as a result. Deliveries to the

Iranian Caspian port of Neka is swaps, with equivalent quantities and grades of oil being made available at Iran's ports in the Persian Gulf. Similar patterns of export flows have been observed in 2008, with two notable additions. Firstly, around 100 KB/D (up to 5 mt for the year) of rail shipments from the Tengiz field in Kazakhstan went to the Ukrainian Black Sea port of Odessa via Russia. Secondly, deliveries along the Baku-Supsa



pipeline between Azerbaijan and Georgia resumed in summer 2008, before being suspended as a result of the conflict in Georgia. This line, which was completed in 1999 as a route for early oil out of the Azeri-Chirag-Guneshli (ACG) complex in Azerbaijan, was not operational in 2007 due to repairs.

In Kazakhstan, production has doubled to 1.4 MB/D (70MT/Y) since 2000, and robust growth is expected to continue through 2013 based on the existing Tengiz and Karachaganak fields. Expansion of the CPC pipeline from Tengiz to Novorossiysk on Russia's Black Sea coast was still stalled at the time of writing. CPC expansion had until recently been seen as an essential prerequisite for higher Tengiz and, later, Kashagan volumes. But a degree of export diversification has been achieved using rail, pipeline shipments to China and plans to expand trans-Caspian shipments to Baku and onwards through the BTC pipeline and other routes. This allows a continued steady increase in Kazakhstan production over the next 5 years, reaching 1.85 MB/D (92.5 MT/Y) in the IEA's forecast by 2013.

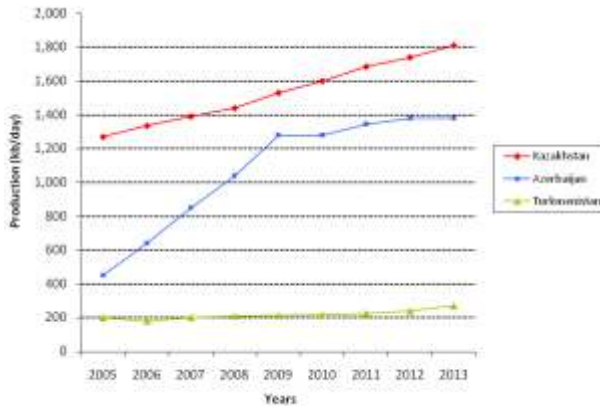


Figure 2. Oil production outlook for Kazakhstan, Azerbaijan and Turkmenistan (KB/Day)

Source: IEA working paper series, Dec. 2008

A key change to the forecast for Kazakhstan was a scaling back of expectations for the Kashagan project. Although early volumes could be higher than previously assumed (at 370 KB/D versus 250 KB/D; 18.5 MT/Y versus 12.5 MT/Y), first oil is assumed only from 2013 rather than 2011. After 2013, once Kashagan ramps up production, total Kazakhstan oil output could reach 2 MB/D by 2015 (100 MT/Y), expanding further thereafter. For incremental exports to reach international markets, Kazakhstan will need to add some 800 KB/D of export capacity by 2013-15.

## Analysis of study

Gaining access to transportation infrastructure to facilitate exports has been a main problem for Caspian oil producers; building pipelines and putting in place other means of moving oil to regional and international markets has been made more difficult by a complex web of logistical, regulatory and political constraints. Kazakhstan and Azerbaijan have had some success in developing oil export capacities, notably with the construction of the CPC and BTC pipelines that today provide the principal routes along which the two countries export oil (Figure 3). Net oil exports from the Caspian region to around 4.5 MB/D in the period between 2025 and 2035. This will call for a sizeable expansion of export capacity. Kazakhstan, in particular, now requires another big increase in capacity in the period to 2025 if it is to realize its production potential.



Figure 3. Caspian Export Flows 2009 (million tons)

Source: World Energy outlook 2010

How export flows evolve over the coming decade and a half as production increases will depend on near-term investment decisions that must balance a range of commercial and strategic considerations. Our analysis of current netback values suggests that, for Azerbaijan, pipeline routes to the Mediterranean and to the Georgian Black Sea coast are the most competitive solution, even when taking into account the cost, for the latter, of an additional pipeline bypassing the Turkish straits. Estimated netbacks for Kazakhstan are lower across the board because of the longer distance to market but, likewise, routes to the Black Sea (via the CPC pipeline and via the South Caucasus) and Mediterranean (via the South Caucasus) are among the most attractive.

## Analyzing interrelationships among the driving forces in Caspian oil/gas producers

To determine interrelationships among the driving forces systemically we use Structure® software program developed by Nezhad. The program draws a signed directed-graph to display the interrelations of driving forces. Nodes represent variables (driving forces), and arrows shows interrelationships between variables. Driving forces in our analyses are: politic conflict in this region, foreign investment, international oil price, lead time, export route capacity and proven reserves.

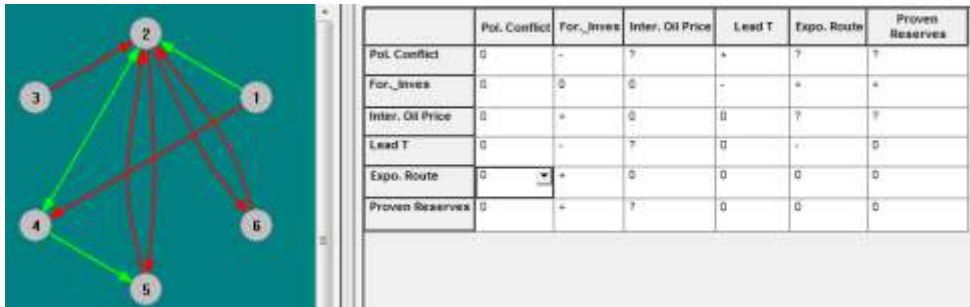


Figure 4. Interrelationship of driving forces of Caspian Sea, Green lines representative of negative relationships and red lines represent positive relationships among variables

Figure 5 shows the table of driving forces (variables) we considered in our analysis.

	Name	Description
1	Pol. Conflict	Political Conflict
2	For_Inves	Foreign Investment
3	Inter. Oil Price	International price of Oil
4	Lead T	Lead time
5	Expo. Route	Export Route Capacity
6	Proven Reserves	Proven Oil/Gas Reserves

Figure 5. Driving forces

Figure 6 shows how each variable depends on other driving forces (dependency level) and how each driving forces affects others (independency level).

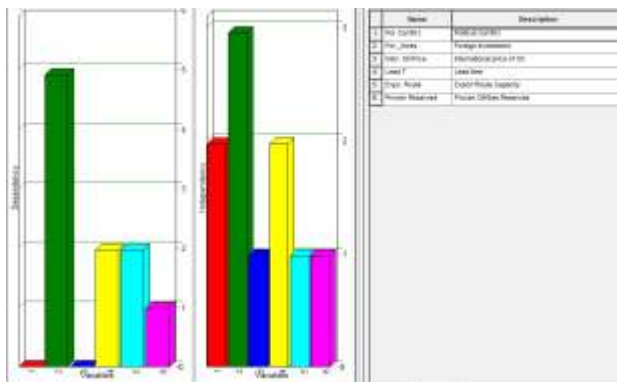


Figure 6. Dependency level of each driving forces

The most independence variable is foreign investment (variable 2) followed by variables 1 and 4 (political conflict and lead time). Figure 7 shows how these three forces affect other driving forces.

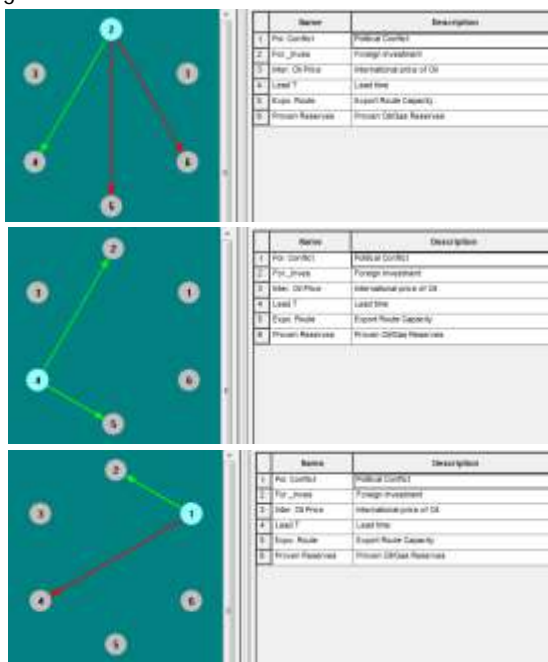


Figure 7. The most independent driving force and their impacts in other variables

The most dependence driving forces are foreign investment (variable 2), and followed by lead time and export route capacity. Since the foreign investment is affected

by lead time and export route capacity showed in figure 8.



Figure 8. The most dependence driving forces

Structure<sup>®</sup> also allows the user to view cycles among the variables. Figure 9 illustrates an example. This circle is positive, or impact amplifying. Higher foreign investment rate (1) will lead to less lead time (4); when lead time is slow down then export route capacity (5) will increase; and finally, higher export route capacity impact will increase the foreign investment (1).



Figure 9. A cycle among the driving forces

## Conclusion

A model to analyze the critical issues related to the Caspian Sea Oil supply chain and the options available to oil exporting countries has been developed. A system dynamics model with applying of Structure<sup>®</sup> software to analyze the critical issues related to these countries for exporting their resources to consumers. The results show that the variable which plays main critical role in this region is political conflict as the most dependent variable. This factor affects potential barriers to investment (as foreign investment) and the implications of energy developments in the region for global energy security and environmental sustainability.

As oil and gas production increases in the Caspian region in the coming years, so too will the reliance of regional producers on energy transit. Of the main flows of oil out of the region, only the direct deliveries from Kazakhstan to China do not involve transit. Russia and Georgia are set to see the largest oil transit flows throughout the period to 2035. Completion of the Caspian Transportation System would make Azerbaijan a major transit country for Kazakhstan oil exports after 2020. For natural gas, the Caspian region will soon have some of Eurasia's most important transit relationships by volume, with Kazakhstan and Uzbekistan joined, again, by Georgia as the main transit countries.

Our analysis of current netback values suggests that, for Azerbaijan, pipeline routes to the Mediterranean and to the Georgian Black Sea coast are the most competitive solution, even when taking into account the cost, for the latter, of an additional pipeline bypassing the Turkish straits. Estimated netbacks for Kazakhstan are lower across the board because of the longer distance to market but, likewise, routes to the Black Sea (via the CPC pipeline and via the South Caucasus) and Mediterranean (via the South Caucasus) are among the most attractive. The worsening of the commercial terms for swap arrangements through Iran in mid-2010, with a reported rise in the swap tariff, is reflected in these calculations. Netbacks for routes through the Transneft system in Russia (but not through the CPC pipeline) are affected by a loss of value as Azerbaijan and Kazakhstan crudes are mixed with Urals blend. The least attractive export option for the moment is the Kazakhstan-China pipeline, where netbacks suffer because of the long distance to market. In developing export strategies and routes, companies will continue to seek the maximum value for their exports allowing for the risks of instability in transit countries and of monopoly control.

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