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A hybrid Delphi-SWOT paradigm for oil and gas pipeline strategic planning in Caspian Sea basin ☆

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ABSTRACT

The Caspian Sea basin holds large quantities of both oil and natural gas that could help meet the increasing global demand for energy resources. Consequently, the oil and gas potential of the region has attracted the attention of the international oil and gas industry. The key to realizing the energy producing potential of the region is the development of transnational export routes to take oil and gas from the landlocked Caspian Sea basin to world markets. The evaluation and selection of alternative transnational export routes is a complex multi-criteria problem with conflicting objectives. The decision makers (DMs) are required to consider a vast amount of information concerning internal strengths and weaknesses of the alternative routes as well as external opportunities and threats to them. This paper presents a hybrid model that combines strength, weakness, opportunity and threat (SWOT) analysis with the Delphi method.

1. Introduction

The oil and natural gas industry is the backbone of the world economy (Balat, 2010). The rapid economic expansion in developed countries coupled with the growing economies in countries such as China and India has precipitated a steady increase in the demand for energy, especially oil and natural gas (Bambawale and Sovacool, 2011a,b; Kun et al., 2011). China has moved to the top spot of energy consumption in 2010 with 20.3% of the global demand, ahead of the U.S.'s 19%, according to British Petroleum's (BP's) 60th annual statistical review of world energy (2011). The U.S.'s consumption edged up 3.7% last year compared with an 11.2% growth in China. According to BP, the demand for all forms of energy grew 5.6% in 2010. The consumption growth accelerated by 3.5% in the organization for economic co-operation and development (OECD) countries (which includes 34 countries including the U.S., U.K., France, Germany and Japan) while the consumption grew by 7.5% in the non-OECD countries. The vital importance of energy together with the constant increase in demand for oil and gas necessitates the exploration, development and distribution of new sources of energy.

The Caspian Sea is the world's largest inland sea and has a significant, but not major, amount of oil and natural gas reserves, based upon estimates by BP Statistical Review of World Energy (2011). The region's relative contribution to world supplies of natural gas is larger than that for oil. The sea is bordered by five states of Azerbaijan, Kazakhstan, Turkmenistan, Iran and Russia. Most of the proven energy reserves in the region belongs to Kazakhstan and is concentrated in the eastern side of the sea. As shown in Table 1, Azerbaijan possesses both oil and natural gas reserves while Turkmenistan possesses mostly natural gas. Russia and Iran hold inconsequential proven reserves in their respective Caspian sectors.

According to BP Statistical Review of World Energy (2011) shown in Table 2, proven oil reserves for the Caspian Sea region are estimated at 47.4 billion barrels at the end of 2010 (ranked 8th in world), comparable to those in Libya (46.4 billion barrels). Natural gas reserves in the Caspian Sea region are even larger than the region's oil reserves. Overall, proven natural gas reserves in the Caspian region are estimated at 11.1 trillion cubic meters at the end of 2010 (ranked 4th in world), greater than Saudi Arabia (8.0 trillion cubic meters) and United States (7.7 trillion cubic meters).

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Table 1
Caspian oil and natural gas proved reserves—at end 2010.
Source: BP Statistical Review of World Energy (2011).

Main producers in the Caspian Sea	Oil reserves (billion barrels)	Gas reserves (trillion cubic meters)
Kazakhstan	39.80	1.80
Azerbaijan	7.00	1.30
Turkmenistan	0.60	8.00

Table 2
Top world countries with oil and natural gas proved reserves—at end 2010.
Source: BP Statistical Review of World Energy (2011).

Oil		Gas	
Country (region)	Oil reserves (billion barrels)	Country (region)	Gas reserves (trillion cubic meters)
Saudi Arabia	264.5	Russian Federation	44.8
Venezuela	211.2	Iran	29.6
Iran	137.0	Qatar	25.3
Iraq	115.0	**Caspian Sea region**	**11.1**
Kuwait	101.5	Saudi Arabia	8.0
United Arab Emirates	97.8	US	7.7
Russian Federation	77.4	United Arab Emirates	6.0
Caspian Sea region	**47.4**	Venezuela	5.5
Libya	46.4	Nigeria	5.3

Despite its modest volumes, Caspian energy has attracted extensive global policy interest during the past two decades. The intense international focus on the region is driven by its geopolitical significance and its unique landlocked location. The Caspian Sea region is on a major junction between Europe and Asia and positioned nearby Russia and China. In addition, due to its landlocked location, the Caspian exporters are dependent on other states for moving their energy products. The control of the oil and gas pipelines in the region provides significant influence over the security and policies of the Caspian states. Thus, the recent intense interest in the Caspian region and the battle over the pipeline routes has been more about determining the geostrategic orientation of the region and had little to do with the control of the Caspian states' modest volumes of oil and gas. Delimitation of the sea borders has been a contested issue in the last two decades among the Caspian states. However, legal disputes have not been an obstacle to the production and export of oil and gas (Shaffer, 2010). The major obstacles to the development of new supplies were not related to underground resources but what happens above the ground such as international relations, governmental affairs and investment in energy and new technological development (Umbach, 2010).

In spite of the potential for the Caspian states to meet the increasing global demand for energy resources, only a few Caspian oil and natural gas export projects have become operational in the region over the last decade (Shaffer, 2010). Bilgin (2007, 2010), Guliyev and Akhrarkhodjaeva (2009), Kakachia (2011), Newnham (2011), Pasquarè et al. (2011), Shaffer (2010) and Umbach (2010) have introduced a large number of factors that has played a significant role in shaping the Caspian energy developments. These factors take into consideration political (Russian influence in the region), economical, social and geological issues.

In this study, we identify and quantify a total of 79 factors that will shape the future of Caspian oil and natural gas export. In doing so, we propose a hybrid model for evaluating five potential pipeline routes for transporting the oil and gas from the Caspian Sea region to the world market. The model integrates strength, weakness, opportunity and threat (SWOT) analysis with the Delphi method and captures the DMs' beliefs through a series of intuitive and analytical methods. The next section presents the details of the Delphi-SWOT hybrid paradigm followed by its application to the gas and oil pipeline evaluation in the Caspian Sea. The final section presents the conclusions and future research directions.

2. The Delphi-SWOT hybrid paradigm

Strategy development is a complex and uncertain process that identifies and evaluates alternatives for utilizing an organization's resources to achieve its mission (Li et al., 2002). Because of actual uncertainty and perceived ambiguity, the process of strategy development requires input from and cooperation of many organizational functions and DMs (Li et al., 2000; Mintzberg, 1994a,b; Eden, 1990; Porter, 1987). The hybrid Delphi-SWOT paradigm proposed in this study is used to identify and evaluate strategies for locating a pipeline to transport oil and gas from the Caspian basin to world markets.

The Delphi method was developed at the RAND Corporation to obtain the most reliable consensus of opinion from a group of knowledgeable individuals about an issue not subject to objective solution (Dalkey and Helmer, 1963). It is a structured group interaction that proceeds through multiple rounds of opinion collection and anonymous feedback. Although Delphi dates back to early 1950s, the most recognized description of the method was offered by Linstone and Turoff (1975). Fischer (1978), Schmidt (1997), Okoli and Pawloski (2004) and Keeney et al. (2006) also provide excellent reviews.

Each round in Delphi involves a written survey of the participants followed by statistical feedback to them for each survey question. After seeing the results from the previous round, the participants are asked to reconsider their opinions. Generally, there is a convergence of opinions after three or four rounds, and a stabilized group opinion emerges. This group opinion may reflect agreement, disagreement or some of each. The optimum number of participants depends on the number needed to have a representative pooling of views (Ndour et al., 1992).

Since its inception in the early 1950s, SWOT analysis has been used with increasing success as a strategic planning tool by both researchers and practitioners (Learned et al., 1965; Panagiotou, 2003). The technique is used to segregate environmental factors and forces into internal strengths and weaknesses and external opportunities and threats (Valentin, 2001; Duarte et al., 2006). The SWOT matrix developed by Weihrich (1982) for situational analysis is one of the most important references in the field. Even with its popularity, Novicevic et al. (2004) observe that SWOT is a conceptual framework with limited prescriptive power. However, SWOT remains a useful tool for assisting DMs to structure complex and ill-structured problems (Hitt et al., 2000; Anderson and Vince, 2002).

3. Delphi-SWOT pipeline planning process

This study was conducted for the Horizon Oil Company,[1] a multinational oil and natural gas producer. The mission of the company is the exploration, development, production and marketing of crude oil and natural gas. Horizon established a group of

[1] The name of the company and some details of the study have been changed to protect the anonymity of the company and the security of strategy.

informed individuals to pool expertise from many domains and evaluate several alternative routes for transporting Caspian oil and gas to the world energy markets. The group included five senior managers and two external facilitators. A common group decision making activity is evaluating and deciding upon various alternatives (Ngwenyama and Brysona, 1999). Decision making bodies in organizations are often formed as groups to evaluate decision alternatives by collecting and synthesizing information from different perspectives. Group decision making is an effective way to overcome judgment errors in organizations due to human fallibility (Koh, 1994). Maier (2010) summarizes the virtues of group decision making as follows: first, if every group member exerts effort to become informed, groups can gather more information than individual members. Better information can lead to better decisions. Second, if all group members have the same information, they may not reach the same conclusion since group members typically have different backgrounds and experiences. Third, if some information is erroneous, a group can pool signals and reduce uncertainty. Fourth, groups provide an insurance against extreme preferences of individual DMs. The key duties and responsibilities of the group at Horizon included the following:

(a) Identifying and selecting the most preferable route for transporting Caspian oil and gas.
(b) Overseeing all phases of the evaluation process.
(c) Resolving conflicts as they arise.
(d) Developing an action plan for the selected route.
(e) Obtaining the approval of the top management in the implementation of the action plan.

The five senior managers were highly educated. Three managers held graduate degrees in engineering, one held a graduate degree in economics and one held a graduate degree in management. Although the members of the group were educated, their managerial judgment and intuition were limited by their background and experience. Nevertheless, all five group members were veteran mangers with 15–43 years of experience in the oil and gas industry. The fact that the group members held different kinds of knowledge made it more likely that all aspects of the decision will come under consideration. In addition, the group also relied on 27 researchers and experts at Horizon who conducted research interviews and collected data over the course of two years from different stakeholders involved in oil and natural gas exploration, production, transmission and distribution. Fig. 1 presents the hybrid Delphi-SWOT paradigm used in this study and the involved actors. The process included six steps using Delphi rounds to get a consensus and SWOT analysis to develop the final strategy.

3.1. *Step 1—group identification of the alternatives*

The process began with the participants meeting to discuss the alternative oil and gas pipeline routes proposed by the team of 27 researchers and experts at Horizon who had collected data and conducted feasibility study for the following nine potential routes in the Caspian Sea region:

- Western route (W).
- Northern route (N).
- Southern route (S).
- Eastern route (E).
- Southeastern route (SE).
- Northwestern route (via Azerbaijan, Russia and Black sea) (NW).
- Western route (via Azerbaijan, Armenia and Turkey) (W2).

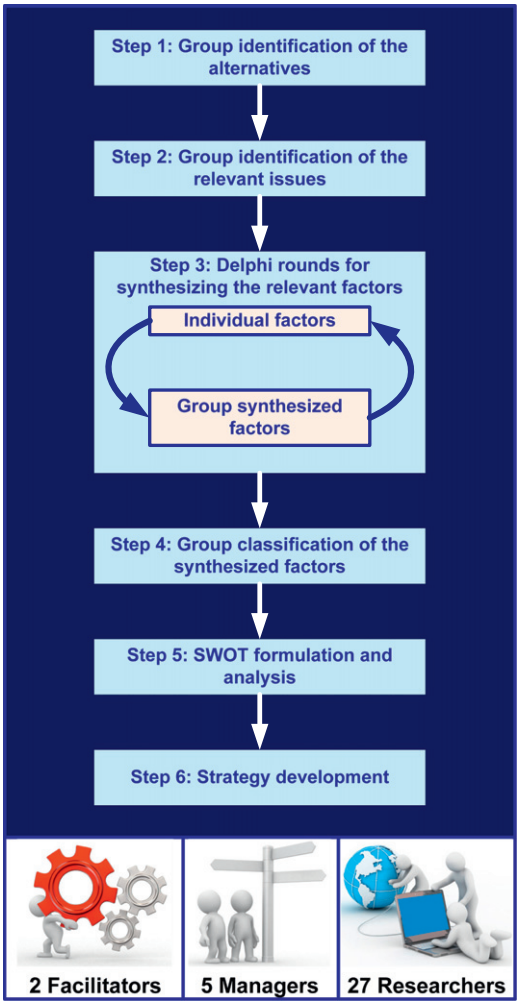

Fig. 1. Hybrid Delphi-SWOT process.

- Southeastern route (via Iran, Afghanistan and Pakistan) (SE2).
- Eastern route (via Kazakhstan, Uzbekistan, Tajikistan and Kyrgyzstan) (E2).

The five senior managers and the team of 27 researchers decided to identify those alternative routes that could be eliminated from further consideration through logical dominance. They agreed to use the following rule for dominance: if alternative route A is better than alternative route B on some objectives and no worse than B on all other objectives, B can be eliminated from consideration. In such cases, B is said to be logically dominated by A (Hammond et al., 1998). Following this agreement, the senior managers and the researchers participated in several rounds of Delphi and discussed the advantages and disadvantages of each alternative route. In each round of Delphi, the senior managers and the experts evaluated the alternative routes and after each round two facilitators provided an anonymous summary of the group's judgments from the previous round as well as the reasons they provided for their judgments. The participants were then encouraged to revise their earlier judgments in light of the responses of other members of the group. In the first round of Delphi, the northern route (N) dominated the northwestern route (via Azerbaijan, Russia and Black sea) (NW) (N > NW) mainly because of the war in Georgia, which posed some risks associated with the NW alternative. In round 2, the western route (W) dominated the western route (via Azerbaijan, Armenia and Turkey) (W2) (W > W2) mainly because of the strained Armenian–Turkish relations over a number of historical and political issues

including the Nagarno–Karabakh War. In the third round of Delphi, the southern route dominated the southeastern route (S > SE2) and in the fourth and final round, the eastern route dominated the eastern route via Kazakhstan, Uzbekistan, Tajikistan and Kyrgyzstan (E > E2) because of ethnic conflict between these countries. Consequently, the NW, W2, SE2 and E2 routes were eliminated from further consideration and a consensus emerged to include the W, N, S, E and SE routes in the SWOT analysis. A detailed mathematical description of the dominance concept is presented in Appendix 1. As for the viability of the five alternative routes, the initial route selection came from Horizon Company and the research team supporting the decision-making process; nevertheless, these five alternatives are widely proposed or discussed in the literature on oil and gas pipeline planning in the Caspian Sea basin as shown below:

- Western route (W): Akdemir (2011, p. 73), Babali (2009, p. 1300), Balat (2010, p. 1999), Bilgin (2007, p. 6384), Guliyev and Akhrarkhodjaeva (2009, p. 3174), Mavrakis et al. (2006, p. 1675), Pasquarè et al. (2011, p. 1774), Shaffer (2010, p. 7211) and Sovacool et al. (2011, p. 611).
- Northern route (N): Newnham (2011, p. 137), SÖderbergh et al. (2010, p. 7830) and Stegen (2011, p. 6508).
- Southern route (S): Akdemir (2011, p. 73), Babali (2009, p. 1300), Bilgin (2009, p. 4488), Kaiser and Pulsipher (2007, p. 1309) and Kakachia (2011, p. 18).
- Eastern route (E): Akdemir (2011, p. 73), Babali (2009, p. 1300) and Shaffer (2010, p. 7211).
- Southeastern route (SE): Akdemir (2011, p. 73) and Babali (2009, p. 1300).

Fig. 2 presents the five alternative transportation routes and the main extraction zones for oil and gas in the Caspian Sea region considered in this study.

Horizon intended to use four general zones shown in Fig. 2 for oil and gas extraction. The plan was to use separate but parallel oil and gas pipelines, similar to the parallel Baku–Tbilisi–Ceyhan oil pipeline and the Baku–Tbilisi–Erzerum South Caucasian natural gas pipeline, traversing the same route through the Republic of Georgia (Pasquarè et al., 2011). Next, we discuss the five alternatives routes formulated in Step 1.

3.1.1. *Alternative 1—western route (W)*

The Caucasus region is between the Black Sea on the west and the Caspian Sea on the east, and it comprises the newly independent states of Armenia, Azerbaijan and Georgia. These three countries have been included in the European Union (EU) Neighborhood Policy since 2004 (Kalyuzhnova, 2005). Although the region has been plagued by conflict, it is an important transit area for oil and gas exports from the Caspian Sea to European and world energy markets (Energy Information Administration, 2006). Much of the production of Caspian region will come from the Baku region of Azerbaijan, in particular from the giant Azeri–Chirag–Gunashli (ACG) oil field that lies about 100 km off the coast of Baku, with about 5.4 billion barrels of recoverable petroleum (Pasquarè et al., 2011). Azerbaijan has been embroiled in a conflict with Armenia, centered over control of the Nagorno–Karabagh region, and resolution of this conflict has been a major feature of the state's national security and foreign policies since its independence (Shaffer, 2010).

Three independent pipelines have been proposed to pass through Georgia: the Baku–Supsa and Baku–Ceyhan crude oil pipelines and the Southern Caucasus natural gas pipeline from Baku to Tbilisi and Erzerum, and in 2005, the Baku–Tbilisi–Ceyhan pipeline became operational (Shaffer, 2010). While the US consistently has supported the principle of multiple export

Fig. 2. Alternative transportation routes and the main oil and gas extraction zones.

options for Caspian energy resources, the Baku–Ceyhan route through Turkey has significant advantages. The port of Cayman is on the Mediterranean and can accommodate very large tankers while Supsa, Georgia and Novorossiysk, Russia are restricted to smaller LR-2 tankers that can transit the Bosporus. Politically, the Baku–Ceyhan route is consistent with US and Turkish efforts to minimize Russian and Iranian control over energy export routes (Sovacool, 2011). The existing Baku–Tbilisi–Erzurum gas pipeline between Azerbaijan and Turkey might be extended to Europe by the Nabucco Project, which is intended to distribute Caspian and Middle Eastern gas in Europe. Nabucco needs additional suppliers because Azerbaijan can supply only half of the amount needed for its feasibility (Bilgin, 2007, 2009). There are environmental and security issues related to these routes. For example, the Georgian government has concerns that the planned routes for Baku–Ceyhan and southern Caucasus pipelines traverse the Borjomi Valley, the source of Georgia's renowned mineral water. Subsequently, the routes were adjusted to bypass the valley. In addition, civil instability in Georgia and the hostilities between Azerbaijan and Armenia have spurred Georgia and the US to create a special military unit for pipeline protection.

The August 2008 Russian invasion of the Georgia and the unilateral recognition of the independence of Abkhazia and South Ossetia fundamentally changed the landscape of the region. The war in Georgia demonstrated some risks associated with the transit energy corridor in the southern Caucasus. It also confirmed the need for broader security guarantees for a region that is vital to the global energy security (Kakachia, 2011). Furthermore, in search of an alternative route, BP switched to the recently reopened western route export pipeline, known as the Baku–Supsa line. Because of the deteriorating military conflict, BP has also suspended shipments through Baku–Supsa, as well as the South Caucasus Pipeline, which transports natural gas from Baku to Turkey through Tbilisi. Completing the lock-in of Azeri oil exports, the fighting caused authorities to suspend seaborne shipments from Georgia's Black Sea port of Batumi and Poti, both supplied by rail. Poti has now been closed following reported Russian airstrikes. Adding to the gloomy picture, authorities also ceased exports from Kulevi, Georgia's third Black Sea oil terminus. The five-day clash has put a serious dent in Georgia's economy both in causalities and in deteriorating the prospects for development and investment (Kakachia, 2011). To make a bad situation worse, Pasquarè et al. (2011), have identified new seismic and volcanic risks threatening the strategic Caspian oil and gas pipelines through the Republic of Georgia.

Turkey is planning to increase its oil and gas pipeline infrastructure to accommodate its increased energy demand (Kiliç, 2006). Turkey and the United State are strategic partners. Azerbaijan supports Turkey for cultural and political reasons and Georgia sees Turkey as a crucial partner in its efforts to join the EU and NATO. Nevertheless, Turkey is dependent on Russia, which supplies about two-thirds of its natural gas. The Bosporus is a viable option for transporting natural gas. However, safety, security and environmental considerations weaken the feasibility of this alternative and Turkey rejects this route because of the congestion in the straights (Çetin and Oguz, 2007). Turkey is one of the major oil and gas importers for its own consumption (Soyhan, 2009; Balat, 2010).

Turkey controls both a sea route, the narrows between Europe and Asia, and overland routes to the Mediterranean. While much of Central Asia's energy resources will continue to move through Russia's pipelines to the Black Sea and the Turkish outlet, some will soon flow through lines westward from the Caspian and across Turkey to terminals on its Mediterranean shores. Healthy competition among the interested powers for Central Asia's oil and gas concessions and pipeline infrastructure is to be welcomed. However, competition that deteriorates into heavy-handed military pressures to gain political positions spells disaster. This type of negative competition may lead to conflict, as outside powers set one Central Asian state against another, or encourage separatist uprisings and domestic coups. Such fragmentation from the combination of external pressures and internal regional divisions would convert Central Asia into the kind of Shatterbelt that has characterized the Middle East since the end of World War I. The alternative for the world's major powers is to collaborate in developing Central Asia by treating it as a Gateway region. The EU is best positioned to lead such a collaborative effort, and Turkey's membership in the Union would enhance its capacity to do so. Ankara can reach out to that part of the Muslim world once known as Turkestan because of their traditional influence based on linguistic, religious and racial ties. In addition, Turkey could help stabilize the Middle East by directing unused fresh waters from rivers such as the Seyhan and Ceyhan that now discharge into the Mediterranean, through a "Peace Pipeline" to the Levant and the Arabian Peninsula, which Turkish leaders first proposed two decades ago (Akdemir, 2011). Turkey is no longer viewed by the states of the region as a state working in the region in synchronization with Washington. In addition, Baku and Tbilisi are much more reserved in their views on sharing strategic partnership with Ankara in the region (Shaffer, 2010).

3.1.2. Alternative 2—northern route (N)

Russia dominates the northern sector of the Caspian region, occupying 30% of the shoreline (Correljé and van der Linde, 2006). Russia's existing national oil trunk pipeline network is a unique technological system and the primacy of Russian gas in the global arena is absolute (Akdemir, 2011; Fernandez, 2009; Fernandez and Palazuelos, 2011). Russia is the principal heir to the Soviet gas industry that was developed at a rapid pace between 1955 and 1990. According to the BP Statistical Review (2011), Russia has 23.9% of the world's total gas reserves, and Russian production equals 18.4% of global production. About 30% of the Russian gas production is exported (Söderbergh et al., 2010). While all the Soviet oil and gas pipelines transit Russia, the Russian influence is more complicated than their geographical paths. Consequently, Russian policy frequently has been determined primarily by geopolitical rather than economic considerations. For instance, the Russian pipeline system is no longer capable of transporting the growing oil and gas production from the region (Bahgat, 2007), and Russia's economic difficulties prevent its development of an adequate infrastructure.

In addition to these geographical and political factors, Russian influence in the region is supported by its potent military presence, the strongest of any littoral state (Correljé and van der Linde, 2006). Almost 90% of Russia's gas exports now transit Ukraine (Akdemir, 2011). During the last few years, Russians have experienced difficulties exporting gas during the winter season. Recent irregularities in gas supply to Turkey again led Russia to blame Ukraine for lack of reliability in its transit responsibilities. Russia is often willing to sacrifice economic gain to assert political advantage (Orttung and Overland, 2011; Bilgin, 2009). Stegen (2011) describes this Russia tool's as an "energy weapon". Russia's new energy weapon is of great importance today because Russia is likely to gain more and more power as oil and gas become scarcer in the future (Newnham, 2011). Russia's need to export its oil and gas to the European market has led to mutual dependence that precludes the instrumentalisation of Russian energy and pipeline policy as a factor of foreign policy in the age of globalization (Umbach, 2010).

3.1.3. Alternative 3—southern route (S)

Iran possesses the world's second largest natural gas reserves and occupies a strategic location between the oil-rich region of

the Middle East and the southern Caspian Sea (Pak and Farajzadeh, 2007). While there are prospects for significant gas reserves in the Caspian region, Iran's largest reserves are in the South Pars located in the Persian Gulf (Mavrakis et al., 2006). In spite of the increase in the natural gas production, Iran is often an importer of its natural gas needs due to higher consumption rate (Mazandarani et al., 2011). Similarly, Iran's oil deposits in the Caspian basin are largely unexplored and underdeveloped (Shaffer, 2010). Furthermore, Iran has access to open seas and world energy markets through the Persian Gulf and the Straits of Hormuz, which lead to the Oman Sea and the Indian Ocean (Pak and Farajzadeh, 2007). Iran interest in the Caspian region is shaped by several considerations. Providing security for its northern border is vital and requires stability in the contiguous Central Asian states. In addition, developing favorable relations with these countries is seen as a means of normalizing relations with the EU, China and Japan. Also, maintaining good relations with Russia and Turkey is essential. Russia is Iran's primary source of military equipment and technology while Iran aims to sell its natural gas to Europe through Turkey's pipeline system (Kjärstad and Johansson, 2007).

Because of this geography factor, Iran dominates the southern route from the Caspian region. Although Iran has an advantageous geographic location and significant energy resources, several interacting conditions have circumscribed its influence in the region and limited the realization of its energy and transit potential. First, Iran itself lacks the resources to develop its energy and transit infrastructure. Second, US efforts to isolate Iran have been a deterrent to foreign investment.

Tehran asserts that routes through Iran to the Persian Gulf are the shortest and most economical for exporting oil from the Caspian Sea. Furthermore, the Persian Gulf routes could transport oil to Asia, where the demand is projected to grow faster and would support a higher price than the Mediterranean markets that most of the competing pipelines serve. Oil could be exported via Iran either by direct transportation pipelines that pass through Iran to the Persian Gulf or by oil swaps. However, investment in Iran's oil sector would be limited by US economic sanctions.

3.1.4. Alternative 4—eastern route (E)

The Central Asian Republics (CARS) include Kazakhstan, Uzbekistan, Tajikistan and Kyrgyzstan. While Kyrgyzstan and Tajikistan possess few fossil fuel deposits, Kazakhstan and Uzbekistan have substantial energy reserves. None of the CARS has direct access to open sea routes; however, they are strategically located between Russia, China, Iran and Turkey. Because of this geology and geography, the EU, US and Japan in addition to China and Russia have revealed intense interest in the region (Dorian, 2006). Kazakhstan is energy rich, the third largest energy-producing country of the former Soviet Union, and the only one of the CARS bordering the Caspian Sea. Uzbekistan also has abundant energy resources with 60% of its land area showing oil and gas potential (Finon and Locatelli, 2008). Kazakhstan has emerged as the main recipient of oil and gas investment in the Caspian region, because of the discovery of the fifth largest ever found oil field in the world at the offshore Kashagan field (Babli, 2009).

Although Central Asia enjoys vast energy development potential, there are significant obstacles to exploiting these resources, such as the limited infrastructure for transporting energy, poor communications infrastructure, unstable government structures, political conflict, payments difficulties and inadequate energy policies (Dorian et al., 1999). However, transportation is a major constraint for the CARS (Dahl and Kuralbayeva, 2001). A northern route through Russia is limited by transit quotas. Exports westward through the Caspian and Black Sea are restricted by terminal capacity. Southward via swaps with Iran is restrained by US economic and political pressure. To the East, China has a large 3700 km border with the CARS, and its large, rapidly growing economy has created an increasing demand for energy (Dorian, 2006).

China, the world's second-largest economy, is worried about energy security, which underpins the core objectives of Beijing and the political legitimacy of the Communist Party. Oil is the second most prominent fuel in China's energy mix after coal, but production has not kept up with the rising demand and China now imports half of its crude oil. This situation shows no signs of abating, because rising incomes in China will likely lead to further increases in demand. The usage of natural gas is also growing in China, especially within the residential sector, and it now represents 3% of China's total primary energy supply (Bambawale and Sovacool, 2011a). On the supply side, the Kazakhstan–China oil pipeline, currently China's only cross-country oil pipeline has not been able to secure enough crude in Kazakhstan to exhaust the pipe's capacity as competition for oil in Kazakhstan is fierce. Even if the pipeline can deliver enough crude oil to China each year, the amount of oil transported accounts for about 12–13% of the annual demand and less in the future (Leung, 2011).

3.1.5. Alternative 5—southeastern route (SE)

Turkmenistan, Afghanistan and Pakistan had signed a memorandum of understanding to build the Central Asian Oil Pipeline to transport oil to Pakistan and world markets via Afghanistan. However, no progress was made on the pipeline because of the instability in Afghanistan. The death of Osama bin Laden could have a number of short and long-term effects on the stability and security of the oil and gas production and transportation in the Caspian region. The implications for the oil market are unclear. Nevertheless, this event could weaken the terrorist threat in the region and underscore the effectiveness of U.S. covert operations or it could spawn a wave of poorly planned but destructive terrorist attacks.

Turkmenistan ranks third in the Caspian region in liquid and gaseous hydrocarbons (Dorian, 2006). However, it has made less progress than other littoral states in developing its energy resources because of transportation bottlenecks (Kaliyva, 2004). Turkmenistan lacks direct access to global waterways. For this reason, a number of pipelines have been proposed to transport Turkmenistan's oil and gas westward through Azerbaijan or Iran. These routes connect with existing pipeline systems to deliver product to Turkey and world markets.

An alternative export route for Turkmenistan energy resources is through Afghanistan to Pakistan. Pakistan has a fast growing economy and has a strategic location. On its southern side, it has a long coastline on the Oman Sea with two deep water ports, Karachi and Gwadar. On its east and northeast, it borders the economic giants of India and China. Furthermore, Pakistan has well-developed road and railroad networks that link to India and China.

Similarly, India is also investing in international pipeline networks to guarantee secure supplies of oil and gas. India is planning to reduce its energy dependence from the Middle Eastern countries and use the Central Asia countries as its long-term alternative energy supply (Bambawale and Sovacool, 2011b; Pandian, 2005).

While Turkmenistan, Afghanistan and Pakistan share a historical and cultural heritage, political instability and terrorism threaten the development of the route. However, the US, the EU and China are major actors in the region supporting Pakistan as an international trade corridor. The energy security of Pakistan is complicated by global and regional geopolitical interests because of its unique geographical location, its potential to influence the Muslim world, and its relations with the US, EU and China. During

and after the cold war, Pakistan has been a part of the major international moves that have shaped the world in general and Asia in particular. It is likely to remain an important geo-political actor of the region in the foreseeable future as well. Pakistan is a fast growing economy that has a very important strategic location with respect to the energy rich Persian Gulf and Central Asia (Sahir and Qureshi, 2007).

Most of the proposed pipelines must pass through or near politically troubled areas. This has raised concerns that some pipelines could become vulnerable targets for terrorist activity. The existence of multiple routes would increase the energy security of both exporters and importers by making export less subject to technical or political disruptions on any one route. However, energy security must be balanced by economic feasibility because a larger number of pipelines would mean smaller economies of scale and greater expenses for each project (Priddle, 1998).

Once the alternative routes were formulated, the process proceeded to Step 2.

3.2. Step 2—group identification of the relevant issues

As in Step 1, the DMs began their discussion of the issues relevant to selecting a pipeline route in face-to-face brainstorming sessions. Based on these discussions, the DMs collectively decided to consider the following issues when identifying the relevant factors for the SWOT analysis.

Economic issues. Building an oil or gas pipeline is fundamentally a business proposition. Therefore, return on investment (ROI) is a primary decision variable. While ROI is a principal factor in the selection of a pipeline route, it is affected by other factors including cultural, environmental, geographical, legal, political, social and technological issues. For example, some proposals would construct a portion of the pipeline under the Caspian seabed. This impacts the ROI by exacerbating environmental and legal problems as well as technological obstacles. A plan for a pipeline transiting the Caspian would invoke the Caspian Environmental Program (CEP) and involve all the littoral states in evaluating the environmental risks. In addition, the technologies required to build a seabed pipeline would be difficult and costly to transport to the landlocked Caspian. All these factors would significantly alter the ROI of a seabed route.

For other routes, political factors would impact the risk inherent in estimating the ROI because the transport countries are not friendly or terrorist groups operate within their borders. In some cases, ancient cultural and religious discord is prevalent. These factors can interact to increase the costs and risks associated with a project. Consequently, ROI is truly a socioeconomic variable in the decision to choose a pipeline route.

Political issues. During the Soviet era, the Caspian region was dominated by the USSR with Moscow controlling regional activities including energy exploration, development and transit. The disintegration of the Soviet Union has fundamentally changed the geopolitical conditions around the Caspian basin. New regional and global actors have emerged asserting their own particular interests. Kaliyva (2004) had identified three primary interest groups: the Caspian basin states, the transit countries and global and regional powers.

The Caspian basin states include Azerbaijan, Iran, Kazakhstan, Russia and Turkmenistan as well as Uzbekistan because it shares several of the regions hydrocarbon basins. These countries are interested in the development of their rich energy resources and in exporting them to world markets. Kalyuzhnova (2008) suggests that the exploration of oil and gas in the Caspian Sea region has had important impacts on the economic growth and the poverty alleviation in Azerbaijan, Kazakhstan and Turkmenistan. She predicts that these countries' financial situation may improve even further with the discovery and development of new energy fields and the signing of new production sharing agreements between governments and international oil and gas companies. However, she cautions that transparency and accountability on the management of energy resources is needed for maximizing the economic and financial benefits of oil and gas for future generations. She also argues that all policies should seek to restore the deterioration of environmental conditions in the Caspian Sea and support sustainable growth.

Transit states include Russia, the Ukraine, Romania, Bulgaria, Georgia, Armenia, Turkey, Iran, Afghanistan and Pakistan. These countries seek to benefit from their geographic location between the Caspian oil and gas fields and world markets by promoting pipelines that transit their territories. Global and regional powers with economic and strategic interests in the Caspian region include Russia, the EU, the US, China, India, Pakistan, Iran and Turkey. These countries strive to strengthen their positions as a platform for promoting their global or regional strategies (Kaliyva, 2004).

These competing economic and national interests make the region the most dangerous and geopolitically complicated area in the world. Consequently, the critical challenge is to maintain stability and security in the region. The concerns range from environmental accidents to political instability and terrorism. Since the September 11 attacks, the US and the EU have made energy security a priority and have committed enormous amounts of resources to this effort (Sahir and Qureshi, 2007). It is also a major concern for the large and growing Asian economies of China, Japan, India and South Korea (Bahgat, 2007).

In April 2010, the Council on Foreign Relations convened a group of experts to discuss the current state of energy security research. They described the need for systematic analysis of the relationship between oil and gas supply and political decision making (Levi, 2010). The Russian control of Georgia could strengthen its energy monopoly over Europe and isolate Azerbaijan and Central Asian countries (Bilgin, 2009; Kakachia, 2011; Stegen, 2011).

Legal issues. A large portion of the oil and gas reserves in the Caspian basin is under the seabed. The question of ownership of these resources is disputed and debated by the Caspian littoral states. One of the main problems is the lack of law and law enforcement to define and protect the interests of littoral states.

The seemingly irresolvable status of the Caspian Sea leads to a set of legal issues. One can conclude that the Caspian is both a sea and a lake or neither a sea nor a lake. Azerbaijan, which initially insisted that the Caspian is a sea and must function under the United Nations (UN) Law of the Sea, has profited by the Caspian's uncertain status as a lake on its surface, and a sea underneath. Russia has achieved some of its goals including the control of the surface waters, and consequently is rushing to catch up to Azerbaijan in its capacity to exploit petroleum resources. In the meantime, Iran insists that the Caspian is a lake and must be divided according to terms of the Soviet–Iran Treaties. However, Iranians find themselves excluded from both the seabed and most of the surface resources by the legal vacuum they have created by their intransigence. Ultimately, until the Caspian is brought fully under the control of the international rule of law, these outcomes will remain imperiled by changing circumstances (Zimnitskaya and Geldern, 2011).

Environmental issues. Economic activity in the Caspian region is fundamentally linked to energy exploration, development and export. The oil and gas industry has been the cause of severe air pollution as well as soil and water contamination. The problems began in the Soviet period when the resources were exploited using environmentally unsound practices. After the collapse of

the Soviet Union, the situation became worse because of the lack of cooperation among the Caspian states. Furthermore, the pollutants are accumulating because they are trapped within this land-locked basin. This exacerbates the threat to farming, fishing and the health of the human population.

The solution to this complex environmental crisis requires creating a legal framework that insures a regional approach to environmental management and sustainable development. The CEP was established in 1995 with the support of the World Bank, the EU, the UN Development Program and the UN Environment Program. The CEP is a regional intergovernmental organization that has been instrumental in improving dialog between the Caspian states and drafting regional agreements on environmental issues. In particular, the CEP sponsored a series of intergovernmental meetings that has produced a Framework Convention for the Protection of the Caspian Sea (De Mora and Turner, 2004). This convention is a major step in creating a permanent regional management structure for the Caspian. While the Caspian Sea region is not yet a successful model of intergovernmental collaboration on environmental management and sustainable growth, the discussions produced by the CEP have resulted in a broader awareness and a better understanding of what is at stake.

The Baku–Tbilisi–Ceyhan oil pipeline and the Baku–Tbilisi–Erzerum South Caucasian natural gas pipelines are parallel pipelines traversing the same route through the Republic of Georgia. The pipelines lie within the northern part of the Javakheti recent volcanic province. The primary environmental concern in Georgia is the world-famous natural spring water called the Borjomi areaiver, which would cut off community water supplies and have severe ecological impacts between the spill site and the river (Pasquarè et al., 2011). In addition, the world's attention is attracted to the Caspian by regional rivalries over the highly competitive issues of oil extraction, transportation and profit sharing and occasionally by ethnic tensions. However, there is another, equally important, danger about which politicians and oil-interests generally remain silent, namely the destruction of the Caspian Sea's unique ecosystem. This is due to a lack of respect for overall regional development and the former Soviet Union's long-term violation of generally accepted environmental norms. The Caspian governments including Kazakhstan optimistically hope that they can have a balanced ecosystem and lots of oil (Babali, 2009).

Cultural and social issues. The Caspian Sea basin is located at the fault line of three clashing civilizations (Huntington, 1993). It is in this region that the Russian Orthodox, Islamic and Hindu world views confront each other resulting in a diversity of customs, languages and sects. These cultures frequently spawn closed societies that resist change and resent outsiders. Consequently, any project as massive and geographically lengthy as a pipeline could transit regions occupied by groups such as these and would likely meet aggressive opposition.

During the Soviet era, Moscow imposed a totalitarian regime that suppressed these cultures and forced order. The dissolution of the Soviet Union removed political, economic and military restraints. This has released diverse social and religious forces that generate friction if not outright conflict. For example, Tajikistan is a collection of valleys that was forced into a country under Stalin. This absence of national identity makes the country vulnerable to transnational criminal organizations that are involved in opium production and heroin distribution.

Similarly, the Islamic Movement of Uzbekistan is a fundamentalist sect that utilizes guerrilla tactics and heroin trafficking to create chaos and undermine the Tashkent government. The group's stated goal is the creation of an Islamic state in the Fergana Valley. These circumstances are pandemic in Caspian region and CARS. They present severe threats to any attempt to construct an export pipeline.

Geographical and technological issues. Much of the Caspian basin energy reserves are located under the seabed or far from potential markets in relatively remote Turkmenistan, Kazakhstan and Uzbekistan. The geographical location of these reserves makes transport a major problem. The Caspian is landlocked so shipping directly by tanker is not possible. All export of energy resources from the Caspian states involves extensive pipelines. One of the pipeline routes is proposed to transit the Caspian seabed. Constructing this pipeline would require bringing highly specialized underwater excavating equipment into the region. Transporting this massive machinery overland would be difficult, costly and risky. Other proposed routes cross very difficult topography. Land routes to the east, south and west all encounter mountainous terrain at some point. They also confront extreme meteorological conditions that are challenging for people, equipment and the pipeline.

3.3. Step 3—Delphi rounds for synthesizing the relevant factors

This step involved a series of Delphi rounds to develop a set of relevant factors for use in the SWOT analysis. In the first Delphi round, the DMs were asked individually to consider the economic, political, legal, environmental, cultural and social, geographical and technological issues discussed in Step 2 and to compile a set of factors considered to be important in the pipeline decision. These personal lists were provided to the facilitators anonymously. Then, the facilitators combined all of these factors into a list with 478 factors.

In round 2, this list was shared with all the DMs. They were asked to consider this feedback and then revise and resubmit their initial individual list. The facilitators combined all of these factors into a new list with 242 factors. Again in round 3, the synthesized list of factors from round 2 was shared with all the DMs, and they were asked to revise and resubmit their individual list from round 2. The facilitators then combined all of these factors into another new list with 112 factors. These Delphi rounds were repeated three more times. In round 4, the facilitators synthesized a list of 79 factors. At this point, the DMs agreed that they could not make significant changes to the list. Consequently, a decision was made to use the 79 factors presented in Tables 3(a) and (b) in the subsequent steps.

3.4. Step 4—group classification of the synthesized factors

The DMs collectively classified the 79 factors developed in Step 3 into economic, political, legal, environmental, cultural and social, geographical and technological categories. While 22 factors were identified as economic concerns, only four factors were perceived as legal issues.

3.5. Step 5—SWOT formulation and analysis

Within the categories identified in Step 4, the DMs collectively classified each factor as either *external* or *internal*. Next, the DMs collectively categorized external factors into *opportunities* and *threats* and internal factors into *strengths* and *weaknesses*. Of the 79 factors presented in Table 3, 47 were classified as external and 32 were categorized as internal. Within the external factors, 19 were perceived as opportunities and 28 as threats. Within the internal factors, 16 were identified as strengths and 16 as weaknesses. The balance of factors between external and internal and threats and opportunities suggest a defensive position in reaction to external threats rather than an offensive orientation in the SWOT analysis.

Table 3
Group classification of the synthesized factors.

Factor	Sub-factor	SWOT
(a)		
Economical (22)		
ECN01	Financial support of the international community	Opportunity
ECN02	Availability of investment tax credits for oil and gas explorations in the region countries	Opportunity
ECN03	High ROI potentials	Opportunity
ECN04	Financial support of the region/pipeline countries for oil and gas explorations	Opportunity
ECN05	Availability of cheap labor in the region/pipeline countries	Opportunity
ECN06	High level of export in the region/pipeline countries	Opportunity
ECN07	Potential for high and stable energy demand in the region/pipeline countries	Opportunity
ECN08	High level of GDP in the region/pipeline countries	Opportunity
ECN09	High tax rate in the region/pipeline countries	Threat
ECN10	High cost of building and maintaining pipelines in the region/pipeline countries	Threat
ECN11	High level of tariffs and commissions in the region/pipeline countries	Threat
ECN12	High cost of oil and gas transportation and transfer in the region/pipeline countries	Threat
ECN13	High oil and gas drilling and exploration expenses in the region/pipeline countries	Threat
ECN14	Negative effect of pipelines on other industries such as tourism and fishing	Threat
ECN15	Economic dependency of the region/pipeline countries to other countries	Threat
ECN16	Investment security in the region/pipeline countries	Strength
ECN17	Qualified and productive labor force in the region/pipeline countries	Strength
ECN18	Economic stability of the region/pipeline countries	Strength
ECN19	High current oil and gas supply	Strength
ECN20	Low non-oil and gas import/export level in the region/pipeline countries	Weakness
ECN21	Poor oil and gas quality	Weakness
ECN22	Poor forecast for oil and gas supply	Weakness
Political (9)		
POL01	Political support of the neighboring countries for the project	Opportunity
POL02	Political support of the international community for the project	Opportunity
POL03	Possibility of Russian control of the pipeline	Threat
POL04	Danger of terrorism in the region/pipeline countries	Threat
POL05	Nuclear proliferation initiatives in the region/pipeline countries	Threat
POL06	Foreign oil and gas dependency of the region/pipeline countries	Threat
POL07	Political stability of the region/pipeline countries	Strength
POL08	Poor security in the region/pipeline countries	Weakness
POL09	Military instability of the region/pipeline countries	Weakness
Legal (4)		
LEG01	Oil and gas reserve ownership disputes in the region/pipeline countries	Threat
LEG02	Availability and stability of insurance industry in the region/pipeline countries	Strength
LEG03	Strict import/export laws and regulations in the region/pipeline countries	Weakness
LEG04	Strict foreign investment rules and regulations in the region/pipeline countries	Weakness
(b)		
Environmental (8)		
ENI01	Pollution of the sea surface	Threat
ENI02	Pollution of the sea bottom	Threat
ENI03	Pollution of the beaches	Threat
ENI04	Pollution of the water sources	Threat
ENI05	Pollution of the water destinations	Threat
ENI06	Pollution of the rivers and water canals	Threat
ENI07	Pollution caused by nuclear activities	Threat
ENI08	Availability of underground water sources along the route	Threat
Technological (11)		
TEC01	Ability to maintain and repair current pipelines	Opportunity
TEC02	Ability to expand current pipelines	Opportunity
TEC03	Ability to convert natural gas to liquid gas	Opportunity
TEC04	Adequacy of technologically advanced oil and gas tankers	Strength
TEC05	Adequacy of technologically advanced oil and gas trucks	Strength
TEC06	Adequacy of the oil and gas refineries	Strength
TEC07	Adequacy of the railroad infrastructure	Strength
TEC08	Lack of scientific and technological foundation of the society	Weakness
TEC09	Poor oil and gas transportation infrastructure	Weakness
TEC10	Lack of roads with proper surface and foundation	Weakness
TEC11	Insufficient number of ports for oil and gas transportation	Weakness
Cultural (7)		
CUL01	Common race in the region/pipeline countries	Strength
CUL02	Common culture and customs in the region/pipeline countries	Strength
CUL03	Common national identity in the region/pipeline countries	Strength
CUL04	Common history in the region/pipeline countries	Strength
CUL05	Language diversity in the region/pipeline countries	Weakness
CUL06	Religion diversity in the region/pipeline countries	Weakness
CUL07	Diversity of religious sects in the region/pipeline countries	Weakness
Social (5)		
SOC01	Open society	Opportunity
SOC02	Availability of jobs and public assistance programs	Opportunity

Table 3 (*continued*)

Factor	Sub-factor	SWOT
SOC03	Educated and trained workers	Opportunity
SOC04	Familiarity of the society with oil and gas industries	Strength
SOC05	Traffic obstacles	Weakness
Geographical (13)		
GEO01	Accessibility to open sea and oceans	Opportunity
GEO02	Suitable beaches with calm waves	Opportunity
GEO03	Shorter distance	Opportunity
GEO04	Hilly and mountainous terrain	Threat
GEO05	Active Earthquake region	Threat
GEO06	High temperature and humidity problems	Threat
GEO07	Low temperature and icy conditions	Threat
GEO08	Desert terrain	Threat
GEO09	Swampy terrain	Threat
GEO10	Offshore distance	Threat
GEO11	Accessibility to straits for passage	Threat
GEO12	Accessibility and availability of oil and gas reserves in the region	Strength
GEO13	Poor soil condition and quality	Weakness

In a follow up questionnaire, the participants were asked to score the factors in each category on a scale from 0 to 1, with a 0.1 increment; where a score of 0 represents non-importance and a score of 1 indicates extreme importance. Tables 4(a) and (b) present the importance weight assigned by each DM along with an average for the five DMs.

"Shorter distance" (GEO03), "political support of the international community for the project" (POL02) and "ability to maintain and repair current pipelines" (TEC01) were perceived as leading opportunities by the DMs. In contrast, the group considered "oil and gas reserve ownership disputes in the region/pipeline countries" (LEG01) and "danger of terrorism in the region/pipeline countries" (POL04) as the primary potential threats. While the highest rated strength was "accessibility and availability of oil and gas reserves in the region/pipeline countries" (GEO12), and "traffic obstacles" (SOC05) was seen as the greatest weakness.

Next, the DMs decided to eliminate those factors that they considered to be relatively unimportant. The DMs agreed to use a threshold of 0.2 out of a possible 1.0. Eight opportunities, four threats, eight weaknesses and four strengths had a weight of 0.2 or greater. This resulted in a more manageable number of factors for the DMs to consider and a balance between the external and internal factors in the SWOT analysis. The 24 opportunities, strengths, threats and weaknesses are presented in Table 5 along with their importance weights.

Then, the importance weights presented in Table 5 were normalized using Eq. (1) and (2) in Appendix 2 to ensure that the total of the weights for the positive factors (opportunities and strengths) and the negative factors (threats and weaknesses) each sum to 1. The normalized weights for the 24 strategic factors are presented in Table 6.

3.6. Step 6—strategy development

A questionnaire was designed using a Likert scale with 0=unlikely and 5=very likely to allow the DMs to evaluate the likelihood of each of the 24 SWOT factors for each of the 5 alternatives. Higher scores are preferred to lower scores for the positive factors, those identified as opportunities or strengths. In contrast, lower scores are preferred to higher scores for the negative factors, those perceived as threats or weaknesses. Consequently, the ideal and most attainable likelihood score on each positive factor, any opportunity or strength, is 5. Similarly, the ideal likelihood score on each negative factor, any threat or weakness, is 0. The ideal scores for each factor and the average of the scores assigned by the DMs to each factor for each route are presented in Table 7.

The average likelihood scores in Table 7 were normalized and used with the normalized weights in Table 6 to derive an overall opportunity–strength and an overall threat–weakness score for each route. Eqs. (3) and (4) in Appendix 2 describe the process. Then, each of the 5 alternative routes is plotted by its opportunity–strength and threat–weakness scores in the scatter diagram depicted in Fig. 3. Observe that the ideal strategy would have coordinates of (5,0) on the opportunity–strength and threat–weakness axes of Fig. 3. The Euclidean distance between each alternative and the ideal route (5,0) is calculated using Eq. (5) in Appendix 2. Alternative routes with a smaller Euclidean distance are closer to the ideal route and preferred. These Euclidean distances are the basis for ranking the alternative routes presented in Table 8.

As shown in Table 8, the Southern and Northern routes are the alternatives closest to the ideal route. The gap analysis in this table reveals that the opportunity–strength score for the Southern route (2.656) is slightly lower than the score for the Northern route (2.792) resulting in a smaller opportunity–strength gap from the opportunity–strength ideal score (5) for the Northern route (2.208) compared with the opportunity–strength gap for the Southern route (2.344). However, the threat–weakness score for the Southern route (2.260) is significantly lower than the Northern route (2.672) and the other three remaining routes resulting in the best threat–weakness gap of 2.260 from the threat–weakness ideal score (0). The Southern route with the Euclidean distance of 3.256 and the Northern route with the Euclidean distance of 3.466 were chosen as the best and second-best options, respectively. The overall ranking of the alternative routes can be used as the basis for developing a security strategy if some degree of diversification (more than one route) is needed. Although the diversification of oil and gas pipeline routes can greatly reduce risks due to dependence on a particular route, it is not an energy security 'silver bullet' and cannot eliminate the overall security risk.

Next, the DMs arranged a series of additional face-to-face meetings to develop a set of strategies for exploiting the 24 critical success factors identified in the SWOT analysis. In three

Table 4
Important weights.

Factor	Sub-factor	Group classification	Sub-factor weights					Overall weight
			DM 1	DM 2	DM 3	DM4	DM 5	
(a)								
Economical	ECN01	Opportunity	0.2	0.2	0.2	0.1	0.1	0.16
	ECN02	Opportunity	0.1	0.1	0.1	0.1	0.1	0.10
	ECN03	Opportunity	0.1	0.1	0.1	0.1	0.1	0.10
	ECN04	Opportunity	0.2	0.1	0.1	0.1	0.1	0.12
	ECN05	Opportunity	0.0	0.1	0.1	0.0	0.1	0.06
	ECN06	Opportunity	0.1	0.1	0.1	0.1	0.1	0.10
	ECN07	Opportunity	0.1	0.2	0.1	0.2	0.2	0.16
	ECN08	Opportunity	0.1	0.1	0.2	0.2	0.2	0.16
	ECN09	Threat	0.1	0.1	0.0	0.2	0.1	0.10
	ECN10	Threat	0.2	0.2	0.2	0.2	0.3	0.22
	ECN11	Threat	0.1	0.1	0.1	0.1	0.1	0.10
	ECN12	Threat	0.2	0.2	0.2	0.2	0.3	0.22
	ECN13	Threat	0.2	0.1	0.2	0.1	0.2	0.16
	ECN14	Threat	0.1	0.2	0.1	0.1	0.1	0.12
	ECN15	Threat	0.2	0.1	0.1	0.1	0.0	0.10
	ECN16	Strength	0.1	0.2	0.2	0.1	0.1	0.14
	ECN17	Strength	0.1	0.1	0.0	0.1	0.1	0.08
	ECN18	Strength	0.1	0.2	0.2	0.1	0.2	0.16
	ECN19	Strength	0.2	0.1	0.2	0.2	0.2	0.18
	ECN20	Weakness	0.1	0.1	0.0	0.1	0.2	0.10
	ECN21	Weakness	0.2	0.1	0.1	0.2	0.1	0.14
	ECN22	Weakness	0.2	0.0	0.2	0.2	0.1	0.14
Political	POL01	Opportunity	0.5	0.4	0.4	0.4	0.4	0.42
	POL02	Opportunity	0.6	0.7	0.6	0.7	0.7	0.66
	POL03	Threat	0.2	0.1	0.1	0.2	0.0	0.12
	POL04	Threat	0.6	0.1	0.9	0.6	0.8	0.60
	POL05	Threat	0.1	0.0	0.0	0.1	0.0	0.04
	POL06	Threat	0.2	0.1	0.0	0.1	0.1	0.10
	POL07	Strength	0.4	0.4	0.4	0.5	0.4	0.42
	POL08	Weakness	0.4	0.4	0.4	0.3	0.4	0.38
	POL09	Weakness	0.3	0.3	0.2	0.3	0.2	0.26
Legal	LEG01	Threat	1.0	1.0	1.0	1.0	1.0	1.00
	LEG02	Strength	0.3	0.3	0.3	0.3	0.3	0.30
	LEG03	Weakness	0.3	0.4	0.3	0.3	0.4	0.34
	LEG04	Weakness	0.4	0.4	0.4	0.5	0.4	0.42
(b)								
Environmental	ENI01	Threat	0.2	0.1	0.0	0.2	0.1	0.12
	ENI02	Threat	0.1	0.1	0.1	0.1	0.1	0.10
	ENI03	Threat	0.1	0.0	0.2	0.1	0.1	0.10
	ENI04	Threat	0.1	0.1	0.1	0.2	0.1	0.12
	ENI05	Threat	0.1	0.1	0.1	0.1	0.2	0.12
	ENI06	Threat	0.2	0.1	0.1	0.2	0.1	0.14
	ENI07	Threat	0.1	0.1	0.0	0.1	0.1	0.08
	ENI08	Threat	0.1	0.1	0.2	0.2	0.2	0.16
Technological	TEC01	Opportunity	0.5	0.5	0.5	0.5	0.5	0.50
	TEC02	Opportunity	0.4	0.5	0.5	0.4	0.4	0.44
	TEC03	Opportunity	0.2	0.1	0.0	0.1	0.1	0.10
	TEC04	Strength	0.1	0.0	0.0	0.1	0.1	0.06
	TEC05	Strength	0.1	0.0	0.1	0.1	0.1	0.08
	TEC06	Strength	0.1	0.1	0.2	0.1	0.1	0.12
	TEC07	Strength	0.1	0.0	0.0	0.1	0.1	0.06
	TEC08	Weakness	0.1	0.2	0.2	0.1	0.2	0.16
	TEC09	Weakness	0.3	0.3	0.3	0.3	0.3	0.30
	TEC10	Weakness	0.1	0.1	0.0	0.1	0.1	0.08
	TEC11	Weakness	0.1	0.2	0.1	0.0	0.1	0.10
Cultural	CUL01	Strength	0.2	0.3	0.1	0.0	0.1	0.14
	CUL02	Strength	0.1	0.1	0.1	0.0	0.1	0.08
	CUL03	Strength	0.1	0.1	0.1	0.1	0.0	0.08
	CUL04	Strength	0.1	0.1	0.0	0.0	0.1	0.06
	CUL05	Weakness	0.3	0.3	0.3	0.3	0.3	0.30
	CUL06	Weakness	0.2	0.1	0.0	0.2	0.1	0.12
	CUL07	Weakness	0.2	0.1	0.2	0.2	0.2	0.18
Social	SOC01	Opportunity	0.4	0.4	0.5	0.5	0.3	0.42
	SOC02	Opportunity	0.3	0.4	0.3	0.3	0.4	0.34
	SOC03	Opportunity	0.3	0.4	0.2	0.2	0.4	0.30
	SCC04	Strength	0.6	0.6	0.5	0.6	0.6	0.58
	SOC05	Weakness	0.4	0.5	0.5	0.4	0.5	0.46

Table 4 (*continued*)

Factor	Sub-factor	Group classification	Sub-factor weights					Overall weight
			DM 1	DM 2	DM 3	DM4	DM 5	
Geographical	GEO01	Opportunity	0.2	0.1	0.2	0.2	0.2	0.18
	GEO02	Opportunity	0.2	0.1	0.1	0.1	0.0	0.10
	GEO03	Opportunity	0.7	0.8	0.7	0.7	0.9	0.76
	GEO04	Threat	0.2	0.1	0.2	0.2	0.2	0.18
	GEO05	Threat	0.1	0.1	0.1	0.2	0.1	0.12
	GEO06	Threat	0.1	0.1	0.0	0.1	0.1	0.08
	GEO07	Threat	0.1	0.2	0.1	0.1	0.1	0.12
	GEO08	Threat	0.1	0.1	0.0	0.1	0.1	0.08
	GEO09	Threat	0.1	0.1	0.0	0.1	0.1	0.08
	GEO10	Threat	0.1	0.1	0.2	0.1	0.2	0.14
	GEO11	Threat	0.1	0.2	0.1	0.1	0.0	0.10
	GEO12	Strength	0.6	0.6	0.7	0.8	0.9	0.72
	GEO13	Weakness	0.4	0.4	0.3	0.3	0.2	0.32

Table 5
Key factors with Overall weight ≥ 0.2.

SWOT	Sub-factor	Overall weight
Opportunities	POL01	0.42
	POL02	0.66
	TEC01	0.50
	TEC02	0.44
	SOC01	0.42
	SOC02	0.34
	SOC03	0.30
	GEO03	0.76
Strengths	POL07	0.42
	LEG02	0.30
	SCC04	0.58
	GEO12	0.72
Threats	ECN10	0.22
	ECN12	0.22
	POL04	0.60
	LEG01	1.00
Weaknesses	POL08	0.38
	POL09	0.26
	LEG03	0.34
	LEG04	0.42
	TEC09	0.30
	CUL05	0.30
	SOC05	0.46
	GEO13	0.32

Table 6
Key factors and their normalized weights.

SWOT	Sub-factor	Overall weight
Opportunities	POL01	0.072
	POL02	0.113
	TEC01	0.085
	TEC02	0.075
	SOC01	0.072
	SOC02	0.058
	SOC03	0.051
	GEO03	0.130
Strengths	POL07	0.072
	LEG02	0.051
	SCC04	0.099
	GEO12	0.123
Total weight		**1.000**
Threats	ECN10	0.046
	ECN12	0.046
	POL04	0.124
	LEG01	0.207
Weaknesses	POL08	0.079
	POL09	0.054
	LEG03	0.071
	LEG04	0.087
	TEC09	0.062
	CUL05	0.062
	SOC05	0.095
	GEO13	0.066
Total weight		**1.000**

meetings, the DMs proposed 24 strategies corresponding to the theme in one of the critical SWOT factors. The proposed strategies are presented in Table 9.

- The opportunity strategies proposed by the DMs were in eight categories. The most important strategies were improving political relations with *ultra-regional* powers, strengthening the open-door policy, improving political relations with neighboring countries and strengthening the capacity of employment on oil and gas transportation.
- The proposed threat strategies were categorized into four groups including preventing further terrorist attacks, more control over terrorist groups, creating better conditions for attracting foreign investment and reducing the costs associated with construction and maintenance of pipelines.
- The strategies related to the strength factors were in four categories. The highest ranking were providing more accurate statistics of oil and gas resources in the Caspian coast of Iran and strengthening the insurance industry.
- The strategies linked to the weakness factors by the DMs were divided in eight types. The principal strategies were enhancing the security of pipelines, strengthening the infrastructure of oil and gas pipelines, ensuring military stability and using other domestic routes that have better soil quality because of climate variability in Iran.

The ranking of the strategies in Table 9 reflects the DMs perception of the importance of the related SWOT factor that was reported in Table 6. These priorities are essential to the strategic planning process because the funds and resources available for implementing the strategies are limited.

4. Conclusions and future research directions

With the increasing demand for energy from emerging economies, the demand for oil and natural gas has severely challenged

Table 7
Average likelihood and ideal scores for the 5 DMs and the 5 alternative routes.

SWOT	Sub-factor	Alternative routes					Ideal score
		Southern (S)	Western (W)	Northern (N)	Southeastern (SE)	Eastern (E)	
Opportunities	POL01	2.8	3.0	3.2	2.2	2.8	5.0
	POL02	2.0	3.0	3.6	2.4	2.8	5.0
	TEC01	2.8	2.2	3.2	1.4	1.4	5.0
	TEC02	2.6	2.2	3.4	1.4	1.0	5.0
	SOC01	2.4	3.0	3.0	2.0	2.0	5.0
	SOC02	3.0	2.0	2.0	2.6	2.6	5.0
	SOC03	3.0	1.4	3.0	1.0	0.8	5.0
	GEO03	3.8	1.8	1.8	1.2	1.0	5.0
Strengths	POL07	2.0	1.8	2.8	1.0	1.4	5.0
	LEG02	2.0	2.0	2.8	1.2	1.2	5.0
	SCC04	3.4	2.0	3.0	1.6	1.6	5.0
	GEO12	1.8	2.2	2.2	2.2	2.6	5.0
Threats	ECN10	2.2	3.0	3.0	2.6	2.4	0.0
	ECN12	2.4	3.0	3.0	1.8	2.0	0.0
	POL04	1.6	2.4	2.4	3.2	2.4	0.0
	LEG01	3.2	3.6	3.6	3.6	3.8	0.0
Weaknesses	POL08	1.6	2.6	2.6	4.0	3.2	0.0
	POL09	2.2	2.4	1.4	3.2	3.0	0.0
	LEG03	1.8	2.4	2.4	2.2	2.2	0.0
	LEG04	2.2	2.2	2.6	2.0	2.0	0.0
	TEC09	2.0	2.4	1.6	3.8	3.8	0.0
	CUL05	2.6	2.2	2.2	2.6	2.8	0.0
	SOC05	2.0	3.0	2.8	2.4	2.4	0.0
	GEO13	2.2	2.6	2.6	3.0	3.0	0.0

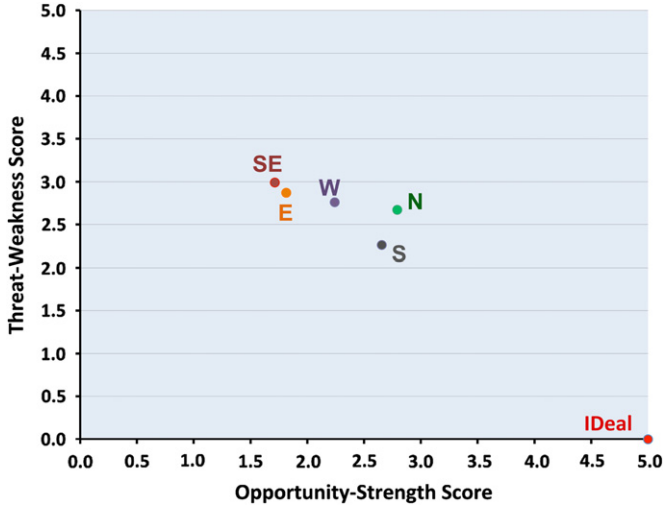

Fig. 3. Route evaluation scatter chart.

the world supply. In response, pipelines are used to transport oil and natural gas over long distances within countries and across borders to meet this increasing demand. The distances between the source of the petroleum products and the destination for energy processing can be thousands of miles over difficult terrain. This is particularly true as more exploration is occurring in remote areas of the world. In this environment, an increasing number of foreign and local state-owned companies have started to evaluate alternative export routes from the Caspian Sea basin because of its vast potential for oil and natural gas production.

The evaluation of alternative transnational export routes for oil and natural gas is a complex multi-criteria problem with conflicting objectives. This study developed a hybrid model combining SWOT analysis with the Delphi method to assist DMs at the Horizon Oil Company in evaluating five export routes. The model decomposed the process into manageable steps and integrated the results to arrive at a solution that was consistent with Horizon goals. The decomposition encouraged DMs to think systematically and consider carefully the elements of uncertainty; however, the proposed framework does not imply a deterministic approach to multi-criteria decision making. While the process enabled DMs at Horizon to identify and assimilate relevant information and organize their beliefs in a formal systematic approach, the effectiveness of the model relies heavily on the DM's cognitive capabilities. In this application, the evaluation process exploited the DMs' experience and knowledge to yield a rich and balanced range of strategic initiatives covering most of the factors identified by the DMs as being important. However, there are factors that need further consideration.

The framework developed in this study can potentially lend itself to many practical applications. However, there are a number of challenges involved in the proposed research that provide a great deal of possibilities for future research. For example, Delphi and SWOT can separately lead to limitations. However, the hybrid method leads to a more efficient approach for integrating subjective judgments with complex multi-criteria problems. Can we estimate a confidence and reliability index? How about the time factor? How do the continuous and dynamic time factors affect the results? How do the short, medium and long term considerations influence the model?

After this human intuition centric approach, another perspective is to develop, on the Southern and Northern routes, a deterministic method according to a systems modeling process. This formal extension of the evaluation process should broaden the initial findings. The result is a complex mathematical model with mixed discrete and continuous variables based on technological, physical and economic equation systems. Using computer-based simulation and optimization methods, the model will allow us to point out advanced economic analysis, technical design, or environmental impact estimation. This integration of a judgmental approach with an analytical process should improve our analysis and the overall decision process for oil and gas pipeline planning in Caspian Sea basin.

Table 8
Route evaluation results.

Route	Opportunity–strength score	Threat–weakness score	Euclidean distance	Ranking	Opportunity–strength gap	Threat–weakness gap
Southern (S)	2.656	2.260	3.256	1	2.344	2.260
Western (W)	2.242	2.760	3.902	3	2.758	2.760
Northern (N)	2.792	2.672	3.466	2	2.208	2.672
Southeastern (SE)	1.715	2.990	4.442	5	3.285	2.990
Eastern (E)	1.815	2.871	4.288	4	3.185	2.871
Ideal score	5.000	0.000				

Table 9
Key strategies.

Rank	Strategies	Remarks
1	To improve political relations with *ultra-regional* powers	To take advantage of the POL02 opportunity
2	To prevent further terrorist attacks	To overcome the POL04 threat
3	To enhance the security of pipelines	To reduce the POL08 weakness
4	To provide more accurate statistics of oil and gas resources in the Caspian coast of Iran	To increase the GEO12 strength
5	To strengthen the infrastructure of oil and gas pipelines	To reduce the TEC09 weakness
6	To ensure military stability	To reduce the POL09 weakness
7	To use other domestic routes that have better soil quality due to climate variability in Iran	To reduce the GEO13 weakness
8	To create better conditions for attracting foreign investment	To overcome the threat LEG01
9	To strengthen the open-door policy	To take advantage of the SOC01 opportunity
10	To remedy the restrict regulations relating to export and import	To reduce the LEG03 weakness
11	To create the infrastructure for solving traffic problems in transportations	To reduce the SOC05 weakness
12	To remedy the restrict regulations for further foreign investment	To reduce the LEG04 weakness
13	To improve political relations with neighboring countries	To take advantage of the POL01 opportunity
14	To reduce the costs associated with the construction and repair of pipelines	To overcome the ECN10 threat
15	To promote common language with the Caspian regional countries	To reduce the CUL05 weakness
16	To strengthen the insurance industry	To increase the LEG02 strength
17	To reduce the costs associated with the transportation of pipelines	To overcome the ECN12 threat
18	To strengthen political stability	To increase the POL07 strength
19	To strengthen the capacity of employment on oil and gas transportation	To take advantage of the SOC02 opportunity
20	To expand pipelines	To take advantage of the TEC02 opportunity
21	To strengthen the maintenance capabilities of the pipelines	To take advantage of the TEC01 opportunity
22	To train the personnel on oil and gas transportation	To take advantage of the SOC03 opportunity
23	To familiarize people with oil and gas transportation lines using mass media	To increase the SOC04 strength
24	To introduce transportation routes with more detailed and factual information	To take advantage of the GEO03 opportunity

It is hard to say for sure which route is the best, but, we made the selection process more comprehensive and systematic. The Hybrid group Delphi-SWOT method used at Horizon was intended to enhance decision making. Upon completion of the evaluation and selection process, the group members met to discuss the results and finalize its recommendations. The five group members unanimously agreed that the proposed framework provided invaluable analysis aids and information processing support. They were convinced that the results were unbiased and consistent with their goals and objectives.

Although the benefits of our model are still nascent, the potential is enormous. We stress that our contribution addresses only the set of issues that were identified by the DMs at the Horizon Oil Company as relevant to the evaluation of alternative export routes from the Caspian Sea basin. We hope that our study can inspire others to pursue further research.

Appendix 1. The dominance concept

Let us assume alternative routes a' and a'' have likelihood scores $x'=(x'_1,\ldots,x'_p,\ldots,x'_m)$ and $x'=(x''_1,\ldots,x''_p,\ldots,x''_m)$ where $x_p(a')\equiv x'_p$ and $x_p(a'')\equiv x''_p$ for $p=1,\ldots,m$. Furthermore, let us assume that preferences increase in each x_p. We say that x' dominates x'' whenever $x'_p\geq x''_p$ (for all p) and $x'_p>x''_p$ (for some p). If x' dominates x'', then the alternative route a'' is not a candidate for "best alternative route," since a' is at least as good as a'' for every SWOT factor (given by $x'_p\geq x''_p$), and strictly better for at least one (given by $x'_p>x''_p$). Note that the idea of dominance exploits only the ordinal character of the likelihood scores (i.e., given two likelihood scores $x'_p=3$ and $x''_p=1$, we are interested in the relationship that $x'_p>x''_p$) and not the cardinal character of these likelihood scores (i.e., the fact that the difference between 5 and 3 is greater than the distance from 3 to 1 or that 3 is three times 1). Also note that dominance does not require comparisons between x'_p and x''_p for $p\neq q$.

Appendix 2. Mathematical notations and equations

Let us define:

m	number of key positive factors
n	number of key negative factors
X_i	score of the key positive factor i
Y_j	score of the key negative factor j
$\tilde{X}_i$	normalized score of the key positive factor i
$\tilde{Y}_j$	normalized score of the key negative factor j
K_i	average likelihood of the key positive factor i
L_j	average likelihood of the key negative factor j
W_{os}	overall opportunity–strength score for each route
W_{tw}	overall threat–weakness score for each route
D	overall distance of each route from the *ideal route*

We first normalize the positive (opportunity and strength) scores using the following normalization process:

$$\tilde{X}_i = \frac{X_i}{\sum_{i=1}^{m} X_i} \ (i = 1,\ldots,m) \tag{1}$$

Similarly, we normalize the negative (threat and weakness) scores using the following normalization process:

$$\tilde{Y}_j = \frac{Y_j}{\sum_{j=1}^{n} Y_j} \ (j = 1,\ldots,n) \tag{2}$$

We then calculate the overall opportunity–strength score for each alternative route as below:

$$W_{os} = \sum_{i=1}^{m} \tilde{X}_i \times K_i \tag{3}$$

Similarly, the overall threat–weakness score for each alternative route is obtained from the following equation:

$$W_{tw} = \sum_{j=1}^{n} \tilde{Y}_j \times L_j \tag{4}$$

Finally, we calculate the overall distance of each alternative route from the *ideal route* (5,0) as

$$D = \sqrt{(W_{os}-5)^2 + (W_{tw}-0)^2} \tag{5}$$

The Euclidean distances are used to rank the alternative routes. The alternatives closer to the *ideal route* are preferred to those farther away from the *ideal route*.

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