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CEVI

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Center for Energy and Value Issues

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Editorial Policy

The Energy and Value Letter brings together academics and practitioners worldwide to discuss timely valuation issues in the energy sector. It publishes news from the Centre for Energy and Value Issues (CEVI), its linked organizations and others (including calls for papers), columns on topical issues, practitioners' papers: short articles from institutions, firms, consultants, etcetera, as well as peer-reviewed academic papers: short articles on theoretical, qualitative or modeling issues, empirical results and the like. Specific topics will refer to energy economics and finance in a broad sense. The journal welcomes unsolicited contributions. Please e-mail to **w.westerman@rug.nl** (Wim Westerman), a copy of a news item, column or a completed paper. Include the affiliation, address, phone, and e-mail of each author with your contribution. A column or news item should not have more than 600 words and a paper should not exceed 5,000 words, albeit that occasionally larger pieces can be accepted.

CEVI policy on “membership” and data protection

Wim Westerman
CEVI/ Energy and Value Issues Board

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The Center for Energy and Value Issues (CEVI) is the label of an association of practitioners and academics in the energy finance field. The association and CEVI are governed by a board, with André B. Dorsman and its chair and Mehmet Baha Karan as its vice chair, see also our regular publications. Anyone who receives the Energy and Value Letter is considered to be linked to our association.

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The above statement can soon be found on the CEVI website: http://www.centerforenergyandvalue.org/

A busy year!

André Dorsman
President of CEVI

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Although it may seem that CEVI is less busy in a between-conferences year, one actually should not think so. Firstly, the sixth book in the Springer series was finished. It is called Energy Economy, Finance and Geostrategy and contains thirteen contributions. We are happy with the great job accomplished by the authors, editors André Dorsman, Volkan S. Ediger and Mehmet Baha Karan. We look forward to see it in print at the end of August and the EVL hopes to publish its abstracts in due time.

Secondly, CEVI contributed to the seminar on Central Asia's Role in World Energy on March 15, 2018, organized by the Central Asian Productivity Research Center's Energy Security Committee Education and Training Committee and supported by the Turkish Consulate General. Under the ever-enthusiastic chairmanship by Harry Lepinske, various contributions were released. We are honored to publish the contribution of Caner Can of the Turkish consulate in Houston in this EVL issue. In addition, a summary of the seminar contribution by our board member Özgür Arslan-Ayadin can be found in here.

Thirdly, we organize a CEVI workshop at the 13th ISINI conference in Wroclaw (Poland), on August 29-31, 2018. Actually, we have a couple of sessions and expect contributions from all over the world. We are happy to cooperate with ISINI, a truly global and friendly organization that does much on societal challenging issues. The CEVI focus on energy transition therefore perfectly matches.

Fourthly, we started up working on the seventh CEVI book. The book is edited by André Dorsman, Özgür Arslan-Ayaydin and James Thewissen. Its provisionary title is: "Financial Implications of Regulations in the Energy Industry" (FIREI). No one can dispute that regulations play a large role in the energy industry and it is therefore more than just worthwhile to shed our light on this topic. About 15 author teams have handed in abstracts that they can work on from now onwards. If things go well, you may expect to find the book (at least virtually) under your 2019 Christmas tree so to say.

In addition, the preparations for our 2019 conference have begun, see a separate announcement. The 7th CEVI conference will be held at Okan International University (Miami Campus). Erdinç Telatar and Mehmet Baha Karan welcome your ideas. Further information, including a Call for Papers, will follow.

Let me finish by drawing your attention to the article by Sıdıka Başçı on the costs of the TANAP pipeline from the Caucasus and Central Asia region to Europe. She discusses two seminal approaches to determine the routes of least-cost and calls for further practical research on this topic.

CALL For PAPERS

7TH MULTINATIONAL ENERGY AND VALUE CONFERENCE

May 23-25, 2019, Miami, USA

Okan International University, Miami, USA

Center For Energy and Value Issues (CEVI), Amsterdam, the Netherlands

Energy Markets Research and Application Center of Hacettepe University, Ankara, Turkey

Central Asia Research and Productivity Center, Chicago, USA

http://www.centerforenergyandvalue.org/conferences.html

The objective of the conference is to bring together academics and practitioners from all over the world to focus on timely energy finance and investments, financial performance, energy markets and valuation issues in the energy sector. Papers dealing with developed as well as developing countries are welcome. *Specific topics* must refer to energy issues and include, but are not limited to:

Financial Regulation; *Financial Markets*; *Financial Risks*; *Asset Pricing*; *Value at Risk*; *Capital Structure*; *Sourcing Capital*; *Corporate (Re-) Structuring*; *Corporate Governance*; *Behavioural Finance*; *Financial Performance*; *Cost Control*; *Financial Accounting*; *Fiscal and Legal Issues*.

The first day of the conference includes practitioner presentations on topics such as; energy strategy, regulation, law and energy security. Senior business and government leaders from different countries share energy-related business opportunities in their markets.

Please submit your papers (completed or nearly completed) or participation interest via e-mail to: Dr. **Dr. Kazım Barış Atıcı (kba@hacettepe.edu.tr)** or **Dr. Yılmaz Yıldız (yilmazyildiz@hacettepe.edu.tr)**, by **15 January 2019.** Authors will be notified regarding the acceptance of their papers after reviewing. Final acceptance of full papers will be notified by **30 January 2019**.

The title page should include the affiliation, address, phone, and e-mail of each author together with the appropriate JEL classifications. Each participant agrees to serve as a discussant of a paper of his/her own area of interest, if needed.

Papers selected for this conference may be submitted for possible publication in a CEVI book, dedicated to this conference by *Springer Verlag*. All submitted papers will be subject to a blind peer review process. Further information regarding conference organisation and accommodation, travel arrangements, fees and activities will be published on the conference website in due course. For any inquiry regarding the submission process and registration at the Conference please contact Dr. Kazım Barış Atıcı by e-mail at: **kba@hacettepe.edu.tr**

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The Turkish Natural Gas Market and Turkey's Structural Changes in its National Gas Sector

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Although it is a rapidly growing energy market, Turkey lacks indigenous reserves of the world's two crucial fossil fuel sources, oil and natural gas. As a result, Turkey is highly dependent on imports to meet its demand (around 99% import dependency in natural gas and 92% in oil), and energy security has been a chief component of Turkey's energy strategy for the past two decades.

The natural gas sector of Turkey is different from other countries in the region: it's big, fast growing and strategically placed. Indeed, Turkey is the only significant European regional gas market to have shown strong growth in the last decade and the second country, after China, in the world in terms of natural gas demand growth in the same period. Natural gas accounts for around 33% of Turkey's electricity generation; and gas demand has more than doubled in one decade, outpacing electricity growth.

Turkey imports nearly 99% of the natural gas it consumes through a diversified portfolio of suppliers. In 2017, Turkey imported around 54 bcm of gas. 53% of the natural gas is imported from Russia, followed by Iran (17%), Azerbaijan (12%), Algeria (9%), Nigeria (2%), and around 7% of the gas was imported as the spot LNG. Turkey has been spending tremendous efforts toward further diversification of energy suppliers and supply routes. Turkey is not only an end market but has also established itself as a reliable transit country, offering short, secure and sustainable route for the energy resources of its energy rich neighborhood.

Turkey is aiming at establishing an uninterrupted and reliable flow of the Greater Caspian and Middle Eastern hydrocarbon resources to Turkey and to Europe via Turkey. Establishing an efficient cooperation and dialogue between producer, transit and consumer countries is of great importance. The Trans Anatolian Natural Gas Pipeline (TANAP) constitutes the backbone of the Southern Gas Corridor, an alternative gas transportation route to Europe from Azerbaijan. The works also are underway for the establishment of the TurkStream Project, which will facilitate to divert and replaced the Russian gas already transported and imported by Turkey through the existing Western Line. It will be Turkey's second direct pipeline with the same producer country, which will enhance gas supply security of Turkey.

Following the shale revolution in the world, the market environment surrounding LNG is now experiencing drastic changes. The fifth natural gas importer of the world, the biggest natural gas market in its region, Turkey is closely following the changes in the natural gas markets. Turkey has recently increased its regasification capacity with the first floating liquefied natural gas import terminal (FSRU). The second FSRU has been recently taken in operation in early 2018. Technical studies are currently underway for the third FSRU of Turkey.

From the final investment decision to completion, record-breaking terminal project development took only 6.5 months for the first FSRU of Turkey. With a capacity of up to 20 million m3 per day of gas send-out, the new ETKI LNG Terminal established by Turkish and French private sectors, will be another contributor to Turkey's natural gas security of supply and will complement Turkey's two existing onshore LNG terminals, thus enhancing the country's diversification of gas import structures as well as supply sources.

Turkey has also recently expanded the underground natural gas storage capacity, which will increase up to 10 bcm by 2023.

These structural changes in Turkish energy sector can be seen to aim to lessen Turkey's dependence on current import and transmission infrastructure capacity, which is constrained and cannot meet peak gas demand in winter, while diversifying supply sources and gas import types (both pipeline gas and LNG) ensuring imports from a wider range of available sources on competitive terms in a buyer's market environment.

Sustainability and the energy sector

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The dark side of the energy industry is imposing significant costs on society. Air pollution, ozone depletion, acid precipitation, forest destruction, emission of radioactive substances, oil spills, injuries and even deaths are some of these costs. They are mainly caused by the fact that fundamental activities in energy industry, such as; extraction, transformation and transportation of resources, are managed by people and thus subject to human error. Nevertheless, energy is one of the sectors that are the most exposed to environmental concerns. Particularly oil and gas industries face considerable environmental, health, safety and liability risks. The trust of the society has been shaken by environmental and social issues originating from the energy industry. Consequently, society demands sustainability from energy companies even more than those in other industries. Specifically, companies in the energy industry are required to take measures that lead them to act beyond their legal and enforceable obligations.

Sustainability is a concept that integrates environmental and social consciousness with economic growth. In other words, socially responsible actions need to be gearing towards the long term impact on communities without sacrificing shareholders' wealth. Companies that aim to build and maintain the trust from their stakeholders need to demonstrate an authentic and visible commitment to sustainability. Nowadays, almost all Fortune 500 companies publish some form of a dedicated report on their social progress and environmental sustainability.

Hanna and Lacy (2015)'s study shows that managers of the energy industry have been more committed to ensure sustainability. Specifically, they survey 53 CEOs of the energy firms from 30 different countries. They repost that 94% of the CEOs are aware that sustainability issues will be critical to their long term success. Similarly, we have been observing that energy firms have been targeting on tackling with environmental and social issues. The following are examples of some of these;

1 – In 2002 BP has developed an initiative that offers micro-credits to the local community in Trinidad and Tobago to start their own businesses.

2 – Shell initiated *LiveWire Smarter Future Programme*, which aims to help young entrepreneurs. In 2014 alone, the programme trained almost 8,000 participants.

3 – Green Mountain Energy avoids mountaintop removal for coal mining to prevent the destruction of the landscape.

Sustainability of the activities carried out by firms in the energy industry has attracted tremendous attention aftermath the recent environmental scandals and social unrests. Therefore, energy industry has not only been under higher scrutiny of the public, but also the industry is heavily regulated. The next question that needs to be answered by the energy industry is how to build and maintain the shareholder value maximization simultaneously with optimizing the social and environmental pillars of the sustainability.

Approaches of Least - Cost Analysis: A Case of Natural Gas Pipeline Routes from the Caucasus and Central Asia Region to Europe[1]

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Abstract

There are lots of studies about natural gas pipeline routes from the Caucasus and Central Asia region to Europe, but most of them are political and related to the international relation discipline. The economic aspects, especially the cost analysis, are not studied very much. However, in fact, large-scale projects should be designed by using the most efficient ways in order to decrease the costs of the projects, since they are static infrastructures and it is very hard to make changes once they are built. If a failure occurs, the financial and environmental costs can be enormous, even in some cases it can cause the shutdown of the projects. The issue is valid for natural gas transfer from the Caucasus and Central Asia Region to Europe as well. European countries are interested in the natural gas pipeline routes very much, because most of the European Countries are energy dependent. The Ukraine – Russia natural gas crisis, which occurred at the beginning of 2009, is a real example of the problem. This paper aims to give information about the two approaches to determine the routes of least-cost. One of them is labelled as Geographic Information System (GIS) and the other one is the Optimization Approach (OA). In the paper, it is shown that for the case of the natural gas transfer from the Caucasus and Central Asia Region to Europe, least cost routes obtained by GIS approach ends up with less cost than straight-line routes. Whereas the paper does not report explicit cost comparisons for OA, it presents the models designed, thereby opening the floor for scholars and practitioners for further in-depth research.

1. Introduction

Large-scale projects should be designed by using the most efficient ways in order to decrease the costs of the projects, since they are static infrastructures and it is very hard to make changes

[1] An earlier version of this paper was presented during the 6th CEVI Conference (2017), Northern Cyprus. I appreciate the valuable contributions of the participants.

once they are built. If a failure occurs, the financial and environmental costs can be enormous and even in some cases it can cause the shutdown of the projects (Brody, Bianca and Krysa, 2012; Yang et al., 2010).

Natural gas transfer from the Caucasus and Central Asia Region to Europe urges such a large-scale project. Moreover, European countries are interested in the natural gas pipeline routes very much because most of them are energy dependent, that is, their economies are dependent on the energy imports they make. The Ukraine – Russia natural gas crisis, which occurred at the beginning of 2009, is a real example of the problem.

In fact, natural gas is not just important for Europe. The following information shows the global importance of this energy source. Natural gas accounts for 25% of the world's primary energy production. Globally, demand for natural gas is expected to grow at a rate of 2.9 - 3.2% per year until 2030, according to recent projections. By the end of the next decade, worldwide demand for natural gas is estimated to bet 2.2 billion cubic meters (bcm) per day (Uster and Dilaveroglu, 2014).

This paper aims to give information about the two approaches to determine the routes of least-cost. One of them is labelled Geographic Information System (GIS) and the other one is the Optimization Approach (OA). Examples of these approaches where they are applied to natural gas pipelines are presented in the paper. Special interest is given to the natural gas pipeline routes from the Caucasus and Central Asia Region to Europe.

The paper continues as follows. Section 2 reviews the literature. In Section 3, the methodologies of GIS and OA are described. Examples of applications of these approaches can be found in Section 4 and finally Section 5 gives some recommendations to practitioners and researchers and concludes.

2. Literature

The first influential paper that provides a solution to the problem of determining routes of least-cost through a surface, by developing an algorithm, belongs to Dijkstra (1959). However, this algorithm is computationally demanding and needs large amounts of data to be stored which is a limitation for its usage. In order to overcome this problem, the Environmental Systems Research Institute (ESRI) has made an extension named, PATHDISTANCE which uses a smaller scale neighborhood analysis. However, Saha et al. (2005) state that the accuracy of PATHDISTANCE prediction diminishes for the mountainous areas. After this observation of Saha et al. (2005), ESRI has developed more complex cost path extensions for these types of areas and included them in their ArcGIS products (Collischonn and Pilar, 2000; Rees 2004). Rees (2004) used digital elevation models of GIS approach to determine the least cost paths in a mountainous area of Wales. Iqbal, Sattar, and Nawaz (2006) wrote another paper that also focuses on the mountainous areas. The criterion that is used is named as Spatial Decision Support System (SDSS), which makes the entire system more result oriented and simpler to process. Another method is View-shed analysis, which offers an approach to determine the least costly routes through a specified area. (Lee and Stucky, 1998) However, this analysis is more appropriate for environmental planning and civil engineering.

Aissi, Chakhar and Mousseau (2012), Rees (2004) and Feldman et al. (1995) provided three influential papers describing the GIS approach. Moreover, the paper by Aissi, Chakhar, and Mousseau (2012) is additionally important, because it provides very good references of applications concerning the identification of least-cost routes for highways, roadways, railways, pipelines and transmission lines. The papers by Feldman et al (1995) and Wasi and Bender (2004) are given as applications for pipelines.

On the other hand, for OA, there are two important papers that have to be mentioned where applications of natural gas transmission exists. Usage of nonlinear optimization methodology is common to both of the papers. Kabirian and Hemmati (2017) wrote the first one. The paper develops a heuristic random search optimization method and, with a simple case study, applies this methodology. The second paper is by Uster and Dilaveroglu (2014). The application area in the paper is the natural gas network in Turkey.

3. Geographic Information System and Optimization Approaches

Kelly (2014) describes the steps to be followed for GIS approach in a very detailed way. In this section, only a brief summary of these steps will be presented. This approach firstly collects all of the necessary geographical data. This data is named as the spatial information. An analysis of this information should be made and secondly the data should be edited and a conversion to maps should be made. Moreover, this analysis step, in itself, includes also techniques that assess risks emerging due to biological hazards like population and environmental risks.

The major criteria considered in GIS are geologic factors named as lithology, proximity to faults, slope, landslide susceptibility and environmental and social factors. These factors are used in order to create the least cost path. There are two different techniques. In the first one, every factor is given an equal weight. The second one assumes different weights for the factors. Finally, the cost of this least cost path is compared with the cost of the straight-line path. The step-wise process can be completed by using the ESRI ArcGIS Cost Path tool.

On the other hand, OA for natural gas transmission pipeline networks is an approach where a cost minimization problem is solved under some constraints. Starting from the end of 1960’s, this approach became popular. Three different challenges are addressed to be solved. The first one is the design of natural gas networks with the purpose of minimizing investment costs for infrastructures. The second one is expansion of already existing networks in order to satisfy increasing demand. The last one is related to demand satisfaction at the operational level (Uster and Dilaveroglu, 2014). The first studies mainly considered linear optimization but, later on, nonlinear studies started to appear as well.

In the objective function to be minimized there can be several different goals. Among these, of course, the goals related to costs are the most important ones. For example, operating and capital costs appear in all of the objective functions. In addition to these, environmental and social criteria can also be considered. Addition of these criteria can ensure sustainable development (Kabirian and Hemmati, 2007).

Coming to the constraints, Kabirian and Hemmati (2007) define four classes of these. These are 1) domain variables, 2) network structure constraints, 3) financial budget constraints and 4) sub-model constraints. Depending on the model designed, the details of the constraints included in these classes can change but in general they can be technical, financial or time constraints.

4. Examples of Existing and Planned Gas Pipeline Routes, GIS and OA Approaches

4.1. GIS Approach

4.1.1. TANAP Project

Currently, existing natural gas pipelines passes through Russia and enters Central Europe through Ukraine. However, in the past, several problems occurred related to the transit fees and the pricing of gas through these existing pipelines, which caused the Russian government to take the action of stopping the supply of gas. The Ukraine – Russia natural gas crisis, which occurred at the beginning of 2009, is an example of such problems. Therefore, the leaders of the European Union started to consider diversifying energy routes for energy security reasons. Fortunately, now, there are newly discovered natural gas sources in Azerbaijan, Iran and Turkmen fields. Therefore, the routing of these newly discovered sources is an important issue. Among various route alternatives, the Trans-Anatolian Natural Gas Pipeline (TANAP) aims to connect Caspian Sea natural gas to southeastern Europe via Turkey. The extreme western portion of the TANAP (Figure 1), which is completely within the borders of Turkey, covers an area of 150,960 square kilometres and is located in northwestern Turkey. It includes the major metropolis of Istanbul, which is an economic hub, the Turkish straits, and the Sea of Marmara, which is the major shipping lane from the Black Sea to the Mediterranean. Eventually, this portion will connect to other major pipelines on the Greece-Turkey border and the Bulgaria-Turkey border. TANAP can provide the European Union freedom from dependency on Russia. (Kelly 2014).

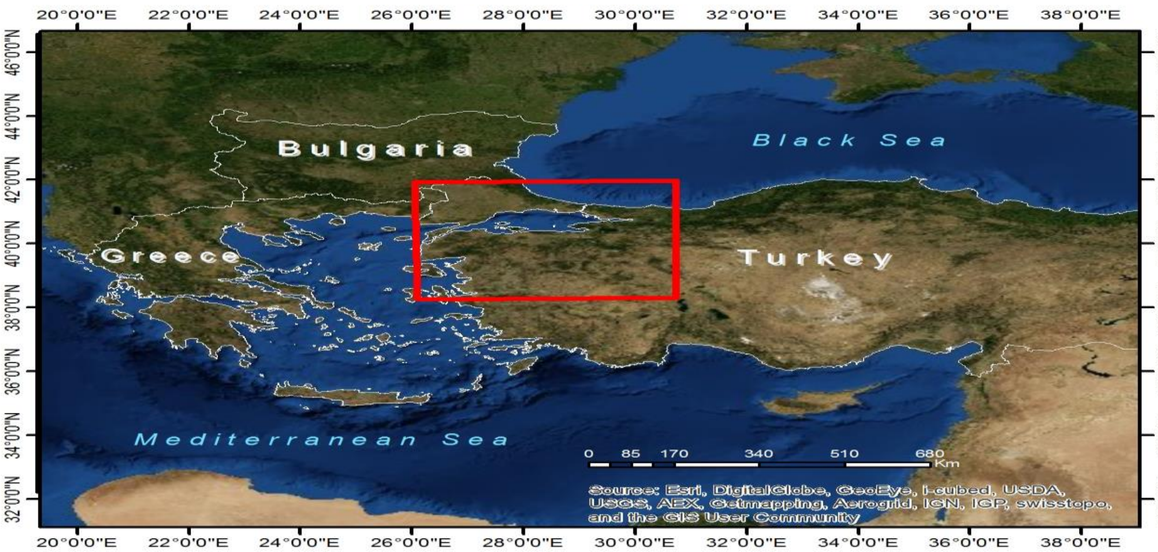

Figure 1: TANAP region (Kelly, 2014)

In March 2013, Cindar Engineering and Consulting Inc proposed the route of the TANAP. This route is presented in Figure 2. Kelly (2014) compares this proposed route of the pipeline with the least-cost paths obtained by using the GIS approach. The data for the analysis is obtained from various different sources like United States Geological Survey (USGS) databases, Eurostat, American Geosciences Institute (AGI) databases and other international GIS repositories displaying physical features of the region.

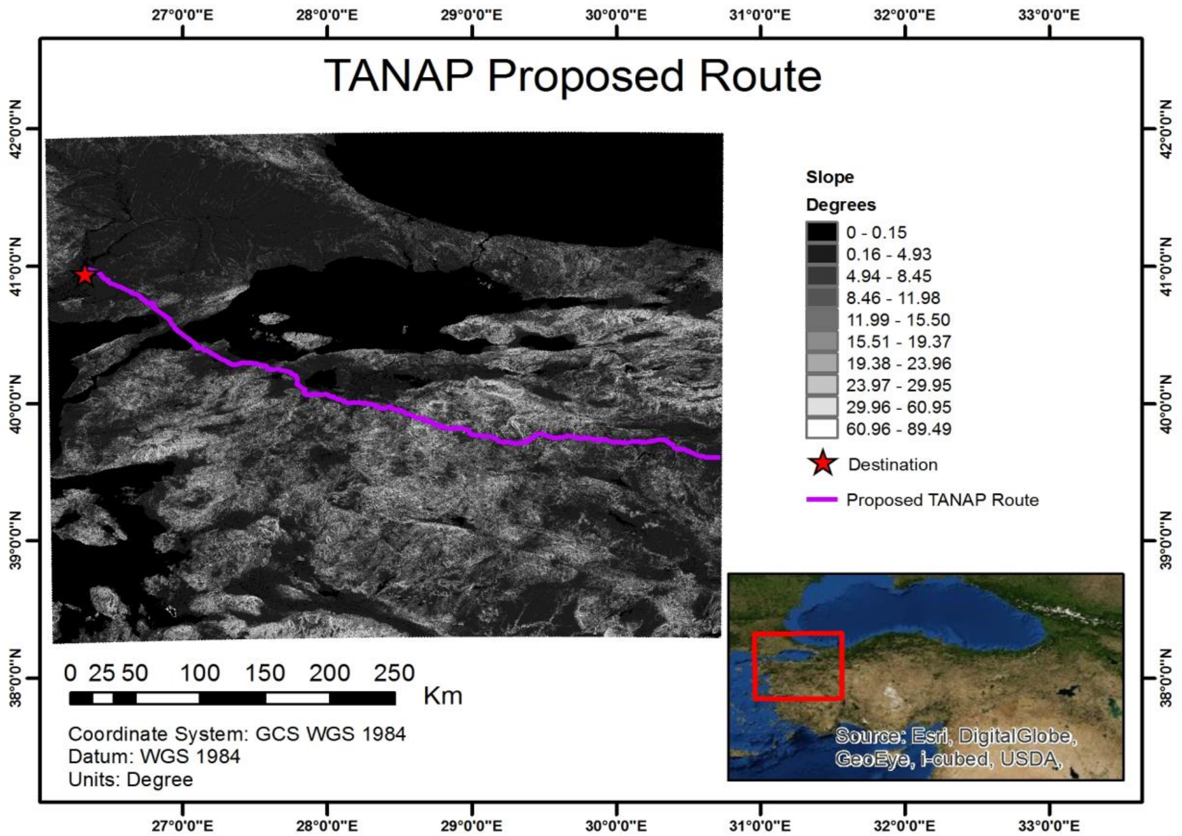

Figure 2: Proposed TANAP route by Cindar Engineering and Consulting Inc. (Kelly, 2014)

The least-cost route model developed by Kelly (2014) displays a more efficient route than the TANAP. Table 1 reports both the route lengths in kilometers and the relative costs of least-cost route obtained by the GIS approach and the straight-line route suggested by Cindar Engineering and Consulting Inc. The relative cost is not a definite quantitative measurement, but instead is a relative indicator of the risks. As stated in section 3, calculation of relative cost is one of the analysis steps of the GIS approach, techniques that assess risks emerging due to biological hazards like population and environmental risks.

As can be seen from Table 1 below, although the length of straight-line route is shorter than the length of least-cost route, the relative cost is 37.93% higher for the straight-line route.

	Route Length (km)	Relative Cost
Least-Cost Route	**441.00**	4084
Straight-Line Route	**392.24**	6580

Table 1: Comparison of least-cost route and straight-line route (Kelly, 2014)

Caspian Pipeline Project

The entire proposed 700 km Caspian pipeline will carry oil from the Tengiz, an oil field in Kazakhstan, to the Caspian Sea and then to Novorossiysk in Russia, which is a city just at the coast of Black Sea (Figure 3). Feldman et al. (1995) use a prototype least cost analysis for a small section of the proposed pipeline.

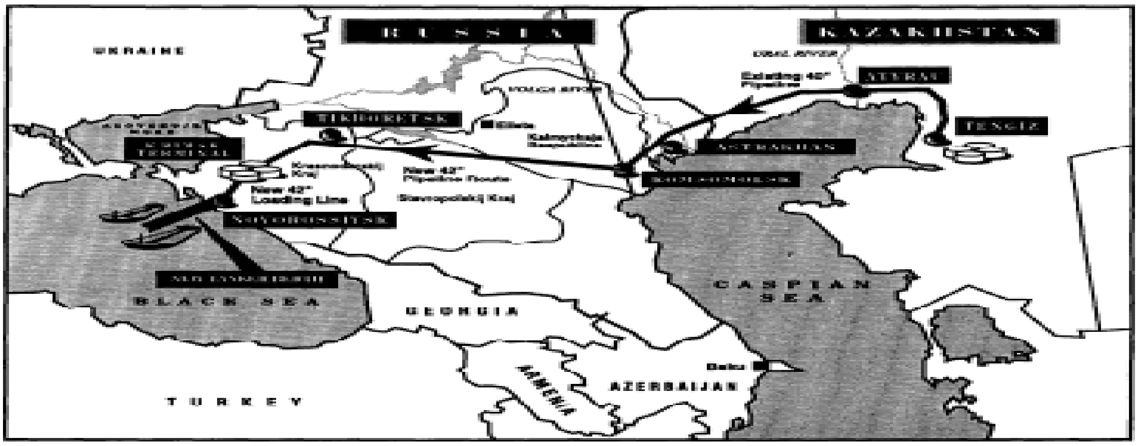

Figure 3: Proposed Caspian pipeline (Feldman et al., 1995)

The length and cost of a straight-line route between four predetermined points of the pipeline are compared with the length and cost of the least cost route in the area considered. The straight-line route is 42 km long and the least cost route is 51 km long. However, the least cost route is 14% less expensive to construct than the straight-line route due to the reason that it avoids higher cost urban and industrial areas on the straight-line route.

4.1.2. Hattar – Muree Pipeline

As stated in Section 2, mountainous areas need some different treatment compared to open plain areas when doing a GIS analysis. Iqbal et al. (2006) gives information about Hattar – Muree Pipeline located in Pakistan, which provides an example of a GIS analysis for a mountainous area. In the paper, it is reported that Hattar, which is the location of source, is 4861 meters high and Muree, which is the location of destination, is 2269 meters high. On the route, there are rivers, streams and human made roads and railways. As a methodology, the ArcGIS of ESRI is used and in the paper the least – cost route is proposed.

4.2. Optimization Approach

4.2.1. A Case Study for Iran

Kabirian and Hemmati (2007) design a case study for Iran to meet the natural gas pipeline planning difficulties in Iran. The study is on the development of an existing natural gas transmission pipeline network. It is realized that there is an increase in the demand by consumers. To satisfy this demand, a model is built by adopting an optimization approach for the period January 1, 2010 to December 31, 2020. Within this 10 years long horizon, there are two 5 years short run horizons. The aim is to find two development plans with the least discounted operating and capital costs. The case study area is 25 km square and it is assumed that during the long-run horizon, no new demand and supply node would be added. In the paper, the results of 1000 iterations of the optimization algorithm, which creates 3000 solutions, are presented. The first development plan suggests some changes of the network, but second development plan suggests no change of the network.

4.2.2. A Case Study for Turkey

The Trans-Anatolian Natural Gas Pipeline (TANAP) and Trans Adriatic Pipeline (TAP) projects are meant for the transportation of natural gas from Azerbaijan through Turkey to Europe. Besides these, other projects also involve Turkey. For example, network expansion project of Blue Stream, the natural gas importing contract between Russia and Turkey. This network can be extended to Lebanon and Syria. Another example is the supply contract between Turkmenistan, Iran and Turkey that will require construction of new pipelines.

Although the Uster and Dilaveroglu (2014) paper does not make real calculations, it designs a new pipeline network and/or expand it due to changing conditions by optimization approach. The aim is to aid system operators. By using the design, the system operators can make decisions about location and capacity of compressor stations, location of new pipelines and scheduling of implementing new pipelines and compressor stations in the network. Of course, these decisions will be made by minimizing the total investment and operating costs. The model can also be used by suppliers to determine the level of supply.

5. Recommendations and Conclusion

This paper gives brief information about two approaches, namely, Geographic Information System (GIS) and Optimization Approach (OA) that makes cost analysis for building the natural gas pipeline routes. Since large-scale projects like natural gas pipeline routes are static infrastructures, they should be designed by using the most efficient ways. Therefore, knowledge of the approaches to determine the costs is important. In the literature, there are also lots of application papers. By going over these papers, practitioners can benefit while giving their decisions.

In the paper, the issue is extended by natural gas transfer cost analysis examples from the Caucasus and Central Asia Region to Europe. This choice is made in the paper because European

Countries are interested in the natural gas pipeline routes very much since most of them are energy dependent and want to diversify the routes coming from Russia.

The GIS approach examples presented explicitly show that the least cost routes have less cost than straight-line routes. However, OA examples just present the models designed, but do not make explicit cost comparisons with the straight-line routes. Applications of OA can be considered as an open area to be studied for the researchers, since both the cost function to be minimized and the constraints can involve various different variables. Therefore, it is possible to make different designs and moving one step further, costs can be explicitly calculated and routes can be determined. These studies can be interdisciplinary as well, involving mathematics, economics and engineering.

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