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ENERGY STABILITY ASSESSMENT AND RANKING IN THE PERSIAN GULF REGION: MADM APPROACH

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ABSTRACT

Security has always been a concern in the political, economical and sociological stability of the region and it is one of the most important factors that affect the stability of a region. But how does one define and measure security? We introduce a method to assess security in the Persian Gulf in terms of adequacy and stability. It derives from stability assessment frameworks developed for the security of this region. The method presented here is based on multi-attribute theory for decision– making and utilizes the fuzzy numbers for modeling this problem.

INTRODUCTION AND LITERATURE REVIEW

The Persian Gulf States have been secured by British soldiers until 1971. After British military forces withdrew from the East of the Suez, the US applied the ''Surrogate Strategy'', a policy of utilizing friendly local powers to serve as guardians of Western interests against Soviet intervention. Substantial US military assistance was given to three key pillars of the Surrogate Strategy, namely Iran, Saudi Arabia and Israel. In this strategy, the US has sold $20 billion worth of arms to Iran between 1970 and 1978 (Klara, 1985). Though the Iranian revolution ended this existing strategy, in response, the US established the Rapid Deployment Force (RDF) for direct intervention to the Persian Gulf region in 1980. In 1983, RDF was reconstituted under the US Central Command (CENTCOM). After the revolution in 1980, Iran, well equipped with modern US arms, began to fight with Iraq which continued until 1988. During this period, Iraq was powered by French and Soviet weapons. Then came the invasion of Kuwait by Iraq in 1990 (Klara, 2001). Later, the Gulf war began between the US-led coalition forces and Iraq. On the other hand, although the Surrogate strategy stopped with Iran's revolution, it has continued in Israel and weaker in Saudi Arabia. Intelligence ties between the US and Saudi Arabia may have indirectly contributed to the formation of the Al-Qaeda terrorist organization (Rashid, 2000).

For more than half a century, threats in the Persian Gulf have had repercussions beyond instability and conflict in the region itself. The Persian Gulf has become a geopolitical and geo-economic epicenter for the rest of the world.

The world's oil reserves are concentrated in the sedimentary basins of the Middle East such as the Persian Gulf States (65% according to OPEC 2003 data or 70% according to USGS, 2000). Persian Gulf States producers accounted for 24.7% of the world oil supply in 2005 (IEA, 2005) and it is important to note that Persian Gulf producers are expected to provide 51.8% of world production in 2030 (IEA, 2004). Therefore, oil from the Persian Gulf States is very important to the USA, European Union and Asia-Pacific in energy supply strategies (Cheney, 2001; APERC, 2003; EU, 2002; Van der Linde et al., 2004). Global oil demand will rise from 84 million barrels per day (mbd) today (IEA, 2005) to 121mbd in 2030 according to 30-year energy requirement projections (IEA, 2004). North America will import 75% of total oil in 2020 (Cheney, 2001), the EU will import 90% of total oil in 2030 (EU, 2002) and, Asia-Pacific oil dependence will also rise to 78% in 2020 (APERC, 2003). Oil supply from sedimentary basins of the Persian Gulf region to world markets is involving basin analysis and petroleum exploration, drilling and production and, transportation which require science, engineering, technology and investment climate (political and economic stability). Put on practice for all of them, petroleum basins and transportation routes must be secure. Energy security is commonly defined as a reliable and adequate supply of energy at reasonable prices (Bielecki, 2002). Uninterrupted oil supply is an important peacekeeping and economic progress factor in the world and is possible only if the energy supply is secure. The Middle East still has 70 percent of proven oil reserves, notwithstanding new sources and means of delivery that are being developed in the Atlantic basin, Russia, and the Caspian Sea (annual energy outlook, 2004). Oil imports could account for as much as 65–70 percent of total domestic demand by 2025, up from 55 percent in 2001. By 2025, 51 percent of world oil production is expected to come from OPEC, compared to the current 38 percent. About two-thirds of OPEC production comes from the Persian Gulf. Prices are expected to rise with world demand, which is projected to increase from 76 million barrels a day in 2001 to 123 mb/d by 2025. The U.S. economy is likely to grow at a rate of 2.5–3.25 percent between 2001 and 2025, and other economies, notably China's, at an even higher rate. So energy consumption will rise even if energy is used more efficiently.

Security problem for the Persian Gulf

Several factors are heightening concern about the security of a energy-rich region such as:

- Political tension in a country
- High –profile terrorist activity,
- Piracy,
- Warfare in two or more country,
- foreign intervention,

While these factors constrain supplies and reduce excess capacity. The security of a region depends upon numerous attributes, some of which can be measured quantitatively and others that must be assessed qualitatively.

To accurately assess the overall security of the region according to the mentioned criteria, we consider the set of alternatives as to the countries in this region as shown in Fig 1:

1. Islamic Republic of Iran
2. Saudi Arabia
3. Iraq
4. Qatar
5. Oman
6. Kuwait
7. Bahrain
8. United Arabian nation

As some of these factors cannot be measured quantitatively with respect to the above alternatives (countries) we introduce a method that addresses all the factors comprehensively using fuzzy theory and base our methodology on the assessment framework using a decision- making process founded on expert opinion and multi-attribute decision- making.

Figure1- countries in the Persian Gulf region

Fuzzy theory

Zadeh (1965) introduced the fuzzy set theory to solve problems involving the absence of sharply defined criteria if uncertainly (fuzziness) of human decision–making is not into account, the results can be misleading. The fuzzy theory thus is used to solve such kind of problems, and it has been applied in a variety of fields in the last four decades.

Fuzzy multi-attribute decision making

When the decision-maker considers the problem of ranking the M alternatives a_1, $a_2 \dots, a_N$ for the N criteria $C_1, C_2 \dots, C_N$, he or she will feel great difficulty in assigning numbers, or ratios of numbers to alternatives in terms of these criteria, the merit of using a fuzzy approach is to assign the relative importance of attributes using fuzzy numbers instead of crisp numbers, for fuzzy numbers we use triangular fuzzy numbers (that is, fuzzy numbers with lower, middle, and upper values) because they are simpler than trapezoidal fuzzy numbers. A fuzzy triangular number is defined as follows:

Definition of fuzzy triangular numbers

A fuzzy numbers M on R∈ (- ∞ , + be) is defined to be fuzzy triangular numbers if its membership function μ_M : R → [0,1] is equal to (Dubois & podes, 1980):

$$\mu_M(x) = \begin{cases} \frac{1}{m-l} * x - \frac{l}{m-l} & x \in [l, m] \\ \frac{1}{m-u} * x - \frac{l}{m-u} & x \in [m, u] \\ 0 & otherwise \end{cases}$$

where L $\leq m \leq u$ *and* L and u stand for the lower and upper values of the support of the fuzzy numbers M, respectively, and m for the modal value. A fuzzy triangular number is denoted by (l,m,u).

operations on fuzzy triangular numbers

The basic operations on fuzzy triangular numbers are defined in the literature as follows:

$n_{1\oplus}\ n_2 = (n_{1l} + n_{2l}, n_{1m}+n_{2m}, n_{1u} + n_{2u})$ for addition,
$n_{1} \otimes n_2 = (n_{1l} * n_{2l}, n_{1m} * n_{2m}, n_{1u} * n_{2u})$ for multiplication,
$\ominus n_1 = (- n_{1u}, - n_{1m}, - n_{1l})$ for negation,
$1/n_1 \cong \left(\frac{1}{n_{1u}}, \frac{1}{n_{1m}}, \frac{1}{n_{1l}}\right)$ for division,
Ln $(n_1) \cong$ (ln (n_{1l}), ln (n_{1m}), ln(n_{1u})) for natural logarithm,
Exp $(n_1 \cong$ (exp(n_{1l}), exp(n_{1m}), exp (n_{1u})) for exponential,

Where ≅ denotes approximation, and $n_1 = (n_{1l}, n_{1m}, n_{1u})$ $n_2 = (n_{2l}, n_{2m}, n_{2u})$ represents two fuzzy triangular numbers with lower, modal, and upper values as shown in Figure 2. In this figure Category 1= n_{1l} , category 2 = n_{1m} , *category* 3 $= n_{1u}$

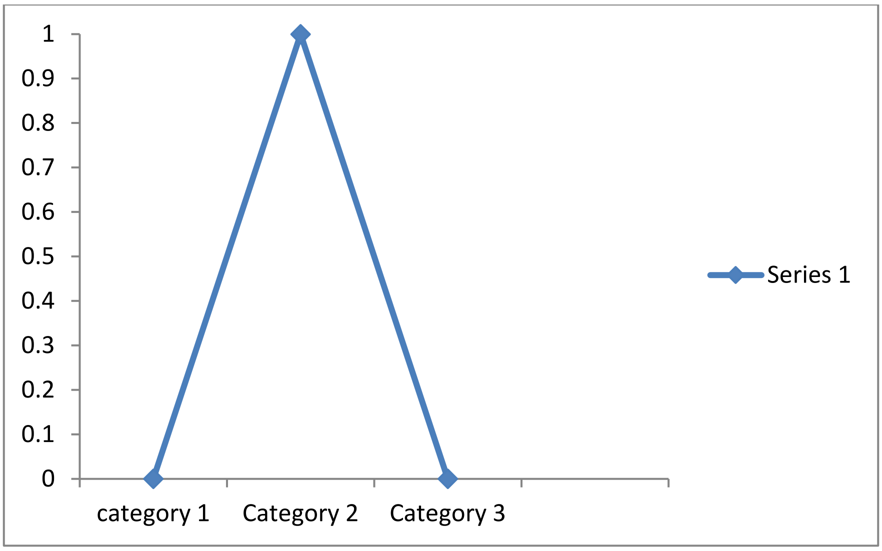

Figure2- fuzzy triangular number

THE PROPOSED FUZZY MADM MODEL

The general structure of the proposed fuzzy multi-attribute decision making (Fuzzy MADM) is as follows:

let X = {x1,..., xn} be set of alternatives. The goals are represented by the fuzzy sets Gj , j=1, …, m. The “importance” (weight) of goal j is expressed by wj. The “attainment” of goal Gj by alternative xi is expressed by the degree of membership μG^{j} (xi).

The decision is defined in line with definition Yager (1978) as the intersection of all fuzzy goals, that is,

$$D = G_1^{w_1} \cap G_2^{w_2} \cap \ldots\ldots\ldots\ldots\ldots \cap G_m^{w_m}$$

and the optimal alternative is defined as achieving the highest degree of membership in D.

The rationale behind using the weights as exponents to express the importance of a goal can be given as: There the modifier “very” was defined as the squaring operation. Thus the higher the importance of a goal the larger should be the exponent of its representing fuzzy set, at least for normalized fuzzy sets and when using the min-operator for the intersection of the fuzzy goals.

The solution procedure can now be described as follows:

1. Establish by pairwise comparison the relative importance, ai, of the goals among themselves. Arrange the ai in a matrix M.
2. Determine consistent weights wj for each goal by employing Saaty’s eigenvector method.
3. Weight the degrees of goal attainment, µGj (xi) exponentially by the respective wj. The resulting fuzzy sets are $(Gj(xi))^{w_j}$
4. Determine the intersection of all $(\,Gj(xi)\,)^{w_j}$

$$\mathbf{M} = \begin{bmatrix} \frac{a_1}{a_1} & \frac{a_1}{a_2} & \cdots & \frac{a_1}{a_n} \\ \frac{a_2}{a_1} & & & \vdots \\ \frac{a_n}{a_1} & & & \frac{a_n}{a_n} \end{bmatrix}$$

$$D = \{ (x_i , \min (\mu G_j (x_i))^{w_j}) \mid i= 1, \ldots, n ; j=1, \ldots, m \}$$

Select the xi with the largest degree of membership in D as the optimal alternative.

CONCLUSION

In this paper, we have adapted and proposed a model that will enable us for using all the quantitative or qualitative and is effective in security assessment in the Persian Gulf region comprehensively. This model can be utilized for ranking and evaluation of the countries in this region concerning the mentioned criteria. We would like to draw the attention that the factors which are presented here are only the ones we could extract from the literature review and detailed sub-criteria can be gathered through experts' interviews. If we assume that a third party country desire to have a contract for investment with one or more countries in this region for cooperation in production or transferring the energy products such as oil, gas and other related products, it would be highly desirable to assess the security of the region and have an exact and overall estimation of the related risk of investment in each country. The proposed fuzzy ranking model offered for eight countries in this region can prioritize the best positions for entering in cooperation for each country (as alternatives) according to a series of security-related factors. Investment risks for each situation in this region can be defined and minimized in this way.

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