Challenging Aspects of MCDM

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Abstract

MCDM (Multi-Criteria Decision Makling) is a very intricate and highly challenging decision making technique for problems with significant implications. We illustrate this with the analysis of a real life situation that is playing out in front of our eyes right now in 2015.

Key words: MCDM (Multi-Criteria Decision Making), two objective optimization problem.

1 Introduction

MCDM (Multi-Criteria Decision Making) is the branch of Optimum Decision Making dealing with problems in which the Decision Maker is confronted with multiple criteria (or objective functions) to optimize. For problems with significant implications, these could be very intricate and highly challenging, and the quality of the outcome may depend on the Decision Maker's point of view. The aim of this chapter is to illustrate these features with a real life situation that is playing out in front of our eyes right now in 2015.

2 The Decision Making Problem

2.1 Historical Background

At the beginning of this year (2015) international press had many headlines with news about the resurgence of the US Oil & Natural Gas industry using the newly developed horizontal drilling and hydraulic fracturing (fracking) techniques. These techniques of course require huge investments. News reports indicated that with these investments US natural gas production will go up so much that the country won't have to import natural gas; and even the US crude oil production will go up to such an extent that pretty soon the country will move from an oil importing country to an oil exporting country. Crude oil produced using these new techniques is usually referred to as *shale oil*. For a background, we remind the reader that for many years, the US has been a net importer of crude oil with 2014 imports of 7 million barrels/day.

Saudi Arabia (SA), the leader of OPEC (Oil Producing and Exporting Countries), is the world's largest exporter of crude oil with exports of 7.4 million barrels/day at the beginning of 2015. Russia which is not a member of OPEC, is the 2nd largest crude oil exporter. Both SA and Russia mainly depend on the revenue from crude oil exports for their sustenance. So, these countries, as well as all other oil exporting countries were mainly interested in raising the crude oil price to maximize their revenue from its sale.

At that time crude oil price was ranging between \$100-110/barrel (in this chapter the symbol " \$ " denotes "US dollar"). Due to huge public expenditures in the country, SA's budget break-even crude oil price was estimated to be \$88/barrel.

2.2 The Two Players Involved in the Decision Making Problem

One of the players with great interest in the outcome of the decision making problem that we will discuss is the US Government. For several years before 2015, the value of the US total annual imports was running higher than that of its total annual exports, resulting in a net annual trade deficit of around \$500 billion. This has a negative effect on the growth of the US economy. US is the world's largest importer of crude oil until 2014, also crude oil imports were a large part of US imports. So, the US in very much interested in keeping the crude oil price as low as possible.

Also, there was another major event that happened in Europe around this time. There was

a civil war in the Crimean Peninsula (or Crimea) that was part of Ukraine at that time. The vast majority of inhabitants of Crimea are Russian people speking the Russian language, and they never liked being a part of Ukraine. At that time the Russian Army marched into Crimea, and annexed it as a part of Russia. Supporting the Ukraine Government, the US Government imposed some sanctions on Russia. When these sanctions had no effect on Russia, the US Government was looking for some other actions they could take for punishing Russia. Since Russia depends heavily on their revenues from the sale of crude oil, reducing crude oil price will result in a severe punishment to Russia.

The 2nd player is the SA Government represented by their Oil Minister. The income from their exports of crude oil is the major source of revenue for the country, another source for them is the revenue from the Haj pilgrimage. SA imports most of their groceries and several other commodities using this income, also SA's population is growing at the annual rate of about 2%. Given these facts, clearly SA is interested in keeping the crude oil price at the then prevailing rate of between $100-110/barrel, and perhaps growing it on par with the growth rate in the prices of other commodities. In fact for a very long time, SA has been very modest in their desire for higher crude oil prices.

Other crude oil exporting countries have been trying vigorously to push up crude oil prices; as the World's largest producer of crude oil, SA has been playing the role of a moderator of these ambitions by increasing their crude oil production rate to keep price raises in check. The world really appreciates this moderating role that SA has been playing regarding crude oil prices.

2.3 History of Saudi Oil Industry

The Kingdom of Saudi Arabia was formed in 1932 with Abdulaziz Al-Saud as its King. A major source of income for the country at that time was the taxes paid by Haj Pilgrims to visit the holy sites of Islam. But the great depression of the 1930's resulted in the number of pilgrims/year decreasing from 100,000 to below 40,000. This hurt the Saudi economy greatly, so they started looking for an alternate source of income. Oil seepages have been observed at Quatif on the eastern seaboard, so the King invited mining engineers to explore the eastern regions of the country for oil. They identified a promising site near Dammam and over the following 3 years they started drilling for oil in that region. They stuck oil on 3 March 1938. This discovery

turned out to be the first of many, eventually revealing the largest source of crude oil in the world. For the kingdom, oil revenues became a crucial source of wealth, and these discoveries altered Middle Eastern political relations forever. Soon the name of the company dealing with these oil producing operations was changed to Arabian American Oil Company (ARAMCO). By 1988, ARAMCO was officially bought by the SA Government and became known as the Saudi ARAMCO.

Now SA is the world's largest producer and exporter of crude oil and has 25% of world's known oil reserves (over 264 billion barrels). As the world's largest producer and exporter of crude oil, SA plays the leading role in the global energy industry, its policies have a major impact on the energy market and the global economy. Mindful of this responsibility, the country is committed to ensuring stability of supplies and prices; so far they have been covering any drop in oil supplies by increasing their output.

With domestic demand and population raising rapidly, a very important objective for the SA Oil Minister to consider in reaching important decisions about oil production levels, is to make sure that his country's domestic oil needs, and needs for revenues from oil exports, will be covered for *as long a planning horizon in future as possible*.

After all, the oil reserves are a fixed finite resource that is being depleted by oil production. The SA Oil Minister is aware that about 40 years ago, the countries in Northern Europe were plush with oil from the reserves in the North sea; now these reserves are nearing depletion, and many of these countries are importing crude oil from Russia. One of his prime responsibilities is to make sure that this does not happen to his country SA, for the largest possible time interval in future.

2.4 The Decision Making Problem

Earlier this year when International News headlines were predicting that with shale oil production US may change from an oil importing country into an oil exporting country, US Secretary of State had discussions with the Saudi Oil Minister and other top level persons in the SA Government. He briefed them about these developments.

One of the countries in the Middle East with which SA does not have good relations is another OPEC member, Iran. At this time, the permanent members of the UN Security Council have

imposed sanctions on Iran under the suspicion that the country is engaged in secret research to produce nuclear weapons, even though Iran has always denied these allegations. For many years now, negotiations have been going on between Iran and these big 6 powers on conditions that Iran has to meet, to lift the sanctions placed on it. In discussions with Saudi authorities, US Secretary of State has pointed out that these Iran nuclear negotiations may at last be successful, and if so the sanctions on Iran will be lifted at that time. If this happens, Iran will begin oil production and enter the oil export market. He pointed out that these recent developments may affect SA's *market share in the crude oil export market*; and that they have to do something to protect their market share.

Now the SA Oil Minister is faced with the following decision making problem: determine the optimum value of the decision variable

x = nonnegative amount of crude oil that SA should produce/day

under the circumstances discussed above. Choosing the value for x is the only way in which they can influence the oil market. They can either keep the value of x at its present value, or increase/decrease it. At the beginning of 2015, SA's crude oil production was 9.6 million barrels/day, of which they were exporting 7.4 million barrels/day in the crude oil export market. SA has several oil refineries, it uses the output products of these refineries for its domestic consumption, and also exports some of them. The oil refining business is commonly known as the "downstream sector" of the oil industry.

From the above discussion, we know that there are two objective functions that he needs to optimize in reaching his decision. They are:

Objective 1: To maximize y_1 = duration that the country's oil reserves keep meeting the country's needs for oil export revenues.

Ojective 2: To maintain y_2 = the market share of SA in the crude oil export market, at its present level or higher.

At the production rate of 9.6 million barrels/day in the beginning of 2015, the estimated

lifetime of the current known reserves of SA is = (264 billion)/(9.6 × 365 million) ≈ 75 years, which we take as the current estimate for y_1.

At that time they were exporting $x = 7.4$ million barrels/day. At \$100/barrel this was providing oil revenues of \$100 ×7.4× 365 million ≈ 270 billion/year. This revenue of \$270 billion was meeting their needs for oil revenues at the beginning of 2015.

At that time world crude oil exports were running at 44 million barrels/day. And SA's oil exports were 7.4 million barrels/day. So the market share of SA in the crude oil export market was 7.4/44 ≈ 17%, which is the estimate of y_2 at that time.

Mathematically our decision making problem, choosing the value for x to maximize y_1 while keeiping the value of y_2 at its present level or higher, is a simple two objective single variable optimization problem; but the huge financial implications , and other very significant impacts make it a very challenging problem.

2.5 The Solution that was Implemented

We really do not know what analysis was carried out by the Saudi Oil Ministry, but according to news reports in the Western media, they focused only on the objective function y_2, totally ignoring the objective function y_1 even though it has serious consequences for the Saudi people. The desert Kingdom has also been moving into oil refining and downstream product business, he has also decided to capture market share downstream as well.

News reports indicate that the SA Oil Minister considered the emerging US Shale oil industry a big threat to the Saudi market share in the crude oil export market. So, in order to discourage additional investment in the US Shale oil industry, he decided to do everything in his power to make these investments unattractive. Knowing that this can be achieved by reducing the price of crude oil in the oil market, which can be achieved by flooding the market with crude oil; he took the decision of increasing the value of x to the maximum extent that the Saudi oil industry can pump.

This recent Saudi action is contrary to the actions of all the OPEC members including SA until recently. Previously all the OPEC countries had the policy of maintaining capacity limits for oil production by each country, to either increase the crude oil price or at least keep it from falling. That was to make sure that they are rewarded adequately for making their precious

natural resource available to the World.

The current action by SA is not popular with other OPEC members, they are keeping their crude oil production levels more or less stable. These actions raised the Saudi crude oil production to 10.6 million barrels/day, a record high. They resulted in the overall OPEC production increasing from 32 million barrels/day in 2014 to 33.1 million barrels/day today. The net result is that crude oil price dropped to 52$/barrel, and falling still further, a 50% drop due to the Saudi action.

We will analyze thie action taken by the Saudi Government in the next section.

2.6 Analysis of the Decision Taken

Our discussion in this section is based only on information released to the press and known publicly. In fact there may be other secret information withheld from the press for political or other reasons. Our discussion is purely for academic purposes based on publicly released information, to make the readers understand how to resolve MCDM that they may encounter later.

First let us examine the consequences of the decisions implemented. In a few days after the decisions mentioned were implemented, the price of crude oil dropped by about 50%. So as a result of the unilateral action by SA, all the oil exporting countries are experiencing a similar decline in their returns/barrel exported these days. Prices of all other goods and commodities remained stable, so the net result is that SA is now having to export twice the amount of their precious natural resource to import the same quantity of other goods and commodities for their national needs, or use up some of their dollar reserves.

It is quite possible that maintaining market share is a matter of national pride, but is it worth having to pay twice the amount of the country's fixed natural resource for importing the same quantity of other goods and commodities? Also at the current production rate of 10.6 million barrels/day, the estimated lifetime of the current known reserves of SA will be (264 billion)/(10.6 $\times$ 365 million) $\approx$ 68.2 years, which is a significant drop of the other objective function y_1 from its previous value of 75 years, as a result of the decision implemented.

Answers to these questions depend on the Decision Maker's point of view; and unfortunately the current MCDM theory cannot help to resolve these questions.