Application Of Game Theory To Strategic Decision Making: Will Ethanol Complement Or Replace Gasoline?

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Abstract

Since the Hubbert model has succeed in forecasting US-48 oil production peak in early 1970s, recent studies have estimated the end of *cheap* oil era. Environmental restrictions especially the replacement of MTBE (Methyl Tert-Butil Ether) and the need to mitigate the emissions of greenhouse gases have elected ethanol as the main candidate to replace gasoline, one of the most important oil derivatives. The expected worldwide growth of light-duty vehicles' fleet and the still limited capacity of ethanol production suggest that the total replacement of gasoline is not feasible in the short to medium-term. However, a 30% ethanol blend to the gasoline could increase the performance of internal combustion engines, decrease the emission of greenhouse gases and alter the rate of depletion for conventional oil reserves, thus extending the oil era. Therefore, we recommend the investigation of ethanol as a complement to the base gasoline and the respective impact over the world's conventional oil reserves. Finally, based upon the game theory, the transition process from the former fossil fuel era to an era with wider use of biomass could focus on cooperation and compromise strategies with optimal results to both oil and ethanol industries.

Key-Words: The Hubbert curve, oil industry, ethanol industry, cooperation strategy, game theory

Introduction

The world's peak oil reserve forecast has been justifying an intense debate among specialists for decades. Since the Hubbert curve calculations were confirmed for North-American oil onshore shale in the 1970s, new studies have anticipated the end of the cheap oil era (Campbell & Lahererre, 1998; Deffeyes, 2005).

Environmental restrictions, such as the MTBE substitution, and the necessity to mitigate de greenhouse gases emission, emphasize ethanol as the main candidate to substitute one of the most important oil-products: gasoline (OPEC, 2007). The expected growth of the world's light-duty vehicle fleet in the next years, and the still limited capacity for producing cheap ethanol indicate that the whole substitution of gasoline is not feasible in the short and medium term[1]. Nevertheless, the Hubbert (1956) curve can be applied to determine the impact

[1] This limited capacity is also explained by the current barriers to the development of a global ethanol market (Szklo et al, 2007).

of the adoption of ethanol as complement rather than a substitute of gasoline for consuming and manufacturing nations.

Technical studies reveal that the 30% biofuel addition to gasoline would increase the performance of Otto cycle engines and decrease greenhouse gases emissions and depletion of oil reserves, extending the oil era (Szklo et al, 2007).

Therefore, this paper assesses the implementation of ethanol as a complement to gasoline, emphasizing its effect on the world's energy system and oil reserve extension. Inasmuch, qualitative evidence regarding a possible extension of the oil era is presented. The benefits of oil usage while in combination with the virtues use of renewable energy sources would mitigate greenhouse gases emissions.

1- Methods

The deductive-hypothetic method was used to built and develop this study. The following hypothesis was formulated to test:

- h_0: The oil industry blocks the ethanol introduction in the oil system in order to seek economical benefits in the long-term;
- h_1: The global ethanol industry obtains 100% of its entrance (E100- pure ethanol), thus as a substitute (not complementary) to gasoline;
- and h_2: The gradual 30% ethanol-gasoline blend allows the transition towards the world's agro-industrial yield production. In this sense, few modifications in the vehicles would be needed. The geopolitic risk would be decentralized, the CO_2 emissions would be mitigated and the oil reserves would extend beyond proportions.

After testing the hypothesis already stated, the oil producing system will be analyzed according to the respective hypothesis while applying compromise games. In compliance with the game theory, in transition from the fossil fuel to the biomass successor, the cooperative game must be introduced, generating positive results to both energy sectors.

2- The game theory application to the hypothesis test

The game theory was structured by Morgansten and Neuwman in 1947 to analyze the strategic interaction between players (organizations, entities or characters). Actually, the game theory is a tool used to study the strategic interactions among agents in extremely competitive markets with a *pay off* matrix and decision trees approach. The game theory had John Nash contribution demonstrating balanced situations where competitors make their choices based upon his opponents (Varian, 2006).

The game could be cooperative, when participants negotiate contracts, which enable the balance among coordinated strategies, or not cooperative, when agreements are not possible. (Pindyck & Rubinfeld, 2006)

According to the game theory, our analysis could be accomplished by observing the interaction between the oil and ethanol industries, thus simulating gain and loss scenarios for each player in the fuel market. In this study, the actions and strategies undertaken by each industry are qualitatively analyzed, especially in regard to the oil industry, which is the incumbent industry.

The hypothesis (h_0), in this case, considers that the oil industry will succeed in blocking the ethanol introduction at large volumes worldwide. In the long-term, the esser competitors the better for the oligopoly's game. Regarding oil reserves, the exhaustion of oil upstream and sunk - atmosphere downstream, may lead the oil and ethanol industries, as well as the planet, to an environmental and energetic collapse.

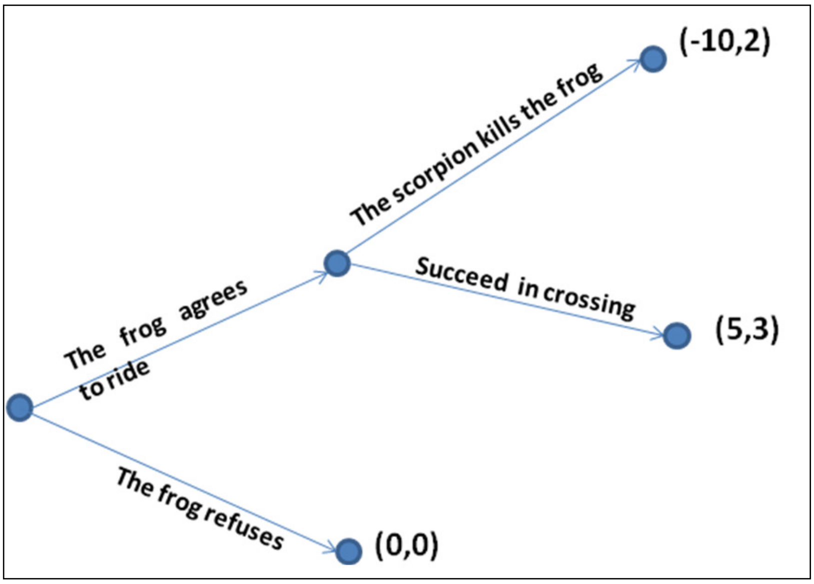
On the other hand, under the h_1 hypothesis – the E100 - the ethanol introduction status in the global market as substitute in the short-term to the gasoline, could be as noxious as the

E0. The frog and scorpion analogy (Varian, 2006) presents the manner in which the game theory interprets the sequential movements of a compromise game where the best option could be the cooperation between the two players.

3- The frog and scorpion metaphor

Varian's analogy describes a frog's negotiation to carry a scorpion on its back in and across a river. The frog has two alternatives: to accept or not to accept giving the scorpion a ride. If the frog accepts, it will have two new possibilities: the scorpion may sting it and both will likely succumb and drawn; on the other hand, if there is no sting, both will cross the river in a win-win result. In case the frog rejects the proposal, neither would achieve any gain.

Figure 1 – The decision tree: the frog and scorpion metaphor in a compromise game

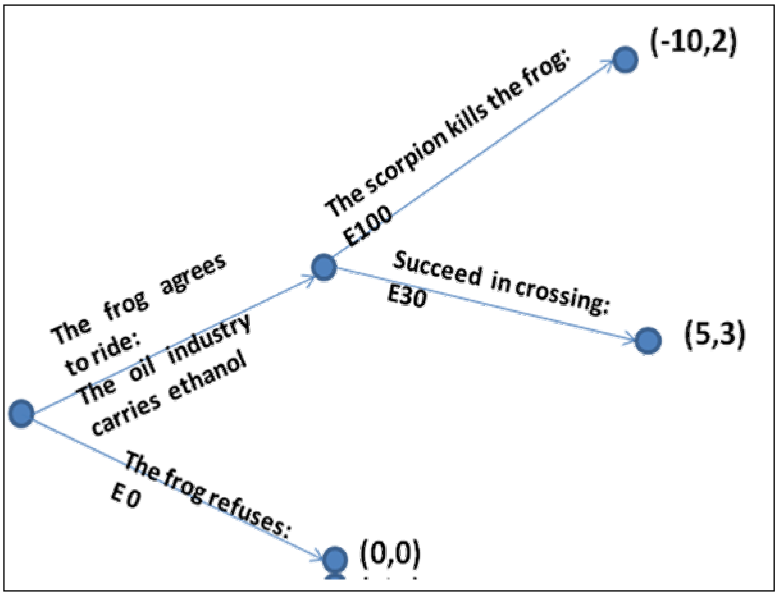


Source: Varian (2006)

Similarly, it is possible to simulate the strategic interaction movement among the oil and ethanol industries. Likewise, the oil industry can carry the scorpion, represented by the ethanol industry. If there is no ethanol introduction in the global market, both industries and the society will lose the gains of this partnership.

If there is cooperation for, for instance, a 30% ethanol-gasoline blend, then both will win with positive marginal results to the entire society. If the scorpion kills the frog, the ethanol will compete with the gasoline completely – 100% (E100), despite its ineffective results to the system in the short-to-medium term (figure 2).

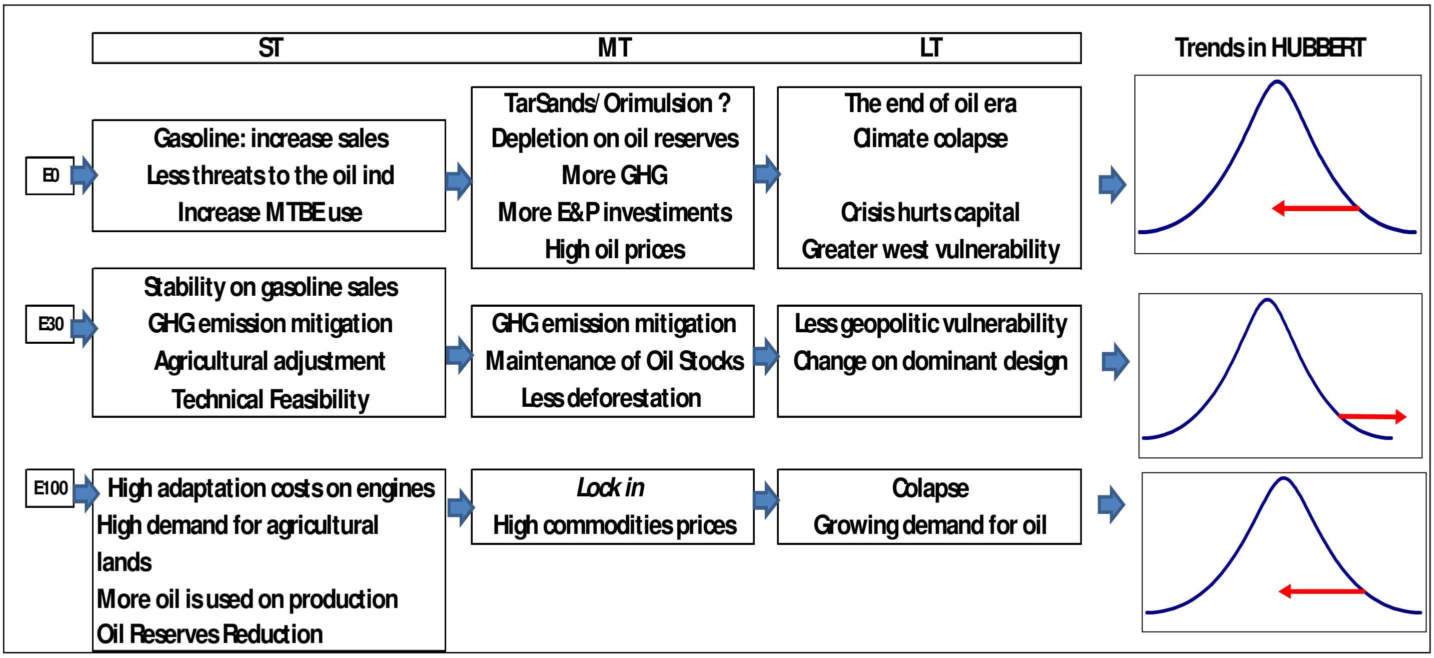
Figure 2 – The compromise game: oil x ethanol



Note: The figures are solely ilustrative of the compromise game. They did not represent a real quantitative assessment of the losses and benefits incurred by the two industries analyzed in this paper.
Source: Authors

Both hypothesis, h_0 and h_1, were also analyzed through a sequential movement test, by simulating a compromise game between ethanol and gasoline (figure 3).

Figure 3 – Sequential Movement in the Ethanol x Gasoline compromise game



Source: Authors.
Note: ST means short-term; MT means mid-term; and LT means long-term

Despites the apparent short-term gain for the oil industry, in the case of banishing ethanol, in the medium-to-long-term, the 'conventional' oil industry would suffer losses and reduction of its hegemony. Henceforth, cheap oil reserves would decline and high prices would force the entrance of backstop technologies[2], particularly orimulsions and tar sands[3] (and even perhaps shale oil).

This would pressure the demand for natural resources (natural gas and water) in the long-term and result in increasing greenhouse gases emissions, aggravating an already delicate situation. In the long-term, results would lead to upstream collapse, reduction of reserves (the Hubbert curve contraction) and to the current energy supply system chaos.

According to h_1, E100 seems to solve this environmental challenge. Nevertheless, as of today, only Brazil has a liquid biofuel industry that is economically and environmentally viable. In other countries, the amount of land required from traditional agriculture for biomass resources could force a continuum of high commodities prices, collapsing this segment. Furthermore, the sudden rise of the initial demand for fossil fuels would amplify these costs and provoke a possible Hubbert curve contraction.

Worldwide, the gradual ethanol introduction hypothesis (E30) facilitates the entrance of this new fuel into the global economy, thus not competing directly against the barriers created by the oil industry. In addition, as mentioned before, E30 blends result in less gasoline consumption (and CO_2 emissions), the possibility of producing all ethanol from inputs that do not pressure land use, leading to competition with food production (basically, sugar cane), and the alternative of adopting lean-combustion high efficiency Otto cycle engines (Szklo et al., 2007).

In this case, the Hubbert curve would be extended, prolonging the oil era. Moreover, crude oil, which would be diverted from gasoline production, could be increasingly used to produce petrochemicals, lube oils, and other products that stocks carbon rather than emit it. Additionally, the sunk (atmosphere) would be less saturated. Meanwhile, the vulnerability and risk generated by the geopolitical issues would be reduced.

4- Conclusions

This article aimed to answer the question regarding the use of 30% ethanol-gasoline blend as a factor of the Hubbert curve distension. Moreover, it intended to analyze the reasons that justify the adoption of liquid biofuels worldwide not as substitute, but rather as complementary products associated to gasoline.

The strategic cooperation between ethanol and oil industries presents benefits to society, because the geo-political and economic risks are lowered; to the ethanol industry because it allows a broader time range of adaptation towards improved ethanol production worldwide; and finally, to the oil industry because it expands its influence in time, hindering the appearance of back stop technologies.

Furthermore, the risk of more stringent petrol fuel specifications is decreased, as ethanol could be also an alternative to improve gasoline specification (e.g., related to sulphur content) without increasing CO_2 emissions in oil refineries.

In sum, the complete substitution from gasoline to ethanol in the short-term is only feasible in some regions or countries, such as Brazil. For the other countries, however, a time-delay for adapting could be necessary; and the transition process, with the ethanol-gasoline blend (E30), is an interesting option[4]. In the medium-term, nevertheless, advanced biofuels

[2] "Any technology which can be used as oil substitute, at a certain price level" (PINTO JR, 2007)

[3] Tar sands (OIL SANDS, 2007) e Orimulsion (PDVSA, 2007)

[4] The benefits are also maximized when ethanol is produced with low input-output ratio.

can alter the 'game' studied. These biofuels, which include the BTLs[5] and the ethanol from hydrolysis, will increase the capacity to offer ethanol. In the medium-term, a suitable more globalized ethanol market can also affect the game, towards a more spread use of biofuels.

In other words, the energetic system needs to adapt to this change: the so-called phase-in[6] to break the established lock-in, delaying the changes in the dominant structure. It is crucial the support to develop further studies enhancing and determining the optimal result of ethanol proportion to be blended to gasoline. The combined level of the two energetic sources could have its production decision made by decision making support systems, for instance, the ANP method (Decision Lens, 2007).

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[5] BTL – biomass to liquid
[6] phase in – "Introduce one stage at a time. For example, New technology must be phased in or the office will be overwhelmed".