Explaining Investment Decisions in the South African Biofuels Industry: A Game Theoretic Approach

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Abstract

The production of biofuels and the establishment of a biofuels industry in South Africa have largely been hampered by the structure, procedures and requirements as set out in the Industrial Biofuel Strategy. This article sketches the industry by means of a game theoretic representation. A model is developed that represents the rational strategies of various role players in the industry with respect to investor decision making. In reality this did not occur and the article develops and documents a variable, σ, which in turn helps to represent the current state of affairs. The study explains why current investment decisions in the industry have been made and why certain role players remain indifferent towards any commitment.

Keywords: Biofuels, Game Theory, Biofuel Industry Investments.

1. Introduction

Biofuel producers in the US and EU and in many other countries strive to influence policies to such an extent in order to make the production of biofuels economically viable within their economic system. The theory to explain the way in which such role players behave has been extensively researched and to a certain extent explained by use of game theory.

Game theory can be applied and used in many different situations and such games often appear where they might not be expected. Consider the role players of the biofuels industry in South Africa as an example. It can be argued that the releasing of the Biofuels Industrial Strategy by the Department of Minerals and Energy (DME) in December of 2007 made them, that is, the government, a first mover. It is now up to the other players in the game namely oil refineries, potential biofuel producers, and farmers to establish themselves with the national strategy in mind. In this instance it can be argued that the release of the strategy, and its conditions, has set many of the

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rules and constraints within which the other players will play there games. One of the main assumptions that have been made is that all players attempt to position themselves so that their payoffs and strategic position within the industry is maximised.

The development process of the South African biofuel policy framework and as a result the progress of the biofuels industry have been characterised by confusion, a morass of government inaction and a lack of policy determination. Various reports and studies, including those by the Foreign Agricultural Service (FAS) of the United States Department of Agriculture (2009), the Bureau for Food and Agricultural Policy (BFAP) (2007; 2008), Meyer, Strauss and Funke (2008), Funke, Meyer, Strauss (2009) and Lemmer, Makanete and Kupka (2007), have stated that the current Industrial Biofuels Strategy of the South African government does not provide the correct measure of incentive, support nor structure to successfully encourage the establishment of a biofuels industry in South Africa. The Gain report by the FAS makes a clear mention of the inadequate support measures that are currently in place, which in turn hinder the industry but in turn makes no recommendations as to what could be done to make this process more efficient. The conclusion that the current framework is unclear and insufficient is also shared by other researchers and research institutions in the field. The Bureau for Food and Agricultural Policy (BFAP) in 2007 and 2008 as well as Meyer, Strauss and Funke (2008) and Funke, Meyer and Strauss (2009) use a partial equilibrium model to simulate and estimate the various impacts that the implementation of the current policy will have on the industry and even model alternative options which could be employed if different and more sustainable outcomes are to be achieved. Again it is advised that the policy be altered to include different levels of support if the renewable energy targets are to be met. Interestingly, all of the articles assume that investment decisions will follow if the correct policy instruments are in place but none of the articles focus on the actual decision making process that takes place at industry level.

This article explores the actions and the possible positioning that the different players in the biofuels industry want to take up, given the set of rules governing the industry. The first section reviews the Biofuels Industrial Strategy issued by the DME and discusses what the strategy means for the different industry players. In the second section, a game theoretic model is developed in which the interactions of the various players are tested against one another, given the rules laid down by the DME. The “biofuels industry development game” in South Africa discusses the calculations of

the payoffs, the game's structure, the actions and strategies, and lastly the outcome of the game. Based on the results of the game, the concept of vertical integration is explored as an additional strategy, which in turn, could positively benefit the industry.

2. The Biofuels Industry Development Game

Section 2 discusses what the Biofuels Industrial Strategy entails while section 3 explains the different goals that the various players in the game would want to achieve. This helps with the understanding of the payoffs as well as the formulation of the payoff function, as depicted in section 4.

2.1 The Rules of the Game

The rules of the game: The Government

The government has a number of goals that need to be achieved and most of these are defined within its Biofuels Industrial Strategy. This means that they have the opportunity to establish their position within the industry by creating a set of rules that will help them to achieve their objectives. A failure to achieving their objectives is also a possibility, as this would mean complete non participation or non establishment within or of the industry.

The strategy is aimed at achieving a number of goals; these include attracting investment into rural areas, promoting agricultural development, and import substitution of foreign oil which should result in balance of payments savings. Other factors also mentioned as key issues are; adding to the renewable energy pool in order to create cleaner energies, adding downward pressure to crude oil prices, and creating a more energy secure environment.

The strategy has a set of primary objectives and these are to realise economic development in rural areas by creating a downstream market for the agricultural commodities produced in these areas. In order to achieve this objective, the government intends to regulate the geographic location of biofuel production plants, and also the type of agricultural commodity used as an input to the production process. The crops that have been proposed include sugar-based commodities for bioethanol production, such as sugarcane and sugar beet, and sunflower, canola and soybeans for biodiesel. While maize and jathropa have been excluded for the 5 year

pilot period, since the use of these commodities could have a negative impact on food security and environmental conditions within the country.

In the Biofuels Industrial Strategy the government proposes various methods through which it aims to achieve the aforementioned objectives and ultimately plans to develop a biofuel sector. The policy tools that the government plans in utilising include a fuel levy exemption scheme, farmer cooperatives and their direct participation in the running of biofuel refineries, quantity control through the issuing of licences, and encouragement of the use of biofuels in the fuel mixture currently produced by the existing refineries.

Rule 1: Fuel levy exemption

Retail fuel prices in South Africa are currently the function of a number of taxes and levies aimed at covering the cost of maintenance and the upgrading of road and logistical infrastructure, as well as profit margins and crude oil prices. These taxes and levies are adjusted every year to keep up with the impact that inflation has on the overall industry. BFP stands for the basic fuel price and represents the import parity price of the refined product. In other words BFP is the price at which one litre of refined fuel is landed at Durban harbour without any taxes or profit margins being added. Various other taxes and costs are added to the price, namely transport, delivery and pipeline costs, road accident fund, custom-and-excise duty, equalisation fund and slate levies and wholesale and retail margins. The strategy proposes the reduction of the fuel tax as a support mechanism to the biofuel industry, the idea being that a lower tax rate on biofuels will increase their competitiveness with fossil fuels and in so doing make them more viable.

The proposed reduction in the fuel levy reduces the fuel tax by 100 % for bioethanol and 50 % for biodiesel. This will drop the biofuels price by between 7 % and 14.8 % below conventional fossil-based petrol and diesel. Since April 2007 fuel tax has totalled R 1.21 per litre for petrol and R 1.00 per litre for diesel, but from April 2008 the amount increased to R 1.27 per litre for petrol and R 1.05 per litre for diesel.

According to the Biofuels Industrial Strategy the fuel levy tool plays a very important role in the indirect subsidisation process. The strategy proposes that the current biodiesel fuel levy exemption be increased from its current level of 40 % by 10 percentage points to 50 %. It also proposes that the fuel levy exemption on bioethanol be increased to 100 % as ethanol gel could be a substitute for illuminating

paraffin, which currently carries no levy. This would translate into R 1.21 per litre and R 0.53 per litre support for bioethanol and biodiesel, respectively, in 2007. The tax increases would augment the support to biofuels and would translate into R 1.27 per litre for bioethanol and R 0.56 per litre for biodiesel in 2008 (DME, 2007).

Rule 2: Rural development and license allocation

According to the strategy the main focus of rural development will be on the former homeland areas in South Africa, especially those neglected under the apartheid system. It is hoped that these initiatives will stimulate development in rural areas and reduce poverty by creating sustainable income earning opportunities.

As poverty alleviation and the generation of economic activity in the former homelands are the strategy's most important objectives, it becomes clear why only those agricultural products grown in the former homelands for energy use will qualify for support, and why only the biofuel plants that can assist in achieving the abovementioned targets will be supported and qualify for a manufacturing licence. Thus the department that ultimately issues the licence will, to a large extent, control the location of biofuel plants and their operating conditions (DME, 2007). It is important to note that should this be the case, sugarcane for ethanol production will then be excluded from any benefits, as almost all of the current industry's production areas fall outside the former homelands and as a result do not qualify for support. This could have an impact on the various targets that are to be achieved.

The government plans to increase agricultural production in order to support biofuel investments by using existing support programmes such as the Comprehensive Agricultural Support Programme (CASP). CASP is expected to prioritise those aspects of production that will enhance effective cropping for biofuels, and in so doing make the supply of feedstock to the biofuels industry more reliable and efficient.

Rule 3: Contracting and mandates on biofuels

According to the strategy, the specifics of the biofuel uptake still need to be negotiated with the oil industry. These include maximising efficiencies, reducing costs and ensuring that fuels adhere to the correct standards, thus allowing them to be sold and used as standard quality fuel. The South African Bureau of Standards (SABS) has recently established a working group among relevant stakeholders to finalise possible future regulations for a biodiesel quality management procedure to be

applied in South Africa. These regulations don't affect the biodiesel product standard, but rather the quality assurance process.

The strategy recommends that biofuels be sold on a contract basis, and bought at a price that will ensure the long term viability of both the biofuels refining and feedstock growing processes. The contract will come with an obligation to use approved crops grown only in designated areas, such as the former homelands, with the guarantee that crops will be bought at a given price, regardless of the price of crude oil. On the other hand the price at which biofuel producers buy crops should be comparable with the price that processors pay for crops destined for the food sector, in other words a market related price.

The strategy suggests that mandatory biofuels uptake can only be guaranteed once there is security in the supply of biofuels. It is at this stage of the bargaining process that both biofuel suppliers and oil refineries will enter into off-take agreements. In other words, the oil company will submit a claim to a certain slate account for the value of biofuels bought. During the initial phases of production, the mandating of biofuels is not favoured. It is instead suggested that biofuel producers be enabled to reduce their prices and, through this initiative, parties who are traditionally supplied by the oil companies are able to purchase fuel directly from the biofuel producers. The strategy further examines the concept of selling petrol containing bioethanol at a deregulated price to facilitate off-take.

The strategy envisages that costs and logistics should be minimised to optimise efficiency. To achieve this, existing oil refineries closest to the biofuels plants should be utilised. Furthermore, biofuels should be blended in accordance with the South African National Standards (SANS), which currently limit biofuel content to 5 % for diesel and approximately 10% for petrol. This would ensure that the appropriate quality blends of biofuels are produced (DME, 2007).

3. Players in the game

Player 1: The Oil Refineries

The oil refining industry, in South Africa, is an extremely large player in the liquid energy market as a total of 4 major refineries control the entire market. In addition to this, the fuel industry is highly regulated and the fuel prices are set once a month depending on the over or under recovery that has been incurred as a result of oil

price and exchange rate fluctuations. A highly regulated fuel industry, in this instance, means that oil refineries have one player to adhere to and in this case it is the government. The actions taken by the oil industry therefore depend directly on the goals and regulations set out in the Biofuels Industrial Strategy and this in turn substantiates the fact that the government is indeed a first mover in this game.

The oil refineries have one major goal namely that of ensuring stable and high profits given the rules that have been laid down by the government. In addition to adhering to these laid down rules, the oil refineries also need to be balanced in their actions, and this includes maximizing own profit by managing income and expenses, but also managing good public relations by means of positive public perceptions about the industry and the individual companies. Negative public perceptions can have a negative impact on income and expenses in the short and long run. Thus, oil refineries are in a situation in which they don't want to avoid biofuels since this will create possible negative public and government perceptions that oil refineries don't care about the environment. On the other hand, the oil companies need to ensure that they can buy biofuels as cheap as possible to ensure high and stable profits. Since oil refineries control the fuel market, they have bargaining power to influence biofuel blending policy as well as biofuel pricing policy to some extent. Based on this argument, it is assumed in the article that the oil refining industry along with the rules laid down by the government are the two key players that will negotiate blending and pricing policies of biofuels.

Player 2: The potential Biofuel Producers

The biofuel producer in this game is assumed to be an independent entity, not necessarily a farmer cooperative, although this could prove to be beneficial, with the sole aim of making as much profit as possible from processing agricultural feedstock into biofuels. The actions of the biofuel producer, as those of the oil refineries, are governed by a set of rules and laws, laid down in the Biofuels Industrial Strategy. In their case these rules refer to the issuing of a license in order to produce the product, the tax rebate and other support that is made available to them as well as the regions in which they may purchase feedstock for biofuel production. These rules govern the actions that the biofuel producers may take with respect to farmers, the producers of their primary feedstock, rather than their type of negotiations with the oil refiners. The negotiation that the biofuel producers will have with oil refiners focuses on the profit margin that they need to maintain in order to stay in business. This means that the way the ethanol price is determined is extremely important as is quantity that the oil

refiners are willing to or will need to accept given the rules laid down by the government. It can therefore be argued that the ethanol price as well as the ethanol mandate or voluntary blending rate, are of the highest importance to these two players.

If the biofuel producer is a sole entity and not an institution run by farmers then he will need to negotiate not just with the oil refiners but also with the farmers in order to maintain, or achieve the best possible price for the feedstock that needs to be purchased. The biofuel producer has a set of options that he can follow in order to achieve this. These include contracting with the farmers for a specific quantity of their produce at a specific price, purchasing the feedstock on the open market or thirdly forming a cooperative by vertically integrating the processing facility with the group of farmers and in so doing creating a combined interest in the company's financial performance. Vertical integration can also have its drawbacks in that the company will be run by a group of individuals, the farmers, who might have ulterior motives in addition to securing the profitability of the biofuel production plant.

Player 3: The Farmers (Commercial and Emerging)

In the case of the farmer, the assumption is made that the goal is the same for both a commercial and an emerging farmer, namely to produce feedstock for biofuel production in order to maximize profit.

The goal of the farmer is to sell high quality produce at the highest possible price and at the lowest possible cost to ensure profits. If the farmer has a choice, he or she would want to earn a price higher than the market price and preferably earn a stable price to be less exposed to risk. In short, the farmer wants to earn as good a price as possible with a minimal amount of risk. The implication is that farmers would want to lobby biofuel producers into buying feedstock under a contract growing scheme, which pays above market related prices on a regular basis. For the purpose of this exercise the actions of farmers need to be kept in mind in order to understand the strategies the drive the biofuel producers. The farmers will therefore only affect the outcome of the game indirectly.

4. The Model

In reality many strategic situations contain elements of both simultaneous and sequential move games. That is what the model in the article will attempt to capture

as the actions and strategies of two players in the game depend on the either the laws laid down by the Department of Minerals and Energy or the impact that the nature player has on the local industry. A nature player is a participant in a game who selects from, among her strategies randomly, based on some predetermined probability distribution rather than based on a set of payoffs. The introduction of a nature player simply allows for the introduction of uncertainty or randomness into the game (Shor, 2008). In this case the nature player will take the form of the price of inputs and outputs used in the production of biofuels, for example the feedstock or biofuel price.

The game is a very simple representation of the situation and it is based on the “rules of the game” as established within the framework of the Industrial Biofuels Strategy with the addition of the nature player. A history of higher commodity prices and higher oil prices influences the actions and strategies that both the biofuel producers and the oil refiners choose. The strategies chosen depend on a range of issues, some relating to the biofuels strategy but most a matter of economic profitability while the payoffs are calculated as a function of input and output prices as well as the implementation of certain policies as additional rules.

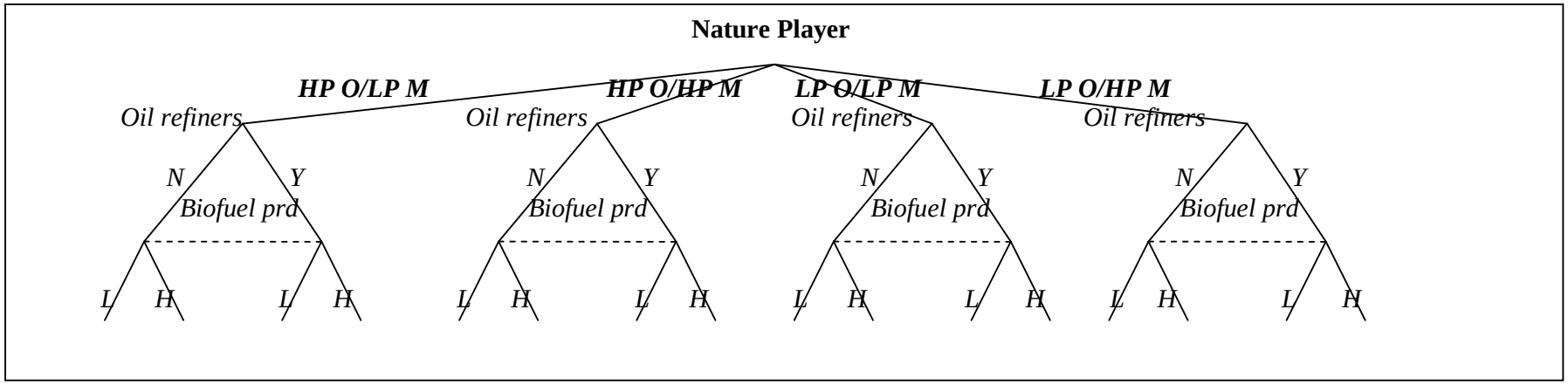

Figure 1: Model 1, the Biofuels Industry Development Game

** HP O: High oil price, LP O: Low oil price, HP M: High maize price, LP M: Low maize price, N: No investment, Y: Investment, L: Low investment, H: High investment*

The game as depicted in Figure 1 represents four possible combinations, in which, 2X2 matrix games are depicted as a result of the “nature player” and other forces, beyond the control of the players in the game. In this instance, these include a variation in the oil price and maize price with different combinations. The payoffs for both the oil refiners and the biofuel producers are calculated, based on functions that take the occurrences based on the set of factors and the combinations that the nature player has “chosen” for each strategy, into account. The payoff functions are:

$$BFCAP = \alpha P_{ET} + (\beta(f/2)) - \theta(M)$$

and

$$OCAP = \frac{\theta(M) - \alpha P_{ET} - (\beta(f/0)/2)}{\gamma}$$

where, α is a coefficient of either 1 or 0.5 times the ethanol price P_{ET}, which in this instance is either 3 or 5, depending on a high or low oil price scenario. (β(f/0)/2) is the full implementation of the tax credit and in this instance either f is selected depending on the need for biofuels by the government. A full implementation of the tax credit under low maize prices results in stronger government incentives gives β and f a value of 1 while a lack of interest and concern of the impact on food security under high maize prices results in lower government incentives with β and f receiving values of 0.5. θ(M) is a factor that represents the chance of a high maize price and in the case of South Africa with its relatively marginal climate, the chance of a high maize price or a smaller crop over time, has been estimated to be a possible outcome. The factor representing the chance of a higher maize price has a value of 0.3 compared to the value of the factor of a low maize price, which has a value of 0.2. In the case of OCAP, the oil producer capacity, γ is a variable that becomes 0 when the nominator is positive and is 1 when the nominator is negative, this as it is not expected that oil refiners will reap direct positive payoffs from installing additional capacity to handle biofuels but will rather incur no cost, especially with the current strategy in that is in place.

5. The Game

In accordance to the game tree depicted in Figure 1, the biofuel producers and oil refiners are rational and play off against each other in order to achieve their highest possible payoff given the circumstances that occur as a result of the scenario created by the nature player.

5.1 High Oil Price, Low Maize Price

In the instance of a high oil price and a low maize price the returns on investments for biofuel producers are expected to be optimal. A high oil price, should in most instances, result in a higher ethanol price while a low maize price would serve as a lower priced input on the production side.

Table 1: The high oil price, low maize price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	4.5	-4.5	**2.5**	**-1**
	Low investment	1	-4.5	0	0

The best strategy for the biofuel producers would be to follow a high investment as in such a situation it seems that they will be able to make maximum profits. The oil refineries will however be a bit reluctant to invest a lot of money if they are not certain that the industry will be able to support the quantity required by them and if a high oil price, low maize price scenario is indeed sustainable in the long term. If they do accept the investment cost their short term payoff will be the lowest as they will have to put up with additional development cost. On the other hand, if the game is repeated in a second period this might be a different scenario. The best payoff for the oil refineries would be to reject the idea of biofuels while a high investment strategy would pose the best possible payoff to the biofuel producers. The Nash Equilibrium is represented by the grey area.

5.2 High Oil Price, High Maize Price

The second nature scenario is the instance in which the oil price reaches a high level, as does the price of maize. This puts additional pressure on oil refiners, so that they can find an alternative market for energy as fear of a shortage emerge, while a high maize price has a negative impact on the profit margin of the ethanol producer and hence impacts on their strategy of investing in additional production capacity or not.

Table 2: The high oil price, high maize price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	2.5	-2.25	**1**	**-1**
	Low investment	1	-2.25	0	0

Investing in the biofuels industry in the time of a high oil price and a high maize price may be a challenge for biofuel producers as their margins will already be squeezed and they might not be able to make high investments. Such a situation will benefit the oil refineries as they are in a position to make abnormal profits, as a result of the high oil prices and in addition to that they can actually use the high maize prices as a reason not to invest in additional capacity. The Nash Equilibrium is again represented by the grey area.

5.3 Low Oil Price, Low Maize Price

The third nature scenario takes place in circumstances in which the oil price and the maize price both drop to a low level. These circumstances offer a relatively profitable environment for the oil producers as they will not have to contend with the research and development of alternative energies due to the relative availability of oil while on the other hand biofuel producers will reconsider developing ethanol plant due the limited potential return on investment.

Table 3: The low oil price, low maize price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	4.5	-2.25	**1**	**-1**
	Low investment	2.5	-2.25	0	0

The low oil price / low maize price scenario benefits both parties as both face a situation of lower input costs. The biofuel producers will have weigh up their options

as a lower oil price means a lower price for the biofuel that they produce but a lower maize price means that they can gain from purchasing their inputs at a lower cost. In addition biofuel producers together with farmers will be looking to take advantage of a low maize price scenario, as an alternative off take market will need to be found for feedstock, in order to make it more profitable. At a low oil price, oil refiners will be reluctant to invest in alternative energy as they do not face an immediate shortage of oil. In a case in which they would invest in such an industry their total increased capacity would be kept lower than as is the case in section 4.1 and 4.2.

5.4 Low Oil Price, High Maize Price

The fourth nature scenario takes place in an environment where biofuel expansion does not seem to be an option due to the profitability of the industry. Low oil prices together with high maize prices put extra strain on the biofuel producers and in addition relieve any obligation that the oil refiners might have felt towards supporting such an industry.

Table 4: Low oil price, high maize price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	2.5	-2.25	**0**	**0**
	Low investment	1	-2.25	**0**	**0**

The low oil price / high maize price game has a set of two Nash Equilibria. In this instance the profit margin of the biofuel producer will be put under pressure as a high input cost together with a low output price, results in a lower overall profit margin. The BFP will therefore be tempted to only invest a little and also not invest at all if the oil refiners choose to not accept biofuels and expand capacity. In addition a low oil price scenario results in oil refineries not investing too heavily in research and development as sufficient supply and does not cause too much of a long term concern. The Nash Equilibrium is therefore at the point where there is not investment from oil refiners to increase capacity and a very low if any investment in additional biofuel capacity from the biofuel producers themselves. Interestingly enough this is an actual depiction of what has been occurring in the industry of late. The two role

players are strategically positioning themselves under the rules laid out by the government and under the current circumstances it seems that a rejection of additional capacity together with low individual small scale investment in biofuel production is the order of the day.

5.5 Discussion of the game

It seems that the industry, with its current structure, shows that players have no desire to work together in achieving a common outcome but would rather settle for strategies which result in little or no biofuel production in the form of transport fuels for the local market. Instead producers are opting to either focus their production on the export market or to be innovative in their approaches and target markets other than the one for renewable transport fuels. One would expect that if the economics of a scenario make sense, oil refiners would accept a high cost in order to create a sustainable strategy for future development. In short, it is perhaps not the economics of blending biofuels into the current mix that result in oil refineries leaning away from production but rather the rules of the game the govern their role as well as the controlled and oligopolistic structure that the oil refiners have in the industry. Changes in the rules of the game, such as the enforcement of a mandate, would alter their payoff structure as a non compliance with legislation and could see refiners facing even higher costs. The following section takes the Z variable as discussed in Chapter 3 into account as part of the explanation as to why the producers are currently not engaging the industry with high value investments. The inclusion of this variable in the payoff structure of the biofuel producers should represent their actions more clearly.

Apart from the changes in the rules of the game, a change in the structure of the industry could perhaps also alter the way in which they perceive the direct costs that they incur in expanding their capacity. The following section explores the possibility of vertical integration with the help of previously researched literature in this specific context.

6. The Game – new version

The outcome from the simple version of the game in section 5 of this chapter is not completely suited to represent what is actually happening in the South African biofuels industry. In order to make the game more realistic the simple version of the

game has been slightly adapted in order to make it more realistic, slightly more complex and more representative.

In order for a company to start producing biofuels in South Africa it needs to comply with a number of licensing criteria. The criteria are rather stringent and state that: “All biofuel manufacturers, including pilot projects, are required to apply for manufacturing licenses. Those manufacturing for own use will have to register with the Petroleum Controller and provide annual statistics on what crops they are utilising, production capacity and detailed information of what the products are used for”. The licensing criteria add various other requirements such as the environmental impact of crops used, the use of feedstock produced under irrigation, the type of crops that may be utilised, restrictions on imports of feedstock, from whom the feedstock must be sourced with emerging farmers taking precedent over the market, the standards to be obtained by biofuel producers as well as proof of off take agreements between biofuel producers and oil companies which need to be submitted (DME, 2007).

The criteria mentioned above therefore set the scene for a market in which a number of costs of monetary and institutional value, have to be incurred prior to the start of the production process. In other words, a number of criteria need to be fulfilled and adhered to before the manufacturer can start with the production process. The σ variable also partly captures the cost of compliance criteria of the government strategy as the lack of good information available in the legislation drafting process has resulted in strict and unrealistic criteria being brought in as part of the regulation. The total cost of compliance, represented by variable σ, therefore includes the governmental cost of compliance factor as well as the cost of other criteria that need to be adhered to in order to register as a biofuel manufacturer. Now taking the current payoff structure into account, the biofuel manufacturer derives a payoff from the following formula,

$$BFCAP = \alpha P_{ET} + (\beta(f)/2) - \theta(M) + \sigma$$

The current biofuel policy shows that the governmental compliance costs of becoming a biofuels manufacturer are far higher if the owner is planning to invest in a larger production plant than if he were to only invest in a very small scale plant for private consumption. The South African Revenue Service, for example, allows for a

100% exemption for small biodiesel producers, producing less than 300 m^3 or 300 000 litres per annum (DME, 2007). The σ variable therefore needs to have a different relative value depending on the choices that the biofuel manufacturer is making in terms of the investments and also in terms of the market that he is attempting to access.

$$\sigma = \Pi ethanol_{\exp orts} - CoC_{includingZ} + \Pi ethanol_{non-transport}$$

Where, $\pi_{ethanol\ exports}$ represents that profits that are made from supplying an international market with the biofuel commodity, such as for example the European Union, while the $CoC_{including\ Z}$ represents the cost of compliance with the governmental licensing procedure and this includes Z, as well as other costs that the biofuel producers are incurring, including risks related to higher value investments. $\pi_{ethanol\ non-transport}$ represents the profit that is made from following an innovative approach and converting the biofuel product into a more processed item such as ethanol gel for heating and cooking purposes. The value of σ will change depending on the actions taken by the oil companies and ultimately on the government legislation.

6.1 High oil, low maize price

The first game includes a scenario in which the oil price is high and the maize price is low. Higher profits would dictate larger investments in the long rung and in theory this would be the investment strategy that the biofuel industry would follow. On the other hand the oil refineries are expected to be rather indifferent to the situation, depending on the government strategy imposed.

Table 5: High oil price, low maize price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	1.5	-4.5	5.5	-1
	Low investment	0	-4.5	**6**	**0**

Under this scenario that payoffs for biofuel producers are far higher if the oil refineries reject any commitment to the programme as they are forced to be

innovative and in so doing either see a future in the export market but would then rather follow a high investment strategy or alternatively and more likely keep a low key and focus on a different market serving different products, such as the paraffin market. The Nash Equilibrium would therefore include a low investment strategy by the biofuel producers together with a rejection of the biofuel programme by the oil refiners.

6.2 High oil price, high maize price

The second game includes a scenario in which high oil prices and high maize prices dominate the industry. This results in lower profit margin in the local market, especially in the transport fuel sector and as a result biofuel manufacturers focus on other markets where profits are expected to be higher. This includes markets such as the EU and others which are not transport related, such as the paraffin market. With σ taken into account, the payoff structure of the biofuel manufacturer changes and so to does his strategy.

Table 6: High oil price, high maize price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	-0.5	-2.25	4	-1
	Low investment	0	-2.25	**6**	**0**

In this game the Nash Equilibrium is found at a low investment for biofuel producers and a non commitment from local oil refiners. The less profitable macro environment for biofuel production impacts severely on the investments made by the biofuel industry and perhaps even more so under a commitment from the oil refiners than in a situation where the oil refiners are not committed. Under the NE biofuel producers make better returns by focussing on the production of alternative products as well as the production of biofuels for other markets and hence the greater payoffs.

6.3 Low oil price, low maize price

Low oil and low maize prices have an interesting effect on the payoff structure of the biofuel producers. The theory shows that biofuel producers will be indifferent to

investing large amounts of capital or lower amounts of capital as their payoffs after taking the cost of compliance into account will be similar. The Nash Equilibrium does however fall into the same strategy as the previous game with biofuel producers opting to produce either for the export or alternative use market.

Table 7: Low oil price, low maize price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	1.5	-2.25	4	-1
	Low investment	1.5	-2.25	**6**	**0**

The oil producers seem to have a dominant strategy in that their lowest costs or highest payoffs that they incur are related to rejecting any involvement in terms of blending biofuels. It therefore does not matter what they do or what strategy they follow or for that matter which strategy the biofuel producers follow, the oil refiners will always choose not to get involved with the blending of biofuels.

6.4 Low oil price, high maize price

The low oil price, high maize price scenario offers the lowest returns to biofuel producers. Paying a high cost for inputs and receiving a relatively low return affects profitability and in turn influences long term sustainability. Longer periods of such price relationship may result in biofuel producers opting not to produce at all and therefore close down the factories or alternatively look for commodities other than the ones used originally in the production process.

Table 8: Low oil price, high maize price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	-0.5	-2.25	3	0
	Low investment	0	-2.25	**6**	**0**

The low oil price and high maize price scenario offers biofuel producers virtually no payoffs in the transport fuel sector. Returns from investing in alternative markets such as exports are profitable but with the low oil price returns are also limited. The most profitable option under this scenario is to invest in markets that are not directly related to transport but rather to other uses.

7. Implications, Conclusions and Limitations

Game theory and game theoretic models do have their limitations. It is the aim of this analysis to capture the interaction of the players in the industry and thereby explain their behaviour. The model and the model assumptions capture the essential features of the interaction between the players rather well. A drawback is that the magnitudes of the payoffs were estimated based on theory and do not specifically represent true costs as these are in any case very difficult to quantify in an industry that has barely been established. A further critique of the model is that the variable σ could be far greater and more complex than anticipated here meaning that the impact of the additional government costs included within the σ coefficient could have a far greater impact on the industry than what has been captured here. The game theoretic approach does however provide a good tool when it comes to developing a framework which captures actions and strategies of role players in the industry.

It seems that relations amongst stakeholders in the biofuel industry are as important to its success as are the economics governing it. The “rules of the game” that have been laid down to govern this industry do not only impact on how the industry develops but have an impact on how the various players within the industry see their chances of success and hence line up their strategies.

The game in which the oil refiners and biofuel producers size up against each other, given the strategies of the nature player, indicates that the losses, at least in the first period are unacceptable to the oil refiners. This is especially true under the circumstances in which the oil price is high and the maize price is low, resulting in maximum profit for biofuel producers, compared to the extremely high costs incurred by the oil refiners. The Nash Equilibria are constantly reached under circumstances where the biofuel producer would like to follow a high investment strategy and the oil refineries reject any voluntary form of involvement with the industry. In fact, under the first game the oil refiners had a dominant strategy which meant that they did not want to invest in biofuels regardless of the strategy that the biofuel producer sought. In the

more complicated version of the game the strategy of the oil refiners remained the same as policies for them did not change, biofuel producers also changed their strategies as they opted for lower investment strategies due to the complications associated with the CoC variable. One important fact is that the game takes place assuming that both parties, the biofuel producers and oil refiners, are independent entities.

Table 9: Summary of the different games

Scenario	Game: Theoretic				Game: Current situation			
	BF producer		Oil company		BF producer		Oil company	
High Oil, Low Maize	2.5	HI	-1	R	6	LI	0	R
High Oil, High Maize	1	HI	-1	R	6	LI	0	R
Low Oil, Low Maize	1	HI	-1	R	6	LI	0	R
Low Oil, High Maize	0,0	HI,LI	0,0	R,R	6	LI	0	R

Legend: HI = High Investment, LI = Low investment, R = Rejection of the biofuel initiative, A = Acceptance of the biofuel initiative.

Table 9 indicates the various Nash Equilibria that have been achieved in the different scenarios and different versions of the game. Within the framework of the theoretic game the NE indicate that the biofuel producers would like to invest significant amounts into the industry in order to achieve financial and strategic success. The payoffs vary according to the scenarios and profits that can be achieved under various scenarios with a high oil / low maize price resulting in greater profits than a scenario in which the oil price is low and the maize price high. The payoffs for the oil companies are always negative and hence it is not in their interest to invest in the industry. Their respective payoffs do not necessarily differ under different scenarios as there are no financial advantages to be drawn from the situation. The inclusion of σ in the game changes the structure of the payoffs completely. Due to the 'greater' profits that can be made from alternative markets, such as exports and non transport fuel derivatives, biofuel producers choose lower investments in the industry, which in turn result in higher payoff structures. The current policy framework that is in place does not make provision for any mandate and hence oil companies still choose to reject the biofuel initiative as non involvement in the industry is their best and cheapest strategy.

To conclude, it seems that the Industrial Biofuels Strategy, as laid out by the South African Department of Minerals and Energy, does not provide the oil refiners with enough incentive to fully support the uptake of biofuels. Taken this fact into account there seems to be an opportunity for local producers to participate in the international

market, given the differences in costs of production and prices in both local and international context (BFAP, 2008). Locally it does however seem clear that the proposed cost to benefit ratio does not offer enough of an incentive and hence, the oil producers are better off not accepting the fuel into their operations and this is especially true in the current context. Changes in policies together with changes in the structure of the biofuel supply chain are definitely required to have a positive impact on the use of biofuels in South Africa.

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