STOCHASTIC RISK ASSESSMENT OF BIO-COMPONENTS INSTALLATION

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Abstract

The paper describes a refinery going through organizational changes. The refinery produces many kinds of fuels and oils but some installations are used only in a small percentage; the plants also employ too much staff. In order to improve the company's performance several investment proposals are being considered. The article presents economic model of a bio-components plants investment and its stochastic equivalent. Based on the Monte Carlo simulation the Net Present Value and Profitability Index were calculated. Two economic models were prepared: deterministic and stochastic. It was found that discrete model is excessively optimistic. The promising profit of nearly 19,000 PLN calculated assuming the most probable values of the variables has only 30% chance of materialization. There is also equal chance of the investment failure. Based on the simulation results there is no grounds for general change from crude oil processing to bio-components production due to low profitability of the installation.

Key words: risk management, economics of engineering, quantitative methods & models, technology management

JEL Code: G32, D81

Introduction

By 2020, European Union rules and regulations impose biofuels consumption on the level of 10% (Directive 2003/30/EC). Each country can choose the most cost-effective implementation of these provisions. In Poland this aim will be covered in 90% by use of biofuels which include bioethanol, biodiesel and biogas. In the years 2007-2013 the biodiesel production in Poland increased 15 times; bioethanol production increased by 30%.Biogas production was insignificant, while biodiesel consumption was equal to 75% of whole biofuel usage (Skudlarski et. al., 2014).Despite of this significant production grow in Poland, Europe's biodiesel consumption for transport purposes decreased by 6.8% since 2013 (Biofuel Barometer, 2014).Regardless of the economic fluctuations, Polish refineries must consider new investments in biofuel plants. Polish refineries are obliged to add a specific amount of biofuels to all fuels sold. It is compulsory for each manufacturer to achieve National Indicative Target which amounts to 7.1%biofuels share in 2015; otherwise the penalties will be imposed on the entrepreneurs (The Polish Ministry Council’s Regulation, 2013).

The subject of the paper is to present a Polish refinery which faces a significant organizational change. Presented information results from a feasibility study aimed at new investment appraisal. The aim of the study is to present income and cost model using stochastic approach to independent variables parametrization.

The refinery produces different kinds of oils and fuels. Its additional activity is oil regeneration. The total production capacity amounts to 80,000 Mg of oils and 5,600 Mg of lubricants, however the current load is estimated to be 25-30% for oils and 20% for lubricants. The regeneration plants can purify 56,000 Mg of used oils but the installations are used in 40%. The oil processing plant is able to transform 95,000 Mg of crude oil and it‘s used in 100%.

The refinery ownsa lot of unnecessary assets, land and workforce. As a result of feasibility study more than 40% staff will be dissmissed, some installations will be dismantled and some land will be sold.The oil production and regeneration plants will be integrated with other Polish oil manufacturer and the part of the company responsible for fuel processing will be transformed into separate partnership. The new company will partly supply big customers, but the emphasis will be placed on small and medium ones, especially representing agri-food sector.The main products of new fuel partnership will be wholesale of other Polish manufacturers‘products, fuel storage, production of heating oiland biocomponents for biodiesel.Facing the need of adding the bio-components to fuels the new fuelcompany anticipate to make profit on new bio-component production. New investment is planned for 2016.

1 Research objectives

The objective of this paper is to present a profit and cost stochastic model of biofuel plants spun off from crude oil refinery. The model is a part of detail feasibility study of whole refinery which is about to be divided into several parts, one of them is biofuel processing plants. Originally the refinery did not produce bio-components, just processed crude oil. Now, besides storage and wholesale activities the refinery will predominantly produce Fatty Acid

Methyl Esters (FAME) from rapeseed oil. It will be a new product for the refinery. The main installations will be constructed from scratch; some crude oil installations will be adapted to FAME production.

The study takes into consideration only bio-components plants and the main objective is to assess if the FAME production will yield any profit. All cash flows presented in this study are shown in Polish currency (Polish Zloty, PLN), in net prices, at the time when the paper was prepared.

2 Methodology

In many cases even large companies use simple deterministic planning methods based on one business model with one set of values. Those kinds of models tend to perform badly when model variables are exposed to high uncertainty and complexity. Schoemaker suggests to identify relevant trends and uncertainties affecting the plan and develop different scenario models depending on various market conditions, however, scenarios are suitable for competitor analysis and strategic vision. At the operational level it is better to use Monte Carlo simulation (Schoemaker, 1991). There are a few papers in the literature on profitability scenario models regarding refineries. Vlysidis and others presented a techno-economic analysis of biodiesel bio-refineries. In economic evaluation part the authors took into consideration four investments scenarios. The refineries which were the subjects of the analysis were calculated from scratch as green field investments. In each case three main groups of costs were considered: land, working capital and investment costs. The first two terms remained the same in all scenarios while capital investment costs were fixed for each scenario and depended on the technology. Annual production costs were also directly affected by the technology. In all scenarios raw material, utility, disposal and some extra costs were considered. All scenarios were economically evaluated. The authors calculated widely used general profitability criteria like Net Present Value (NPV), Internal Rate of Return (IRR), Return On Investment (ROI), Discounted Payback Period (DPP) and Gross Margin. The aim of the study was to choose the best technology with maximum amount of the NPV and minimum amount of water flowrate and cycle time. The authors found global optimum. Based on the deterministic costs the best technology was chosen.(Vlysidiset.al., 2011). Similarly Randelli presented an analysis of biofuel production costs using scenario approach (Randelli,2009). Giampietro and Ulgiati used different discrete scenarios to assess the impact of various biofuel amounts on fuels usefulness. Scenario analysis may indicate the most important elements of the plan but recently stochastic approach is more widely used for enterprise strategy and profit assessment. The latter is sensitive to random changes of materials and equipment prices, demand fluctuations and changes in the level of employment (Khor, Elkamel et al., 2008; Khor, Nguyen, 2009; Mirkhani, Saboohi,2012). Hahnand Cecot used Monte Carlo simulation to assess benefits and costs of bioethanol production (Hahn, Cecot, 2009). Simonton provides detail stochastic analysis of manufacturing vegetable oil for biodiesel (Simonton et.al., 2011). The authors presented stochastic cost model of bio-refinery. The model was prepared to check cost feasibility of cottonseed biodiesel production; the costs of manufacturing, logistics and raw materials were taken into account. Probability distributions were assigned to several input variables. The authors used Monte Carlo simulation to assess whole manufacturing costs and refinery profitability and sensitivity analysis to evaluate key elements that determine profitability of new refinery. In the present paper the similar approach was used.

The financial model presented in this paper consists of a lot of confidential facts. In order to protect company's data only illustrative information was presented. The model took into consideration: the forecast of fundamental macroeconomic data such as inflation, currency rates, labor cost, loans costs and interest rates, utilities costs, capital cost, material costs, transportation cost, direct and indirect cost, overhead cost, revenue forecast, cost related to loans.

The refinery considers several investment projects allowing for diversification of the company's core business. One of them is rapeseed processing installation for bio-components for biodiesel. Its construction will last 14 months and will be finished by the end of 2017. A production start is planned on year 2018. Since the beginning of installation's operation the target production volume will be reached. The total investment cost is 21,700 PLN and it will rely on borrowed funds. The refinery plans to borrow 14,700 PLN from National Fund for Environmental Protection and Water Management, at an interest rate of 3.3%. They are also going to take the bank loan of 7,000 PLN at the 6.5% interest rate. Additionally some existing installations and storage tanks should be improved. The total cost of all investment is presented in the table 1.To assess profitability of bio-components plants investment only this installation will be considered.

Tab. 1: Costs associated with bio-refinery investment. All values are given in PLN

Type of cost	2016	2017	2018	2019	2020	2021	2022	2023
Investment costs, in 1000 PLN	23,578	2,059	2,822	1,796	120	120	123	123
Reconstruction and restoration costs, in 1000 PLN	560	825	1,089	124	1,553	1,996	2,623	2,623
Total costs, in 1000 PLN	**24,138**	**2,884**	**3,911**	**1,919**	**1,674**	**2,116**	**2,745**	**2,745**

Source: Authors' own research

The products of the new refinery partnership will be gasoline fractions, diesel fuel, heating oil, methyl esters, fatty acids, technical grade glycerin, sodium sulfate, fuel storage as well as sales for external customers. The main products of new biofuel plants will be technical grade glycerin and FAME. The products and incomes of new installation during the years 2016 – 2023 are presented in the table 2. Taking into account discrete data presented in tables 1 and 2 Profitability Indexes (PI) of bio-refinery plants are equal: NPV = 18,992.61PLN; PI = 1.41.

Tab. 2: Incomes associated with bio-refinery investment

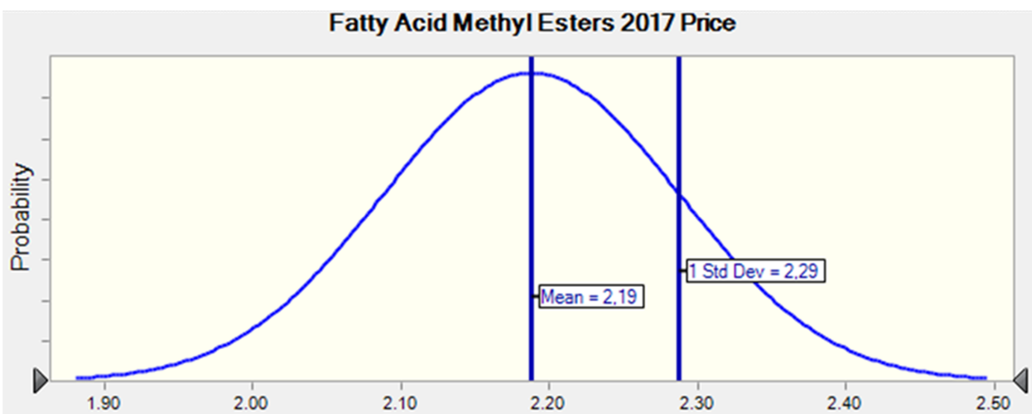
Type of product	2016	2017	2018	2019	2020	2021	2022	2023
Fatty Acid Methyl Esters (FAME)								
Quantity, Mg	0	0	42,000	42,000	42,000	42,000	42,000	42,000
Price, PLN	2.13	2.17	2.19	2.21	2.22	2.24	2.25	2.27
Bio-components income, in 1000 PLN	**0**	**0**	**91,883**	**92,618**	**93, 313**	**93,966**	**94,577**	**95,144**
Technical Grade Glycerin (TGG)								
Quantity, Mg	0	0	3,969	3,969	3,969	3,969	3,969	3,969
Price, PLN	0.51	0.52	0.52	0.53	0.53	0.53	0.54	0.54
TGG income, in 1000 PLN	**0**	**0**	**2,076**	**2,092**	**2,108**	**2,123**	**2,136**	**2,149**
Sodium sulfate								
Quantity, Mg	0	0	840	840	840	840	840	840
Price, PLN	0.75	0.76	0.77	0.78	0.78	0.79	0.79	0.80
Total Amount, in 1000 PLN	**0**	**0**	**646**	**651**	**656**	**660**	**665**	**669**
Fatty Acids								
Quantity, Mg	0	0	125	125	125	125	125	125
Price, PLN	0.64	0.65	0.65	0.66	0.66	0.67	0.67	0.67
Fatty Acids income, in 1000 PLN	**0**	**0**	**81**	**82**	**82**	**83**	**83**	**84**
Total Income, in 1000 PLN	**0**	**0**	**94,687**	**95,444**	**96,160**	**96,833**	**97,462**	**98,047**

Source: Authors' own research

In order to perform a stochastic analysis of the new investment Monte Carlo simulation was used (Jim´Enez, 2005, Willis, Minden, and Snyder, 1969).Probability distributions were assigned to many variables which values vary depending on external conditions. Distribution parameters were selected based on an analysis of market data and on expert judgement. In figures 1 and 2 two exemplary distributions are presented. Figure 1 shows the distribution for FAME price for year 2017. In the model it was necessary to assume discount rate. Figure 2 shows discount rate distribution which has the characteristics of normal distribution with mean 6% and standard deviation 5%. The significant feature is that the distribution is truncated due to the fact that the discount rate on the market is never lower than 3%.

The base financial model was performed in Microsoft Excel. Additionally Oracle Crystal Ball Decision Optimizer was used as a Monte Carlo simulation software.

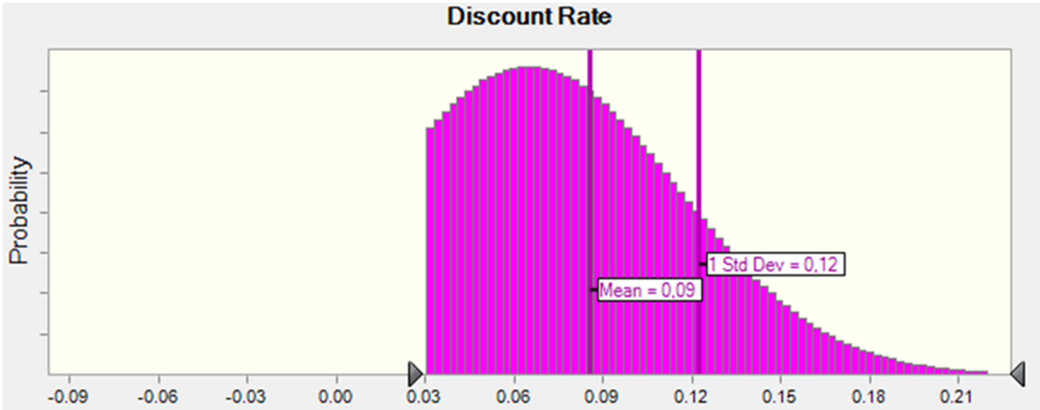
Fig. 1: The assumption of the distribution of Fatty Acids Methyl Esters price in year 2017. Distribution parameters: type: normal, mean value = 2.17 PLN, standard deviation = 0.1 PLN



Source: Authors‘ own research

Fig. 2: The assumption of the discount rate distribution.

Distribution parameters: type: normal, mean value of base distribution = 6%, standard deviation of base distribution = 5% PLN, truncation point: 3%



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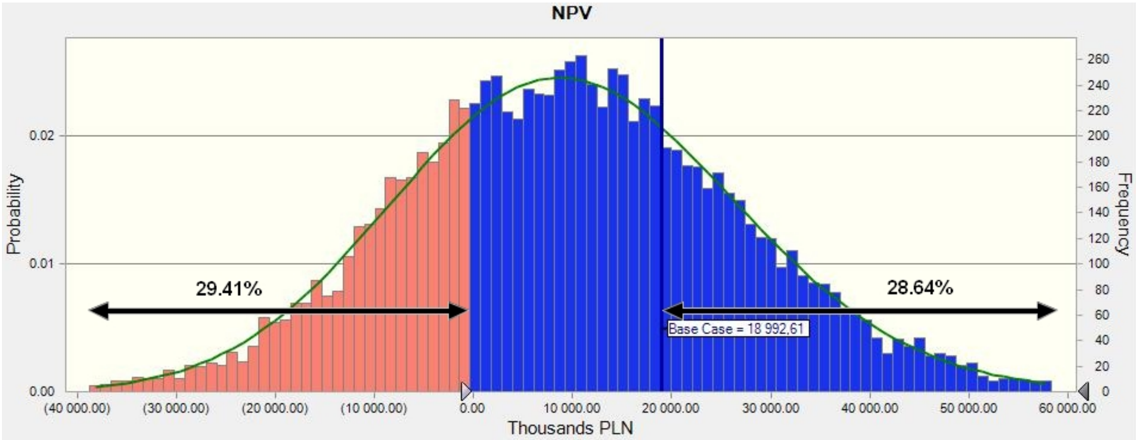
3 Results

The Crystal Ball economic model of the refinery allows the user to perform a "what if" and sensitivity analyses. In each simulation the values of input variables were drawn according to the distributions characteristics and during the calculations output variables distribution were found. Two main results were computed: NPV and PI values.

The probability of achieving NPV calculated in discrete model (base case) is only 28%. There is also 30% chance that the investment will generate losses. The results of the simulation are shown in figure 3. The lognormal distribution was fitted to the simulation results. The fitted distribution parameters: location: 402,337.05; mean value: 9,770.31; standard deviation: 17,350.34. Goodness of Fit parameter calculated using Anderson-Darling method equals 0.8261. This distribution may be used in further simulations. The similar calculations were performed for the Profitability Index. The distribution is presented in figure 4. There is 2% chance that the project will not be profitable, there is almost 55% probability of achieving profitability of average bank deposits and only 29% chance to achieve the PI value calculated by discrete model (base case).

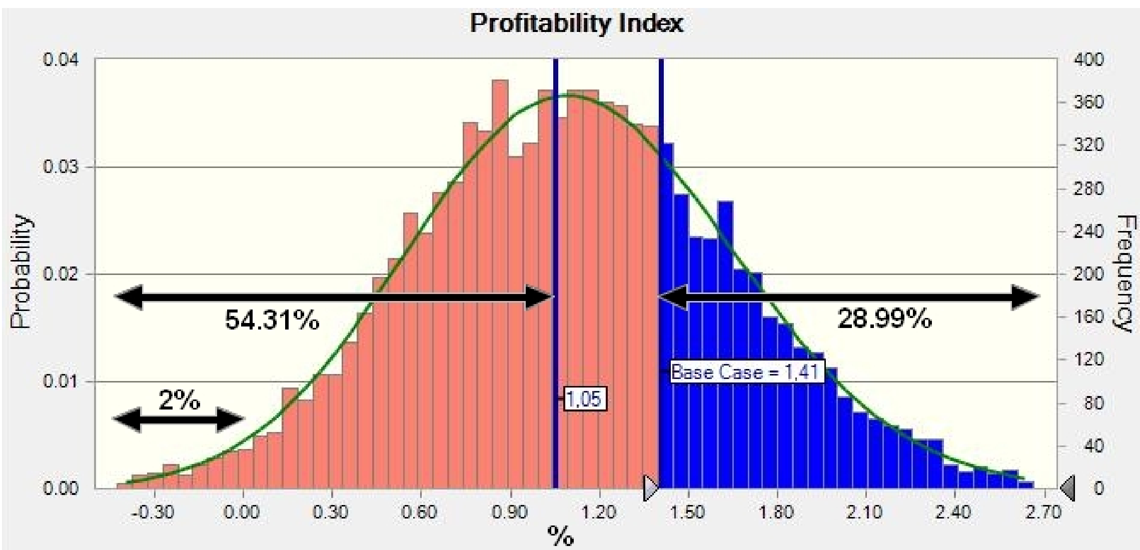
Sensitivity analysis showed that NPV is most sensitive to rapeseed oil price, other raw material prices, variable costs and discount rate.

Fig. 3: Probability distribution of Net Present Value



Source: Authors' own research

Fig. 4: Probability distribution of Profitability Index value



Source: Authors' own research

Conclusion

It was found that the refinery profitability calculated using the discrete model, is overly optimistic. In deterministic model the most probable values of input variables were taken into account, however the NPV = 18,992.61 PLN calculated by discrete model can be achieved in less than 30% of cases. With the same probability the refinery may incur losses. The most probable NPV determined through simulation equals about 10,000 PLN. The Monte Carlo simulation allows the user to make decision regarding investment start and operational management. Based on the simulation results it was decided that the new refinery cannot dispose of the crude oil processing. Even though the most probable investment Profitability

Index is almost equal to profitability of bank deposits, the NPV is too low and revenues from bio-components plants will be insufficient for the company. For these reasons the company will also carry out other activities.

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