



Sensitivity Analysis of Coal Mine Project Investment Using Fuzzy Model

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ABSTRAK

Analisis investasi perlu dilakukan untuk menentukan kelayakan suatu proyek dari sudut pandang ekonomi. Dalam penelitian ini, analisis investasi diterapkan pada proyek tambang batubara. Analisis yang dilakukan mempertimbangkan hasil NPV dan IRR. NPV adalah hasil pengurangan biaya yang didiskon (Khotimah & Sutiono, 2014). IRR merupakan tingkat bunga yang menunjukkan nilai bersih sekarang sama dengan jumlah total investasi (Pahlevi et al., 2014). Metode yang digunakan dalam analisis adalah metode konvensional dan metode *fuzzy*. Metode konvensional dilakukan dengan menggunakan rumus NPV dan IRR pada Ms.Excel sedangkan metode *fuzzy* menggunakan Matlab. Metode *fuzzy* yang digunakan yaitu *triangular fuzzy number*. Hasil analisis menggunakan metode konvensional menunjukkan nilai NPV sebesar \$14.900.691 atau setara dengan Rp 223 Milyar dengan nilai IRR sebesar 69,8%. Hasil analisis menggunakan metode *fuzzy* dengan fungsi keanggotaan *triangular fuzzy number* menunjukkan nilai NPV sebesar Rp 232 Milyar dan IRR 40,1%. Dari analisis dapat diketahui bahwa metode *fuzzy* mampu menghasilkan nilai NPV yang lebih besar dengan nilai IRR yang lebih kecil yang nilainya mendekati metode konvensional dengan variabel input yang sama. Jadi dapat disimpulkan bahwa metode *fuzzy* cukup baik diterapkan dalam analisis investasi dan dapat membantu untuk pengambilan keputusan akhir suatu proyek.

Kata Kunci : NPV, Fuzzy, Batubara

ABSTRACT

Investment analysis needs to be done to determine the feasibility of a project from an economic perspective. In this research, an investment analysis were applied in a coal mine project. The analysis were considering the results of NPV and IRR. NPV is the result of subtracting discounted costs (Khotimah & Sutiono, 2014). IRR is an interest rate that shows the net present value is equal to the total amount of business investment (Pahlevi et al., 2014). The methods used in the analysis are the conventional method and the Fuzzy method. Conventional method is done by using NPV and IRR formula in Ms.Excel while Matlab for Fuzzy. The Fuzzy method apply a membership functions, namely triangular fuzzy number. The results of the analysis using conventional methods show an NPV value of \$ 14,900,691 or IDR 223 Million with an IRR value of 69.8%. The results of the analysis using the fuzzy method with triangular membership functions showed the NPV values of IDR 232 Million and IRR 40.1 %. From the analysis, it can be seen that the fuzzy method is able to produce a larger NPV but a smaller IRR value whose value is close to conventional methods with the same input variables. So it can be concluded that the fuzzy method is quite well applied in investment analysis and it can help for the final decision of a project.

Keywords : NPV, Fuzzy, Coal

I. INTRODUCTION

Indonesia included to the largest coal source in the world (the-3rd rank). According to data from BP's Statistical Review of World Energy 2021, It is about 562.5 million ton production in 2020. To explore coal's potential in the future, investment plans are needed. PT. XYZ is the company that will start opening a coal mining project in 2024. Investment is a sacrifice of resources made now with the aim of getting greater profits or benefits in the future (Brigham & Houston, 2006). Because the funds spent on investment are large, while the benefits will only be received in the future, there is always a risk (Farida, 2015).

In investment principles, what is considered as a profitable investment is the investment that provides the greatest returns. Conventionally, the financial feasibility of a project is evaluated based on economic - financial criteria with a ratio of benefits and costs (cost – benefit analysis), net present value (NPV), internal rate of return (IRR)

etc. In this research, the financial feasibility evaluation method used is net present value (NPV) and internal rate of return (IRR). The project evaluation tool is used considering the ease of application in providing an objective assessment of the future cash flows of a project whose value is expressed in the current/present time, so this method is most widely used in assessing the feasibility of a project (Kahraman, 2001).

Fuzzy Logic is a logic system developed by Lofti A. Zadeh. Fuzzy logic has a membership value that is between 0 and 1. If the membership value is close to 0 then the condition can be stated to be increasingly false and if the membership value is close to 1 then the condition can be stated to be increasingly true (Hellmann, 2001). In NPV and IRR there are variables that are uncertain, such as coal prices and Weight Average of Capital, this can influence investment decisions. These variables can be fuzzified through several membership functions contained in the fuzzy model, in this research Triangular Fuzzy Number is applied. Fuzzification is the stage of changing numerical variables (non-Fuzzy variables) into linguistic variables (Fuzzy variables) (Jang et al., 1997). From the background that has been explained, in this research fuzzification was carried out to quantify the value of an uncertain variable in a coal mine project investment.

II. METHODS

This research is carried out using a quantitative approach and descriptive methods. Descriptive method can explain the solutions for current problems based on data, by presenting, analyzing and interpreting them (Narbuko & Achmadi, 2005). The current problem is to calculated NPV and IRR. In this research we use several secondary data consists of:

- 1) Coal prices
- 2) Production targets
- 3) Cost of Capital
- 4) Production cost
- 5) General and administrative costs
- 6) WACC

The research flow diagram can be seen in Figure 1.

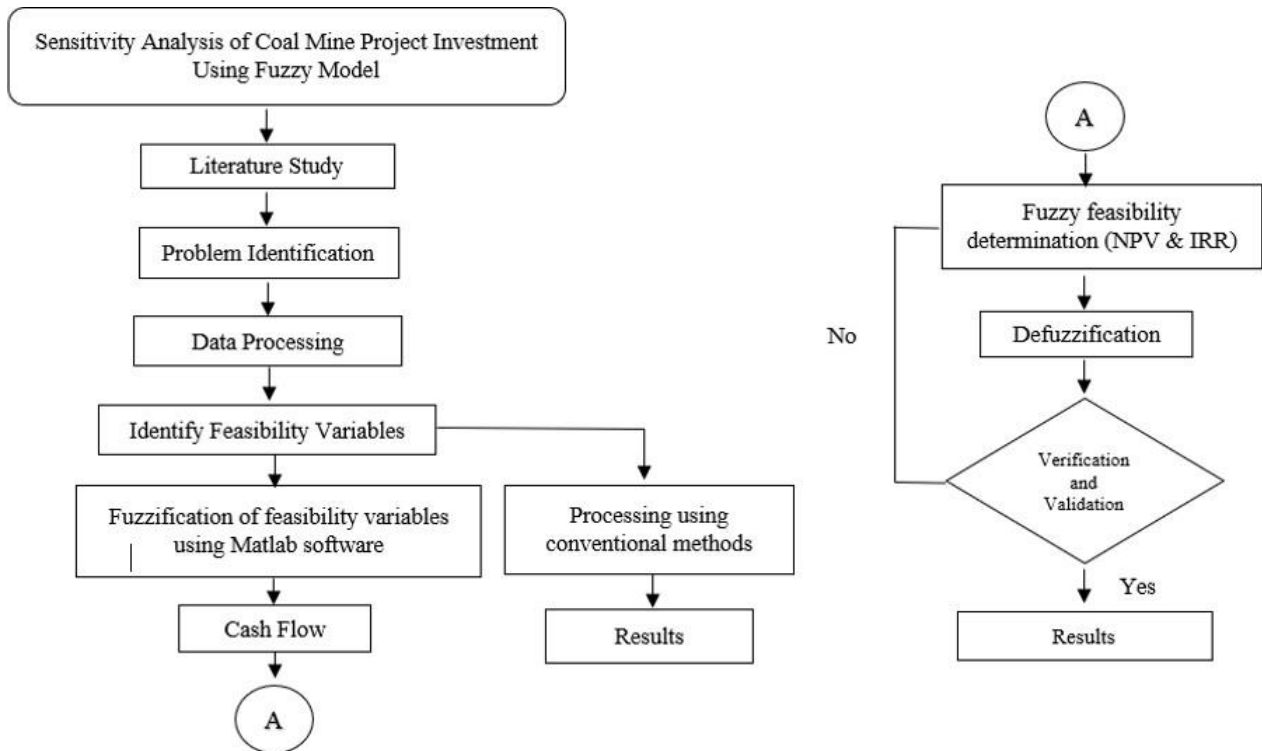


Figure 1. Research flow diagram

III. RESULTS AND DISCUSSION

3.1. Coal Price Analysis

In this research, price data was used which was taken from the ESDM Ministry's reference coal price data. The Formula to determine coal price is based on Ministerial Decree of ESDM Number 58.K/HK.02/MEM.B/2022. Coal prices have been adjusted to the number of calories and coal quality. The price of coal used in conventional method calculations is 34.71 \$/ton or the equivalent of IDR 520,640.62. As for the fuzzy selling price input method used with the help of Matlab, it can be seen in Table 1.

Table 1. Fuzzification of coal price

Coal Price Classification	Fuzzification	
	Range (USD)	TFN
High	50-80	(50;65;80)
Medium	30-60	(30;45;60)
Low	20-40	(20;30;40)

The results of inputting the coal price in Matlab can be seen in Figure 1.

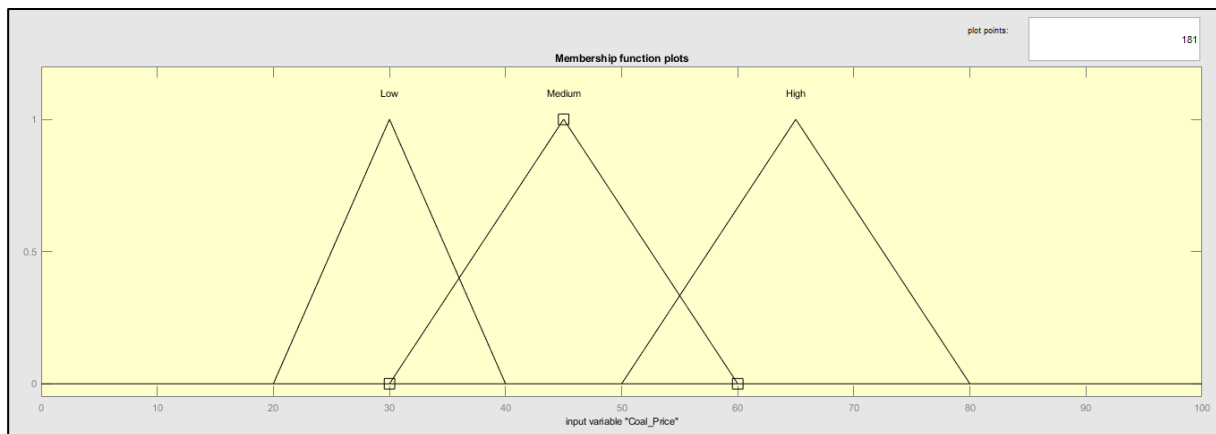


Figure 2. Triangular fuzzy number of coal price

The figure 2 forms a triangular graph which is a form of one of the fuzzy membership functions, namely a triangular fuzzy number where there is a lower limit, an upper limit and a middle value. All the value is created based on the coal price data that can be seen in the table classification.

3.2. Weight Average Cost of Capital (WACC) Analysis

WACC is average weighted from components such as cost of debt, shares preferred and ordinary equity (Brigham & Houston, 2006). The WACC used in conventional method is the result of the weight average cost of capital that was calculated using the following formula :

$$WACC = (E \times Re) + [(D \times Rd) \times (1-T)] \quad (1)$$

The data that were use to calculated WACC consist of E = Percentage to equity, Re = cost of equity, D = Percentage to Debt, Rd = cost of debt, T = tax rate. The data that were use can be seen in Table 2. The result of the WACC calculation is 15.51%.

Table 2. WACC data calculation

Cost of Equity		
Risk Free Rate	Rf	6.39%
Country Risk Premium	Rc	2.89%
Equity Beta	β	0.79
Equity Market Risk Premium	EMRP	7.89%
Percentage to Equity		100.00%
Cost of Debt		
Bank Debt Interest		8.05%
Percentage to Debt		0.00%
WACC		
Cost of Equity		15.51%
Cost of Debt		8.05%
WACC as Discount Rate		15.51%

Table 3. Fuzzification of WACC

WACC Classification	Fuzzification	
	Range (%)	TFN
High	20-50	(20;35;50)
Medium	15-22	(15;18.5;22)
Low	1-17	(0;8.5;17)

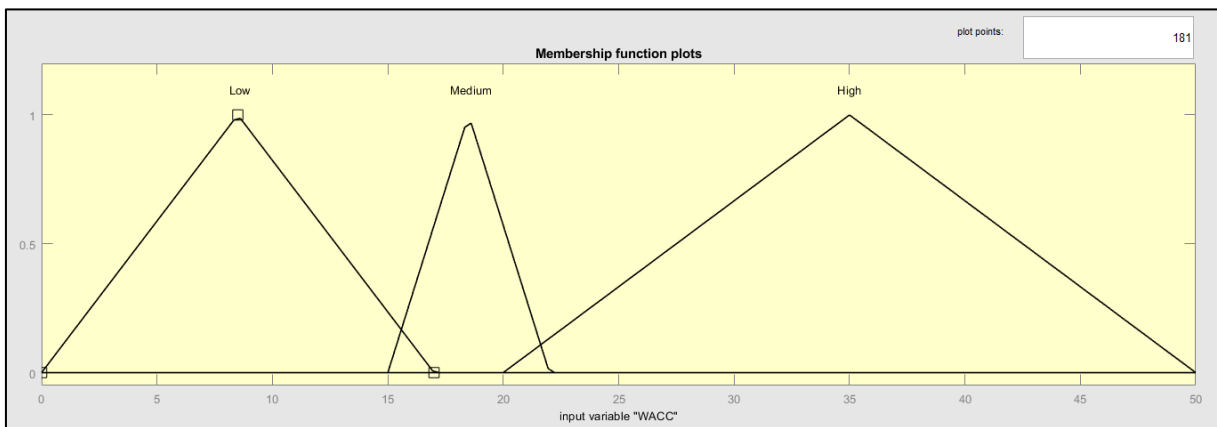


Figure 3. Triangular fuzzy number of WACC

WACC is the interest rate that determines the level of return on an investment that consist cost of equity and cost of debt (Kusumadewi & Purnomo, 2010). Classification of WACC can be seen in the Table 3.

3.3. Net Present Value (NPV) Calculation

NPV is one of the variables that determines the feasibility of a project investment. NPV is the result of subtracting discounted costs (Khotimah & Sutiono, 2014). In this analysis to calculate the NPV several data are used, they are total production, coal price, operating costs and other general costs. According to (Umar, 2013), Net present value used in conventional method can be calculated using the following formula :

$$NPV = \sum_{t=1}^n \frac{CF_t}{(1+i)^t} - I_0 \quad (2)$$

The interest rate that were use to replace *i* in the formula is WACC. The result of the NPV is calculated with the help of Ms.Excell. The result of the calculation is \$ 14,900,691 or IDR 223 Million which can be seen in Table 4.

Table 4. NPV Result Value using Ms.Excell

Period	0	1	2	3	4	5
Year		2024	2025	2026	2027	2028
Coal Production (ton)		500,000	720,000	720,000	720,000	720,000
Coal Price (\$/ton)		\$ 34.71	\$ 34.71	\$ 34.71	\$ 34.71	\$ 34.71
Gross income		\$ 17,354,687	\$ 24,990,750	\$ 24,990,750	\$ 24,990,750	\$ 24,990,750
Royalty	10%	\$ (1,735,469)	\$ (2,499,075)	\$ (2,499,075)	\$ (2,499,075)	\$ (2,499,075)
Income		\$ 15,619,219	\$ 22,491,675	\$ 22,491,675	\$ 22,491,675	\$ 22,491,675
Operating Cost						
Land Clearing		\$ (300,000)	\$ (317,760)	\$ (327,030)	\$ (336,571)	\$ (366,896)
Coal getting		\$ (650,496)	\$ (689,005)	\$ (709,106)	\$ (729,793)	\$ (795,548)
OB Removal		\$ (1,383,782)	\$ (1,424,153)	\$ (1,465,701)	\$ (1,508,462)	\$ (1,597,762)
Coal Hauling		\$ (547,008)	\$ (579,390)	\$ (596,294)	\$ (613,690)	\$ (668,984)
Processing		\$ (8,176)	\$ (8,660)	\$ (8,913)	\$ (9,173)	\$ (9,999)
Shipping		\$ (333,333.33)	\$ (353,066.42)	\$ (384,877.86)	\$ (431,795.67)	\$ (498,565.78)
Administration Cost Etc.						
Employee Salary		\$ (470,367)	\$ (498,212)	\$ (512,747)	\$ (527,706)	\$ (575,252)
CSR		\$ (33,333)	\$ (35,307)	\$ (36,337)	\$ (37,397)	\$ (40,766)
K3		\$ (20,000)	\$ (21,184)	\$ (14,535)	\$ (14,959)	\$ (15,395)
Enviromental		\$ (13,333)	\$ (10,916)	\$ (11,234)	\$ (11,562)	\$ (11,899)
Administration		\$ (10,000)	\$ (10,592)	\$ (10,901)	\$ (11,219)	\$ (12,230)
Catering		\$ (119,188)	\$ (122,665)	\$ (126,244)	\$ (129,927)	\$ (137,618)
Marketing		\$ (20,000)	\$ (21,184)	\$ (21,802)	\$ (22,438)	\$ (24,460)
Asurance		\$ (16,667)	\$ (17,653)	\$ (18,168)	\$ (18,698)	\$ (20,383)
Reclamation		\$ (74,212)	\$ (81,941)	\$ (103,989)	\$ (103,989)	\$ (103,989)
Post-Mining Guarantee		\$ (68,506)	\$ (72,561)	\$ (74,678)	\$ (76,857)	\$ (83,782)
Electric and water		\$ (10,000)	\$ (17,320)	\$ (17,825)	\$ (18,345)	\$ (19,998)
Maintenance		\$ (15,000)	\$ (15,888)	\$ (16,352)	\$ (16,829)	\$ (18,345)
Total operating cost		\$ (4,093,402)	\$ (4,297,458)	\$ (4,456,734)	\$ (4,619,410)	\$ (5,001,873)
Over Head Cost	2%	\$ (312,384)	\$ 449,833	\$ 449,833	\$ 449,833	\$ 449,833
Salvage value		\$ (2,470,869)	\$ (1,976,695)	\$ (1,581,356)	\$ (1,265,085)	\$ (1,012,068)
Depreciation		\$ (617,717)	\$ (494,174)	\$ (395,339)	\$ (316,271)	\$ (253,017)
Amortization		\$ (80,000)	\$ (80,000)	\$ (80,000)	\$ (80,000)	\$ (80,000)
Income before Tax		\$ 8,044,846	\$ 16,093,181	\$ 16,428,079	\$ 16,660,742	\$ 16,594,550

Period	0	1	2	3	4	5
Tax						
PP No. 37 Tahun 2018	25%	\$ (2,011,212)	\$ (4,023,295)	\$ (4,107,020)	\$ (4,165,185)	\$ (4,148,638)
Income after Tax		\$ 6,033,635	\$ 12,069,886	\$ 12,321,060	\$ 12,495,556	\$ 12,445,913
Depreciation		\$ (617,717)	\$ (494,174)	\$ (395,339)	\$ (316,271)	\$ (253,017)
Amortization		\$ (80,000)	\$ (80,000)	\$ (80,000)	\$ (80,000)	\$ (80,000)
Working Capital	\$ (1,023,350)					
Capital Costs	\$ (8,696,948)					
Cash Flow	\$ (9,720,298)	\$ 6,731,352	\$ 12,644,059	\$ 12,796,399	\$ 12,891,828	\$ 12,778,930
Cumulative Cash Flow	\$ (9,720,298)	\$ (2,988,946)	\$ 9,655,113	\$ 22,451,512	\$ 35,343,339	\$ 48,122,269
Discount rate	1	0.87	0.75	0.65	0.56	0.49
Present Value	\$ (9,720,298)	\$ 5,827,349	\$ 9,475,978	\$ 8,302,216	\$ 7,240,850	\$ 6,213,528
Payback Periode	\$ 2					
NPV	\$ 14,900,691					
IRR	69.8%					

The fuzzy method can calculated the NPV using the following rules which was simulated in the Matlab. The rules can be seen in the **Table 5**.

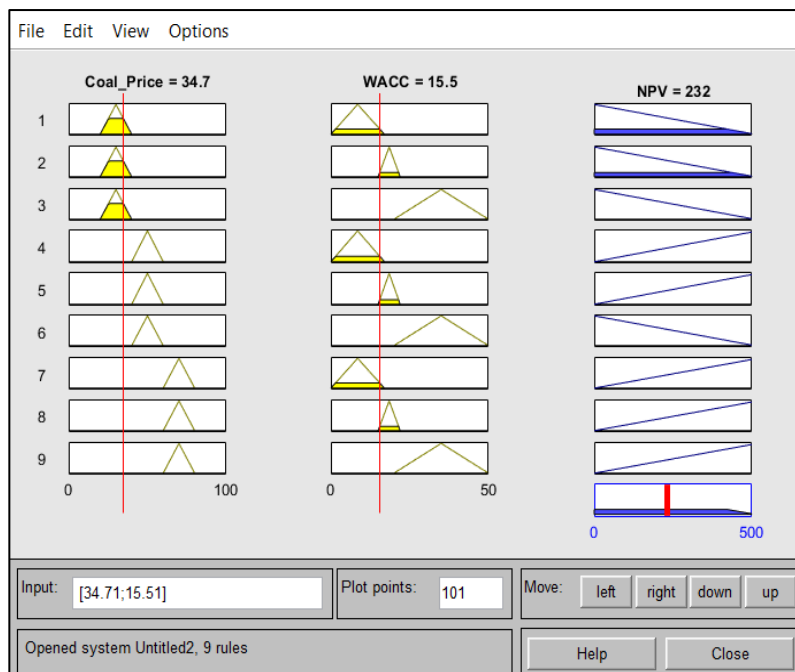


Figure 4. The Result of NPV simulation in Matlab

To calculate NPV in Matlab we can use the coal price and WACC as the input variable while NPV as the output variable. The result value of the simulation though is IDR 232 Million. The result based on the centroid method. From the Figure 4, we can conclude that the value of NPV in fuzzy model is larger than the conventional method.

Table 5. The rules of the NPV calculation

No	Coal Price	WACC	Ouput
1	Low	Low	IF "Coal Price" Low AND "WACC" Low THEN "NPV" is Down
2	Low	Medium	IF "Coal Price" Low AND "WACC" Medium THEN "NPV" is Down
3	Low	High	IF "Coal Price" Low AND "WACC" High THEN "NPV" is Down
4	Medium	Low	IF "Coal Price" Medium AND "WACC" Low THEN "NPV" is Up
5	Medium	Medium	IF "Coal Price" Medium AND "WACC" Medium THEN "NPV" is Up
6	Medium	High	IF "Coal Price" Medium AND "WACC" High THEN "NPV" is Down
7	High	Low	IF "Coal Price" High AND "WACC" Low THEN "NPV" is Up
8	High	Medium	IF "Coal Price" High AND "WACC" Medium THEN "NPV" is Up
9	High	High	IF "Coal Price" High ND "WACC" High THEN "NPV" is Up

3.4. Internal Rate of Return (IRR) Calculation

IRR is an interest rate that shows the net present value is equal to the total amount of business investment (Pahlevi et al., 2014). IRR is a method of depreciating the ranking of investment proposals using the rate of return on an investment, which is calculated by finding the discount rate that equates the present value of future cash inflows to the project costs according to (Brigham & Houston, 2006). In conventional method the result of IRR is 69.8% which can be seen in Table 4 . The result of IRR is calculated using the following formula.

i = Interest rate, which is the same with WACC. IRR can be simulated through matlab. The rules which were used to simulated can be seen in Table 6.

$$IRR = i1 + \frac{NPV1}{NPV1 - NPV2} \quad (3)$$

Table 6. The rules of the IRR calculation

No	Coal Price	WACC	Ouput
1	Low	Low	IF "Coal Price" Low AND "WACC" Low THEN "IRR" is Down
2	Low	Medium	IF "Coal Price" Low AND "WACC" Medium THEN "IRR" is Down
3	Low	High	IF "Coal Price" Low AND "WACC" High THEN "IRR" is Down
4	Medium	Low	IF "Coal Price" Medium AND "WACC" Low THEN "IRR" is Up
5	Medium	Medium	IF "Coal Price" Medium AND "WACC" Medium THEN "IRR" is Up
6	Medium	High	IF "Coal Price" Medium AND "WACC" High THEN "IRR" is Down
7	High	Low	IF "Coal Price" High AND "WACC" Low THEN "IRR" is Up
8	High	Medium	IF "Coal Price" High AND "WACC" Medium THEN "IRR" is Up
9	High	High	IF "Coal Price" High AND "WACC" High THEN "IRR" is Up

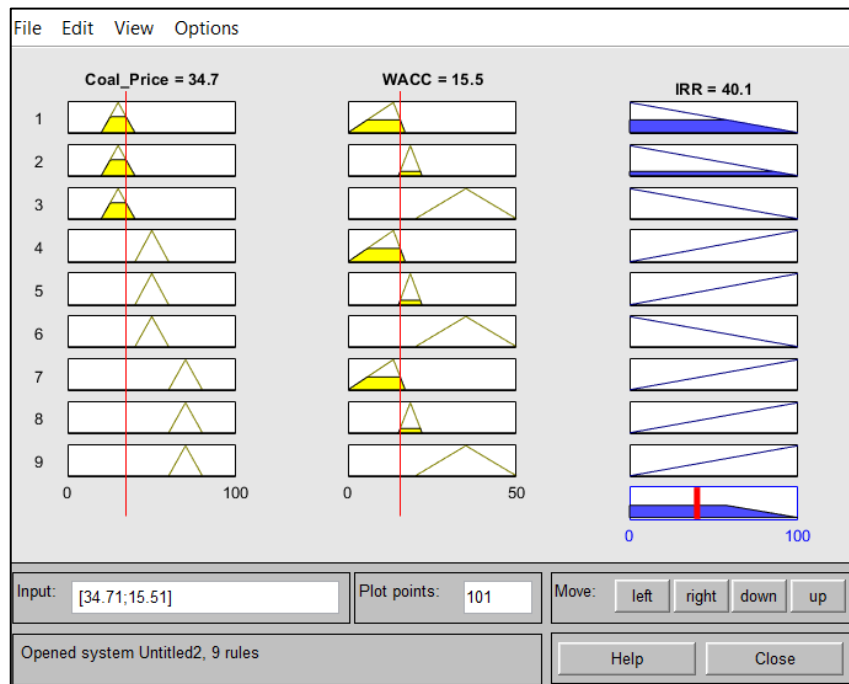


Figure 5. The result of IRR simulation in Matlab

From the figure 5. we can see that coal price and WACC as the input variabel can be simulated through matlab. The result of the simulation through Matlab is IRR as the output value. The result based on the centroid method in the matlab. The centroid method is a method where all fuzzy areas from the rule composition results are combined with the aim of forming optimal results and taking the center point of the fuzzy area. The centroid method determining the moment (integral of each membership function of the rule composition), the area, and the center point. The result value using fuzzy model is 40.1% which is smaller than conventional method.

IV. CONCLUSION

From the result of the analysis we can see that the investment of coal mine project is feasible according to the value of NPV and IRR. These two variable is important because it will influence the company decision. The results of the analysis using conventional methods show an NPV value of \$ 14,900,691 or IDR 223 Million with an IRR value of 69.8%. The results of the analysis using the fuzzy method with triangular membership functions showed the NPV values of IDR 232 Million and IRR 40.1 %. From the analysis, it can be seen that the fuzzy method is able to produce a larger NPV but a smaller IRR value whose value is close to conventional methods with the same input variables. So it can be concluded that the fuzzy method is quite well applied in investment analysis based on the NPV value which is larger than the conventional method. The result can help for the final decision of a coal mine project.

ACKNOWLEDGEMENTS

The authors gratefully acknowledgements to those who support the research, especially the lecture of mine engineer and faculty of technology mineral of UPN “Veteran” Yogyakarta.

REFERENCES

- Brigham, E. F., & Houston, J. F. (2006). Dasar-dasar manajemen keuangan.
- Farida, Y. (2015). Pengembangan Model Fuzzy Project Evaluation Untuk Analisis Kelayakan Finansial Pendirian Pabrik Baru. *Jurnal Matematika MANTIK*, 1(1), 22-30.
- Hellmann, M. (2001). Fuzzy logic introduction. *Université de Rennes*, 1(1).

- Jang, J. S. R., Sun, C. T., & Mizutani, E. (1997). Fuzzy inference systems. *Neuro-fuzzy and soft computing: a computational approach to learning and machine intelligence*, 73-91.
- Kahraman, C. (2001). Fuzzy versus probabilistic benefit/cost ratio analysis for public work projects. *International Journal of Applied Mathematics and Computer Science*, 11(3), 705-718.
- Karsak, E. E., & Tolga, E. (2001). Fuzzy multi-criteria decision-making procedure for evaluating advanced manufacturing system investments. *International journal of production economics*, 69(1), 49-64.
- Khotimah, H., & Sutiono, S. (2014). Analisis kelayakan finansial usaha budidaya bambu. *Jurnal ilmu kehutanan*, 8(1), 14-24.
- Kusumadewi, S., & Purnomo, H. (2010). Aplikasi Logika Fuzzy untuk pendukung keputusan. *Yogyakarta: Graha Ilmu*, 2.
- Narbuko, C., & Achmadi, A. (2005). Metode Penelitian. *Penerbit Bumi Aksara, Jakarta*.
- Pahlevi, R., Zakaria, W. A., & Kalsum, U. (2014). Analisis Kelayakan Usaha Agroindustri Kopi Luwak di Kecamatan Balik Bukit Kabupaten Lampung Barat. *Jurnal Ilmu-Ilmu Agribisnis*, 2(1), 48-55.
- Umar, H. (2013). Metode penelitian untuk skripsi dan tesis bisnis..