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Economic Analysis of Automatic Process Control for Peanut Oil Production by Payback Period Method

May Thida Than[1], Wunna Swe[2]
Maythidathan90@gmail.com, swethulay@gmail.com[2]
[1]Department of Electrical Power Engineering, Mandalay Technology University
[2]Department of Electrical Power Engineering, Mandalay Technology University

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Abstract

This study examined the production method and rate at a peanut oil production industry in Myingyan Township, Mandalay Region. The actual operation time for each machine was collected from this industry. According to the operation process of this industry, 75% of the workers engaged in peanut oil processing used the traditional technologies, which are labor-intensive and time-consuming. This paper presented a study on improving the production rate of peanut oil through the development and implementation of an automated process control system. To control and automate the production process, a programmable logic controller (Siemens S-7 1200) is used by a ladder logic diagram with TIA portal software. The conventional method produced 752 kg of peanut oil for one day, whereas 1127 kg of oil can be achieved by the automatic method. A detailed methodology for economic analysis of peanut oil production, involving the main variables that affect its profitability, was presented and tested by the payback period method. This method refers to the time it takes to recover the initial investment capital for a cloud project.

A. Introduction

Peanut is a widespread industrial oil crop, mainly cultivated in tropical and subtropical regions. Peanut seeds also include a good source of protein, different vitamins, and essential trace minerals. Peanut has 45 to 50 % oil content. To remove the oil content from the peanut seed, the process is known as oil extraction. It has light yellow, transparent edible oil with a pleasant fragrance and good taste. The peanut oil production industry is a large and highly developed business for the market economic system. The production rate can be improved to increase yield and profit. To maintain quality and reduce the expense, the production method is very important [3].

The technical factor is important for the peanut oil production, which can reduce costs and enhance productivity while simultaneously reducing dangers to workers operating them. If a firm decided to change the order of operations, it would turn out to be a major expense and a loss of production time until a system was functional again. Programmable logic controller is applied for the automated factories in plant control, such as the automation of production and assembly processes. The processes of the peanut oil production are controlled by Programmable Logic Controller (PLC) programmed in ladder diagram. The PLC control system can save valuable factory time and can improve the control system of the peanut oil production industry [8].

The production method is important for the economic feasibility, which can be evaluated by an economic analysis. It can perform with the main objectives of verifying all the project risks and minimizing investment failures. The method used for performing this analysis is the cash flow model, representing a balance of the amount of revenues and expenses of an investment during the lifetime of project, and indicating its feasibility by economic indices. There is a need for a joint analysis involving the main technical and economic parameters of this process. This work presents a detailed methodology for economic analysis of the automatic process control method, based on the cash flow model, which allows the evaluation of revenues and expenses by using the payback period method. [6].

B. Peanut Oil Production Process

The peanut oil production process involves machines that are developed to carry out sub-processing operations involved in traditional peanut oil extraction. These machines are; shelling, grading, drying, and pressing [1].

Shelling Process: The peanut shelling machine is a machine used to remove the shell of peanuts to obtain the peanut seeds [1].

Grading Process: The grading is the process of classification of a given product in terms of the stipulated categories. The grading machine can remove the impurity and unsound kernel of peanut seed [3].

Drying Process: After grading, the moisture content of peanuts is high and must be dried to prevent mildew. To reduce the moisture content of the material, the drying process can also be done mechanically with hot air flow in an enclosed space, which takes a shorter time [2].

Pressing Process: The peanut pressing process is developed to extract peanut oil from the just-shelled peanut seeds, such as cool press and screw press. Screw presses are reported to be more efficient than all other mechanical methods of oil extraction [3].

The peanut oil production process can be performed based on the convitional method and the automatic control method. The conventional method usually takes a long time and is affected by labor. The automatic process control system is made up of a group of electronic devices and equipment that provide stability, accuracy, and production rate.

1. Conventional Method

Generally, peanut oil extraction involves shelling the peanut pods, drying the peanut seeds and milling the cleaned peanut seeds. Among this method of oil extraction, 75% of labors in peanut processing used the conventional method which are labors intensive and time consuming [4]. In this production method, labors are involved at all stages of transportation process as shown in Figure 1. Labor sources and production rate are the most important factors in increasing productivity when producing peanut oil. The related processing equipment is out of design which results in the yields of low production rate and causes waste by using the traditional processing methods.

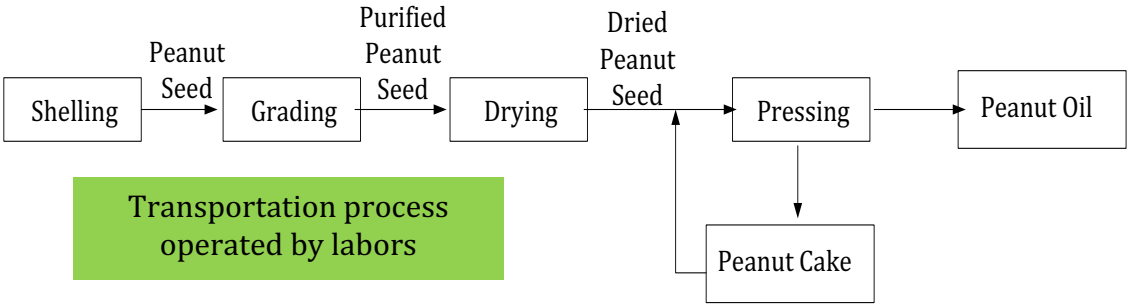

Figure 1. Peanut Oil Production by Conventional Method

2. Automatic Process Control

Programmable logic controller is used for the whole production system to operate the system and transport the material for the processing industry, as shown in Figure 2.

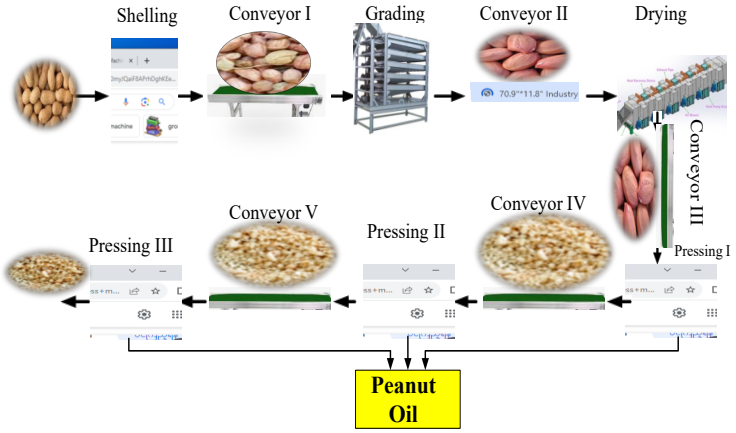

Figure 2. Peanut Oil Production by Automatic Process Control Method [6]

The automatic process controls the whole system to extract peanut oil for the processing industry. For materials transportation and warehousing, conveyor systems are durable and reliable. The peculiarities of a belt conveyor are easy and cheap to maintain. It has high loading and unloading capacity and can transport dense materials economically at very high efficiency over long distances [7]. It can also allow the relative movement of material.

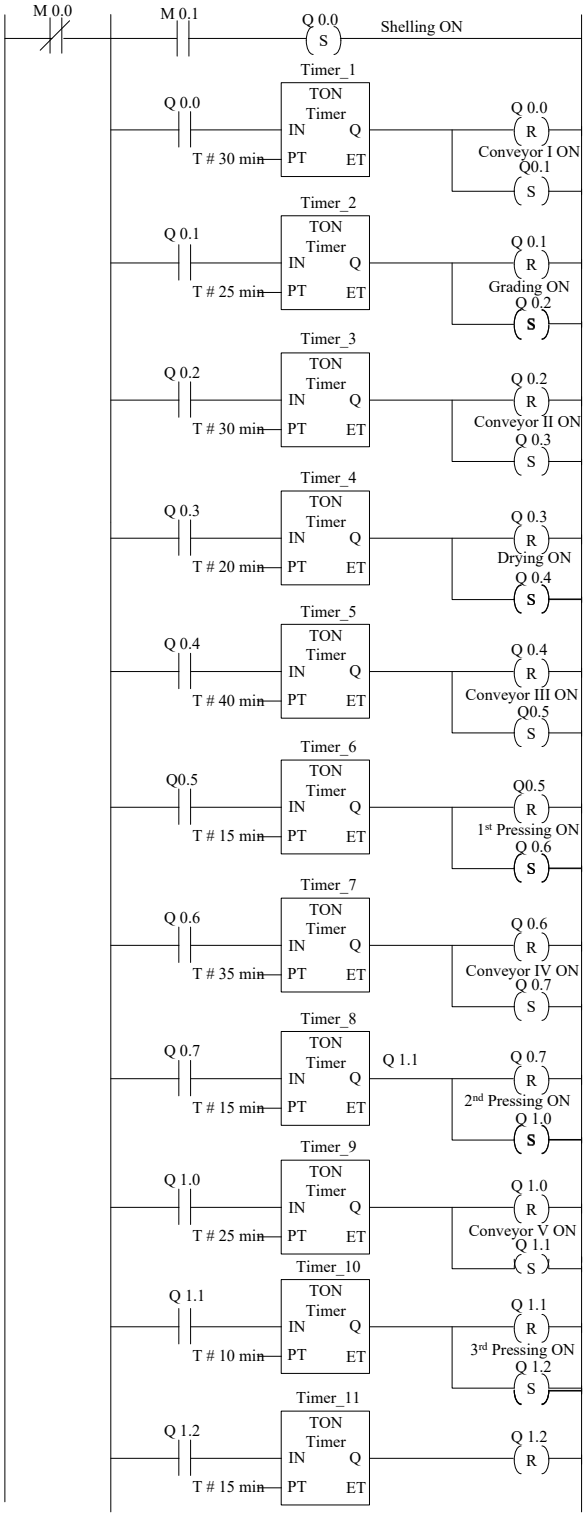

Figure 3. Programmable Ladder Diagram for Automatic Process Control Method

With program memory, PLC continuously monitors status of the system through signals from input devices. Based on the logic implementation, PLC determines which actions need to be executed with output instruments [9]. The operation sequence of automated peanut oil production consists of eleven processes. There are conveyor motors and four production porcess motor. Ladder diagram, input and output program notation of automatic process control of peanut oil production are described in Fig 3, Table 1 andTable 2 respectively.

Table 1. Input Program Notrtion of The Process

No.	Input Device	Description
1.	M0.1	Start push button
2.	M0.0	Stop Push button

Table 2. Output Program Notrtion of The Process

No.	Output Device	Description
1.	Q 0.0	Shelling Machine
2.	Q 0.1	Conveyor I motor
3.	Q 0.2	Grading machine
4.	Q 0.3	Conveyor II motor
5.	Q 0.4	Drying machine
6.	Q 0.5	Conveyor III motor
7.	Q 0.6	1st Pressing machine
8.	Q 0.7	Conveyor IV motor
9.	Q 1.0	2nd Pressing Machine
10.	Q 1.1	Conveyor V motor
11.	Q 1.2	3rd Pressing machine

C. Project Information

A detailed analysis is provided for the peanut oil manufacturing plant for the automatic process control method and the conventional method [9]. It encompasses all critical aspects necessary for peanut oil production, including the cost of peanut oil production, raw material requirements, utility requirements, infrastructure needs, machinery and technology requirements, and manpower requirements, as shown in Table 3.

Table 3. Received Data for Automatic Process Control Method and Conventional Method

Analysis Data per Day	Automatic Process Control Method	Conventional Method
Raw Material (kg)	4177	2784
Production Rate (kg)	1127	752
Labors requirement	1	15
Investment (kyats)	331,740,000	126,240,000

D. Economic Analysis

The production of the peanut and peanut-based material is a great demand for an industrial method that meets the needs of the producers and consumers. For economic analysis, the payback period is used to play a key role in testing and calculating the profit based on the net present value method [8].

Payback period is the time required for positive project cash flow to recover negative project cash flow from the acquisition and development years. Payback can be calculated from the start of a production or project. Payback period is commonly calculated based on discounted cash flow with a specified minimum rate of return. The intuition behind the payback period is to recover the invested money as quickly as possible. The payback period is the duration required to redeem the capital investment of the project. The payback period calculation is shown in Eq. 1.

$$\text{Payback period} = \frac{\text{Capital investnent}}{\text{Annual Cash flows}} \quad (1)$$

Economic analysis will offer information on the most effective and efficient investment alternative by comparing cost and benefit in a certain manner and also calculating the assumed risks. Net present value (NPV) is the difference between the present value of cash inflows and cash outflows over a period of time. NPV is used in capital budgeting and investment planning to analyze the profitability of a projected investment or project [10]. NPV is the result of calculating the current value of a future stream of payments using the proper discount rate. If there is one cash flow from a project that will be paid one year from now, then the calculation for the NPV of the project is as follows:

If a longer-term project with multiple cash flows is analyzed, then the formula for the NPV of the project is as follows:

$$\text{NPV} = \sum_{n=0}^{t} \frac{R_t}{(1+i)^t} - \text{initial investment} \quad (2)$$

where;

I = required return or discount rate
n = number of time period
Rt = net cash flow

In this case, risk is neutralized in the estimation of cash flows. The dispersion of the values of NPV can also calculate the overall risk of the project with standard deviation or dispersion coefficient [10].

$$\text{Deviation} = \frac{\text{Investment - Salvage value}}{\text{Time period}} \quad (3)$$

If the capital equipment will have a scrap value, the working capital should be recovered in full.

$$\text{PV for salvage value} = \frac{\text{Salvage value}}{(1+i)^t} \quad (4)$$

$$\text{PV for cash flow} = \sum_{n=0}^{t} \frac{R_t}{(1+i)^t} \quad (5)$$

E. Result and Discussion

The industry, with a cost of capital of 8%, has the opportunity to introduce a new product. The industry will be able to sell 1127 kg of peanut oil for 4177 kg of peanut kernels for each day. This paper calculates for the one year (314 days) at 8600 kyats per kg of oil. The machines cost 331,740,000 kyats with a salvage value of 10% of the investment. The cost of raw material for one kilogram of peanut kernel is 2750 kyats, and the running time per day is 8 hrs. The industry is in the 10% income tax bracket. The net present value per annum for the automatic process control of peanut oil is calculated for the annual shown in Table 4.

Table 4. NPV of Automatic Process Control Method for 1 Year Project Life

Revenue	3,683,220,000
Expense	3,611,628,000
Cash flow before tax (revenue -expense)	71,592,000
Depreciation	298,566,000
Taxable income (Cash flow before tax-depreciation)	-226,974,000
Income tax of 10 %	-22,697,400
After tax income	-204,276,600
Net cash flow after tax(Depreciation+after tax income)	94,289,400
PV for net cash flow	87,311,984
PV for salvage value	33,174,000
Total present value	118,028,651
Investment	331,740,000
Net Present Value	**-213,711,349**

In the traditional method, peanut oil is produced by isolated machines, and manpower is used. There is no investment for control and transportation processes. But it is involved in the labor cost. There are ten labors (8000 kyats for each). Their machine investment is 126,240,000 kyats. The industry will be able to sell 752 kg of peanut oil for 2784 kg of peanut kernels for one day. The net present value per annum for the traditional method is calculated for the annual shown in Table 5.

Table 5. NPV of Automatic Process Control Method and Conventional Method for 10 Year Project Life

Year	NPV for Automatic Process Control Method	NPV for Conventional Method
1	**-213,711,349**	**-85,188,762**
2	**-161,797,801**	**-69,009,031**
3	**-113,715,264**	**-54,024,313**
4	**-69,233,421**	**-40,163,652**
5	**-28,038,682**	**-27,328,574**
6	10,042,592	**-15,465,520**
7	45,258,647	**-4,496,710**
8	77,926,417	5,677,602
9	108,090,759	15,070,314
10	136,003,847	23,760,700

In Figure 4, the net present value of automatic process control and traditional method is shown for ten year project life. It can be seen that the NPV of the automatic process control method and the traditional method was negative at first. And then, NPV was positive for later years.

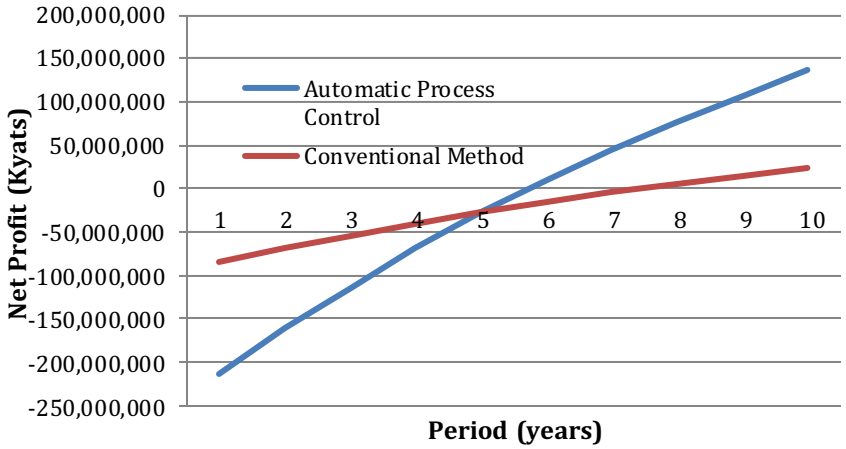

Figure 4. NPV of Automatic Process Control Method and Conventional Method for (1-10) Year Period

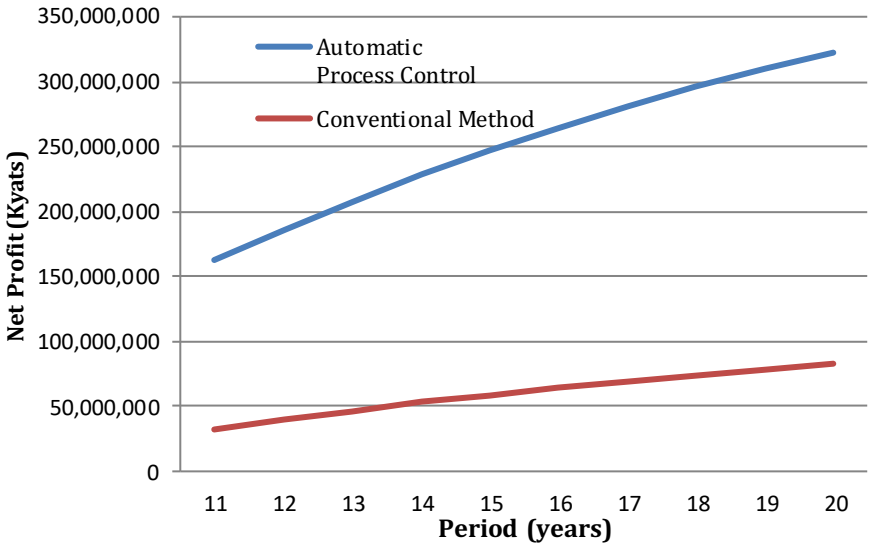

Figure 5. NPV of Automatic Process Control Method and Conventional Method for (11-20) Year Period

Figure 5 shows the comparison of the net present value of the automatic method and the traditional method for an (11-20) year project life. The net present value for the automatic process control method and the traditional method is compared for a (21-30) year project life as shown in Figure 6.

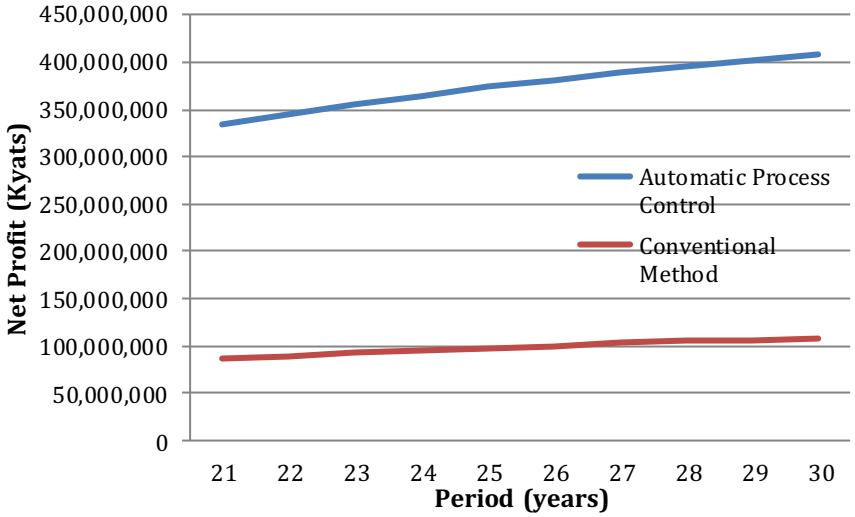

Figure 6. NPV of Automatic Process Control Method and Conventioal Method (21-30) Year Period

The payback period is the amount of time calculated to recover the cost of an investment. The payback period is used to determine the recovered time and can be done by dividing the initial investment by the average cash flows. The payback period can be calculated by eq. (5).

For automatic process control method, it is calculated for 10 year project life.

Investment = 331,740,000 Kyats
Annual cash flows = 67,418,460 Kyats

$$\text{Payback period} = \frac{\text{Capital investnent}}{\text{Annual Cash flows}}$$
$$= \frac{331740000}{67418460}$$
$$= 4.9 \text{ yrs (5 years)}$$

To recover the cost of investmenrt, it will take five years as the payback period is five.

For conventional method, it is calculated for 10 year project life.

Investment = 126,240,000 kyats

Annual cash flows = 21,483,360 kyats

$$\text{Payback period} = \frac{\text{Capital investnent}}{\text{Annual Cash flows}}$$
$$= \frac{126240000}{21483360}$$
$$= 12.4 \text{ yrs (12 years)}$$

The longer the payback, the less desirable the method becomes. Conversely, the shorter the payback, the more undesirable the investment gets.

F. Conclusion

By applying PLCs in peanut oil production, the process can be completed without an operator. TIA Portal S7-1200 software is used as programming software. Therefore, the process can be completed without an operator being present, which means that maximum reliability is acquired over the whole automatic system. Although screw pressing machines are used in a traditional way, they extract new peanut kernels and peanut cake again and again. By the new method, 75% of peanut oil is squeezed in the 1st pressing state, 22% of peanut oil is for the 2nd pressing and 3% of peanut oil is for the final stage. This pressing method is the squeezing of all oil content from peanut seed. Because of this pressing method and automatic process control, the automatic process took 8 hrs for 1127 kg of peanut oil, whereas the traditional method took 12 hrs. Therefore, 1127 kg of peanut oil will be produced by the automatic method for one day, although 752 kg of peanut oil will be produced by traditional method.

It also calculated the economic analysis for automatic process control method and traditional method by payback period method. It described the NPV of the two methods for (1-10) year project life, (11-20) year project life and (21-30) year project life. From the result, the two investment alternatives have 10-year lifetimes, and the recovery time for automatic process control is 5 years and this for traditional method is 12 years from the payback period point of view. It can conclude that automatic process control method is more economically satisfactory than conventional method. Now a day, some producers face rising production costs as well as declining productivity. Because production costs influence profits and output, this study looked into the costs of peanut oil production in industry. Because the automatic process control method and conventional method had a positive relationship in this production function, output was affected. Thus, in order for capital to be affected by output, it is necessary to substitute the automatic method instead of using more labors in peanut production method.

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H. References

[1] Wang, Q.; Liu, H.Z.; Shi, A.M.; Hu, H.; Liu, L.; Wang, L.; Yu, H.W. "Review on the processing characteristics of cereals and oilseeds and their processing suitability evaluation technology". J. Integr. Agr. 16, 2886-2897, 2017.

[2] Bitra, Venkata S.P., Banu, Shamina, Ramakrishna P., Narender G. : "Moisture dependent thermal properties of peanut pods, kernels, and shells." Biosystems Engineering, 106(4), 2013.

[3] Khant Phyo Wai, May 2018, "A study on groundnut production in Bago Region", Master of Economics, Yangon University of Economics, 2018.

[4] Win, S. S., Kitchaicharoen, J., & Chaovanapoonpho, Y. "An empirical study of the efficiency of groundnut production in central of Myanmar: A stochastic frontier analysis. Department of Agricultural Economics, Faculty of Agriculture, Chiang Mai University, Thailand, 2007.

[5] Aniket A Jagtap. "Design Of Material Handling Equipment: Belt Conveyor System For Crushed Biomass Wood Using V Merge Conveying System." International Journal of Mechanical Engineering and Robotica Research, 2015.

[6] Anonymous: Programmable Logic Controllers, Training Manual, Q-Series Basic Course (for GX Developer), January, 2006.

[7] Hugh Jack: Automating Manufacturing Systems with PLCs, MC Grall Hill, 2005.

[8] Alaba Femi, AWOMEWE & Oludele Olawale, OGUNDELE, "The Importance Of The Payback Method In Capital Budgeting Decision", Thesis for the Master's degree in Business Administration, Blekinge Institute of Technology, 2008.

[9] Win, S. S., Kitchaicharoen, J., & Chaovanapoonpho, Y. "An empirical study of the efficiency of groundnut production in central of Myanmar: A stochastic frontier analysis." Department of Agricultural Economics, Faculty of Agriculture, Chiang Mai University, Thailand, 2007.

[10] A., Marchioni, & C. A., Magni. Investment decisions and sensitivity analysis: "NPV-consistency of rates of return". European Journal of Operational Research, 268(1), 361-372. DOI: 10.1016/j.ejor.2018.01.007, 2018.