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Decisions of investments in operating fixed assets using an indicator arising from financial analysis, engineering Economics and strategy of operations.

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Abstract:- The need for new investments in operating fixed assets is a present reality in the company environment. Therefore, this article has as its main purpose to demonstrate the application of an evaluating indicator of investments in operating fixed assets involving methods and techniques arising from investment analysis, from engineering economics and from the strategy of operations. Departing from the model developed by Slack and Lewis (2009) for measuring performance goals, a bibliographical review has been elaborated, where an indicator has been able to be created, here denominated as RLL. Simulations of a new investment have been done, in which the condition of mutually exclusive projects created some analyses where the conditions were either producing or alternatively outsourcing. The projects have been analyzed through the method return on investment (ROI) and net present value (NPV) and eventually through the RLL. The results have been tested and demonstrated statistical adherence. As a conclusion, the RLL can be used as a complementary indicator in the analyses of new investments in operating fixed assets, as well as the generation of sectorial benchmarking, once it uses information from financial demonstrations.

Keywords:- Investments, fixed assets, financial analysis, engineering economics, operations strategy

I. INTRODUCTION

Competitiveness between companies requires constant investments in assets, making it necessary to create differentials that guarantee the competitiveness of organizations. Some authors claim that many companies apply resources seeking for the improvement of operational efficiency, a better return to shareholders, customers' loyalty, as well as the establishment of a better competitive position, seeking to invest in the best technologies and available equipment, apart from the application of modern enterprise management techniques, maximizing the use of tangible and intangible resources [1-3].

Besides profitability, the great contribution of an asset must be the increase of production capacity. However, this asset may bring the increase of operating fixed costs, as well as the destruction of aggregated value due to the reduction of financial profit. To avoid this, enterprise strategies aligned with market trends are necessary, comparing the need for new investments to inherent risks.

Once the investment has been defined, it's necessary to gather knowledge in several areas. One of the contributions from production engineering is the harmonization of these investments with the strategy of operations [4] and with the precepts of Total Productive Maintenance (TPM) [5].

Thus, this article seeks to align the expected profitability through a new investment in operating fixed assets with the need for an increase of production capacity. Recently, some researchers have addressed this condition, such as Magni [6], who mathematically proved the implications of the use of Net Present Value (NPV) as a main criterion for evaluation of investment decisions in finance theories. Yet Miler and Park [7] tested the validity of the NPV versus the MRO (Maintenance, Repair and Overhaul), claiming that the decision of investing, for several economic reasons demonstrated in the research, prevailed over the decision of not investing, which came from the financial analysis obtained through the finance theory.

According to several authors [2, 8-10], searching for new ways of obtaining financial and non-financial management information in the form of vectors is one of the major allies in the view of new investments, on account of the transformations occurred in the world economy, mainly in the end of the twentieth century, in which the advance in global competition and the scarcity of resources made companies search for new models of generating and analyzing information which was able to increasingly measure the application and the return over the applied resources.

Therefore, the general goal of this article is corroborating the knowledge advance about the analysis of investments in operating fixed assets. Seeking for methods to reach this contribution, Lacey [11] points out that the search for the explanation of social phenomena winds up generating conditions that explore cognitive and social aspects of scientific research, and that must be understood as a problem. Thereby, for this research the problem is represented this way:

"DOES THE USE OF AN INDICATOR INVOLVING CONCEPTS OF ENGINEERING ECONOMICS, STRATEGY OF OPERATIONS AND FINANCIAL ANALYSIS OF INVESTMENTS GENERATE SUPPORT TO DECISIONS OF INVESTMENTS IN OPERATING FIXED ASSETS?"

The specific aim of this article is to suggest an indicator that contains attributes that are able to measure, besides the financial profitability of new investments in operating fixed assets, its lifespan, the impact on fixed and operating costs and the increase of production capacity.

The justifications for this research concentrate on the set of views that this indicator will provide, mainly to the condition of mutually exclusive projects, enabling an opportune analysis in consonance with the conditions mentioned by the researchers used as reference.

II. THEORETICAL FRAMEWORK

2.1 Investment Analyses

One of the views generated by this literary review is in the condition that the success of a company depends on various factors. One of them is the effective and efficient management of its investments and results. This occurs due to the great need of new products, which makes their lifespan shorten. In the past, the need for new products was smaller and consequently the lifespan of products was bigger.

The scenario changes oblige managers to identify what the existing techniques are so that they can choose a good investment and what the impacts in the results will be, regarding that in the present days the economy is not local anymore, but it has an ample competition worldwide.

Aligning these views with the scope of this article, it's evident that all the areas of a company demand investments. However, in industrial enterprises, the main destination for new investments is in production, with complex and extensive projects and with many variants to be analyzed [12].

For the approval of new investments, there are numerous ways for the measurement of demand and choice of the winning project. However, what ends up prevailing in investors' decisions is the condition of financial profitability [13].

The initial view here presumed is that the focus of decision based on financial results may generate middle and long-term problems. Triantis and Borison [14] defend that new investments must contain in their projects, besides all the scope involving risk and financial return, information that aims at analyzing the necessary flexibilities which the company will eventually need.

The fixed assets of companies are important components of the manufacturing function, which, in a healthy state, allow organizations to reach their goals. Thus, engineering economics and financial engineering have recently played an important role in management decisions, mainly seeking to project security in decisions, through mechanisms that project time, rates and estimated return [15].

Corroborating this thought, Santos and Pamplona [16] wrote a paper about the Real Options Theory (ROT), originated in the Financial Options Theory, previously defended by Black and Scholes [17]. Departing from some existing models, they put investments to the test, by measuring new quantitative variants, besides the ones commonly used in investment projects, abbreviated in net present value and return time. For the enterprises participating in the research, one of the views extracted from this experiment is that the volume of involved variants can only be restricted with the participation of tactical level managers and with a better operating management level. They have also come to the conclusion that Brazil still lacks researches that can prove the effectiveness of the Options Theory. Furthermore, it has been stressed that this theory needs to be more used by organizations.

Advancing with the use of this analysis methodology of investment projects (ROT), Oliveira and Pamplona [18] tested the models of Copeland and Antikarov [19], Herath and Park [20] and concluded that the determination of volatility in industrial projects for risk analysis in investments may still be the theme of a lot of discussion, because there are discrepancies in the reached results due to the number of variants to be tested, which demands more research and scientific evidence.

This result corroborates what Krisztina [21] concluded in his research, proving that the strategic manufacturing (SM) involves production managers in the decision-making process, and, consequently, better information about strategic investments are gathered, reducing several variants in the production process. Also, in this same research, she creates a survey confronting companies with this management style and others from the same sector without this attribute, and proves through market-share and return on sales (ROS) that the use of strategic manufacturing (SM) produces positive results.

Another view extracted from the bibliographical research is that strategic manufacturing conducts to investments that generate flexibility in production, and this is a performance goal that may lead to a necessary competitive advantage in the new times of short lifespan products. New investments should include flexibility in production as a performance goal for acceptance as defended by other authors [22]. According to these authors, based on production flexibility decisions, the reduction of economic risk will be a real and reachable goal.

According to *Ministério do Desenvolvimento, Indústria e Comércio (MDIC*) [23], Ministry of Development, Industry, and Trade, Brazil has a great number of companies classified as small and medium businesses, which need to be consolidated on a more and more competitive market. Having a benchmarking of your sector is fundamental [24]. The creation of this evaluating parameter (benchmarking) among companies and economic sectors needs a standardized basis of quantitative and qualitative information, mainly when dealing with issues involving engineering production and investments.

Thus, starting the introduction of this benchmarking, the use of the return on investment (ROI) is a way of measuring the capital amount that has been invested. This indicator goes beyond the evaluation of the return on the own capital, once the investment also counts on third party capital, whose return will be given based on interest. Another important use of the ROI in this paper is demonstrating the weighted average cost of capital (WACC), represented by the denominator in Equation 1. This will allow the businessman or investor to quickly know if the investment to be made generates some expectations on the capital cost applied, demonstrating the creation or destruction of value [25].

As an option and a complement to this indicator, by starting with a minimum acceptable rate of return required by investors, it is possible to project on net results of the investment (cashflow) the present value of a certain project. The net present value (NPV), according to Samanez [26], is a method that aims at monetarily valuing in terms of present value the impact of future events associated to a project or investment alternative, that is, it measures the present value of cash flow generated by the project along its lifespan.

As a complement to the use of the NPV, the Internal Rate of Return (IRR) of a project must be calculated, which, according to Ross et al. [27], is used as the minimum acceptable rate of return and opportunity cost, but it presents limitations such as the use in non-conventional cash flow, in which there is exchange of signals in cash flow. Amplifying these limitations is the research of Abensur [28], who, for the deficiencies of the internal rate of return (IRR) related to mutually exclusive projects, tested a multi-objective mathematical problem as opposed to its use, demonstrating the ineffectiveness of its use when singly applied. Ratifying this position, there are the researches of Hazen [29] and Percoco and Borgonovo [30]. Thereafter, ROI, NPV and IRR are considered indicators that measure the financial return of an investment [31].

2.2 Perspectives of Operating Earnings

Slack and Lewis [4] claim that investments must reach not only financial return, but also attributes that promote improvements of performance goals classified as: quality, reliability, flexibility, speed and costs. These benefits will be translated into performance, classified as “qualifiers”, “order winners” and “surprise”.

In operation strategy, it is necessary to know how to differ in what level the desired performance is located, for not running the risk of being situated either in a negative range of results or low performance. Thus, order qualifiers are minimal attributes that a product or service should possess. However, a positive performance will only be assured if these characteristics comprise the so called order winner factors, where clients see the key conditions for their acquisition. And, by attaining the maximum performance, there is the surprise effect, given this definition with the purpose of assigning benefits and advantages that had not been provided to the client so far.

One of the causes for not reaching performance goals is the loss of equipment capacity, as well as high maintenance cost and obsolescence [4]

There are many factors that can cause equipment substitution at manufacturing companies. Deterioration is one of the causes and manifests itself through excessive operating costs and increasing maintenance costs; however, according to Casarotto Filho and Pires [32], it has been found that many Brazilian companies (probably the majority) have the habit of maintaining old equipment in use, even when its operation is not economically viable anymore. Expenditures on maintenance in general largely surpass the value of investments.

According to Hipkin and De Cock [33], in the fight for survival, companies constantly seek to perform interventions to improve the performance of their operations, and the TPM has been very used. In this context, Tsang *et al*. [34] observed that expenditures on maintenance has represented a meaningful part of operating budgets in companies, involving high investments in facilities, machinery and equipment. The proof of this citation is found in the results published by ABRAMAN (Associação Brasileira de Manutenção e Gestão de Ativos; Brazilian Association of Maintenance and Asset Management) in its National Document of 2013. In its biannual survey that measures the situation of Maintenance in Brazil, in relation to the same document of 2011, it has been found out that the hierarchical level of maintenance management has increased, as well as the demand for qualified labor and specialization [35].

Reinforcing, TPM means no failures and no breaking of machinery. Like any process, maintenance also has its restrictions, because the product of maintenance is the sum of its activities and services (corrective, preventive and predictive maintenance and improvements), since these services are performed through the use of human resources (technical maintenance labor) and materials (tools, maintenance parts, etc.) [5].

Summarizing this condition, if a company stops substituting its equipment at the ideal moment, it ends up financially and operationally suffering from maintenance costs. Now, if it keeps a satisfactory maintenance level through the TPM, it winds up promoting a demand for the retention of talented personnel according to ABRAMAN [35], what ends up generating bigger expenditures on labor.

To understand the relation between cause and effect that this last paragraph generates in investment decisions, an indicator that measures the variation of sales volume and the respective variation in operating profit is used, which necessarily goes through the mensuration of the total cost of the enterprise's activity, denominated Degree of Operating Leverage (DOL).

According to Famá *et al*. [36], the bigger the operating leverage, the smaller the debt, that is, companies that present bigger levels of operating leverage and, consequently, bigger business risk show a lower level of debt. Souza at al. [37] go further and claim that the operating leverage is inserted in a bigger context denominated CVP, that is, the analysis of cost, volume and profit, where it is characterized that the positive results of this analysis has as an attribute a low operating risk.

Dantas et al. [38] did a study in which the logic of earnings-return researches, substituting the measures of accounting results for the operating leverage, having as basis the data of companies from the stock market of oil and gas sectors, basic materials, industrial assets, construction and transport, cyclic and non-cyclic consumption, related to the period between the second trimester of 2001 and the third trimester of 2004, found that there is a positive theoretical relation between systematic risk and operating leverage, and a positive relation between the stocks return and the operating leverage of a company must be expected. Marx [39] corroborates this condition and goes further claiming that his tests proved that companies demonstrate great variation of the DOL according to the intensity of the capital applied in production. Guthrie [40] also claimed that this relation in investment projects must be considered, because it is in the same proportion that Marx [39] defined to the analysis of capital market.

III. METHOD

Assuming that the investment needs to generate financial return and that this must come from the balance between capacity and demand, as the numerator in this proposal we present the multiplication of return on operating fixed assets (ROFA) by their average lifespan (AL). This represents how long it will take to reach this return. As a denominator is the degree of operating leverage (DOL), once the reduction of operating risk is expected from the decision of investing. As a basic result of this analytical reasoning there is Equation 1 determining the RLL, that is, the financial return, the average lifespan and the operating leverage:

$$\text{RLL} = \frac{[(\text{Net Profit on Sales})/(\text{Op. fixed asset})\text{x}[(\text{gross total of fixed asset})/(\text{year depreciation})]}{(\Delta\% \text{ of operational profit})/(\Delta\% \text{ in activity volume})} \quad (01)$$

Summarizing the expressions contained in Equation 1, Equation 2 can be used, which represents the synthetic RLL, by means of acronyms.

$$\text{RLL} = \frac{\text{ROFA x AL}}{\text{DOL}} \quad (02)$$

The acronym RLL is the junction of the initials of three indicators, that is, return, lifespan and leverage. Melnyk *et al*. [41] claim that metrics are fundamental for the competitive position, and that a good metric must follow the guidance of agency theory, the theory of strategic adjustments and mainly suggest important answers after its measurement.

Therefore, as a means of testing the validity of this proposal, initially, decision making has been simulated, involving investments in mutually exclusive projects, where a shoe company with an increase in sales, that is, an increasing market demand, needs to increase its production capacity, seeking for the balance defended by Slack & Lewis [4]. The present production of this company is 20.000 (twenty thousand) pairs a month, and it needs to be raised to 25.000 (twenty-five thousand) pairs a month, that is, an increase of 5.000 (five thousand) pairs a month. For better visualization of the projects, the data has been inserted in Figure 1.

Investment A	Investment B
Acquiring sewing, cutting, and folding machines, in the amount of R$ 100,000.00, but without internal allocation, that is, these machines would be passed on to shoe workshops (*ateliers*),which would become a variable cost, for they earn by production.	Acquiring a new conveyer belt and some other sewing and cutting machines in the amount of R$ 70.000,00, but this would entail the hiring of 12 more employees, thus, increasing fixed costs.

Figure 1 – Mutually exclusive investments

Carraro and Lima [42] have already tested this kind of decision, where at the time in light of the reduction of operational risks through operations strategy focused on five performance goals by Slack & Lewis [4], it was proved that labor outsourcing brought tangible benefits in reducing the DOL and consequently increasing the ROI.

To follow with the assumptions of the research, it was necessary to establish the capital budget for the projects, disregarding residual value for investments. The results are shown in Table 1.

Table 1 – Incremental revenue in thousands of reais (R$)

Year	Project A	Project B
1	75	96
2	60	55
3	69	67
4	64	65
5	60	62
6	68	63

To identify whether there is statistical significance between the returns, descriptive statistical measures were used as an initial way to get views that allow comparisons and analyzes of the results (Table 2).

Table 2 - Descriptive measures on primary data of

Descriptive measure	Project A	Project B
Average	$ 66	$ 68
Median	$ 66	$ 64
Variance	28,3	170,67
Standard Deviation	5,32	13,06
Variation Coefficient	8%	19%

Source: from authors, based on the data of the projects

According to Martins and Domingues [43], the coefficient of variation between 15 and 30% represents the average dispersion, which means that the arithmetic mean as a measure of central location is just regular. Thus, it is understood that there is statistical significance between both investment projects and that analysis should proceed.

Complementing the statistical analysis, a financial analysis of these investments through the use of traditional financial indicators described in Topic 2.1 was performed. Considering an opportunity cost of 15% per year, which can be considered as the required or expected rate for the projects and even as the discount rate, we come to the calculation of the NPV and IRR using a financial calculator, follows (Table3):

Table 3 – Analysis of excluding investments through NPV e IRR

Project A	Project B
100.000 Chs g Cfo	70.000 Chs g Cfo
75.000 g Cfj	96.000 g Cfj
60.000 g Cfj	55.000 g Cfj
69.000 g Cfj	67.000 g Cfj
64.000 g Cfj	65.000 g Cfj
60.000 g Cfj	62.000 g Cfj
68.000 g Cfj	63.000 g Cfj
15 i	15 i
F NPV	F NPV
R$ 151.775,72	**R$ 194.345,30**

Source: from authors, based on the data of the projects

According to the analysis of decision through the NPV method, project B will yield better financial results to investors, even increasing the operational risk with rising fixed costs and higher capital expenditure. Confirming this position, there is the calculation of the IRR (internal rate of return), demonstrating higher rate for project B. Through the presented theoretical reasoning, the project with the highest NPV will also have a higher IRR.

However, there is a special feature to be tested, that is, they are mutually exclusive projects, one in the aspect of reducing economic risk, in the case of a decision of outsourcing (Project A) generating variable costs, the other is the case of a project for equipment acquisition and hiring personnel (Project B), that is, capacity increase, but increasing fixed costs.

Carraro et al. [44] proved in studies that not always the best NPV and IRR bring in the light of operations strategy the best economic value added (EVA), which means that the DOL affects this analysis by the recovery of net operating income by deducting portions of operating costs in tax revenue.

Seeking to analytically demonstrate the results of the descriptive statistical measurements shown in Table 2 and the traditional financial analysis shown in Table 3, the same data were tested under the assumptions of the indicator RLL, where it was initially necessary to calculate the ROFA (Table 4) because only the net financial results obtained with the projects have been demonstrated so far.

Table 4 - ROFA (return on fixed assets)

Project A	Project B
520.000 : 1.850.000 = 28	520.000 : 1.820.000 = 28
555.000 : 1.665.000 = 33	555.000 : 1.638.000 = 33
598.000 : 1.498.500 = 39	598.000 : 1.474.200 = 39
634.000 : 1.348.650 = 47	634.000 : 1.326.780 = 47
687.000 : 1.213.785 = 56	687.000 : 1.194.102 = 56
723.000 : 1.092.406 = 66	723.000 : 1.074.691 = 66

Source: from authors, based on the data of the projects

It is clear that for both projects the ROFA has the same weight every year, this is due to the fact that in both conditions for investment net revenues are the same. Actually, what will differentiate this condition is the effect that the ROFA has on economic risk, that is, on the reduction or increase in fixed costs. Therefore, to proceed with the calculation of the RLL, it is necessary to calculate the AL (average lifespan), which is an indicator that measures the lifespan of operating fixed assets, because, for the fact they are tangible, they suffer from natural wear, plus devaluation itself. One of the most important questions to determine the optimal time of replacement of depreciable assets is to ascertain the average and economic lifespan that they have, because when you apply the analytical method of substitution it is necessary to take into account another factor of extreme importance that is depreciation. Therefore, understanding these concepts is critical to the development of a program to replace equipment [45]. The AL calculation in this project follows as described in Table 5.

Table 5 -AL (average lifespan)

Project A	Project B
1.850.000 .... = 10 years	1.820.000 : ....= 10 years
1.665.000 :185.000 = 9 years	1.638.000 : 182.000 = 9 years
1.498.500 : 166.500 = 8 years	1.474.200 : 163.800 = 8 years
1.348.650 : 149.850 = 7 years	1.326.780 : 147.420 = 7 years
1.213.785 : 134.865 = 6 years	1.194.102 : 132.678 = 6 years
1.092.406 : 121.378 = 5 years	1.074.691 : 119.410 = 5 years

Source: from authors, based on the data of the projects

This indicator also shows the same results, which corresponds in terms of net income that the investment options look the same, that is, investing in outsourcing or vertical integration seems to have the same effect. To confirm or correct this inference, it is still necessary to calculate the DOL.

Table 6 -DOL (degree of operating leverage)

Project A	Project B
220.588 : 520.000 = 42	**282.352: 520.000 = 54**
176.470 : 555.000 = 31	**161.764: 555.000 = 29**
202.941: 598.000 = 33	**197.058 : 598.000 = 32**
188.235 : 634.000 = 29	**191.176 : 634.000 = 30**
176.470 : 687.000 = 25	**182.352 : 687.000 = 26**
200.000 : 723.000 = 27	**185.294 : 723.000 = 25**

Source: from authors, based on the data of the projects

The results of the DOL were more scattered than the RLL and the AL. This is because the projects have similarities to the time when investments and earnings are prospected, however, when it comes to costs, given the nature of the decision, both are well differentiated. Once calculated the three key indicators of this study, it is possible to demonstrate the practical use of the new indicator model.

Table 7 – RLL of exclusive investments

Project	**Project B**
(28 x 10) : 42 = 6,6	(28 x 10) : 54 = 5,1
(33 x 9) : 31 = 9,5	(33 x 9) : 29 = 10,2
(39 x 8) : 33 = 9,4	(39 x 8) : 32 = 9,7
(47 x 7) : 29 = 11,3	(47 x 7) : 30 = 10,9
(56 x 6) : 25 = 13,4	(56 x 6) : 26 = 12,9
(66 x 5) : 27 = 12,2	(66 x 5) : 25 = 13,2
∑ **62,4**	∑ **62,0**

Source: from authors, based on the data of the projects

Due to the results obtained by calculating the RLL, again statistics based on descriptive measures are used to analyze the central tendency and dispersion, and demonstrate the statistical significance of the presented results. Departing from the same tests applied in Table 2, the RLL is statistically tested.

Table 8 -Descriptive measures on the RLL of the project

Descriptive measure	**Project A**	**Project B**
Average	10,4	10,3
Median	10,4	10,5
Variance	4,8	7,16
Standard Deviation	2,19	2,67
Variation Coefficient	21,0%	25,9%

Source: from authors, based on the data of the projects

Analyzing the RLL through statistical measures it is noticed that the behaviors of the projects are very similar, and it differs from the financial results obtained in the analysis of Table 2.

IV. FINAL CONSIDERATIONS

Using the elements described in the investment analysis (section 2.1) project B showed a return of 28.05% over project A.

Using the elements described in the prospects of operating earnings (section 2.2) through the RLL, project A was higher in 0.65%.

Comparing the statistical results of Tables 2 and 8, one realizes that the greatest variation is concentrated in Table 2.

Taking into consideration that the RLL is an indicator of the type bigger is better, and its denominator is the element that defines the level of exposure to economic and operational risk, this study demonstrates that project B has higher financial profitability and that under the RLL analysis the results are practically identical.

Thus, the decision maker may feel more secure about the decision to be made, because once aspects such as engineering economics, operations strategy and financial analysis of investments were encompassed in the analysis provided by this indicator, the answer to the problem outlined in this research is positive, also reaching the general and specific goal, which respectively provided a new indicator for the assessment of joint issues in making investment decisions in operating fixed assets.

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