An integrated methodology of efficiency-risk for choosing material handling projects

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Abstract—Effective role in the transportation of industrial units has made material transportation projects evaluation and selection very important. One-sided focus of this assessment on quantitative and efficiency parameters and lack of attention to the risk and qualitative parameters, causing error in this kind of evaluation projects. This paper presents an integrated methodology of efficiency-risk for choosing material handling projects. This new approach focuses on tangible and intangible costs which offers a methodology for estimating the efficiency-risk and decision making method of investment. In this method, all parameters are considered such as labor, productivity, maintenance, system changes, insurance, loans, taxes, risk, etc. Furthermore, a perfect study on Material Handling is possible with use of sensitivity analysis and powerful software (Comfar III Expert). With the help of the above methodology, we can decide on all measures of performance parameters and the risks involved and the results obtained are more realistic. Because of the risk importance of this type of projects with the help of sensitivity analysis, sustainability of transportation projects is checked.

Index Terms—material handling projects; efficiency-risk; Investment; sensitivity analysis; COMFAR III Expert software

1. INTRODUCTION

Given the essential role of transport in production systems, today the evaluation and selection of the most effective and efficient materials handling projects is manufacturing concerns. in the other words, the material handling projects (MHP) plays a strategic role in increasing the efficiency of production lines.[1]. Comprehensive Focus on qualitative and quantitative selection of this type of projects and taking into account individual parameters of efficiency and risk in many studies of researchers have been looking for.

According to (Tompkins et al. 2002), about 20–50% of the total production cost is paid out on material handling. It makes the theme of material handling increasingly important. In addition, all the intricacy of manufacturing is transferred to the MHP. Therefore, the MHP has been vital for improving the product line to fulfill the requirements of high product proliferation. (Tompkins et al. 1996) estimate that, in a quintessential manufacturing operation, MH accounts for 25% of the number of employees, 55% of all factory space, and87% of production time, and that MH costs describe amid 15% and 70% of the total cost of manufacturing a product. Certainly, MH is one of the first areas to examine in efficiency activities. In the majority of small and medium sized enterprises (SEMs), the direct costs of material handling cannot be distinctly measured. There are several reasons for this, including the large number of product types, intricacy of their production cycle, and continuous change in markets. Therefore, production managers need flexible tools to create a proper material handling projects model which explicitly and rapidly calculates the indices required as these are customary neglected or laboriously approximated[2].

The tangible and intangible advantages of the automatic MHP are well described in literature, such as Boucher and Mac. Stravic (1991)[3].Attributes of the MHP such as expandability, flexibility and reliability are rated by a committee of three experts to get a value score, that is used to compute the net present worth (NPW) for economic justification of material handling [4].These benefits and costs of the MHP are estimated by a fuzzy benefit/cost ratio analysis, and then the ratio of the present value of merit and the present value of cost is computed to justify the investment[5]. However, both papers do not mention the evidence to get the imprecise estimation of benefits and costs in adopting the new MHP. Therefore, it desires for a costing system that can overcome the above problem and activity-based costing (ABC) is such a system (Harrison and Sullivan, 1996).

A two-phase method for the investment justification based on characteristics of material handling activities in modern MHPs is proposed in Ioannou and Sullivan (1999)[6]. The first stage collects the life-cycle costs , benefits resulting and efficiency analysis from the reconfiguration of MHP in manufacturing facilities, and the second stage performs an economic value analysis (EVA) on the basis of these activity-related costs as well as various opportunity costs for each material handling alternative. Ryan (2004) considers an option pricing based model which takes into account uncertain exponential demand growth and expansion end times[7].

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Economic metrics have been applied include, payback period, net present value (NPV), return of investment (ROI) and the internal rate of return (IRR) (Meredith and Suresh, 1986). To generate these economic metrics for a new MHP, it is necessary to identify its efficiency and inefficiency ,which have been extensively studied in the MHP selection literature such as Devise and Pierreval (2000), Lashkari et al (2004) and Sujono and Lashkari (2007)[8-10].

Marathe and Ryan (2009) formulate a model to minimize expected discounted expansion cost under a service level constraint for infinite horizon[11]. Ceryan and Koren (2009) show how a range of investment cost parameters, demand uncertainties and, product revenues influence capacity portfolio by considering dedicated and MHP which have different scalabilities. Also they studied on investment cost arrangement parameters, product revenues and demand uncertainties[12].The approach developed by Ruhl (2010) strives for the economic evaluation of manufacturing in the design step, considering the flexibility and risk criteria.

Dai and Lee (2012) provide a methodology to estimate the incremental cost induced by adopting

MHPs, particularly the free-ranging MHP, and then investigate the economic feasibility of such

MHPs in the apparel industry [13]Larriba, Garde et al. (2013) studied on fuel cell powered of materials handling vehicles [14].However, all of studies have ever been done are just focused on clear and tangible costs of MHPs, whereas other intangible costs have not considered such as productivity improvement, system change cost, inflation, etc. Because

MHP does bring many benefits which are difficult to be transformed into hard dollars. Meanwhile, fast changeable demand, inflation etc. are items that never mentioned in another articles.

2. METHODOLOGY

For evaluating projects efficiency, material handling projects is needed for all investment cost estimate of the entire system. This is exactly similar to the estimated investment cost of each project is done. Then all operation costs and revenues resulting from use of the material handling projects in line will estimate such as system cost, improve efficiency, and risk factors such as certain parameters material handling projects. Based on the foregoing, the economic and financial indicators are calculated to decide. In this way, we can take advantage of powerful software Comfar. In the end, owing to the dynamics of production lines, we calculated the sensitivity analysis. All procedures are fully described in the following sections.

2.1. MHP investment costs estimation flowchart

Generally, MHP investment costs estimation is critical to the system investment. Based on the number of work stations, and the investment per workstation, the system investment of the MHP is estimated. The detailed MHP investment cost estimation scheme is shown in Fig.1.

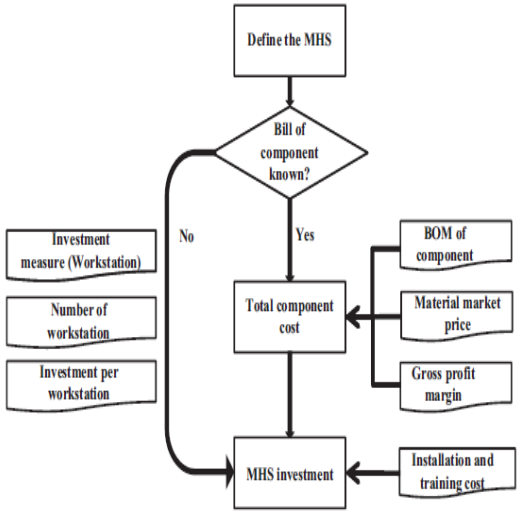

Fig.1. Scheme of the component-based cost estimation

2.2. MHP cost estimation of production

MHP costs and benefits estimation of production include

Service benefits: estimate benefits of transport projects

Labor cost: Labor cost is the only common element between traditional and MHPs

Maintenance cost: Maintenance activities include process monitoring, planning, problem solving and such actions. The maintenance cost comprises two parts: labor cost and system or equipment directed cost.

System change cost: System change occurs when the system layout or the product changes caused by product proliferation. System change is used for MHPs aren't flexible enough .so we can estimate the system change cost benchmarking on the installation cost ,and it is given by [13].

$$CS_n^{sc} = \frac{I_n}{1 + R_{i_n}} R_{i_n} F_n^{sc} \quad (1)$$

In: the total investment

Rin: the ratio of the installation cost to the equipment cost in the nth system

Fnsc: the ratio of the system change cost to the installation cost in the nth system.

Salvage value: Salvage value is the estimated value that an asset will realize at the end of its useful life

Productivity improvement: Productivity improvement may bring the benefit of an equivalent ratio of labor cost saving to match the throughput of the manual MHP. However, productivity improvement has no impact on the maintenance cost or other operating cost related to equipment. Therefore, the cost saving by productivity improvement from adopting the nth MHP could be estimated by[13].

$$CS_n^P = N_m L_r T_h (1+R_p)(1-R_n^l)\frac{R_{pi}}{1+R_{pi}} \quad (2)$$

Nm: the number of labors required in the manual system
Lr: the labor rate per hour
Th: the average working hours per labor per year
Rp: the fringe benefit as a percentage of pay roll
Rln: the rate of labor saving comparing the manual system with the nth MHP
Rpi: the percentage of the productivity improvement

Risk factors: There are a few issues which may potentially skew our estimation for the economic feasibility study. First, cost may be over- estimated or underestimated although we did compare our cost to an equivalent system investment cost. Moreover, although we exhaust the potential list of all system investment cost, there will plausible be items that we must purchase that we did not expect, particularly in those maintenance activities. Other potential risk could be equipment reliability

2.3. The investment decision making with COMFAR III Expert software

COMFAR, the Computer Software for Feasibility Analysis and Reporting, is a software application developed by UNIDO for the analysis and the investment projects assessment of any kind. Comfar include following advantages:

- ✓ We are able to adjust the detailed financial and economic appraisal of investment projects.
- ✓ We are able to adjust the special characteristics of a project for analyzing.
- ✓ We are able to produces detailed and standardized financial and economic statements.
- ✓ The NPV, payback period and the ROI are used to evaluate the economic performance
- ✓ Supports us with powerful Sensitivity analysis and risk module.
- ✓ We are able to adjust inflation rate, discounting rate, tax, subsidies, loans, depreciation, risk and efficiency.

2.4. Sensitivity analysis on MHPs

Given the importance of risk in MHP projects, In addition to calculating the cost of risk in the past, the project situation is reviewed in terms of sustainability of efficiency-risk with the help of sensitivity analysis at this point.
Considering that there are large variations in sensitivity analysis is a way to predict the result of a decision when a situation turns out, sensitivity analysis of the MHPs investment is necessary.

3. CASE STUDY

In order to illustrate the methodology, we present a numerical example in which company is planning to use of a new material handling. Two alternatives are being considered:
Alternative A: Automated guided vehicle system (AGVS)
Total investment (unit price):- 334000, Labor cost (unit price): 30000, Maintenance cost (unit price): -45860, System change cost (unit price):0, Salvage value (unit price): 58500, saving by productivity improvement (unit price): 100000, Life cycle: 5 year, Discounting Rate: 15%, Inflation Rate: 20%
Alternative B: Conveyor system
Total investment (unit price):- 250000, Labor cost (unit price):30000, Maintenance cost (unit price):- 20000, System change cost (unit price):- 45000, Salvage value (unit price): 43635, saving by productivity improvement (unit price): 65000, Life cycle: 5 year, Discounting Rate: 15%, Inflation Rate: 20%

3.1. MHP investment costs estimation

Cost of investment and the creation of Conveyor Equipment and AGV in this area are estimated as follows:

TABLE.1.FIX INVESTMENT COST

AGV	Conveyor	unit
-334000	-250000	$

1.1. MHP costs, benefits and risk-efficiency estimation of material handling projects

In this part, all costs and outputs of AGV equipment and Conveyor utilization is estimated as follows:

TABLE.2 ANNUAL COSTS AND BENEFITS

	AGV	Conveyor	unit
Labor cost	30000	30000	$
Maintenance cost	-45860	-20000	$
System change cost	0	45000	$
Salvage value	58500	43635	$
saving by productivity improvement	100000	65000	$
Life cycle	5	5	$
Discounting rate	15%	15%	$

Inflation rate	20%	20%	$

1.2. The investment decision making with COMFAR III Expert software

In this section, based on investment cost, revenue, cost and utilization of material handling systems the AGV and Conveyor, we begin to calculate financial decisions indices. Such as Internal Rate of Return, Net Present Value, Payback Period These indicators will assist investors in making decisions. An example of financial indicators by software comfar is calculated as follows:

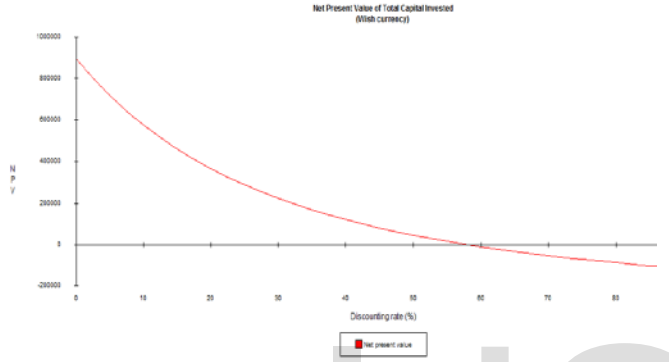

Fig.2.AGV Internal Rate of Return

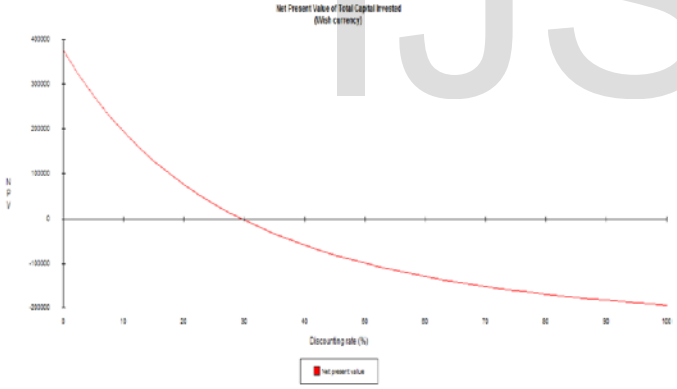

Fig.3.Conveyor Internal Rate of Return

All the economic and financial indicators calculated by the software for the system and Conveyor Material Handling AGV can be seen in Table 4 below.

Sorted by Indicator | Sorted by Project | Graphical presentation

	1	2
☑ Internal Rate of Return on investment	58.02	29.53
	AGV.C30	Convoyer.C30
☑ NPV Ratio on investment	1.15	0.43
	AGV.C30	Convoyer.C30
☑ Internal Rate of Return on equity	58.02	29.53
	AGV.C30	Convoyer.C30
☑ NPV Ratio on equity	0.00	0.00
	Convoyer.C30	AGV.C30
☑ Unit Cost Product 1	81,859.75	116,024.50
	AGV.C30	Convoyer.C30

Fig.4.Comparison of deferent indices of both MHP alternatives

1.3. sensitivity analysis on MHPs

Due to the instability of the parameter estimates at this stage, by changing them we try to review the financial and economic indicators of response. Internal Rate of Return is one of the most important indicators that the changes in revenues, costs of investment and operation decisions will change the index In Figure 5 and 6 shows the variation of the individual for the material handling projects and Conveyor AGV can see on changes in income and expenses. Following figures shows sensitivity analysis of both MHP (AGV& Conveyor) which calculated by COMFAR software:

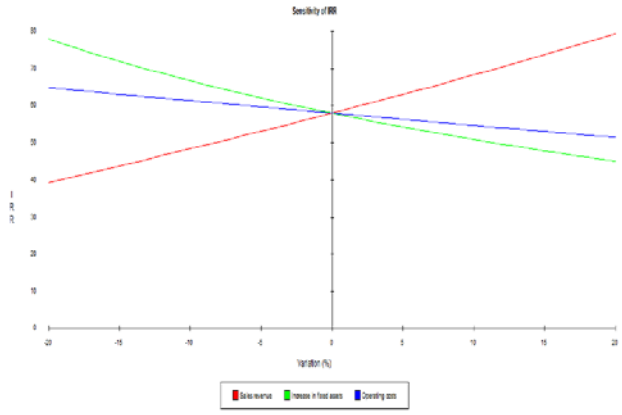

Fig.5.AGV sensitivity analysis

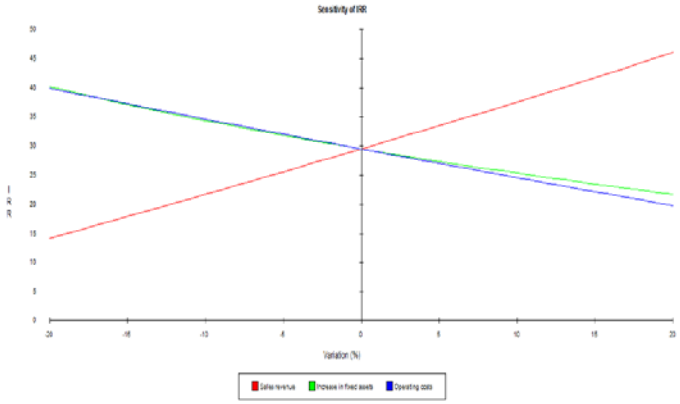

Fig.6.Conveyor sensitivity analysis

2. CONCLUSION

This paper has developed a combined method of efficiency-risk in assessment and selection of transport projects that in this new approach focuses on tangible and intangible costs which offers a methodology for estimating the costs, benefits, sensitivity analysis and decision making method of investment. In this method, all parameters are considered such as labor, productivity, maintenance, system changes, insurance, loans, taxes, etc. In addition, a perfect study on Material Handling is possible by use of sensitivity analysis and powerful software 'ComfarIII Expert'. According to this research, the result of considering of two alternatives (AGV& Conveyor) is as following:

- ✓ AGV IRR is equal to 58.02 and conveyor IRR is equal to 29.53
- ✓ In terms of all tangible and intangible parameters considering such as system change cost, saving by productivity improvement (increasing efficiency), discounting rate, and inflation rate MHPs have competitive advantages in comparison with other MHPs.
- ✓ AGV (part of MHP) in comparison with Conveyor (traditional MHP) has high priority.
- ✓ With considering sensitivity analysis graphs, it is clear that changes in product quantity, growth of using costs and productivity saving, AGV system has more stable benefit margin and always has higher acceptable IRR. So, because of AGV flexibility, growth of trend in changes doesn't have any influence on financial justification, while above items in relation with conveyor system is nonconformance.

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