OPTIMIZING INVESTMENTS' CASHFLOW: A SCHEDULING APPROACH

V. O. Oladokun
Department of Industrial and Production Engineering,
University of Ibadan,
Ibadan, NIGERIA.

ABSTRACT

In this paper, the problem of optimising cash flow so as to enhance the financial feasibility of a multipart project is considered. The problem has been modelled as a single machine scheduling problem. Several sectors of the Nigerian economy where this problem is encountered are also discussed. A real life problem was solved on a PC using an electronic spreadsheet.

Keywords: Scheduling. Project financing. Cash flow. Optimisation. Electronic Spreadsheet

1. INTRODUCTION

Scheduling is the allocation of resources over time to perform a collection of tasks. Because scheduling is a decision making function, much of what we learn about scheduling can apply to other kinds of decision-making; Baker (1974). Thus this work seeks to use some scheduling concepts to address a problem of optimising cash flow during development period of a multi – parts project type.

The high cost of capital, as reflected by high interest rates, has become a major factor responsible for high cost of production in the Nigerian economy. Also several cases of abandonment of engineering projects may be traced to problem of financing. According to Akinbinu (2002), financing is the major constraint of most small-scale enterprise (SME) start-ups. The challenge facing many engineering managers involves that of cash flow management in order to improve the financial feasibility of such projects.

Zheng et.al. (1993) proposed a single machine scheduling method for minimising the total flowtime cost and penaltycost of earliness and tardiness for a set of tasks. Also, Kum khiong et al (1993) proposed an integer programing algorithim for maximising the net present value of a project using a scheduling aproach . Zimmermann (2001) and Kimms (2001) addresed similar problem of scheduling of large-scale projects to maximize the net present value. While each of these works addressed some economic aspects of project management, the issue of cash flow optimization was not addressed. There are several investment scenarios that can be modelled as scheduling problems, particularly as single machine problem. Some of these real life problems are briefly described.

Equipment Hiring

There are many engineering firms that specialise in buying scraps or unserviceable heavy equipments like bulldozers, trucks, generators etc with the aim refurbishing them either for sales or hiring. These scraps are mostly bought at auctions from construction firms or government agencies at attractive prices. So such organisations are most of the times forced to buy several of such equipments that may necessitate investing substantial capital. Refurbishing these equipments as quickly as possible in order not tie down capital may compel borrowing to finance the project.

Since each type of equipment requires different levels of input resources for refurbishing and has different income generation capacities when operational, there is the need therefore to determine a schedule. which will be attractive in terms of net cash flow over the project duration.

Telecom Sector

A similar scenario is a GSM operator's roll out project where the operator has to put up base stations in various locations for effective coverage as well as the need to fulfil regulatory requirements. The cost of installation may differ from one location to the other while each location will have different market or call generating potentials. Meanwhile, there is a limitation on the number of base stations the engineering team can handle at a time. This scenario may also be treated as scheduling problem if cash flow optimisation is desired.

Oil Companies

Another common example may be an oil company with many oil fields for development. Limitation on capacity may require that the fields have to be developed one after the other. Also each field may demand different levels of resources as well as possess different yield potentials. **An estate developer** with many lands for development with each location attracting different development cost as well as having different market values may face similar problem.

The problem of determining in what sequence should these companies' resources or capabilities like manpower, oilrigs, equipments etc be committed to these locations or fields over time to optimise cash flow may be modelled as a scheduling problem.

The objective of the study is to model the above problem as a scheduling problem and demonstrate the use of scheduling techniques for handling such.

2. NOTATIONS:

n: No of jobs or subprojects for development index indicating job / subproject identity

t_j: Execution or Processing time for job/ subproject

C_j Development or processing cost for subproject j in Naira

F_j: Flow time i.e. the amount of time the job j spent in the system for given schedule

C_{max} Make span for the entire project i.e. the development period

Note $C_{max} = F_j$: for j = n

[j]: jth position in a given schedule

x_j : Yield or contribution per unit time of job j after completion e.g. hire or production rate in naira

Xj: Total yield of subproject j during the development period (C_{max}) of entire project

3. MODEL DEVELOPMENT

Note $F_j = t_{[1]} + t_{[2]} + \ldots + t_{[j-1]} + t_{[j]}$

Also observe that the total contribution X_j (cash inflow) of subproject j during development period T (i.e. C_{max}) is given by

$$X_j = (C_{max} - F_j)x_j \qquad \ldots (1)$$

Note $C_{max} - F_j$ is the income-yielding period of subproject during entire period T

Therefore ($C_{max} - F_j$) is minimum (zero) for subproject scheduled last i.e. the nth position and maximum for the first position.

The total contributions of all subprojects to cash inflow during the development period of the entire project is XT where

$$XT = \sum_{j=1}^{n} Xj = \sum_{j=1}^{n} (C\max - Fj)xj \qquad \ldots (2)$$

$$XT = \sum_{j=1}^{n} xjC\max - \sum_{j=1}^{n} xjFj \qquad \ldots (2a)$$

Observe that the desire of a developer is to maximize XT in Eqn. 2 so that the project can contribute as much as possible to the project financing during development period thereby minimizing the amount of loan or borrowings required.

Assumptions.

(1) Set up times for the subprojects are independent of subproject sequence and can be included in the processing times.

(2) Subproject processing is non pre-emptive.

(3) There is no precedent constraint

Then the first part of eqn 2a is a constant and the same for all sequences.

Optimisation problem

Therefore the optimal sequence is that which maximizes XT. But since the first part of XT is a constant for a group of subprojects then the optimal sequence is that which minimizes the second (negative) part of XT. i.e. Minimizing $\sum_{j=1}^{n} xjFj$ ...3

Looking closely at Eqn. 3 shows that it is equivalent to an job single machine scheduling problem with the total weighted flow time as objective, 1| | $\sum wjFj$ in scheduling notation, where w_j is the weight associated with each job. This problem gives rise to one of better-known rules in schedule theory, the weighted shortest processing time first (**WSPT**) **rule,** Smith (1956). According to this rule, optimal sequence is found by ordering jobs in decreasing order of w_j / t_j. Pinedo (1995), Baker (1974).

Therefore by minimizing ($\sum_{j-1}^{n} xjFj$), of Eqn. 2a, the WSPT rule maximizes XT (the total cash in flow)

APPLICATION

A Lagos based equipment-hiring firm acquired a set of 12 equipment auctioned by a construction company as 'scraps'. The purchase was funded through a bank loan and the firm has decided to refurbish the entire set for hiring purpose. The company is constrained by factors such as workshop space and manpower availability to handle only one equipment at a time. Table 1 shows the equipment types and the estimated processing times.

Applying the WSPT rule gives a sequence shown on Table 2. The Total cash inflow XT of Eqn 2 is shown also.

Table 1: Estimated Processing Times and Weights (Hire Rate.)

Job index j	Equipment type	Estimated Processing time t_j	Hire rate, w_j, Naira/wk
1	Grader 1	2	150000
2	Grader 2	3.5	150000
3	Bulldozer	6.5	300000
4	500kvaGenerator	3.5	70000
5	Dump truck	4	140000
6	Wheel loader	2.5	150000
7	Compressor	4	35000
8	Trailer 1	3	250000
9	Trailer 2	2.5	200000
10	Trailer 3	3	200000
11	Fork lift	1	150000
12	Concrete mixer	3	150000
		38.5	

Table 2: Optimal Sequences Using WSPT Rule

Job index j	Equipment type	Estimated Processing time t_j	Hire rate (w_j) Naira/wk	w_j/t_j	F_j	C_{max}-F_j	$(C_{max}-F_j)w_j$
11	Fork lift	1	150000	150000	1	37.5	5625000
8	Trailer 1	3	250000	83333.33	4	34.5	8625000
9	Trailer 2	2.5	200000	80000	6.5	32	6400000
1	Grader 1	2	150000	75000	8.5	30	4500000
10	Trailer 3	3	200000	66666.67	11.5	27	5400000
6	Wheel loader	2.5	150000	60000	14	24.5	3675000
12	Concrete mixer	3	150000	50000	17	21.5	3225000
3	Buldozer	6.5	300000	46153.85	23.5	15	4500000
2	Grader 2	3.5	150000	42857.14	27	11.5	1725000
5	Dump truck	4	140000	35000	31	7.5	1050000
4	500kva Genset	3.5	70000	20000	34.5	4	280000
7	Compressor	4	35000	8750	38.5	0	0
		Cmax= 38.5					XT= 45005000

Table 3: Cash Flow Based on Initial (non optimal) Sequence of Table 1

Job index j	Equipment type	Estimated Processing time t_j	Hire rate (w_j) Naira/wk	w_j/t_j	F_j	C_{max}-F_j	(C_{max}-F_j)w_j
1	Grader 1	2	150000	75000	2	36.5	5475000
2	Grader 2	3.5	150000	42857.14	5.5	33	4950000
3	Bulldozer	6.5	300000	46153.85	12	26.5	7950000
4	500kva Generator	3.5	70000	20000	15.5	23	1610000
5	Dump truck	4	140000	35000	19.5	19	2660000
6	Wheel loader	2.5	150000	60000	22	16.5	2475000
7	Compressor	4	35000	8750	26	12.5	437500
8	Trailer 1	3	250000	83333.33	29	9.5	2375000
9	Trailer 2	2.5	200000	80000	31.5	7	1400000
10	Trailer 3	3	200000	66666.67	34.5	4	800000
11	Fork lift	1	150000	150000	35.5	3	450000
12	Concrete mixer	3	150000	50000	38.5	0	0
		38.5					XT= 30582500

Observe that the non-optimal sequence of Table 3 gives cash inflow of N30, 582,500 against the N45, 005,000 of the optimal sequence.

CONCLUSION

This paper models the problem of optimising cash flow during development period of a project with **n** number of subprojects as a single machine-scheduling problem. A solution technique involving the WSPT rule is suggested. This rule is easy to apply with an electronic spreadsheet. A real life problem was solved to demonstrate the usefulness. It should be stated that the problem was solved using an electronic spreadsheet: Microsoft Excel.

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