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# Integrating financial planning, loaning strategies and project scheduling on a discrete-time model



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## ABSTRACT

In spite of the large amount of work relating project scheduling and cash-flows, less attention has been given to borrowing strategies for supporting projects' costs. In many practical problems, loaning is not a choice but the unique option for initiating the process. In fact, an adequate loaning strategy is crucial, not just for launching the project but also for guaranteeing its financial success.

In this work, we discuss project scheduling along a fixed horizon cash-flow stream that incorporates loaning strategies. There is an initial capital made available by the project owner (client), to be used to support the activities' costs, together with cash in-flows brought by loans. These loans are assumed to be fully amortized within the given time horizon. After completion, the activities start generating profits, feeding back the financial stream. In addition, the project is not forced to be fully implemented, in the sense that the activities are allowed not to perform, although assuming the precedence relationships imposed. So, the problem is to determine when to launch the elected activities such that the cash-flow at the end of the planning horizon is maximized.

We propose a mixed integer linear programming model for the problem and discuss applications involving different environments and specificities.

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### 1. Introduction

Given a project composed by a number of activities with known precedence relations, the project scheduling problem involves planning the activities' layout in order to optimize a given objective function. This problem has long been discussed in the literature, first addressing the minimization of the total duration of the project (minimum makespan problem), and then integrating a number of additional features in order to make it closer to real-world project scheduling concerns. Two of the most common such features involve resource requirements to carry out the activities and cash-flows interactions.

Resource-constrained versions impose restrictions to perform the activities, involving renewable and/or non-renewable resources. It may also involve alternative ways or modes to accomplish the activities and time/resource trade-offs for their execution, among others.

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The integration of cash-flows along with the project execution has also received much attention in the literature. The most common settings involve the maximization of the net present value (NPV) or the maximization of cash availability (CA). Most authors distinguish two players in this process: the contractor and the client. The first one (contractor) is paid for executing the project, while the second one (client) furnishes the financial means for supporting the project's execution, generating cash in-flows. Most literature gives primary attention to the contractor's NPV. Those that consider the client's NPV include, e.g., Ulusoy and Cebelli [1] and Szmerekovsky [2]. Approaches that comprise both cash inflows and out-flows, addressing the maximization of the NPV of all cash-flows are also described in Icmeli and Erenguc [3].

Some works consider that payments made by the client are done periodically, while others consider a single payment made at the start or at the end of the project, representing a lump sum payment (see, e.g., [17–19]). In addition, lending capital is discussed in Kimms [4], considering that capital is lent from one period to the very next one at a given lending rate. Alternatively, capital is allowed to be borrowed whenever the cash-flows are negative, at rates larger than the discount rate and lending rate. These capitals

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are positive cash in-flows, being employed in Herroelen et al. [5], Özdamar & Dündar [6] and Ulusoy and Cebelli [1].

Capital availability can be seen as a special resource constraint. This interpretation is explicitly explored in Smith-Daniels et al. [7]. It is also considered in Hassanzadeh et al. [8], including the decision on whether or not to perform some activities. In this work [8], the authors discuss an R&D project portfolio optimization problem from the Pharmaceutical Industry. It involves the decision of which projects should be included in the firm's portfolio, given the existing constraints, and financial and resource capabilities. They propose a mathematical programming model addressing a capital budgeting problem for revising and rescheduling the project portfolio. The model is discussed using robust optimization techniques in order to capture uncertainty of pharmaceutical R&D cost estimates in drug development stages. The problem involves project scheduling conditions with a predefined selection of mandatory projects. It also includes capital availability as a resource constraint and the possibility to borrow capital in order to attain the highest financial profits at the end of the planning horizon, as in our case. The main difference is that the hierarchical structure among the projects is only preserved among those being selected, while in our case we can only perform an activity if all its original predecessors have been executed.

The integration of resource-constraints together with cashflows in the same project scheduling framework has also received attention in the literature, namely in Patterson et al. [9], Icmeli and Erenguc [10], Padman et al. [11], De Reyck and Herroelen [12], Ulusoy and Cebelli [1], Ulusoy et al. [13] and Mika et al. [14]. We provide a brief description of the three last works.

In Ulusoy and Cebelli [1], the authors address a payment scheduling problem, where the main concern is the amount and the time to release capital by the client and received by the contractor, in order to achieve an equitable solution. The study involves a multi-mode resource constrained project scheduling problem, with a fixed deadline, being handled by a genetic based algorithm. The objective is to find an equitable solution for the client and for the contractor, where their ideal solutions deviate by an equal amount from real results. For the client, the ideal solution is to make a single payment at the end of the project; while for the contractor, the ideal solution is to receive the entire payment at the beginning of the project. For comparing the effective deviations, both parties' capital must be comparable, which requires using the NPV transformations. Their problem also integrates the chance to borrow. Besides the methodology, the main differences from our work involve: i) the mandatory execution of all activities; and ii) payments made along the project execution, while in our work all capital is reinvested in the system along the entire planning horizon, being released just at the end.

In Ulusoy et al. [13], the authors also propose a genetic based algorithm for a multi-mode resource constrained project scheduling problem with discounted cash-flows, where cash-flows are released along the planning horizon in the form of payments. The authors discuss four different strategies for performing the payments. An important difference from the former work is in the objective function. In this case, the objective is to maximize the NPV of all cash-flows. Compared to our approach, we do not consider discounted cash-flows as all capital is reinvested, being released just at the end of the planning horizon. This option is comparable to the lump-sum payment version discussed in Ulusoy et al. [13], but taking the NPV at the last period cash-flow as the lumpsum amount. Although the NPV may provide an important indicator for decision-making purposes when the problem involves the two players (client/contractor); the fact is that it does not correspond to the real capital returned by the system at the end of the planning process when that is the goal of the problem. This is an important difference from our approach, where the last period capital is the

real result of the process, reflecting the financial exercise along the entire planning horizon. Other important differences are also the mandatory execution of all activities and the absence of borrowed capital.

The last work to compare with, Mika et al. [14], also addresses a multi-mode resource-constrained project scheduling problem with discounted cash-flows. The authors also consider the four payment options described in Ulusoy et al. [13], including the closest procedure to our work, involving a lump-sum payment at the end of the project. The objective is the maximization of the NPV of all cash-flows. The authors propose an integer linear programming formulation and use two metaheuristics for solving the problem. The two metaheuristics involve Simulated Annealing and Tabu Search based algorithms. Besides the methodology, the main differences from our work involve the use of the NPV for maximizing cash-flows returns, the mandatory execution of all activities and also the absence of borrowed capital.

As observed above, all these works use the NPV for adjusting all cash-flows to their value at a single moment in time (usually moment 0), so involving the concept of the time value of money, being widely used for valuing a project and test its potential for investment. However, it does not reflect the real capital returned by the project at the end of the planning horizon, which is right the perspective that we want to establish in our work, that is, we assume that this project is the investment we want to make and we want to get the largest profits from it within the given time horizon. Under this perspective, the project is conducted the furthest the possible, as long as the elected activities can contribute to the global financial outcome. The NPV is also important to regulate the equitability between the client and the contractor, which is a relevant aspect when the two players are involved. This equitability is no longer adequate when the players are the project owner and the market.

In a wider comparison to our work, we also consider a cash-flow stream running in parallel with the project's progress. So, given a planning horizon on *tm* periods, we want to plan the cash-flows during the *tm* periods in order to maximize the project's return at the end of the planning horizon. Besides the various aspects in common, the main differences to our approach are the following:

1- We consider a sequence of overlapping loans, with different maturities, in order to cover the financial costs for accomplishing the activities. We also impose a limit for the total debt in each period.

2- Financial resources are spent for performing each activity. However, after completion they start generating profits, feeding back the financial stream and increasing the current cash-flows for undertaking the execution of forthcoming activities. These profits should also cover other financial expenses, namely those involving the running loans.

3- The activities are not forced to be implemented, allowing the model to decide to what extent the project will be executed, respecting the initial hierarchical order of the activities.

As suggested in Smith-Daniels et al. [7], capital availability can be seen as a non-renewable resource constraint, though in our case the current financial budget in each period is also being fed by the activities' profits, considering those already concluded. This way, the decision process should deal with the two following situations: i) if we launch the activities too early we may run out of cash; while ii) if we launch them too late we may be missing their profits. So, the problem involves a decision process for planning the start times of the activities, respecting given precedence constraints, in order to maximize the financial profits at the end of the planning horizon. In addition, the process can resort to borrowed capital for leveraging cash availability.

Considering capital availability and the limit for the capital in debt in each period as resource-constraints, then the problem here Download English Version:

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