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Project Portfolio Management, selection and scheduling. Bridging the gap between strategy and operations *

Javier Pajares[1], Adolfo López, Alberto Araúzo[1], Cesáreo Hernández[1]

[1] Grupo INSISOC. Dpto. de Organización de Empresas y CIM. Escuela de Ingenierías Industriales. Universidad de Valladolid. Pso del Cauce S/N, 47011 Valladolid.

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Abstract

Corporate strategy can be successfully implemented by means of a portfolio of projects. Project portfolio management has focussed on project valuation, selection and ranking. On the other side, multi-project management literature has been concerned with multi-project scheduling and resource allocation. In this paper, we show that both processes are not independent, as the decision to include a new project into the portfolio not only depends on the financial value or strategic alignment with firm strategy, but also on how the new project interacts with the existing portfolio schedule, risk, capital cost, etc. We show why this happens, stressing the problems and possible solutions. We advocate for distributed approaches to bridge the gap between corporate strategic decisions and operational decisions in projects.

1. Introduction.

Traditionally, firm strategy is implemented by splitting it into functional strategies (marketing, operations, financial strategy, etc), and functional plans. But also, firm strategy can be successfully implemented by translating general strategic objectives into projects. Therefore, project portfolio management is becoming a discipline of increasing interest, in a global economy where innovation and competitiveness are the driving forces of firm success.

Portfolio Project Management (PPM) is involved in developing methodologies for aligning projects to strategy, valuing projects, selecting the best ones, balancing the portfolio in terms of risk, cost, etc, and coordinating the joint execution of individual projects, so that synergies could be achieved. The output of this process is a set of projects to be done, ranked in terms of strategic and financial importance to the firm.

On the other side, multi-project management literature has been related to project portfolio scheduling, taking into account the constraints in firm resources. Usually, most of the methodologies have been developed from the field of Operations Research. The rank of accepted projects is the input to this process, whereas the schedules of all the individual projects become the output.

In this paper, we show that both processes are not independent, as there are feedbacks between scheduling and portfolio value. First, project raking should be taken into account

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when resources are allocated among projects and schedules are determined, so that most important projects received more resources.

Second, whenever a new project is accepted to form part of the portfolio, the value of the portfolio itself might be affected by the new cross-relations among the schedules. The main idea is that the decision to include or not a project in a portfolio not only depends on the financial and strategic value of this particular project, but it also depends on how the new project could fit into the structure of schedules and resources allocation of previous projects. Moreover, we also argue that not only schedules should be taken into account, as the new project also could affect to other portfolio variables, as risk, capital cost, strategy goals, etc.

We show some examples and we will propose some solutions to overcome these problems. Our work will contribute to bridge the gap between corporate strategy and operational management within the firm.

This paper is organised in the following way. First we will summarise the role of project portfolio management and how project strategy can be implemented by means of a balanced portfolio of projects. We will also explain recent works in multi-project scheduling under resource constraints. Then we will argue the reasons why portfolio decisions cannot be managed without realising that the value of the portfolio can be affected, not only by the value of the new project itself, but by its relations with scheduling, cost, strategy, etc. of existing projects. We will discuss some problems suggesting some solutions. We will finish with the main conclusions of our work.

2. Project Portfolio Management and multi-project environments.

In real world, up to 90 % of the projects are carried out in a multi-project context (Payne, 1995). However, it seems that there are two independent (and separated) research fields: project portfolio management and multi-project management (Pennypacker & Dye, 2002). The former is mainly concerned with portfolio valuation and project selection, assuring that selected projects will be aligned to corporate strategy, increasing the firm value (Kendall &. Rollins, 2003). On the other side, multi-project management faces problems related portfolio scheduling under resource allocation constraints, so that coordination among projects could be carried out efficiently. (Pennypacker & Dye, *op.cit*.).

Because of its strategic component, CEOs and top corporate managers are responsible for defining and managing the firm portfolio, whereas multi-project management is carried out by project and resource managers, more related to tactical and operational decisions. Project management literature explains "how to do projects right", and portfolio project management suggest "how to do the right projects".

We will comment the main contributions in both fields, and we will argue about the need of bridging the gap between them.

2.1. Project Portfolio Management and Corporate Strategy.

Following PMI(2008) a portfolio is "*a collection of projects (temporary endeavours undertaken to create a unique product, service, or result) and/or programs and other work that are grouped together to facilitate the effective management of that work to meet strategic business objectives*". Projects included in the portfolio should help firms to accomplish their strategic and financial objectives.

Corporate portfolio may include both external (a client outside the firm) and internal projects (within the corporation). Internal projects may have different purposes: new product development, maintenance (e.g. updating information systems) or growth oriented, in order to increase the competitive position of the firm (e.g. opening overseas markets).

Project portfolio management is a dynamic and continuous process (see figure 1). Portfolio definition starts with the definition of corporate strategy. Firm culture, vision and mission suggest what projects should be rejected and what projects could became a candidate to form part of the portfolio. After the vision and the mission have been set up, firm environment and firm internal strengths and weaknesses are analysed, so that strategies and objectives are defined and ranked according to their importance. Strategies are implemented by means of firm "line operations" and by means of the project portfolio.

Project identification can be performed top-down (as the last stage of all the strategy development process) or bottom-up (as result of human resources proposals). Once new projects have been identified, they must be evaluation. Most common evaluation methodologies are check-lists, multi-criteria scoring and mathematical models. Main evaluation criteria are strategy alignment (contribution to organisational goals), financial (ROI, Net Present Value, Pay-back, etc.), technical issues, marketing (market share), etc.

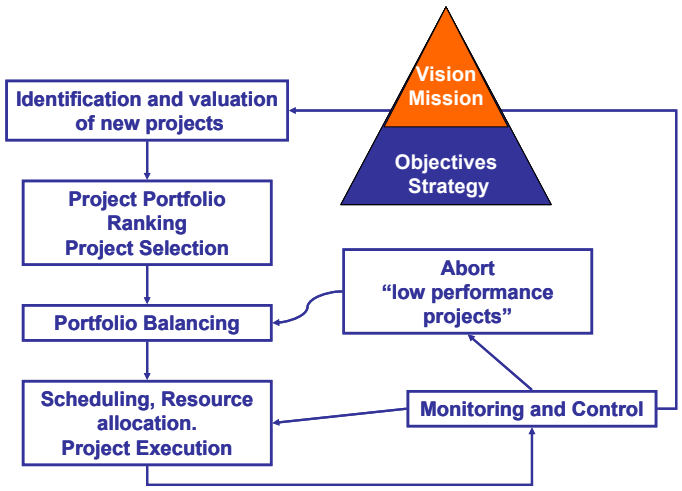

Figure 1. Project Portfolio Management dynamic process.

Projects can be prioritized by means of the results from the evaluation process, or by means of other methodologies like Multi-attribute Utility Analysis, the Analytical Hierarchical Process (AHP) proposed by Saaty (1980) or Mathematical Programming (see Fernández Carazo et al. (2008) for a deep description of evaluation and raking methods). Constraints related to human resources, financial capability, firm assets, etc. should be taken into consideration.

Portfolios must be balanced. For instance, it makes not sense to have many short term projects and a small number of longer term ones; a balanced portfolio combines projects with different levels of risk, and it is necessary to have balance among projects related to R&D, growth, maintenance, etc.; it makes no sense to concentrate all our resources in projects related to one particular corporate objective, forgetting the others.

The purpose of "portfolio monitoring" is to check whether the projects execution contributes to the objectives of the firm, so that corrective actions could be done as soon as overruns take place (e.g. project abortion, re-scheduling, resource re-allocation, etc.). Projects execution gives important feedback to the top managers, so that, strategies and objectives could be changed or enriched.

This process is dynamic, as continually new projects become candidates to belong to the portfolio. Project ranking changes over time, as new projects enter the portfolio and other exit because of underperformance or because of corporate strategy changes. Overruns and priority

changes take place in parallel, and as consequence, conflicts among projects emerge, since individual projects compete for the same scarce resources.

2.2. Multi-project scheduling and resource allocation.

Once the candidate projects have been defined and ranked according to their importance, each project has to be scheduled, computing starting and finishing dates of each activity. In practice, projects compete for the same resources, so the literature has been focussed on the resource-constraint multi-project approach. As the underlying scheduling problem is NP-hard, the research has been mainly focused on the development of heuristics for static environments (Anvari-Isacow & Golany, 2003).

In some approaches, the portfolio is considered a macro-project, whose activities are the single projects. Precedence relations between projects could be established, because of technical, strategic or portfolio balancing reasons. On the other side, we can find hierarchical approaches where in a first stage, resources are assigned to projects and then, each project is scheduled independently (see Speranza & Vercelis, 1993). For a deep review of the literature, see Has et al. (2007) and Herroelen (2005).

But, as explained in figure 1, in practice, project portfolio is not a static process but a dynamic one. Continually, new projects become candidate to be included in the portfolio, as new market, technical or strategic opportunities emerge. Unfortunately, the research in the dynamic scheduling problem has not converged to one solution or scheduling rule robust enough to hold in the general case (Anavi-Isakov and Golany, *op.cit.*).

In practice, multi-project problems are extremely complex, because of the complex constraints concerning particular projects and the firm as a whole. For instance, although in theory resources could be moved from one project to other to optimise portfolio performance, in practice, human resources cannot be moved without reducing his/her productivity. Kruger & Scholl (2009) propose to include resource-dependent transfer times, which represent the setup activities performed when a resource is removed from one project and reassigned to another (or from one job to another within the same project).

Moreover, within the same portfolio, some projects might be very sensible to the finishing date, where others need intensively a particular resource. Multi-tasking makes people to increase mistakes, and mistakes mean re-working. Individual project delays and over cost are common issues in real projects, because of under-estimation and uncertainty.

For all the reasons explained here, multi-project scheduling and resource allocation problems are difficult to model, and the rigorous solutions from Operational Research have limited utility in real portfolios because, beyond its NP-hard intrinsic nature, it is difficult to formalise mathematically both objective functions and constraints.

Critical Chain methodology can also be used for multi-project scheduling. This methodology applies Goldratt´s (1997) Theory of Constraints (TOC) to project scheduling under resources constraints. Cohen et al. (2004) study the application of the methodology to multi-project environments and Steyn (2002) suggest further applications in project management. Herroelen & Leus (2001) discuss about the merits and pitfalls of the methodology, arguing that the proposed rule for buffer sizing may lead to a serious overestimation of the required buffer protection. Anyway, the methodology is becoming popular for managing multi-project environments, as it offers satisfying solutions in real problems. It has been also suggested by authors like Kendal & Rollins (2003) or Levine (2005), some of them close involved in portfolio management practice and consulting.

3. Bridging the gap between portfolio management and multi-project environments.

There is a gap between project portfolio methodologies, involved in the alignment of projects with strategy, project selection and ranking, and project balancing on one side, and project scheduling and resource allocation among projects (multi-project management) on the other. Although the output of the portfolio management is (or should be) the input of multi-project planning, both fields seems to be independent. As far as we understand, they are not independent, because there are forward and backward interrelations.

The decision to include a new project within the existing portfolio not only depends on the new project features as strategic alignment, financial value, ROI or risk, but with it also depends on how the new project interacts with the existing portfolio and affects some properties of the existing portfolio.

In particular, we will concentrate of how the candidate project schedule interacts with the schedules and resources of the projects belonging to the portfolio, and how it affects to other variables as portfolio risk or capital cost. We will discuss some of these issues, stressing the problems and possible solutions. Anyway, we understand that bridging the gap might be the beginning of complete research program.

3.1. Portfolio risk and hedging projects.

Portfolios must be risk balanced, i.e., including projects with different risk levels. When a new project enters into the portfolio, it affects the overall portfolio risk. We emphasise here that the new portfolio risk not only depends on the risk of the new project but on how this project interacts with the sources of risk of the existing portfolio. In other words, a project with a particular level of risk, could increase dramatically the risk of a portfolio A, without affecting too much the risk of a portfolio B; even it could be possible that the new project could reduce the portfolio risk (hedging project).

For instance, suppose that a portfolio is very sensible to oil prices or to interest rates. A new project requiring high quantities of raw materials related to oil prices will increase dramatically the (oil-related) risk of the project. Something similar applies to exchange rates, so that we should give preference to new projects whose sensitivity to a currency hedges the exposure of the existing portfolio.

If the aggregate portfolio cash flow structure depends on financing, a new project demanding high financial resources during all the stages of its life cycle will increase the interest-rate related risk of the whole portfolio. On the other hand, a project less capital intensive, could be more interesting.

In some cases, derivative markets (e.g. forward, futures and options markets) might help portfolio managers to hedge the portfolio against some row material prices, foreign exchange rates o interest rates.

Financial portfolio theory shows us to diversify investments in order to reduce risk. Similarly, portfolio managers should monitor project portfolio risk and exposure to certain variables, so that they take into account theses issues when deciding to undertake new projects.

3.2. Portfolio capital cost.

All projects need financial resources to be implemented. When a new project is included in the portfolio, new financial resources are needed. But usually, firms do not change their financial structure of equity and debt (except in the case of Project Finance, where debt is paid only with the cash in-flows generated by the project). As the portfolio risk changes,

equity cost changes, and so it does capital cost. Again, the new project could affect overall portfolio capital cost.

As explained in previous section, the new project cash in-flow and out-flow structure also interacts with the existing portfolio structure; therefore, the decision to include the project in the portfolio should depend on this interaction. This is specially important in times of high interest rate levels. In some cases, short term projects with early positive cash-flows could finance the remaining portfolio.

3.3. Scheduling and resource allocation.

Firms usually have a limited amount of resources (asset, human resources, machines, etc.). Therefore, when a new project is included within a portfolio, the schedule and resource demanded by this project interacts with the schedules and resources previously allocated to the existing portfolio. Other factors equal, a strongly ranked project during the portfolio evaluation phase could affect negatively the schedules and resource availability of the whole portfolio, whereas another project, maybe with less priority, could complement the portfolio resources structure in periods of low resource usage. For this reason, the priority of a project should depend not only on its strategy alignment of financial properties, but on how its schedule interacts with the resource allocation of the existing portfolio.

It is clear that strategy alignment and project value should play an important role in scheduling and resource allocation rules. This means that, in case of conflicts, high priority projects should receive more resources, even at the expense of other low ranked projects. Therefore, multi-project methodologies should take into account portfolio priorities, but it is also true that multi-project scheduling issues also affect project priority.

Building frameworks integrating portfolio strategy and multi-project allocation decisions are still an open promising research area. Ghasemzadeh et al. (1999) propose and a zero-one integer linear programming model for selecting and scheduling an optimal project portfolio, based on the organisation's objectives and constraints such as resource limitations and interdependence among projects.

However, in practice, mathematical and heuristic models exhibit limited usefulness because of uncertainty, project over-costs and delays, and the intrinsic dynamic nature of the portfolio processes.

One way to face with this complexity is by means of distributed approaches, as muti-agent systems. Indeed, we know that some complex socio-economic problems are solved by means of distributed procedures, like markets or auctions (Hernández et al. 2008). The distributed approach has been proposed for project scheduling by Kobbacy et al. (1996) and Yan et al. 1998). More recently, Kumara et al. (2002) and Lee et al. (2003) have proposed a multi-agent dynamic resource scheduling in mult-project environments and Confesore et at. (2007) use a combinational auction as a coordination mechanism.

In Arauzo et al. (2008), a muti-agent approach for dynamic scheduling and resource allocations is proposed. By means of a distributed structure, the model integrates strategic and scheduling issue within the same framework. Project priority is updated depending on how new projects interact with the existing portfolio.

Agents in the model are projects and resources (see figure 2.). Projects have scheduled work to be done by different resources. Resources are endowed with some capabilities (knowledge, work force, etc.) that are needed to do the work. Projects demand resources over time and resources offer their capabilities and time availability. There is an auction process, and the price of resource-time slot emerges endogenously as a result of supply and demand.

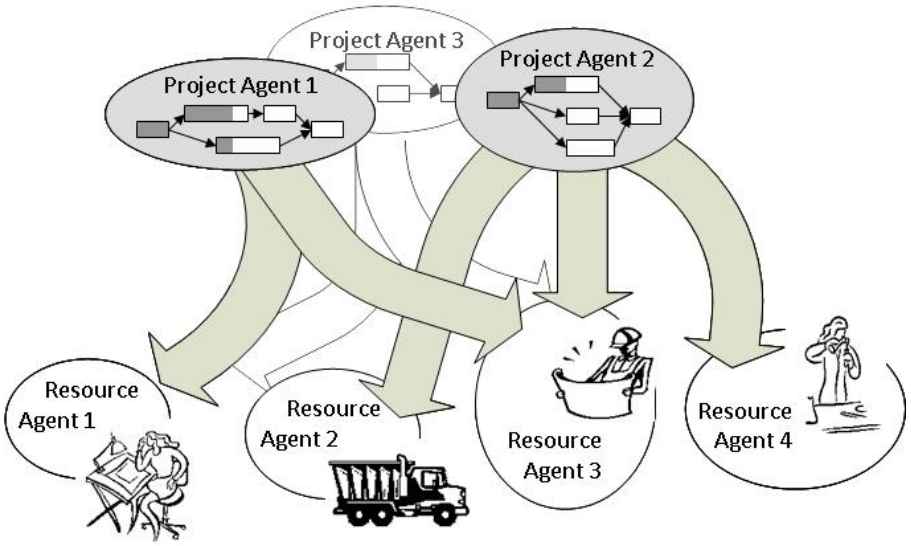

Figure 2. A muti-agent approach for multi-project dynamic scheduling and resource allocation.

Our approach helps us to address with some of the problems faced in multi-project environments: dynamic allocation of resources, the role of capabilities, flexibility, portfolio decisions, etc. And it opens a research agenda to explore more complex environments.

4. Conclusions.

Project portfolio management is a natural an efficient mean to implement corporate objectives and strategy, translating strategy into projects. It has the advantage that it forces top management to translate corporate strategy in specific projects. Top management is encouraged to think in terms of results and deliverables (what to do), priorities (what is important ad how much many I am going to provide), ant time (when).

For this reason, the interest for project portfolio management has been increasing during the last years. But the researchers and professionals have focussed on two different issues: project portfolio, engaged in portfolio selection and raking on one side; project scheduling and resource allocation on the other. In this paper, we suggest that the gap has to be bridged, as the decision to include a new project in the portfolio not only depends on the properties of the new project, but on the interaction of the new project with the risk, capital costs, schedules, resources, etc. of the existing portfolio.

Bridging the gap is quite difficult, as some of the solutions from operations research have limited utility, because the complexity increases when both banks are included, and real constraints are difficult to translate into mathematical equations.

We suggest that distributed frameworks, as muti-agent systems could help us to get satisfying solutions to real project portfolio problems. As far as we understand, bridging the gap between strategy and project scheduling might be a promising research program.

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