Product Development Process: Using Real Options for Assessments and to support the Decision-Making at Decision Gates

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Abstract. Enterprises need continuous product development activities to remain competitive in the marketplace. Their product development process (PDP) must manage stakeholders' needs – technical, financial, legal, and environmental aspects, customer requirements, Corporate strategy, etc. -, being a multidisciplinary and strategic issue. An approach to use real option to support the decision-making process at PDP phases in taken. The real option valuation method is often presented as an alternative to the conventional net present value (NPV) approach. It is based on the same principals of financial options: the right to buy or sell financial values (mostly stocks) at a predetermined price, with no obligation to do so. In PDP, a multi-period approach that takes into account the flexibility of, for instance, being able to postpone prototyping and design decisions, waiting for more information about technologies, customer acceptance, funding, etc. In the present article, the state of the art of real options theory is prospected and a model to use the real options in PDP is proposed, so that financial aspects can be properly considered at each project phase of the product development. Conclusion is that such model can provide more robustness to the decisions processes within PDP.

Keywords. Real options theory, product development process, risk, investment decision making under uncertainty

1 Introduction and Problem Definition

Clark and Fujimoto [6] define the activity of product development as the process to transform information from the market into information required to the production of finished goods for commercial purposes. Decisions can no longer be based on trial and error, since the changes occur more quickly than the lessons can be learned [32,33].

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Enterprises need continuous product development activities to remain competitive in the marketplace. Their product development process (PDP) must manage stakeholders' needs – technical, financial, legal, and environmental aspects, customer requirements, Corporate strategy, etc. -, being a multidisciplinary and strategic issue.

In the nowadays-competitive environment, companies must optimize the resources usage to remain in the market game. Therefore, it is critical to study methodologies of product development, establishing connection between concepts of return and risk in decision-making processes with better practices and models to help management to maximize the expected value of the investments in product development. According to Baxter [3], out of ten ideas on new products, three will be developed, 1,3 will be launched in the market and only one will be lucrative. As the same author, the companies need to introduce new products continuously, to prevent competitors from getting part of their market share.

Norton and Kaplan [27] stated that prior to developing a project, one must establish cost-objectives and perform value-engineering analysis, so that a combination of quality, functionality, and price desired by the customers can be incorporated to evaluate the profit feasibility. The present article is intended to study PDP methodologies, mainly return and risk concepts, methodologies, best practices, and working models to maximize the expected return value of the investments in product development.

Several methods have been proposed to value such situation, including decision trees, but the appropriate risk-adjusted discount rate is still virtually indeterminate. The real option valuation method is often presented as an alternative to the conventional net present value (NPV) approach. It is based on the same principals of financial options: the right to buy or sell financial values (mostly stocks) at a predetermined price, with no obligation to do so. Options associated with non-financial investment opportunities are called "real options". In PDP, a multi-period approach that takes into account the flexibility of, for instance, being able to postpone prototyping and design decisions, waiting for more information about technologies, customer acceptance, funding, etc.

2 Background

The present article used the following theoretical references to develop a model for product development: project life cycle, product life cycle, and real options theory.

2.1 Project Life Cycle

Projects, defined as temporary efforts undertaken to create a product or service, have a certain degree of uncertainty. Therefore, organizations have better management control by dividing the project in phases, so that each phase is marked by the conclusion of activities, in a tangible and verifiable form. The set of the phases, which composes a logical sequence, is called project life cycle. Projects must have a well-defined beginning and an end. The end is reached when the objectives of the project will have been reached, or when it becomes clear that the project objectives will not be reached or when its needs no longer exist.

PDPs are usually broken into sequential stages (or phases), so that requirements can be checked against plans to evaluate the process alignment and trends towards the objectives. Checkpoints between phases involve “go/no go” decisions, leading the process towards later management decisions or terminating projects that do not offer good chances of revenue/profits to the company, nor opportunities for a better strategic positioning.

2.2 Product Life Cycle

Many authors studied the product life cycle [3, 18, 21, 31, 42]. Kotler [21] divides it in five periods: development, introduction, growth, maturity and decline. According to author, during the development of the product the company accumulates costs of investments. The period of introduction is characterized by the launch of the product in the market, followed by an increase in sales. After that, the product goes in a period of stability (maturity), and from this point on, sales and profits decline.

2.3 Real Options

In the corporate finance literature, the value of a risky project is calculated by the net present value (NPV) of its cash flows, discounted at a discount rate that reflects the project risk: such method is not able to capture the management flexibility along the decision-making process. The decision-making during the product development requires that the existing options can be evaluated based on expected values earnings and involved risks.

This concept can be calculated by the Capital Asset Pricing Model (CAPM) [10, 15, 34]. Such calculation establishes a discounting factor to be used in the analysis of an investment by its net present value (NPV): the discount tax is increased to compensate the existing risk, beyond the value of the money in the time (which would be the tax free of risk). However, in the PDP, the risk variation has no linear relation with the expected returns: at phases transition, the project evaluation will drive to a decision whether the project goes on (if favorable conditions occur), requires changes (due to consumer needs changes, competition, technological change or a composition of diverse factors), or even be cancelled.

Santos and Pamplona [39] stated that in markets characterized for competitive change, uncertainty and interactions, management has the flexibility to modify the operation strategy to capitalize favorable future chances or to minimize losses. The probability of success in a project usually increases with the reduction of the inherent risk along the time [30]. The deducted cashflow understates projects, therefore it ignores and it does not accommodate the main strategic questions in its analyses: management does not have to accept a NPV calculation, positive or negative, unless an explanation to it exists [24]. Therefore, the CAPM becomes inadequate: some models are used to measure the return and risk in the process of decision making, mainly the Black & Scholes formulae and the binomial model, used in the financial market. However, these methodologies assume a passive involvement of management too [9].

The real options fill this gap: based in contracts of options in the financial market, it becomes a powerful ally in the management process in risk conditions. As stated by Minardi [26] "management flexibility is a possibility, but not obligation to modify a project in different stages of its operational life". Figueiredo Neto, Manfrinato and Crepaldi [9] compiled the existing real options in projects:

- Option to wait: postpone an investment, benefiting by value favorable movements in the project (as increase on product prices), and preventing losses if unfavorable scenarios occur;
- Option to abandon (sell): abandonment of a project when future losses are foreseen and/or selling the project (for example, to another company);
- Option to expand: expand the operation scale of a project previously defined, if foreseen conditions are more favorable than initially analyzed;
- Option to contract: opposite of the expansion option;
- Option to move: changes in conditions (for example, to restart operations), or changes of a product or technology; and
- Composed option: combination of any of the previous ones (called rainbow options).

Diverse applications of real options have been developed: Pinto and Montezano [29] used them to evaluate the project of digital cartographic bases (used for geo-marketing, urban zoning, environmental licensing, etc.); Saito, Schiozer and Castro [36] included management flexibility in the evaluation of reservoirs, while Gustafsson [12] and Gustafsson and Salo [13] focused the studies of real options in management of project portfolio. Santos [40] used real options to measure the potential value of organizational restructure in merges and acquisitions; Brobouski [4] used the real options to analyze forest projects and Martinez [25] analyzed leasing contracts. Many authors studied the use of real options to evaluate R&D prior to production investments [1, 2, 5, 8, 11, 14, 16, 19, 20, 23, 28, 35, 38, 39, 41, 43], while Keizer and Vos [17] describe a method to identify, measure and manage the risks in product development, however the decision-making process has not been analyzed by the authors.

3 Proposed model for decision-making in PDP

Taking a hypothetical PDP, with activities related to the project life cycle and product life cycle within it, resources, parts involved, dates, etc., are to be established in this plan. At same time, a calendarized budget, based on resources usage, dates, etc., can be elaborated (investments during the project phase and operational costs along the product life cycle). In addition, from the cashflow that comes from the budget and revenue expectations, the NPV can be calculated (without management flexibility).

Based on the budget and phases information, it would be possible to create a decision-tree, with all key decision-points along the whole PDP, as represented at Figure 1.

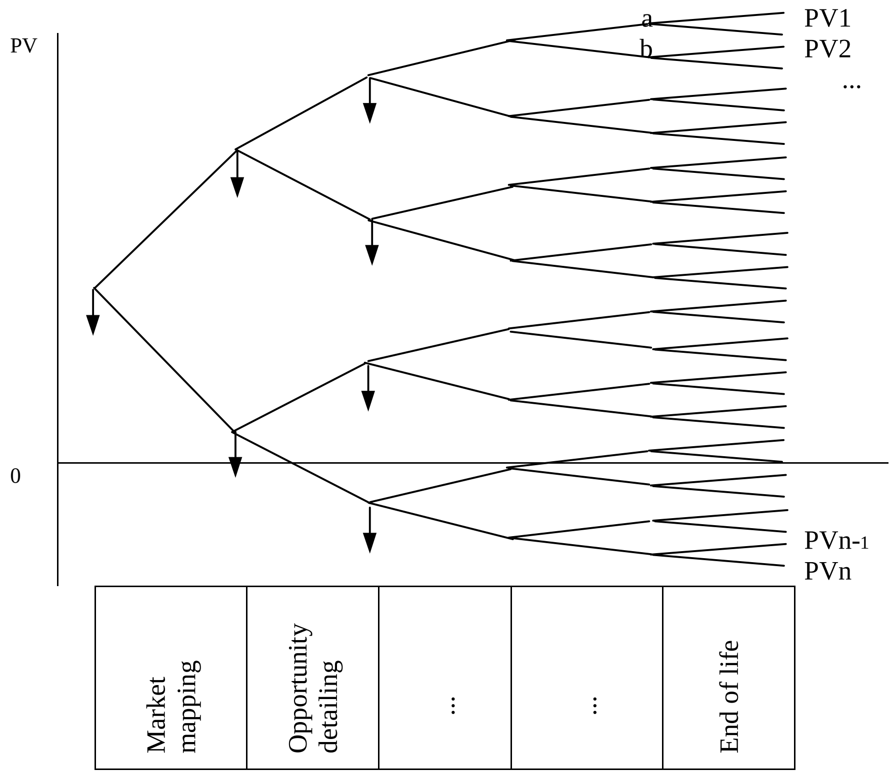

Figure 1. NPV event tree

Then, it is necessary to incorporated it management flexibility - management decisions based in new information that appear - in the tree of events, transforming it into tree of decisions [7]. By doing that, which means, getting rid of alternatives were NPV would be reduced, due to negative values, the adjusted project NPV (adding flexibility benefits) would be calculated.

This calculation - "from right to the left" – along the whole tree, would characterize the consideration the flexibility and management action, supporting the decision-making process since the early phases of the PDP, or at any other phase. The decision on future investments is function of the expected profit when management action is taken and the cost to continue the project [37].

4 Final Considerations

The use of the real options to revision the performance criteria in each of the project phases seems to be an obvious and natural choice. Krishnan and

Bhattacharya [22] approached to such proposal, suggesting a model to evaluate the optimal point to freeze technology through stochastic formulas. Santiago and Bifano [37] described the use of the real options in the development of a laser oftalmoscope, showing as the project can be managed by the estimate of its value and determining the management actions to be taken at each phase revision. However, the authors had only used of the options to continue, improve the technology or to abandon the project in the last phases of the project, while the proposal of the present article is to use real options to evaluate all phases and explore all potential type of options listed by Figueiredo Neto, Manfrinato and Crepaldi [9].

Identified the existing gap, the recommendation to the organizations that develop products is to use real options at each phase of the PDP. To be able to do so, the existence of a structured PDP for the organization becomes a need: such PDP must contain stages (phases) predefined that not only contemplate the phases of the project life cycle, but also the product life cycle.

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