How Different R&D Project Types are Terminated

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Abstract--**This paper studies the main reasons given for early termination of different types of New Product Development (NPD) projects. Early termination here means before reaching its objectives. Our case study, a large Brazilian chemical company, is a B2B operation with three types of NPD projects: line extension, new application and innovation. We found that they mostly replace decisions to kill projects with project prioritization. Managers prefer to keep projects in the pipeline, even in stand-by, instead of terminating them. Moreover, they apply different criteria for deprioritizing/killing each type of project. The most used criteria for line extension and new application projects are the expected financial results, followed by customer interest in the resulting product. Costumer commitment is also more relevant for line extensions than new applications. For innovation projects, the former criteria are less stringent and greater emphasis is put on the strategic fit.**

I. INTRODUCTION

Project termination is one of the most difficult decisions in a company [1; 2; 3; 10; 12] Nevertheless, it is still poorly understood. Although vital for keeping the sanity of the company's portfolio [8; 10], the main textbooks on project portfolio management still do not deepen the discussion on factors, motives and consequences of project termination. [10] for example, discuss the consequences of having too many projects on the pipeline (the "gridlock"), mentions the problem of having too many projects on hold, show some generic "red flags" on project reviews, but still leave open the discussion on criteria for project termination.

Recent research have enriched the discussion on project termination, but it is still a source of conflict on the R&D Manager's routine. Having a clear go/kill criteria definition is indeed fundamental for the portfolio's performance, as shown by [8]. Nevertheless, the authors state that the lack of such definition is still widespread.

After [1] had kicked off the discussion on killing "that R&D project" and deepened the discussion in further papers, a reasonable number of authors have studied the matter, but most of them have done it in only one portfolio dimension. We could not find any work comparing criteria used for terminating different types of R&D projects. [11] mentions that in some companies there are different criteria for different types of project, but does not specify these differences. Is killing a derivative project as difficult as killing a breakthrough project? Are there any differences in the set of criteria used for terminating different types of new product development projects?

To begin answering these questions, the present paper will try to understand how the criteria applied in project termination is distributed along the different dimensions of new product development (NPD) projects. Therefore, the research intends to explore the question: Which factors are referred to at the decision to terminate different types of NPD projects?

Many authors have studied project termination in the last few decades [1; 2; 4; 5; 6; 13; 15; 16; 21]. Yet others have studied project prioritization [10; 12; 23].[17] have shown that the discussion on the degree of novelty in innovation is far from consensus, therefore the present work will apply the case study's company own taxonomy, since defining this concept is not this paper's goal.

The paper begins presenting the research question and objectives. Then, the methods will be presented and discussed. We proceed with a literature review on the main concepts used to answer the research question. Finally, the case study gives us data for our conclusions and contributions.

II. RESEARCH QUESTION AND OBJECTIVES

The present paper aims at answering the following fundamental question: *Are there any differences in the criteria used for terminating different types of new product development projects?* More specifically, the research intends to answer the question: *Which factors are used at the decision to terminate different types of new product development projects?*

As an exploratory study, the objectives of the present research are:

- To review the literature on project termination;
- To study cases of terminated projects in order to identify and characterize the criteria which has taken the managers to terminate the projects;
- To organize the criteria by project type.

III. METHODS

The research relies on two distinctive methods for each of its parts. Part I – literature review – deals mainly with published documents (articles, books and essays) and Part II – case study, will use interviews, participant observation, and document analysis. Non-published documents, such as information made available by the studied company, are analyzed as a source of relevant information for understanding the research problem. Interviews with the three research area managers and the R&D manager deepen documented information on methods and practices. Participating observation then checks the informal and varied ways in which practices reflect, complement or contradict formal procedures.

We asked interviewees to state the reasons they use for terminating projects. Examples of different types of project

were discussed. Then, they were asked to verify the factors that are considered to terminate different types of projects. Finally, the authors analyze the data and build a framework to explain different project types termination.

We complement the information gathered from interviewees in a participant observation, with a daily presence in the company studied. During daily routine, project termination was discussed many times with different involved people, checking in this wider internal setting if and how formal procedures are actually implemented.

As an exploratory study, this paper does not intend to generalize its results, but to describe why and how one company deals with their projects' termination. A single case study may be quite revealing to this kind of research question [24].

IV. LITERATURE REVIEW

This section will present the main concepts and latest findings on this paper's theme. We begin with the types of innovation projects [22]. R&D performance measures are then quickly presented [8]. Then, we present the current discussion on Project Portfolio Management (PPM), with a special look on the work of [10; 12; 18], and finish the section with a deep understanding of the state-of-the-art on project termination.

A. New product project types

[22] divided the research & development projects in five different types, according to the degree of newness in product and process change:

1. Research and advanced development projects;
2. Breaktrought projects;
3. Platform projects;
4. Derivative projects; and
5. Projects developed in alliances and partnerships (which may include any of the above).

Although their typology is well accepted, the authors recognize that it may not be the best categorization for a given company. In practice, they recommend a first step of finding the adequate categories for a given company.

Anyway, the discussion on the taxonomy and terminology on project types is large and yet unfinished. [17] work shows the many taxonomies and nomenclatures used to measure the degree of novelty of R&D projects. Therefore, we will stay with [22] recommendation and adopt our company's own typology, concerning product and process development. As a B2B, our company values in large extent their clients' inputs on an intended new application. Theirs is a taxonomy heavily influenced by a potential contract partnership with their clients.

B. Project termination and the R&D projects portfolio management

Project termination is one of the tasks an R&D manager should worry as part of the Projects Portfolio Management (PPM). Each project is managed individually, as a gardener manages each plant in a garden. But the gardener should also pay attention on the overall conditions that all plants are facing, and eventually remove individuals so that the garden as a whole could grow healthier.

A classical definition is given by [9]:

> Portfolio management is a dynamic process, whereby a business's list of active new product (and R&D) projects is constantly up-dated and revised. In the process new projects are evaluated, selected and prioritized, existing projects may be accelerated, killed or de-prioritized; and resources are allocated and re-allocated to the active projects.

The termination phase is present in this definition as part of the core nucleus of PPM. Projects with unsatisfactory performance should be identified during their development and killed as early as possible, in order to gain time and free resources for other more profitable projects [1].

The most popular theme on PPM is project selection methods, as pointed out by [18]. [9] made a comprehensive research revealing the most popular and the best performing companies' methods used by USA industry on their project portfolios.

Project termination is directly linked to the methods applied to manage each project individually. [12] developed his Stage-Gate® methodology and showed later [11] that his tool is widely used in industry. The author tracked the changes the companies applied to the original methodology in order to correct mistakes and to address questions it was not designed to answer.

The Stage-Gate® methodology consists of stages of development intercalated by gates, in which the go/no go decisions are made. At every gate, criteria are applied to verify if the project is ready for the next phase or if it should be terminated. [11] identified that the greatest challenge of Stage-Gate® is making the gates work. The author describes the "gates without teeth" or "hollow gates" problem as a recurring issue faced by companies that apply the method.

When the problem is identified, the main symptom is having too many projects on the pipeline. Therefore, resources are wasted and the projects' have a late time-to-market [11]. The Projects Funnel, defined by the idea that some projects that enter the pipeline will be abandoned during its development, becomes a Project Tunnel, in which every project that get into the process will reach the market [11].

The author affirms that the greatest cause for "gates without teeth" is the existence of complicated and bureaucratic process for gate review [11]. He suggests the concept of "lean gates", in which only the most sensitive

information gets to the decision makers – the "gate keepers", or the resource owners [11].

Turning back to our gardener metaphor, plants must also be removed from the garden if their development harms other plants' growth. Interactions and synergies can also be motives for terminating projects during the portfolio review meetings. As [18] postulates, the value of a portfolio is not a linear sum of the projects, unless they are independent. Project termination or scope reduction as means for improving portfolio performance is anticipated by [3; 22; 11; 12; 19].

The discussion on project termination, therefore, has aspects in both individual and portfolio levels [8]. Next section will discuss criteria used for project termination.

C. Decision to terminate R&D Projects

There are two kinds of decisions: routine and non-routine. Routine decisions relies on a great amount of data in a well-known environment, therefore the forecasting is more precise. For non-routine decisions, for which there may be a lack of data and previous experiences, the forecast is more complicated and the incidence of Type I (false positive) and type II (false negative) errors is greater [7].

Depending on novelty degree, project termination can be either a routine or a non-routine decision, therefore, may have different Type I (not killing a bad project) and Type II (killing a good project) error costs. Moreover, wrongfully terminating a project may cause relationship and motivation problems [15; 21]. The decision makers must try to avoid these errors in an uncertain environment. Terminating different types of projects using different criteria or weights looks like a rational idea.

Most of the current literature about project termination deals with the late abandonment of the projects, after reaching their established objectives. [1] present a checklist of 12 criteria for killing R&D projects, some of which are by themselves strong enough motives for abandoning a project in any phase of its development. A combination of nine factors, regardless of its nature, indicates a project that should be terminated. The 12 factors presented by [1] are:

1. Lack of top management support;
2. High rate of new product introduction;
3. Low probability of technical support;
4. Clarity on the technological route to be followed;
5. The project leader is not a project champion;
6. Lack of association between marketing and technical aspects;
7. Lack of focus on the product design (designing for a myriad of end uses);
8. Low effectiveness of the project manager;
9. Lack of commitment of project workers;
10. Life cycle of the product being developed is not on growth phase;
11. Low internal competition for resources (competition acts as a catalyst for successful project completion);
12. Frequent revision of the cost schedule.

The paper from [1] started a debate on when to kill R&D projects as early as possible, avoiding expenditures on the wrong projects. As [9] would later point out, if a company develops the wrong projects, this will result in a poor project portfolio performance, and the methods surveyed by the authors are also applied to go/kill decisions. However, the paper pays very little attention to how these methods are specifically applied on these decisions.

In another work from [2], different countries were tested for a list of criteria for abandoning projects. The study compared factors for project termination in four countries: USA, Germany, UK and Japan. The author studied a series of projects (both successful and unsuccessful) to find the main reasons presented for project termination in these nations. The results show a list of 16 main criteria (out of a preliminary list of 34) that are most used across countries:

1. Probability of success via the selected technological route;
2. Deviations in time schedules;
3. Deviations in cost schedules;
4. Time of anticipated competition;
5. Chance event;
6. Smoothness of technological route;
7. Pressure on project leader;
8. Presence of a project champion;
9. Change in probability of commercial success;
10. Change in number of end uses;
11. Change in support of top management;
12. Change in support of R&D management;
13. Change in commitment of project leader;
14. Change in availability of experts;
15. Stage of lifecycle;
16. Adaptability of project leader.

[2] in this research deepens the discussion on criteria for terminating projects, although this study could not build a method or a decision framework for applying these factors on a portfolio. This paper captured not only the absolute factors but also the change in some characteristics that may indicate termination. The use of factors "deviance" instead of absolute factors shows that uncertainty is not tolerated in any aspect of the project. Moreover, the study examines the hypothesis of "universal factors" for terminating projects. In an environment where internationalization of R&D is growing, such discussion is of relevance.

[4] develop this framework for determining critical success and failure factor in projects. The authors gather factors for success and failure in the literature and test them in an empirical case study. The framework organizes the literature factors in groups:

- Factors related to project manager & project members;
- Factors related to the project;
- Factors related to the organization;
- Project manager's performance on the job;
- Factors related to the external environment.

By doing so, the authors make it easier for the manager to evaluate his company's critical success factors. The framework, though, do not distinguish between the project phases or project types. The factors identified are yet generic, and there were still some factors that remained ungrouped.

[6] not only gathered the criteria for terminating projects, but also organized them into the different phases of the project. They use the Stage-Gate® model [12] in their analysis. The research provided a discussion on terminating highly innovative projects with a scheme on how and when to kill projects, with the relevant criteria for each phase, assuming they have different characteristics, which demand different considerations on go/no-go decisions.

Finally, killing R&D projects decision may be closely related to how performance is measured on R&D centers. [8] made another very comprehensive survey on how companies measure their R&D performance. The authors affirm that in top performers the gatekeeper plays a vital role on go/kill decisions. The best performers assign gatekeepers that may vary from gate to gate and for different types of projects. For example, for lower risk projects, the Stage-Gate® process is abbreviated and the gate keepers may be lower-level personnel, while for higher risk projects, senior personnel are assigned as gate keepers. The same applies for the different gates. Senior personnel may keep the gates where more commitment is made, such as "go to development" or "go to launch" gates. Having effective gate meetings and having clear go/kill criteria are also stressed as good practices. The authors also affirm that the lack of such definition is widespread, with less then a quarter of companies studied having such practice.

Roles of the executives and project leaders in project termination were studied by [13], where bias such as sunk costs were identified. [20] showed the importance of project termination on strategy enforcement. [14] discussed the competences a company must have to early terminate unsuccessful projects.

As we saw in literature, there are already a reasonable number of criteria identified for the decision to terminate R&D projects. What is still lacking is the organization of these criteria not only on the different phases of the project pipe-line, but also in different types of projects. This paper is aimed at discussing this matter. The question this paper will try to answer is: Which are the main factors taken into account for terminating different types of NPD projects? To do so, we present a case study for showing which of the already presented factors influence in different types of NPD projects termination.

V. CASE STUDY

A. The Company

We studied the management of an R&D Center of a large Brazilian Chemical Company – hereby called simply "Company". The Company is a B2B operation with industrial units and commercial offices in Latin and North America, Europe and Asia.

The Company's product portfolio consists mainly of Surfactants and Solvents, commercialized in six main application markets: Home & Personal Care, Agrochemicals, Paints & Coatings, Automotive Fluids, Oil & Gas and Performance Products. There are three R&D managers: one for Home & Personal Care; one for Agrochemicals and one for Industrial Markets (which consists of Paints & Coatings, Oil & Gas, Automotive Fluids and Performance Products).

The R&D Center's main job is to validate the Company's products on the Customer's industrial units' requirements. When the existing set of products does not meet the Customer's needs, the Company's researchers will try to develop a new blend, composition or molecule. The development may be either solo or in a co-development project. The resulting product will be offered not only for the Customer that generated the project, but will figure on the Company's product portfolio. In most cases, the results are protected by one or more patent application on relevant markets.

1. Company's Project pipeline

The Company has a well-established Project Management manual. The pipeline is represented by an Innovation Funnel, while the projects are managed in phases, following the Stage-Gate® model by [12]. The figure 1 represents the Innovation Funnel, with the project phases positioned in it.

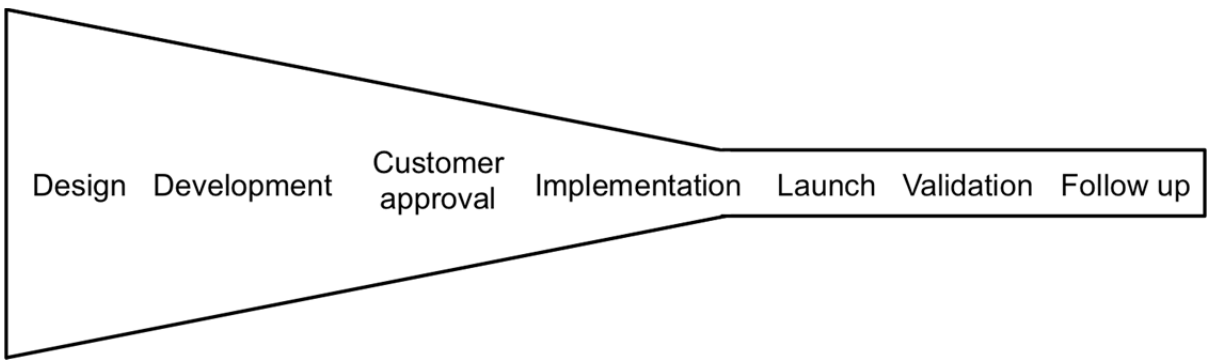

Fig. 1 – Company's project phases.
Source: Modified from Company's institutional material.

Every phase has its set of tasks to be achieved before passing through the gate to the next phase. During phase zero, or Design phase, the value proposition of the project is assessed, as well as regulatory assets for the target markets. In this phase, the project scope is defined based on the customer's needs and a preliminary state-of-the-art search. In this phase the economic feasibility is evaluated in terms of expected gross margin and expected volume. When all the information is gathered, there is the "go/no go" decision and the project begins its development.

Phase 1, or Development phase, is the longest and most expensive phase. In this phase researchers will actually find the technical solution to the proposed problem. In this phase the new product is created along with its production process. It consists of regulatory, toxicological and environmental issues, pilot plan tests, first draft specifications, and other information required for defining the product needs, manufacturing process and applications. The gate review at this phase consists of a reevaluation of the value proposal defined at phase zero.

The main objective of Phase 2 is obtaining Customer Approval of the product developed at Phase 1. In this phase, samples are sent to the customer and commercial conditions are defined. This is the phase where all the negotiation involved in business development is made. The gate review consists of a validation of the value proposition to ensure the feasibility to continue the project.

Phase 3, Implementation, consists of the final approval of raw materials and suppliers, manufacturing plant, creation of official technical documentation and technology transfer. The gate review is akin to Phase 2, with the validation of the value proposition.

Phase 4, or Launch phase, consists of the creation of the launching plan, where target customers, communication plan and strategy positioning are defined. The new product is positioned according to its value proposition. Gate review is the same as the previous phases.

On Phase 5, or Validation phase, occurs the confirmation of the achievement of customer's needs and expectations. The feasibility of all aspects of product implementation, manufacturing capability, sources of raw materials, technical documentation and technology is evaluated. At this phase there is the final gate review, with the assessment of initial project assumptions.

Finally, on Phase 6, of Follow Up phase, the results of margin and volume are monitored and compared to the potential of the project for three years. There is no gate review on this phase, but it can flag some needed actions to assure the project success.

2. Company's Project typology

The Company has also its own project types taxonomy. Those that end up with new products are:

Line extension – Projects with the objective of modifying minor characteristics of existing products in the portfolio. Clients or potential clients usually request projects in this category.

Application development – Projects with the objective of developing a new blend or mixture of existing products, so that it can be used in a determined market with the requested chemical and physical characteristics. Clients or potential clients usually request projects in this category.

Innovation – Projects that aim at developing new molecules, new feedstocks or new productive processes, which may result in new platforms for new or existing products. Products in this category are usually born inside the company – by means of market knowledge of its researchers – and its outcomes are offered to the market once the technology is dominated.

It is important to note that Innovation projects may lead to Application and Line Extension projects once the studied technology is dominated. Innovation projects rarely reach the Launch phase, as its goal is not a new product, but rather a new competence, which will make possible a series of new products and applications.

3. Institutional tool for portfolio review

The Company recently tried to unify the criteria for projects review with a tool where the managers would rate the projects on the pipeline with a scorecard. The scorecard plots the project in an Attractiveness x Positioning matrix. The Attractiveness axis analyses the financial and part of the strategic aspects of each project, while Positioning analyses the market and other strategic aspects.

While the managers said this was a good tool for decision-making and projects review, the tool is no longer used and we could not get more details of it. The managers reported that the tool was time consuming – it used to take at least a day to update – and required a group review, which was not always possible.

The managers independently developed their own systems for evaluating, reviewing and finally terminating projects as the official tool was abandoned. Nevertheless, the logic they adopted derives from the concepts present in the tool, therefore, the differences observed was not so big.

All managers reported that the projects are reviewed monthly in an event called "Projects forum", in which the portfolio is discussed and the projects are reviewed individually. Discussions on interactions between projects are not usual. The most common practice is to discuss details of projects that need more resources or some technical problem that may appear during the development.

4. Company's Project Termination

The Company does not have a unified system for terminating projects. It has a very well established and detailed system for managing the Innovation Funnel, not always followed strictly. A manager reported that is somewhat usual, albeit not at all desired, that a project move from one phase to the other without passing through a gate.

Besides the variability between market segments, the interviews revealed some common criteria the managers use to verify, along with formal criteria that form the gates between the project phases, such as tests protocols, regulatory and freedom to operate analysis.

Managers gave one example for each project type of recent terminated project that best summarizes the area's policy for project termination. The projects are shown in Table 1. The managers, during the interviews, also pointed a series of other criteria that are applied to the portfolio that did not shown up in the examined projects. These criteria are analyzed on the next section of this paper.

We will begin with the similarities and try to group them to better understand the relationship between the criteria and the project types. Then, the exceptions and exclusive criteria will be discussed and a scheme for illustrating the case will be drawn.

B. General criteria

The two main criteria for terminating a project are Financial feasibility and Customer commitment. All the managers observe these two criteria and a change in their value will kick off the process of ad hoc review for that project.

Financial feasibility means the potential gross margin and volume the market will provide. This is seen as a variable during the planning phase and may change during development; therefore, it is always monitored. The input to estimate this variable is a responsibility of the Commercial team, which will try to provide accurate forecasts for the market.

Customer commitment represents the guarantee that the client will buy a certain volume of the resulting product. This factor is very volatile and always surrounded by uncertainties. The Commercial team is responsible to assess costumer commitment, since they verify if client maintains the same commitment during development. The Customer's commitment is one of the deliverables in the project's Design phase.

C. Gate review criterion

Each gate has its own criteria to pass a project one phase to another. Almost every criterion is related to protocols and technical development of the project, but in every gate there is a review of the Value Proposition.

Value proposition is defined in phase zero (Design) and consists of the technical benefits the solution will provide to the customer. It also consists of the price target and economic differentials. After complying with the technical research and development protocols, changes to the Value Proposition are always assessed in every gate review.

D. Specific criteria for each market segment

Depending on the market segment, the profile changes. Criteria for termination varies in order to attend to the particularities of each market. Sometimes, to satisfy a demanding client, a project must continue regardless of its situation on termination criteria.

In the Home & Personal Care (HPC) segment, the projects are reviewed and plotted in a simple Effort x Financial Results matrix. The greater the effort needed to finish the project successfully, the stricter is the tolerance for deviations in the expected results. This is the general rule, but there are exceptions, that keep a project from being killed. Therefore, the manager cited more criteria he uses to check whether or not the project should be killed:

- Impact on Company's image on market. If the termination of a specific project affects negatively the Company's image on HPC market, the project is kept on the portfolio. This is a very rare case, though;
- Impact of the project on a specific customer's relationship. There may be situations where a less profitable project may validate the Company as a partner for future projects with the Customer. When this is the case, the project goes on;
- For Innovation projects, the impact of the project on the team's capabilities is taken into account. Even if a project has a low value proposition in terms of margin, if it is needed to acquire new competences for the Company, it is not terminated.

For the Agrochemicals market, when a project is for too long on the portfolio, it is seen as a termination candidate. The decision to kill the project is taken upon verifying the willingness of the client to pay for the results. If the client is not committed to the project, it is killed. However, some factors prevent the project from terminating, such as strategy

TABLE 1 – PROJECTS PRESENTED AND DISCUSSED BY THE MANAGERS.

Project	Project type	History
Project A	Line Extension	Customer changed commitment with volumes and project shown itself as more challenging than expected. Terminated because of low relation between effort and return.
Project B	Application	Project had high technical success probability but Customer did not guarantee volume after project completion. Terminated because of lack of customer commitment.
Project C	Innovation	New molecule development. During development phase, the toxicological exams costs have shown themselves as too expensive when compared to the return. Terminated because of low relation between effort and return.

Source: the authors

and "pet projects". In common with HPC market, the criteria are applied with higher tolerance according to the growing technological challenge. The manager cited the following extra criteria for terminating a project:

- Impact on the portfolio. If terminating a project causes a big change in the portfolio composition (in terms of project types, project phases, financial results, etc), a deeper evaluation is made.
- Existence of technological knowledge (capabilities and competences). If the team doesn't have the needed capability for the project, it is supposed to acquire during the development. However, if the capability is still a problem after some time, it can be a reason for terminating the project.
- Resource consumption. If a project has already consumed resources, the inertia is stronger. The most usual behavior is to seek "optimization" and avoid "resource waste". This orientation has the objective to support persistence and effort when facing difficulties

The Industrial markets manager applies the same Effort x Returns logic from HPC. A questionnaire is applied to every project on the pipeline. The questionnaire evaluates each project and positions it on a Attractiveness x Positioning matrix. The matrix is then used to compare projects' positions and to make decisions on prioritization and termination. The aspects evaluated in each dimension of the matrix are:

- Project Attractiveness: market competition, market barriers to entrance, market growth, customer's sensitiveness to price, product life cycle and legal and environmental aspects.
- Project Positioning: application knowledge, market knowledge, first in market, competitive barriers, production costs and product performance.

A project is actually killed when the effort needed for completion is much higher than the return it promises. Another strong reason for killing is toxicological and environmental issues, such as legal restrictions.

E. Grouping criteria

It is possible to gather the described criteria in five groups: Financial, Regulatory, Customer, Strategic and Technological. Table 2 summarizes the groups and the criteria under them.

The next section will present the variation in application of these groups of criteria to different types of project.

1. Line Extension

For the less risky projects, the Customer and Financial criteria are standalone reasons for terminating. Deviations in Customer commitment and in the expected financial results are not tolerated in these projects. The cost of killing such projects is relatively low, although very few Line Extension projects are killed.

The Innovation Funnel for this kind of project has a very low termination index, and most of the killed projects are on the beginning of the funnel. The figure 2 illustrates the funnel for the case and the main criteria used for project termination.

TABLE 2 – GROUPS OF CRITERIA OBSERVED AT COMPANY

Group	Criteria
Financial	Financial feasibility
	Financial returns (Gross margin)
	Resource consumption
Regulatory	Toxicological analysis and restrictions
	Environmental analysis and restrictions
	Legal aspects
Customer	Customer willingness to buy a certain volume of resulting product (Customer commitment)
	Customer's sensitiveness to price
	Impact on customer's relation
	Impact on Company's image
Strategic	First in market
	Competitive barriers
	Impact on portfolio
	Possibility of acquiring new capabilities
Technological	Existence of capability and competence
	Technological challenge
	Product life cycle
	Product performance
	Production costs

Source: the authors

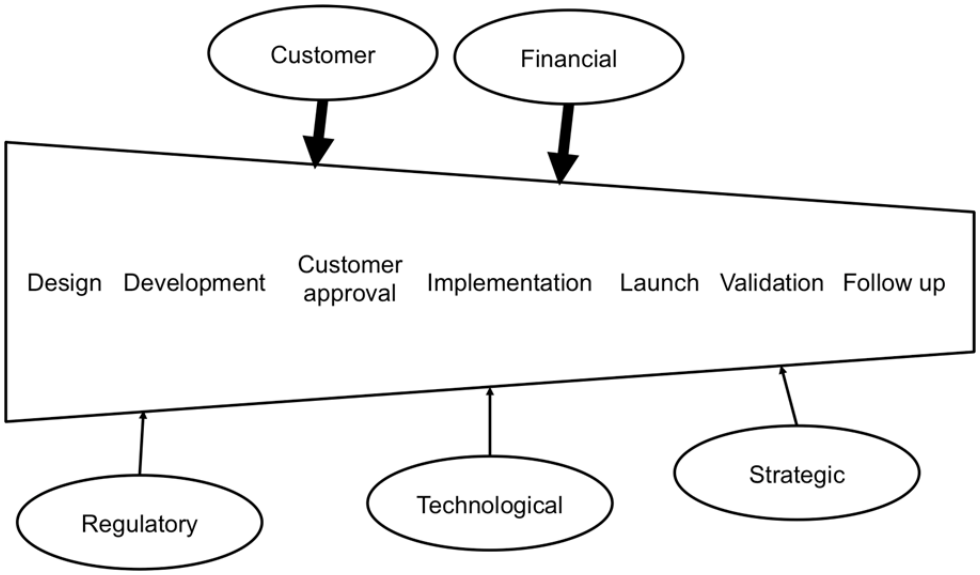

Fig. 2 – Line Extension funnel and main criteria for termination. The criteria are not linked to the phases.
Source: the authors

2. Application development

For Application development projects, the same criteria are applied, with a change on the weight each of them have, but the main criteria are still the Customer and Financial. As these projects are more risky than Line Extension, the Technological and Regulatory criteria has a stronger role.

Strategic criteria start to be more relevant as the technical complexity grows. In an extreme case, a project without any customer's commitment was not killed due to the strategic importance of developing the product for the Agrochemicals market. After the development, the Commercial team made an effort to get the samples of the product to the potential clients.

The Innovation Funnel for Application Development is stricter, with more projects being terminated during the Development phase. The figure 3 illustrates the Funnel with the main criteria used for project termination.

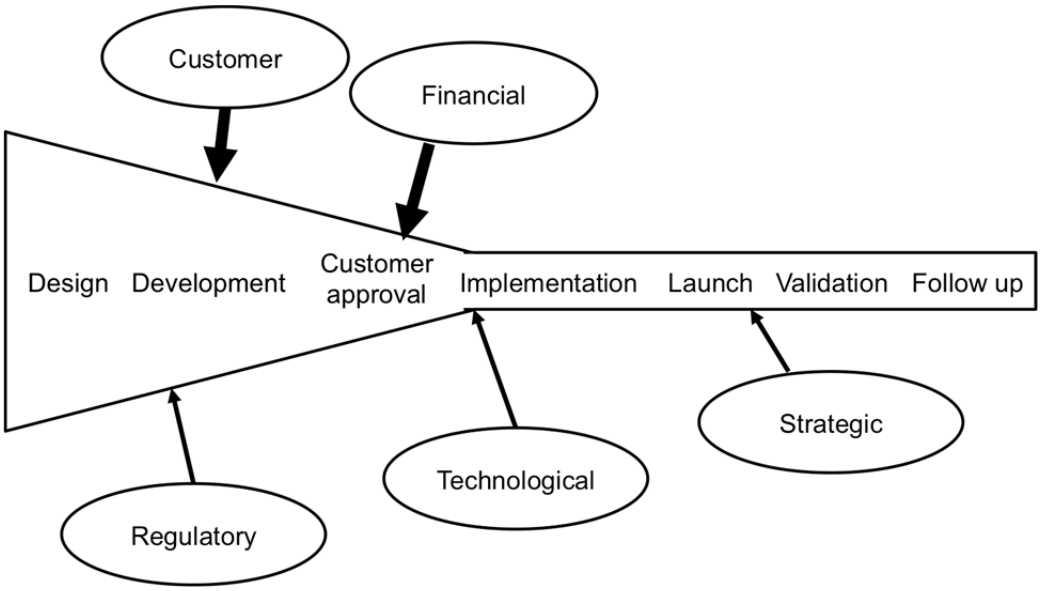

Fig. 3 – Application development funnel and main criteria for termination. The criteria are not linked to the phases.
Source: the authors

3. Innovation projects

Innovation projects are rarer in the pipeline, but when they exist, Strategic criteria are the most important for termination. The importance of Customer, Regulatory and Financial criteria is very low. Technical criteria are not barriers for development. Instead they are drivers for this kind of project. Their main goal is to dominate a new technology in order to make possible other Line Extension and Application Development projects.

For Innovation projects, the pipeline seldom reaches Launch phase. It usually finishes its development before Customer Approval, as soon as the technology is dominated and the capability is created. From that phase on, if there is Customer interest, it will give birth to new projects that was not possible before.

As this kind of project deals with many uncertain aspects, it is usual to terminate them only after the development is completed, unless there is some unsolvable technical problem during the research. The pipeline has then fewer projects than the other two, but termination usually happens at the end of the development. Figure 4 illustrates the Innovation projects pipeline and the main criteria used for termination.

VI. CONCLUSION

After all, is there any difference on terminating different types of R&D projects?

Our case study shows that different types of projects are indeed terminated using different methodologies. Nevertheless, the same criteria are applied in every division we studied. Other aspects of projects management are although very different from type to type.

We found three different Innovation Funnels, one for each type of project. For line extensions, the funnel is almost a tunnel. Probably due to very low uncertainty. For applications, there is a larger early termination of projects during development. It I harder than the other two. The innovation projects funnel, on the other hand, is less likely to terminate a project during development.

Also, the relative importance of each factor on termination varies from funnel to funnel. While Customer commitment is a standalone criterion for project termination on Line Extension, it is little used on Innovation, although the lack of Customer interest on the results affects the amount of new Line Extension and Application projects created from a completed Innovation project. Strategic criteria are the most relevant for innovation projects.

The criteria we found for terminating projects have mostly been anticipated by existing literature. However, our research revealed a new relevant actor on project termination: the project's specific Customer. Its interest on the project's outcome is crucial, especially on the less innovative projects. Lack of Customer commitment is by itself a criterion strong enough to immediately terminate a Line Extension project. The previous literature, as far as we know, did not anticipate the strength of this criterion, probably because their case studies mainly reflected B2C companies, while our case studies a B2B operation company. This paper does not address the discussion on the differences between B2B and B2C companies regarding project termination, but the question remains to be discussed.

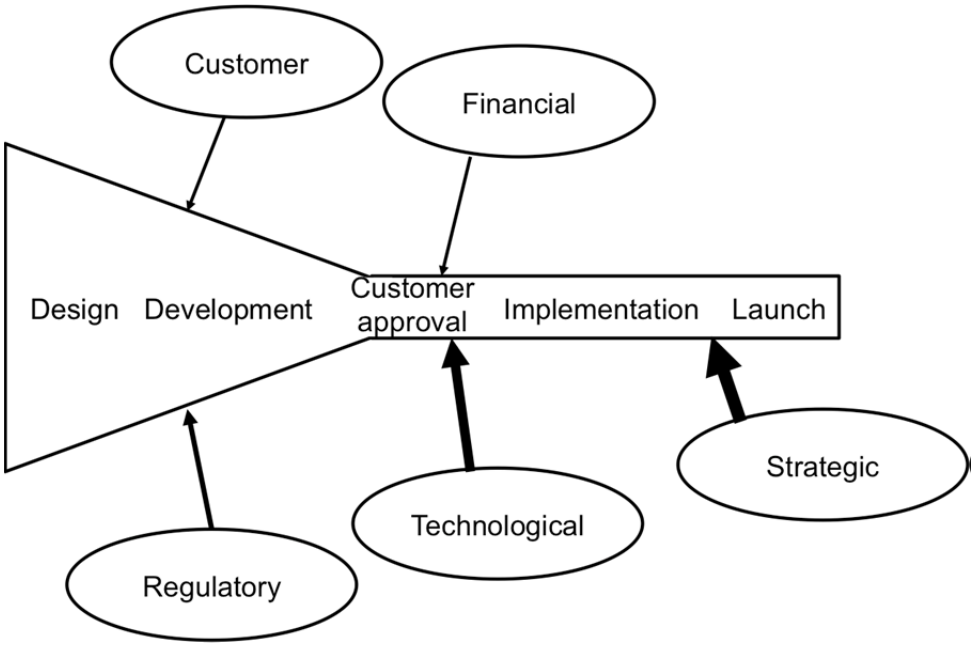

Fig. 4 – Innovation projects funnel and main criteria for termination. The criteria are not linked to the phases.
Source: the authors

Prioritization, not termination: Is sunk costs bias influencing?

The objective of this paper is not to verify psychological and cognitive aspects such as decision bias, but we found evidences that may lead us to hypothesize that sunk costs bias is strongly related to project termination. We observed a strong willingness to prioritize instead of terminating projects. In most cases, resources are reallocated to prioritized projects, but the "donator" is not immediately terminated, remaining in the pipeline as a "zombie" project, waiting for the (very uncertain) occasion when it may become relevant again.

In practice, the relocation of resources ends up by doing the work of terminating projects, but there is a perception that this is not the best practice. It was reported by one manager that the presence of "zombie" projects affects negatively the success of prioritized projects. He suggested that the team will always try to do something to "save" the project from its effectively terminated state.

There is room for behavior discussion on project termination. Can we reduce the incidence of Type I and Type II errors by better understanding the cognitive biases that influence R&D projects termination decision? Is it possible to make better decisions and improve the R&D portfolio management performance by better dealing with our heuristics?

Different approaches on the same Company

Although this paper categorized the described criteria on five groups, it does not reflect the diversity found on the case study. When gathering information from different managers, we observed different approaches for terminating projects. The managers mentioned a movement for unifying the main criteria for project review, but they all agree that there will always be particularities that will be barriers for an extreme generalization of selection, prioritization and termination of projects.

Unifying projects review has been tried at least once. The managers mentioned a tool they used to apply on the portfolio, consisting of a series of questions that would assess the projects' attractiveness and return. But the tool was very time consuming and, therefore, not adequate for the needed decision speed. The managers stopped using it independently and build their own tools that better reflected their needs.

This paper tried to generalize the criteria found in the five groups presented earlier: Financial, Regulatory, Customer, Strategic and Technological criteria. The complexity of each group was discussed along the paper, but is not reflected on the final framework. Nevertheless the main contribution remains on evidencing that, regardless of the set of criteria the Company uses to terminate projects, they indeed vary when the Company is dealing with different types of R&D projects.

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