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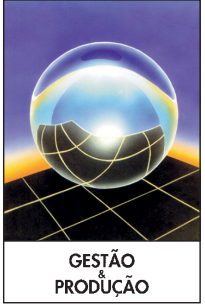

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Adherence between project management practices and environmental critical factors in biotechnology companies

Aderência entre práticas de gerenciamento de projeto e fatores críticos ambientais em empresas de biotecnologia

Ian Marques Porto Linares[1]
Marlon Fernandes Rodrigues Alves[1]
Raphael Lovadine Tristão[2]
Daniel Capaldo Amaral[2]

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Abstract: The traditional project management, agile project management and the combination of both, called hybrid project management or a combined approach are among the project management strands. This study analyzes the critical factors of projects in the area of biotechnology and the appropriateness of approaches to the development projects of the area. The data were obtained from the questionnaires administered in a sample of incubated biotechnology companies from the state of São Paulo in the regions of Ribeirão Preto and Piracicaba. The results indicated that the analyzed companies, which were from different fields of biotechnology (agricultural, pharmaceutical and industrial), have peculiarities regarding the characteristics of the projects and the project management environments of these companies involve both traditional and agile management, suggesting that initiatives of project management techniques should consider a hybrid project management model.

Keywords: Critical success factors; Agility evaluation; Technology development process; Agile project management; Innovative project management; Project management.

Resumo: *Dentre as vertentes do gerenciamento de projetos, é possível citar o gerenciamento de projetos tradicional, o ágil e a combinação de ambos, denominada gerenciamento de projetos híbrido ou abordagem combinada. O presente estudo analisa os fatores críticos de projetos da área de biotecnologia e analisa a adequação das abordagens para os projetos de desenvolvimento da área. Os dados foram obtidos de questionários aplicados em uma amostra de empresas de biotecnologia incubadas do estado de São Paulo nas regiões de Ribeirão Preto e Piracicaba. Os resultados indicam que as empresas analisadas, de campos diferentes da biotecnologia (agrícola, farmacêutica e industrial), possuem particularidades quanto às características dos projetos e que os ambientes de gerenciamento de projeto destas empresas se aproximam tanto do gerenciamento tradicional quanto ágil, sugerindo que iniciativas de adaptação das técnicas de gerenciamento de projetos devam considerar um modelo de gestão híbrida de projetos.*

Palavras-chave: *Fatores críticos de sucesso; Avaliação da agilidade; Processo de desenvolvimento de tecnologia; Gerenciamento ágil de projetos; Gerenciamento de projetos inovadores; Gestão de projetos.*

1 Introduction

Anticipation of the future is intrinsic to project management activity. It is what allows us to establish a bridge between present and future reality (Boutinet, 2002). There is a new approach to project management, called agile management, which differentiates itself from this fundamental aspect of the theory, proposing a continuous adaptation rather than full anticipation of the future enterprise through an iterative strategy (Wysocki, 2011). This initiative was developed in software projects and the possibility of extend the

[1] Faculdade de Economia, Administração e Contabilidade de Ribeirão Preto, Universidade de São Paulo – USP, Av. Bandeirantes, 3900, CEP 14040-905, Ribeirão Preto, SP, Brasil, e-mail: ianmplinares@hotmail.com; mfralves@fearp.usp.br

[2] Escola de Engenharia de São Carlos, Universidade de São Paulo – USP, Av. Trabalhador São-carlense, 400, CEP 13566-590, São Carlos, SP, Brasil, e-mail: raphael.lovadine@gmail.com; amaral@sc.usp.br

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application in other industries was noted and are capturing new adopters (Conforto et al., 2014). The application of this new approach in other contexts has enabled the creation of new practices, often involving a combination of agile proposals and consolidated project planning practices, capable of leveraging the benefits of both so-called hybrid management approaches (Hass, 2007).

The approach of hybrid project management is a result of empirical practice in companies, which, as pointed out by Vinekar et al. (2006), have used traditional and agile management simultaneously in the management of projects whose results point to the development of organizational ambidexterity capacity. It is possible that hybrid management can generate extra processes and/or costs due to increased management complexity by reconciling both approaches (Karlström & Runeson, 2006), but what is lost in simplicity is compensated for by the increase in results due to the extrapolation of the reductions from one approach to another. Examples of the benefits of the hybrid approach are: focus on business value versus time and budget (Hass, 2007), the ability to customize the project management methodology for the problem in question rather than applying a single method for all projects (Vinekar et al., 2006; Wysocki, 2011), and higher software quality in complex projects (Beckett, 2008).

Researchers, such as Conforto et al. (2014) and, more recently, Ćirić & Gračanin (2017), have indicated that agile management practices can be adapted into other sectors besides software. However, a field of study still unexplored by agile and hybrid management methodologies is that of biotechnology. According to the text of the 1992 United Nations Convention on Biological Diversity, biotechnology is understood to mean any technological application using biological systems, living organisms, or derivatives thereof to manufacture or modify products or processes for specific use (Brasil, 1994). The importance of this field becomes clear when it is taken into account that along with information technology (IT): biotechnology and IT are the two industries that have grown most in the 21st century, and many consider them the fields in which greater financial and technological development will occur in the next few years (Gartland et al., 2013).

Biotechnology accounts for 17% of EU spending, 22% of US spending, and 11% of Japanese spending (European Commission, 2014) for total research and development (R&D) investments. To complete, the field presented its twelfth four-month period followed by above-average performance on the stock exchange, demonstrating investor confidence in the issue (Valuewalk, 2014). Because it is pervasive, biotechnology has cross-cutting applications in the fabric of production, so it is strongly present in the medical, pharmaceutical, agricultural, zootechnical, industrial and medical fields and accompanies the relatively recent field of environmental protection technologies. Considering the importance of the sector and the lack of innovative methodologies in its project management process, hybrid management approaches may prove to be an interesting alternative. However, what approach, if applied, could improve project management in the field of biotechnology?

The objective of this work was to identify the critical factors of the environment of biotechnology companies' projects and, from the analysis of these conditions, to discuss the relationship between the approaches of project management, including the analysis of the practices used. In order to obtain a diversified sample, the companies studied participated in different aspects of biotechnology, including agricultural, pharmaceutical and industrial biotechnology. The survey included the measurement of the critical factors for agility present in a sample of companies in the sector and then an analysis of which approaches (agile, traditional or hybrid) have greater adherence, generating hypotheses and indications to be investigated and detailed in future research.

2 Theoretical framework

2.1 Innovation in biotechnology

Due to a number of issues, ranging from regulatory pressures to the very duration and uncertainty of experiments, product development cycles involving biotechnological processes are relatively long. In the pharmaceutical sector, taking into account only pre-clinical and clinical tests, the duration of the phases reaches 133.7 months (Dimasi & Grabowski, 2007), with only 10% of the drugs reaching clinical trials (Hay et al., 2014). Investments in pharmaceutical biotechnology vary across companies, with the largest (with spending above US$ 20 billion in R&D) averaging US$6.3 billion per drug approved in the last decade and the lowest (spending between US$ 5 and 10 billion in R&D) had a median approved drug cost of US$2.8 billion (Herper, 2014). In agricultural biotechnology, the cycles average 157 months, depending on crop development and regulatory tests, and the projects completed between 2008 and 2011 had an average cost of 136 million dollars: The factors with the greatest impact on time and costs come from steps related to regulatory aspects (McDougall, 2011).

Another important point regarding the development of products in biotechnology is the level of training required of participating employees given the

complexity of the projects. In an attempt to increase the company's intellectual capital without costing more skilled labor, biotechnology companies have invested in open innovation processes, focusing on contracts with specialized companies, licensing or acquisition of technologies, and cooperation with universities (Pugatch Consilium, 2014; Bianchi et al., 2011). For these reasons, both the investment and the risk in the development of research projects in biotechnology are very high. In addition to the costs of hiring highly qualified professionals, long project duration, high uncertainty about feasibility and strong regulatory pressures, the need for the sector to minimize these costs is evident, as the high investments in biotechnology by the main world economies show that despite the risks, the international competitiveness of countries in this sector has strengthened (European Commission, 2014).

Considering the Brazilian scenario, of a group of 92 companies identified as firms dedicated exclusively to biotechnology (FDB), approximately 60% went through the business incubator system, regardless of the sector of activity, except for agricultural companies, which in most cases arose independently from incubators. Additionally, one of the main characteristics of these companies is recent emergence, 70% over the last 10 years (Bianchi, 2013).

2.2 Approaches, practices and critical factors in project management

Each company's internal processes assume their own characteristics, and the project management practices are not different. However, a widely accepted taxonomy for analysis points to two main strands: a well-established, denominated traditional project management; and another, which later came to be called agile project management. Based on the definitions in Eder et al. (2015), it is possible to clearly delineate the differences between the two methodologies.

In traditional project management, there is a greater focus on defining and adhering to a highly detailed scope, with tools like Work Breakdown Structure (WBS), and extensive use of process documentation. The planning of the steps is carried out at the beginning of the project, and the decisions regarding changes in schedule or methodology were concentrated in the hands of the project manager, whose main duties are to coordinate and supervise the work of the other team members, and the client does not actively participate in decisions during the project. In contrast, in agile project management, the main focus is on delivering the results necessary to fulfill a goal defined by the team, following the concepts of vision and visual representation of deliveries to be achieved. The planning of steps occurs more broadly at the beginning of the project and in more detail iteratively (and not exhaustively detailed at the beginning). The teams are self-managed, each member being responsible for coordinating his or her performance and the other members', and the client is present throughout the project, evaluating and prioritizing the results.

Chart 1 summarizes the characteristics of each approach.

There is also a third method of project management called hybrid project management, an amalgam of good practices of traditional management and good practices of agile management (Fernandez & Fernandez, 2008). It is a more recent approach in which one makes combined use of agile management practices with traditional ones that are plan-driven. There are still no defined models or clear and precise theories about the management of hybrid projects that allow for generalizations. On a recurring basis, most of the researchers in the subject end up defining their own views on hybridism.

Vinekar et al. (2006) describe a near concept, ambidexterity, whereby organizations must be able to encourage and balance paradoxical ideas such as stability and adaptability, investment and exploration, among others. Zaki & Moawad (2010) propose a central axis model in agile management, using the traditional practices to attack the weak points of the method, producing in this way an average between the two methodologies. The model proposed by the authors mixes the focus on people, self-management and the simplicity of the agile method with the stability of traditional methods. There are, therefore, two sets of practices that can be adopted separately or in combination. The success of practices, however, also depends on context. Almeida et al. (2012, p. 97) proposed the concept of critical factors for agility. In the authors' words, these are

> [...] internal or external factors to the organization that are directly or indirectly related to the process of product development project management, and may have a positive or negative impact on the performance of a given practice, technique or project management tool [...].

The authors compiled 36 potential critical factors from textbooks and articles that state important conditions for the success of agile practices.

The use of agile practices when appropriate—that is, in the presence of the corresponding critical factors—can generate greater flexibility in the project team. Conforto et al. (2016) conducted a detailed study on the agile construct in project management theory. They proposed a definition for agility as the ability (in the sense of competence) of a project

Chart 1. Characteristics related to project management, and their approaches in agile and traditional project management.

Characteristic	Traditional project management approach	Agile project management approach
1) The way the project plan is elaborated	There is a single project plan, which covers the total project time and contains the products, deliveries, work packages and activities.	There are two project plans: a) a general plan that considers the total project duration time, but which contains only the main project products; b) a short-term (iteration) plan that contains only the deliverables and activities for a fraction of the project time.
2) The way the project scope is described	Exact description of the final result by means of text, with contractual type norms, objective numbers and performance indicators.	Description of the final result in a comprehensive, challenging, ambiguous and metaphorical way.
3) The level of detail and standardization with which each project activity is defined	The activities are described in a standardized way and organized into WBS-type lists. The descriptions contain codes and are classified into sets of work packages, deliverables and project products.	There is no standard for describing activities, which can be written in the form of stories, problems, actions or deliveries. There is no attempt at organization, just the prioritization of what should be done at the moment.
4) The planning horizon of the project team activities	The activity lists are valid for the total project horizon.	Activity lists are valid for an iteration, which is defined as a fraction of the total project time.
5) The strategy used to control project time	Reports with performance indicators, written documents, audits and analysis of phase transitions are used. Team meetings are not frequent.	Visual devices are used that indicate physical deliveries of the final result (posters, self-adhesive, etc.). Meetings are short and frequent.
6) The strategy used to guarantee the achievement of the project scope	The project manager evaluates, prioritizes, adds or changes project activities so that the results are consistent with the scope of the project signed with the client.	The client evaluates, prioritizes, adds or changes the final product of the project, according to the experience with the results achieved. The team changes activities to obtain the results proposed by the client.

Source: Eder et al. (2015).

team to collect customers' needs continuously and to make decisions quickly, adapting the project plan frequently. According to Conforto et al. (2016), the agility construct, or that capacity, can be measured and results from the application of the appropriate practices to the organization's project environment.

2.3 Empirical research

On executive support in incubated companies, Coleman & O'Connor (2007) pointed out the facilitation of communication due to the co-location of company managers and teams in the case of startups. Regarding the topic of customer participation in product or service generation, Durugbo & Pawar (2014), in an extensive review, indicated the importance of the presence of customers and suppliers in the case of companies that have other companies as customers, for the co-creation process. On the subject of hybrid project management, there are theoretical studies such as the one by Conforto & Amaral (2016), which analyzed the success of the application of a system focused on technology-intensive companies, which crossed elements of agile management such as iterations and visual physical boards with reference models of traditional project management. Other examples of research in this topic are the cases of Cho (2009) and Bashir & Qureshi (2012), but given their genesis in the empirical practice of companies, there are still few empirical academic studies on the hybrid management of projects when compared to the relative production of traditional methodologies.

Cohendet & Simon (2007), for example, conducted a case study with a video game developer and identified conditioning organizational factors that favored team creativity in the context of hybrid project management, but with an intrinsic cut in the company that does not favor generalizations. Similarly, Batra et al. (2010) devoted themselves to a case study; however, their results indicate that hybrid management is recommended for specific cases: projects that involve a large volume of resources in the midst of an unstable and imprecise scope.

D'Ambrosio et al. (2011) analyzed the process of adopting hybrid management in an ICT (information and communication technology) company as a support for knowledge sharing. Ihme (2013), who studied a software company, identified that hybrid management was mainly due to the customization of certain agile issues rather than the mixture of methodologies. Jahr (2014) proposed a hybrid model resulting from the incorporation of quantitative models into agile management with positive results, mainly in terms of deadlines and budgets.

Yim et al. (2013) analyzed the factors that increased risk in 11 projects that used hybrid management. Their results indicate that the greater the number of activities included in a project, the greater the risk to it. Chow & Cao (2008) conducted a survey, evaluating a total of 109 projects of Agile Alliance companies in several countries around the world. The authors aimed to evaluate 12 possible success factors in agile project management. In the end, the authors verified that only critical success factors can be considered: a) precise delivery strategy; b) appropriate use of agile techniques; and c) a highly trained project team.

Almeida et al. (2016) carried out a joint investigation of practices, critical factors and agility in project management. They measured these factors in two research teams using the practices identified in the work of Eder et al. (2015), the critical factors identified in the study of Almeida et al. (2012) and the levels of agility proposed by Conforto (2013). As a result, they demonstrated the feasibility of verifying the profile of management practices and context, enabling a comparison of the management approaches used. There are also agility-level detection tools in project management, such as the Home Grounds methodology and the risk-based approach (Boehm & Turner, 2003); tests adapted or developed for sectors other than IT are present in the literature.

Despite the recent progress in this area, there is, however, no survey of levels of agility in managing biotechnology projects. This initiative could be the first step to seek a model of project management adapted to the sector.

3 Method

This research adopts a quantitative and descriptive approach conducted through a survey. Thus, the perception of relevant organizational aspects is provided by the managers (Rungtusanatham et al., 2003) and approaches academia and the business environment by facilitating the evaluation of conceptual models with real data (Flynn et al., 1990). The population of the present study is composed of biotechnology companies incubated in the cities of Ribeirão Preto and Piracicaba in the state of São Paulo. The choice of incubated companies is justified by the fact that they have a smaller number of projects in parallel and lack literature focused on their needs. The reason for the choice of the cities of Ribeirão Preto and Piracicaba is due to the diversity of focus that allowed the research to evaluate applications of pharmaceutical, agricultural and industrial biotechnology. Fifteen questionnaires were sent out; this number corresponded to all incubated biotechnology companies from the cities of Ribeirão Preto (FIPASE Foundation) and Piracicaba (ESALQTec - Incubadora Tecnológica). Responses were obtained for 5 questionnaires from Piracicaba and 5 from Ribeirão Preto, one being discarded because it is a consulting company, not having development projects for new products.

In order to evaluate project management in biotechnology companies, the agility evaluation tool was used in project management, developed in a research program supported by FAPESP between 2009 and 2011. It is composed of the survey of practices carried out by Eder et al. (2015), the critical design factors identified by Almeida et al. (2012) and the agility construct recently published by Conforto et al. (2016). These elements were combined and adapted into an inventory for the diagnosis of organizations in the work of Schnetzler (2012), applied in the field in the projects of a large ERP consulting company by Santos et al. (2013) and by Almeida et al. (2016). The improved questionnaire was published in the work of Conforto (2013). It is, therefore, an analysis tool whose feasibility of use was demonstrated by two application cases, ERP and scientific research teams. The advantage of this tool above the other tools cited in the review is that it provides complete diagnostics, including practices, context (critical factors) and the output generated on the project team (agility).

This tool consists of a questionnaire with 41 questions, divided into 7 dimensions according to their measurement purpose. For the purposes of this research, the following dimensions will be raised: company (1) the respondent characterization (2), and agility critical factors (3) and agility performance (4). All the items rated on a scale from 1 to 7. The survey form is presented at Annex A. The questions were randomized in order to avoid bias and the correspondence between each item and dimension is presented at Table 1.

The assumption is that low levels of agility would be related to traditional project management, pure intermediate values would indicate agility, and the presence of conflicting conditions and practices (agile and traditional) would indicate the need for methods conforming to the hybrid management approach.

The themes related to agility critical factors aim to find indications of design environments that favor the use of agile or traditional management techniques (project environment analysis). Agility performance indicates team effectiveness into change the plan along the project, measured into five dimensions according

Table 1. Distribution of survey questions.

Set of questions	Number of questions	Quantity
Characterization of the Company (CC)	1, 2, 3	3
Characterization of Respondent (CR)	4	1
Critical Agility Factors (CAF)	5, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 25	14
Performance in Agility (PA)	22, 23, 24, 26, 27	5
Total		23

the agility definition: continuous search and data collection; client/market information; regular delivery of project results with client/market validation; speed of processing information and making decisions; quickness to update the project plan; communication of changes in the project plan.

The metric is given by the sum of the questions divided by the maximum possible value in that dimension. Therefore, the values of the agility critical factors dimension were summed and divided by 98 (14 questions multiplied by the maximum possible value in the answers, which is 7). For the same reasons, the values of the agility performance dimension were summed and divided by 35 (5 questions multiplied by the maximum possible value in the answers, which is 7).

Adjustments were made in the Conforto (2013) questionnaire to better apply to the biotechnology market. In this case, terminologies related to software and manufactured products were changed to correspond to elements of biotechnology. Other changes were made, however, not due exclusively to the biotechnology market conditions, but rather because the companies interviewed are incubated startups, in which there may be little familiarity with terms used in the questionnaire. For example, a brief glossary was included covering the terms scope, client and stakeholder. The final adapted questionnaire is available upon request.

4 Results

The results of the medians of the critical factors are in Figure 1 and indicate a similarity between incubator companies regarding the conditions of the design environment. In this case, these companies were divided into the following categories: biotechnology with processes directed to the agricultural area (four companies); with processes focused on the pharmaceutical area (three companies); and with processes focused on the industrial area (two companies). Below are represented the medians (Figures 1 and 2) separated by sector of performance in relation to the critical factors and performance in agility.

First of all, all three types of companies analyzed had in common high executive support, small size and high proximity of the team members. The fact of companies be in the incubation phase explains this common profile. It is usual for companies operating in the same location, smaller teams and entrepreneurs generally to be part of the development team supporting the work being done (Coleman & O'Connor, 2007). On the other hand, high managerial and team experience and low delivery of partial results were also similar in the three types of biotechnology companies. The origin in the field of biotechnology itself, which, due to its complexity, requires a high level of qualification can explain this result. The average project time in this area is high for the reason cited above. The following analyses show comparative aspects of the biotechnology fields identified.

4.1 Agricultural biotechnology

Agricultural biotechnology showed high medians regarding the ease of presenting results to clients (5.5), validation of partial results by the client (7), and alteration of scope (5.5). However, it presented comparatively low scores in aspects related to previous competences, level of interdisciplinary, autonomy to carry out changes in the project, and frequency of communication with the client. Analyzing the results, it is possible to infer two possibilities: (i) the companies generate products and/or byproducts of easy demonstration for clients; or (ii) the clients of these companies have a high technical level in the subject, which, in addition to the possibility of co-creation of new products, could generate even more value in terms of the interaction between both parties (Durugbo & Pawar, 2014).

Regardless of the triggering event, this ease of presenting results facilitates approvals for changes in scope by customers, which increases the agility of these projects. Regarding the elements in which agricultural biotechnology companies presented low scores, once again, the influence of the client on the final product is visible: Even with the low frequency of interaction between both parties, this influence is manifested in the low autonomy of change of scope by the project team.

Considering the ease of presentation of byproducts to the customer, it is expected that there will be meetings with the project team during these presentations. Finally, the companies related to agricultural biotechnology had low scores on technological competencies prior to the project, which may be associated with the low interdisciplinary of the teams.

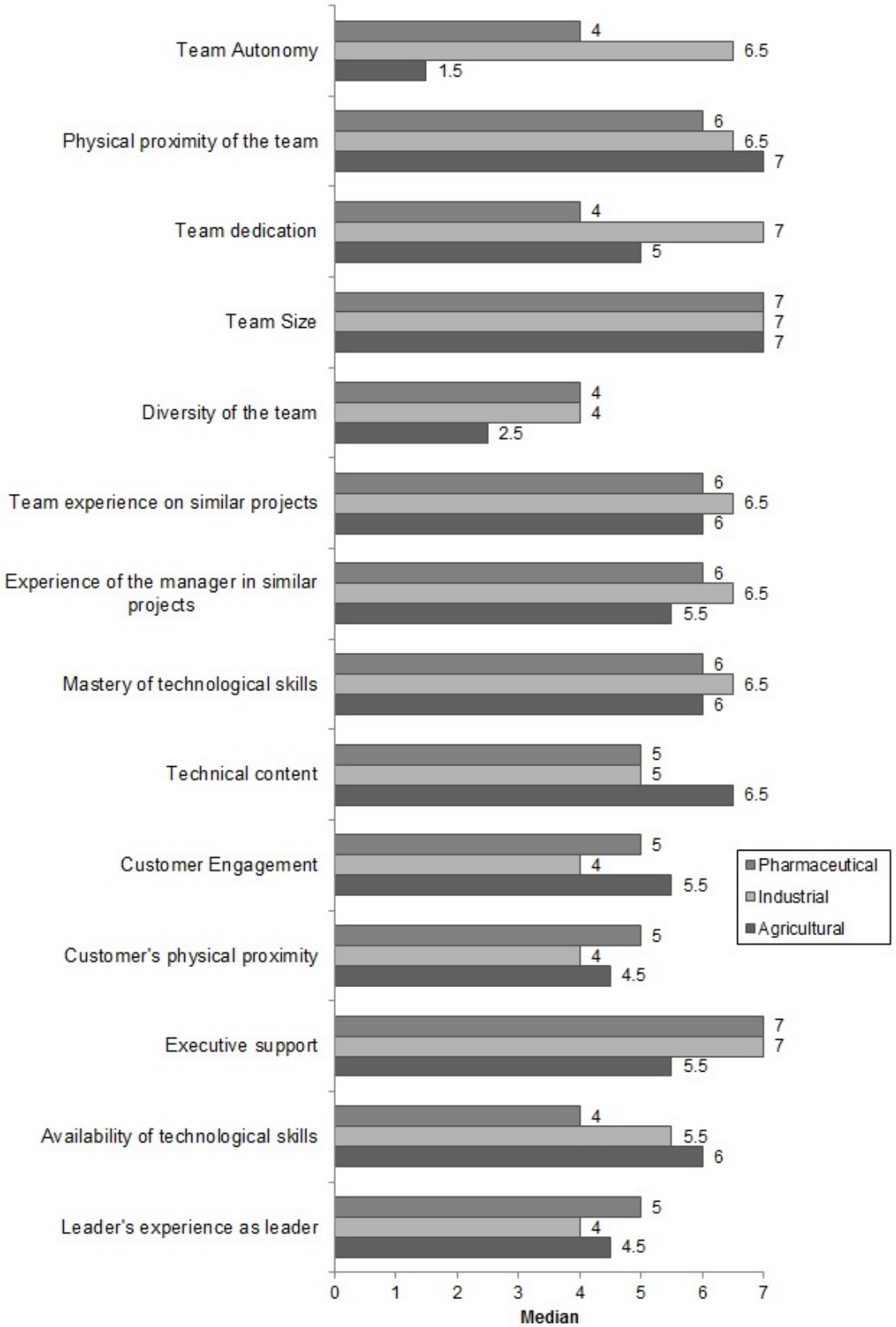

Figure 1. Medians of critical agility factors presence in incubated biotechnology companies. Source: Own elaboration.

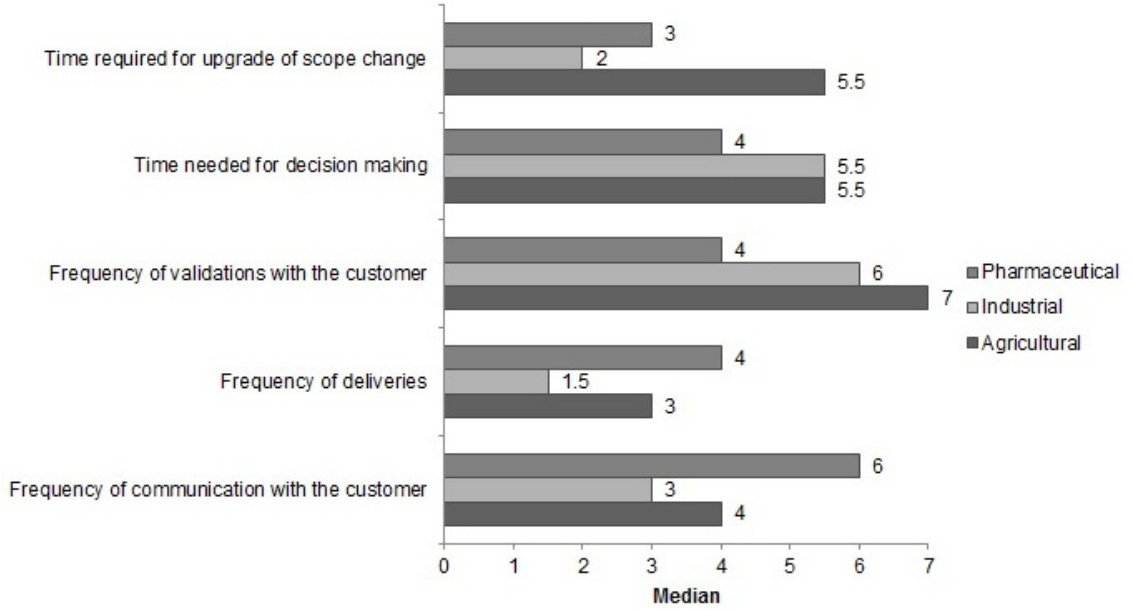

Figure 2. Medians of agility performance of incubated biotechnology companies. Source: Own elaboration.

4.2 Pharmaceutical biotechnology

The key elements of the companies related to pharmaceutical biotechnology were high managerial experience, frequency of communication with clients, and time needed to gather stakeholders. The elements of pharmaceutical biotechnology companies that had low scores were related to the low availability of the client to get involved in the project, high difficulty in presenting partial results to clients, low frequency of validation of results on the part of the clients, and high difficulty in changing the scope of the project.

The results of the analyses of the related companies and pharmaceutical biotechnology presented interesting data. This group of companies claims to have relative ease in communicating with customers by doing this often. However, these companies have high difficulty in presenting partial results to these clients, a possible consequence of which is the low frequency of validation of results, as well as the difficulty in getting customers to become directly involved with the project. Recalling that the main clients of biotechnology companies dedicated to the pharmaceutical sector are larger pharmaceutical companies, it is possible that these larger companies have an interest in following projects of incubated companies, but they are also highly reluctant to invest directly in them. The high difficulty element of altering project scope is also characteristic of these companies because they have a cycle of product generation that is even bigger than that of other companies linked to different types of biotechnology, in addition to a high specificity of the topic regarding the research generated, hindering changes in the middle of the project.

4.3 Industrial biotechnology

The companies related to industrial biotechnology presented mixed behavior among that found in the companies related to agricultural and pharmaceutical biotechnology, not presenting such results in the criteria investigated. Among the highlights were the following: The client was very available and the teams had high interdisciplinary. However, the companies related to industrial biotechnology presented low marks on customer engagement, customer physical proximity and barriers to delivery or demonstrate results to customers (low delivery frequency).

To understand these results, it is important to remember that the clients of this type of company are other companies that use their byproducts as inputs. Thus, it is imperative that the customer be present during the project so that it is adapted to the needs and infrastructure of the customer. In addition, this need to adapt products to different types of customers requires greater interdisciplinary because not only employees linked to biotechnology but also those related to engineering areas are necessary. Even with the alleged customer availability, the companies claimed that bringing all stakeholders together was time-consuming and that there was a low frequency of partial results.

Finally, the results were plotted in Figure 3. It is possible to verify that the scores surpass those of the companies connected to the ICT (Santos et al., 2013) sector, from where the agile method originates, indicating the hypothesis that the biotechnology sector is favorable to the application of agile methods.

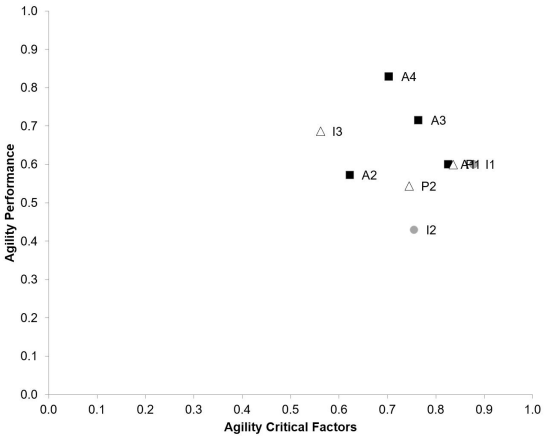

Figure 3. Agility critical factors (x-axis) and agility performance (y-axis) of the companies by biotech sector Pharmaceutical (P), Agriculture (A) and Industrial (I). Source: Own elaboration.

5 Conclusion

The companies studied presented a greater proximity to the ideal environment for agile project management, which indicates the hypothesis of a predisposition to the use of this methodology, even though almost none of them used formalized project management methods. One of the factors that may have also contributed to the agile environment is the chosen population of incubated companies and, therefore, the degree of innovation of the projects. Some of the characteristics of the projects in the sector, such as the use of small and highly trained teams (that is, with a high degree of training and co-location), are favorable to the use of agile management.

Another critical factor for which companies in general presented high scores is the proximity to the customer, which is linked to agile project management. As for the critical factors that inclined companies to traditional project management, it is possible to cite the frequency of deliveries and level of knowledge of the team members. In this case, it is noted that the biotechnology companies of the pharmaceutical sector stood out as an exception. They had low scores on customer availability and easy results for customers. This may lead to the need to use hybrid techniques while maintaining traditional planning.

An important contribution was the design of differences related to the fields of biotechnology. The data indicated important differences according to the identified field. The hypothesis is that different approaches to project management may be required depending on the area of the biotechnology companies, which would require more sampling to be generalized. The results show that the use of agile and/or hybrid approaches to the development of biotechnology products should be considered, depending on the field, size and maturity of project management.

One limitation is that it is impossible to extrapolate the results to all biotechnology companies in view of the population and sample chosen. This study, however, serves as a guide to better project management methods that would meet the needs of biotechnology companies as well as reinforce the importance of taking into account the inherent characteristics of the product, market and teams before defining how the project will be planned and executed.

As future work, it is suggested to investigate more mature biotechnology companies in other fields of biotechnology, as well as companies from other regions or countries. One can also propose and test the use of these methods in real cases through action-type surveys and case studies.

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Annex A. Questionnaire. Adapted from Conforto (2013).

The following questions are related to the characterization of the respondent and his/her company.

1. What is the name of the organization you work in? (the name will only be used in order to identify the data internally. After data analysis the name will be anonymized as letters (A,B, C…). The respondents will be notified on the study results regarding his/her company.

2. 1. What is the number of employees in the organization? If it is a multinational company, please consider the total number in Brazil.

- 1 - 19 (1)
- 20 - 99 (2)
- 100 - 499 (3)
- 500 - 1000 (4)
- More than 1000 (5)

3. 2. What is the main industry sector?

- Agricultural and animal production (1)
- Consultancy (2)
- Mining (wood, oil and gas) (3)
- Medical and hospital equipment (4)
- Government (5)
- Paper and cellulose (as well as derived products) (6)
- Research and development (7)
- Food products (beverages, processed foods, etc.) (8)
- Rubber products (9)
- Petroleum products and biofuels (10)
- Chemical and pharmaceutical products (11)
- Textile products (12)

4. Identify your position in the project according the options.

- Team member (1)
- First in charge of the project (2)
- First in charge of the program (3)
- Responsible for the business unit (4)

5. Identify the alternative that best fits your experience in charge of product development programs and projects in your organization:

- No experience (1)
- Less than 1 year (2)
- Between 1 and 3 years (3)
- Between 4 and 6 years (4)
- Between 7 and 9 years (5)
- Between 10 and 15 years (6)
- More than 15 years (7)

6.1 Was the team supported by some project management software tools (Microsoft Project, Excel, etc.)? If yes, please indicate the tool's name.

▪ No

▪ Yes:

6.2 Considering the methodology applied to this project, please identify the alternative that best fits it:

▪ We adopted a method based on a classical theory such as PMBOK, PRINCE, etc. (1)

▪ We adopted a method based on agile theory such as SCRUM, XP, LEAN, etc. (2)

▪ No formalized method was applied to this project.

7. Fill the space with the lead time of this project, start to finish. Use only a numerical value (in months).

8. Identify the final product of the project according the options:

▪ Product (goods) (1)

▪ A product associated with a service (2)

▪ A method implementation (3)

▪ Improvement of a service or other (4)

9. Choose the alternative that best fits the level of innovation of this project:

▪ Innovative in some components or parts and new to the enterprise (1)

▪ Innovative in some components or parts and new to the market (2)

▪ Innovative in the resultant method and new to the enterprise (3)

▪ Innovative in the resultant method and new to the market (4)

▪ Product totally new to the enterprise (5)

▪ Product totally new to the market (6)

The following questions are about the practices applied during the development of the project under analysis. Identify the option that best fits the project, considering the extreme options (scenario).

10. All the competencies needed were present since the start of the project.

▪ 1 - I totally disagree

▪ 2

▪ 3

▪ 4

▪ 5

▪ 6

▪ 7 - I totally agree

11. Regarding the CEO support for execution and strategic importance of this project, the following is true:

▪ 1 - All necessary support was provided because the project was one of the highest priorities in the organization.

▪ 2

▪ 3

▪ 4

▪ 5

▪ 6

▪ 7 The executive support was limited because the project had low priority in the organization.

12. Regarding the client LOCALIZATION and proximity to the development team (members and management) ...

▪ 1 The client and team were working from a distance, in other countries.

▪ 2

▪ 3

▪ 4

▪ 5

▪ 6

▪ 7 – The client and team were frequently in touch, working in the same room, co-located.

13. With respect to the client's OPENING and INVOLVEMENT demonstrated during the project:

▪ 1 The client did not demonstrate interest and involvement during the project execution.

▪ 2

▪ 3

▪ 4

▪ 5

▪ 6

▪ 7 The client ALWAYS demonstrated interest and involvement during the project execution.

14. Regarding the technical content...

▪ 1 - The technical content made it impossible to obtain partial results that could be presented to the client (for example, it demanded too much effort to produce or some expertise that was not present at the client's organization).

▪ 2

▪ 3

▪ 4

▪ 5

▪ 6

▪ 7 The technical content enabled the presentation of partial results to the client (the results could be materialized in partial and understandable deliverables).

15. Considering the presence of COMPETENCIES in all product parts of this project, when it started…

▪ 1 It was under the project team's control.

▪ 2

▪ 3

▪ 4

▪ 5

▪ 6

▪ 7 It was not under the project team's control because there were one or more significant gaps.

16. Please indicate the scenario that best fits the project regarding the MANAGER EXPERIENCE with similar efforts:

▪ 1 It was the first project that the manager was in charge of with this innovative nature.

▪ 2

▪ 3

▪ 4

▪ 5

▪ 6

▪ 7 The manager is the most experienced professional at the organization with respect to projects of this innovative nature.

17. Please indicate the scenario that best fits the project regarding the TEAM EXPERIENCE with similar efforts:

▪ 1 It was the first project that the team was in charge of with this innovative nature.

▪ 2

▪ 3

▪ 4

▪ 5

▪ 6

▪ 7 The team was formed with the most experienced professionals at the organization with respect to innovative projects.

18. Please indicate the scenario that best fits the project with respect to the project team composition:

▪ 1 The professionals that were part of the project team originated from one unique functional area with unique competence and experience.

▪ 2

▪ 3

▪ 4

▪ 5

▪ 6

▪ 7 The professionals that were part of the project team originated from different functional areas, containing multiple competences and varying experience.

19. Please indicate the option that best fits the TEAM SIZE:

▪ Up to 6 members (1)

▪ Between 7 and 12 members (2)

▪ Between 13 and 18 members (3)

▪ Between 19 and 24 members (4)

▪ Between 25 and 30 members (5)

▪ Between 31 and 36 members (6)

▪ More than 36 members (7)

20. Please indicate the scenario that best fits the project with respect to the COMMITMENT of the project team:

▪ 1 - Less than 10% of the weekly time was spent on the project (4 hours per week).

▪ 2

▪ 3

▪ 4

▪ 5

▪ 6

▪ 7 - 100% or exclusive dedication to the project

21. Please choose the scenario that best represents the reality of the project with respect to the LOCALIZATION of the team (responsible and team members):

▪ 1 The team was located in different countries, physically distant.

▪ 2

▪ 3

▪ 4

▪ 5

▪ 6

▪ 7 The team was located in the same room, co-located.

22. Please identify the communication frequency between the project team and client according the options:
- Daily
- Weekly
- Every two weeks
- Monthly
- Every two months
- Each semester
- The interaction with the client during the project was not significant.

23. Please identify the delivery frequency of partial results according the options (product reports, prototypes, drawings, simulations, testing reports, etc.):
- There were not any significant deliverables during the project time span.
- Each semester
- Every two months
- Monthly
- Every two weeks
- Weekly
- Daily

24. Please identify the option considering the statement: The partial results obtained from this project were constantly DISCUSSED and were VALIDATED by the client during the project.
- 1 I totally disagree
- 2
- 3
- 4
- 5
- 6
- 7 I totally agree

25. With respect to the AUTONOMY of the team to perform changes:
- 1 - In 100% of changes, the team had the autonomy to decide on and implement them.
- 2
- 3
- 4
- 5
- 6
- 7 - In 100% of changes, the team was obligated to ask for some kind of approval from a superior.

26. The time spent by all team members, including managers and stakeholders, to analyze information and implement changes was:
- Beyond 30 days (1)
- Between 16 and 30 days (2)
- Between 11 and 15 days
- Between 6 and 10 days
- Between 3 and 5 days
- Between 1 and 2 days
- Less than 24 hours

27. The time taken to change the project plan and communicate it to all members, including stakeholders, was:
- Beyond 30 days (1)
- Between 16 and 30 days (2)
- Between 11 and 15 days
- Between 6 and 10 days
- Between 3 and 5 days
- Between 1 and 2 days
- Less than 24 hours