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Budget deviations in RD&I projects: a comparative analysis of projected and actual values

Desvios orçamentários em projetos de PD&I: análise comparativa entre valores projetados e realizados

Desviaciones presupuestarias en proyectos de I+D+i: análisis comparativo entre valores proyectados y ejecutados

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Abstract:
This study investigates the budget execution of six RD&I projects across multiple sectors, with budget levels ranging from R$1,182,486.05 to R$3,968,702.23. Accordingly, these projects' forecasted and realized values are compared using three physical execution milestones (25%, 50% and 100%). Specifically, eight cost categories were employed, and three represented the most common causes of budget overspend: man-hours (MH), execution time, and financial expenses. These results reveal a concerning scenario. MH exceeded the budget in five of the six selected projects, resulting in an overrun of R$967,098.55 (19% above the forecasted budget). Regarding the time to completion, five out of the six projects required extensions. Furthermore, the proportion of actual to projected durations stayed largely consistent during the project's execution, indicating that delays were present from the beginning. Yet, extensions were only requested after the 50% milestones. Regarding financial expenses, none of the six projects had initially allocated funds for this item; however, all of them experienced actual expenditures in this category. The study discusses the probable causes of this underestimation in the initial proposals, along with the absence of planning for certain budget lines and a possible ripple effect linking deadline extensions to personnel costs. As such, this study ultimately proposes practical recommendations for improving budgeting in future similar projects.

Keywords:
Cost Management; RD&I; Budget Deviation; Project Budgeting; Earned Value Management.

Resumo:
O presente artigo é um estudo de caso que analisa a execução orçamentária de seis projetos de PD&I nos diferentes setores com orçamentos que variam entre R$1.182.486,05 e R$3.968.702,23, comparando valores projetados e realizados em três marcos de execução física (25%, 50% e 100%). Das oito categorias de custo levantadas, três concentraram os desvios mais recorrentes: HH (Homem-Hora), Tempo de execução e Despesas Financeiras. Os resultados revelam um cenário preocupante. Em HH, o orçamento estourou em 5 dos 6 projetos, com excesso de R$967.098,55 (19% acima do previsto). Em tempo, 5 dos 6 projetos foram prorrogados, e a razão realizada/projetada se manteve praticamente constante nos três marcos, sinal de que o atraso já vinha se formando desde o início, embora os termos aditivos só tenham sido formalizados a partir do marco de 50%. Já em Despesas Financeiras, nenhum dos seis projetos previu qualquer valor, mas todos tiveram execução real nessa rubrica. O estudo discute as prováveis causas do subdimensionamento na proposta original, a ausência de rubrica de planejamento e um possível efeito em cascata entre a prorrogação de prazo e o custo de pessoal e propõe recomendações práticas para o aprimoramento de orçamentos em projetos futuros semelhantes.

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Palavras-chave:
Gestão de custos; PD&I; Desvio Orçamentário; Orçamento de Projetos; Earned Value Management.

Resumen:
Este artículo es un estudio de caso que analiza la ejecución presupuestaria de seis proyectos de I+D+i en diferentes sectores con presupuestos que oscilan entre R$ 1.182.486,05 y R$ 3.968.702,23, comparando los valores proyectados y realizados en tres hitos de ejecución física (25%, 50% y 100%). De las ocho categorías de costos relevadas, tres concentraron las desviaciones más recurrentes: HH (Hora-Hombre), Tiempo de ejecución y Gastos Financieros. Los resultados revelan un escenario preocupante. En HH, el presupuesto fue rebasado en 5 de los 6 proyectos, con un exceso de R$ 967.098,55 (19% por encima de lo previsto). Con el tiempo, 5 de los 6 proyectos fueron prorrogados, y el ratio realizado/proyectado se mantuvo prácticamente constante en los tres hitos, señal de que el retraso se había ido gestando desde el principio, aunque los plazos aditivos sólo se formalizaron después del hito del 50%. En Gastos Financieros, ninguno de los seis proyectos preveía valor alguno, pero todos tuvieron ejecución real bajo este epígrafe. El estudio analiza las causas probables del subdimensionamiento en la propuesta original, la ausencia de una rúbrica de planificación y un posible efecto en cascada entre la extensión del plazo y los costos de personal y propone recomendaciones prácticas para mejorar los presupuestos en proyectos futuros similares.

Palabras clave:
Gestión de costos; I+D+i; Desviación Presupuestaria; Presupuesto del Proyecto; Gestión del Valor Ganado.

1. Introduction

Budget management is a central element of governance in research, development and innovation (RD&I) projects. Its relevance increases when there is external financing, the need to be accountable to development institutions and partnerships between public and private entities, a situation in which the budget ceases to be an internal control instrument and becomes a contractual commitment.

In RD&I projects, the difference between the approved budget and actual execution is recurrent. Budget deviation is not restricted to an accounting issue: it can compromise the continuity of the project and require additional resources from proponents or financiers, with effects that, in extreme cases, affect the executing organization itself (FLYVBJERG et al., 2022). The origin of this deviation, however, remains controversial. One line attributes the deviation to a systematic error in the initial estimate, resulting from the optimism bias in defining cost targets (FLYVBJERG, 2008). Another maintains that it is formed in events that arise during the execution of the project, such as scope changes or deadline extensions (LOVE; AHIAGA-DAGBUI, 2018).

Therefore, this work investigates six completed RD&I projects, identified as Projects A to F, carried out by a company in the sector located in Três Lagoas (MS). The general objective of this work is to compare budgeted and realized values in three physical execution milestones of the six projects, identifying whether the deviations are structural, present since the beginning of execution, or reactive, resulting from events throughout the project, in order to support recommendations for the preparation of future budgets.

The specific objectives of this work were: i) to quantify, in each of the eight categories, how many of the six projects exceeded the planned budget; ii) check whether the budget overrun already appears in the first monitoring milestone (25% of physical execution) or whether it only manifests itself in subsequent milestones; iii) relate the existence of contract amendment terms with the overrun behavior; iv) point out, based on the observed patterns, practical recommendations to improve budget preparation in future projects of a similar nature.

This analysis is of great importance for the organization involved, as it identifies when deviations manifest themselves and verifying their association with events that occurred during execution can contribute to improving the preparation and monitoring of budgets in RD&I projects. This allows development institutions and proponents to better adjust the budgets of future projects, avoiding both under-evaluation and the excessive inclusion of contingencies, which unnecessarily increase costs. Thus, the results of this study can be directly applied to the practice of budget preparation in RD&I projects.

2. Bibliographic review

2.1 Budget Management

Financially, the budget is a forecast of expenses and income for a specific period (GIACOMONI, 2018). The approved budget is established during the planning phase and represents the expected costs for completing the project and serves as a basis for measuring deviations in actual expenses, monitoring financial performance and estimating the final cost (ENAYATI FATOLLAH; DABBAGH; SHAHSAVAR JALAVAT, 2025). Its preparation presupposes the division of the total value into categories or cost items, each representing a specific type of expense, which makes it possible to estimate and monitor expenses per item (PROJECT MANAGEMENT INSTITUTE [PMI], 2017). The difference between the value predicted in the baseline and the amount actually executed constitutes the budget deviation (TONCHIA, 2018). Deviations of this nature are recurrent and can compromise the continuity

of the project, requiring extra investments from proponents or financiers (FLYVBJERG et al., 2022).

The choice of reference baseline differs in the literature. Love and Ahiaga-Dagbui (2018) defend the adoption of the contracted budget, on the argument that previous references inflate the deviations found. Flyvbjerg et al. (2018) argue that the definition of the reference must correspond to what is intended to be measured, so there is no universally adequate baseline. In this study, the budget approved in the original work plan was adopted as a baseline.

As for their origin, deviations can be classified according to the moment in which they appear during execution. For this work, structural deviation was adopted, which is already present in the first stages of execution, and reactive deviation, which only manifests itself in intermediate or final stages, due to events occurring during execution.

The cost estimate in projects is prepared in the proposal phase, characterized by an undefined scope and lack of information, increasing the possibility of errors in the initial phase (BERG et al., 2025).

Estimation errors do not cancel each other out, because if they were random, it would be expected to find both cases of overestimation and underestimation. However, the literature documents that deviations are concentrated in underestimation, a pattern attributed to systematic optimism in defining cost targets (FLYVBJERG, 2008). Berg et al. (2025), in interviews with cost engineers, found that the pressure for reduced values comes from decision-makers and the environment external to the project, and not from the optimism of the estimating team itself. Therefore, this study observes whether deviations are concentrated above the predicted value, which would indicate underestimation in the proposal phase.

2.2 Interdependence between deadline and cost

The total cost of a project is the sum of direct and indirect costs. Direct costs can be attributed to specific activities or work packages, such as the sum of labor, equipment and materials (ELKLINY; SANAD; ETMAN, 2023). While indirect costs are associated with execution and are not directly linked to a specific activity, they may vary depending on the length of execution (ELKLINY; SANAD; ETMAN, 2023), even without changing the scope or including new activities. For example, labor can be classified as a direct cost when it is linked to the project or activities performed (ABDELBASSET et al., 2023). However, in RD&I projects, team allocation can occur continuously throughout the execution period, depending on the duration of the project and causing the extension to affect the Man-Hour item.

Changing the contractual term requires formalization, called an addendum. Between the identification of the delay and the need to change the deadline, there may be a gap resulting from recognition, negotiation and approval of the change. When present, this lag separates temporally the moment in which the deviation manifests itself from the moment in which it formally becomes part of the contractual schedule and budget. Therefore, the deadline is analyzed here together with the monetary items, allowing us to verify whether the extension of the execution time is accompanied by an increase in duration-dependent costs.

2.3 Monitoring by milestones and added value

Comparing the budgeted amount with the amount spent is the most immediate way to evaluate the financial performance of a project, but this comparison does not tell you how much work was performed compared to the cost incurred. Spending less than expected may represent savings or result from physical execution that is lower than planned. Therefore, an isolated comparison does not allow us to distinguish the reason for the deviation or its impact on the progress of the project. Similarly, when carried out only at the end of the project, the comparison highlights the existence of the deviation, but does not allow identifying when it started.

In earned value management, the approved budget is distributed throughout execution, so that each milestone now has a predicted value against which the cost incurred can be compared (ANBARI, 2011). For this work, a linear distribution was adopted, which assumes growth at a constant rate: Linear distribution assumes that when labor dominates expenditure, the number of people allocated remains constant and the journey is uniform in each period, the accumulated values become linearly proportional to time (Warburton and Cioffi, 2016).

By observing intermediate milestones, it is possible to identify at which stage of execution the deviation manifested itself. Without this physical reference, it is not possible to distinguish a deviation that appeared only at the end from another that was already present in the initial stages.

2.4 RD&I projects

RD&I projects are a way of promoting innovation that connects Brazilian industry demand directly to research centers and universities and are carried out by companies in partnership with accredited research institutions to develop innovation projects. The model provides for the sharing of costs and risks associated with technological development, with the

contribution of non-reimbursable resources (EMBRAPII, 2024; GORDON; STALLIVIERI, 2019).

The execution of projects is formalized through a work plan that defines the results, activities, resources and deliverables of the project (GORDON; STALLIVIERI, 2019; EMBRAPII, 2024). Deliveries are organized into macro deliveries, which guide the monitoring of execution and establish the milestones foreseen in the work plan. Financial planning is, therefore, fixed at the beginning, while activities develop throughout execution.

Differences between planned and realized costs arise from this, especially when the effort required to perform the activities changes during the project. Among the components of the budget, labor costs are directly related to the intensity of work required to achieve expected deliverables.

Studies on this model have focused mainly on aspects related to financing, governance, performance indicators and the results of partnerships between companies and research institutions (GORDON; STALLIVIERI, 2019; AZEVEDO; VIEIRA, 2024; SENA et al., 2025). The literature located, however, presents little evidence on the behavior of costs during the execution of projects and on the relationship between the values initially budgeted and the costs actually realized. The gap matters for budget management precisely in projects in which labor represents a significant portion of the resources.

3. Research method

3.1 Search classification

This research is classified as applied, as it seeks to generate knowledge aimed at solving a specific budget management problem. Being exploratory and descriptive in nature, it investigates the origins of budget deviations in the chosen projects and formulates practical recommendations to identify recurring patterns among the cases studied.

As for the technical procedure, the case study was adopted, which is capable of in-depth investigation of a single case or a small group of them, seeking, from this data, to understand patterns that can apply to a larger universe of similar situations (GERRING, 2019). From this, the research method called case study was adopted, with a quantitative-descriptive methodological approach.

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3.2 Case characterization and unit of analysis

In general, the definition of the case study or unit of analysis arises from how the initial research questions were formulated (Yin, 2015). In this study, company "X", referred to here as the case, was defined as the case and the individual RD&I project as the unit of analysis.

Company "X" began its activities in 2014, in the city of Três Lagoas, Mato Grosso do Sul, focusing on the development of innovative products, services and processes. It operates in the industrial sectors of steel/mining, paper and cellulose, sugar-energy, biofuels, chemicals and cosmetics, oil and gas, among others. It currently has 75 employees, including employees, interns and scholarship holders, distributed in the Administrative, Quality, Project Management Office (PMO), Management, Coordinators and Operational areas.

As this is budget execution data of a sensitive nature, the organization and projects analyzed are identified as company "X" and projects "A to F", according to authorization granted by the company for academic use of the data.

3.3 Sample selection

Company "X" maintains a portfolio of 106 projects, including canceled, ongoing and completed. Among the 106, 6 were selected, using exclusion and inclusion criteria. The first criterion was to select completed projects, leaving a total of 37 projects. The second criterion was to select projects with a total value greater than R$1,000,000.00 and less than R$5,000,000.00, resulting in 29 remaining projects. And finally, the last criterion restricted the sample to 6 projects that used the Brazilian Industrial Research and Innovation Company (EMBRAPII) funding model. The project work plan provided for macro deliveries, but presented the budget only in total value, without dividing the disbursement by execution stage. In this way, the distribution of the budget between the milestones was defined by the authors, according to the criteria described in section 3.4. Considering that all cases follow the same work plan format, the same budget line structure and the same accountability rules, they can be compared with each other. The six selected projects, identified as Projects A to F, began between 2021 and 2023 and were completed between 2023 and 2026. Together, they total a total investment of less than R$11.5 million, with individual values between R$1.1 million and R$4.0 million, approximately, operating in the sectors of biomaterials and bioproducts, bioprocess engineering and biotechnology, decarbonization technology and energy and sustainability, which guarantees some size diversity to the sample studied.

3.4 Data collection and data analysis

Data were collected through document analysis of Company X's internal records. The sources consulted were each project's work plans, pricing records, and data from spreadsheets used for physical and financial monitoring and project financial management. These data were organized in a Microsoft Excel 2021 spreadsheet.

Eight cost categories were adopted: Man-Hour (MH), Material, Service, Financial Expenses, Travel, Grants, Operational Support and Time. The Time category, although expressed in months, was incorporated into the analysis as it is part of the same monitoring instrument and maintains a direct relationship with the other categories. In the Financial Expenses category, the predicted value is equal to zero in all projects, which makes calculating the ratio unfeasible. In these cases, execution without budgetary forecast was recorded.

For each project, data was organized into three physical execution milestones: 25%, 50%, and 100% of scope completed. The work plans analyzed present an approved budget in total value per category, without detailing the planned disbursement per stage. In view of this, a uniform distribution of the budget was adopted in relation to physical execution, attributing to each milestone the corresponding fraction of the total amount budgeted in the category. This is what the earned value management literature calls a linear planned value curve, in which each interval receives a uniform budget (KIM; KIM, 2014). This profile is appropriate when labor dominates expenditure and the team remains stable throughout execution (WARBURTON; CIOFFI, 2016), a condition close to that of the RD&I projects analyzed. As the predicted value at each milestone corresponds to the physically completed portion of the scope, it is equivalent to the earned value of the project at that stage.

For each category and milestone, the percentage proportion between the amount actually spent and the predicted amount (% of the amount realized) was calculated, where rates above 100% point to exceeding the budget. Indexes above 100% in most projects were read as a sign of underestimation in the proposal. The deviation was called structural when it was repeated in most projects in the first milestones, and reactive when it was punctual and appeared mainly at 50% or 100%. With no common standard, the category was considered mixed. Finally, it was verified in each project where a delay appeared, when the deadline amendment was formalized, and it was verified whether the duration-dependent items grew along with the extension.

Table 1 - Characterization of the analyzed projects.

Project	Sector	Total investment (R$)	Planned months	Actual months
A	Biomaterials and Bioproducts	1.849.066,70	24	32
B	Process Engineering and Biotechnology	1.738.418,88	24	33
C	Decarbonization Technology	3.968.702,23	41	41
D	Energy and Sustainability	1.182.486,05	20	32
E	Biomaterials and Bioproducts	1.291.044,18	24	30
F	Process Engineering and Biotechnology	1.438.929,06	30	40

Source: Prepared by the authors (2026)

4. Results and discussion

4.1 General overview of deviations

The analysis covered six projects, eight cost categories and three physical execution milestones, totaling 144 comparisons between budgeted and realized values. Tables 2 to 7 present the individual results of each project. Consolidation by category (Table 9) reveals that the deviations are not distributed homogeneously between the headings.

Table 2 - Comparison between Projected and Realized Values by Project A Execution Milestone

Project A — physical execution milestone: 25%

Category	Projected	Actual	% actual
MH (R$)	151.611,50	296.421,51	195,51%
Material (R$)	42.030,58	22.310,61	53,08%
Service (R$)	106.429,00	62.012,24	58,27%
Financial expenses (R$)	0,00	239,71	n.a.
Travel (R$)	11.300,00	13.041,57	115,41%

Category	Projected	Actual	% actual
Scholarships (R$)	48.000,00	72.000,00	150,00%
Operational support (R$)	79.931,93	51.732,56	64,72%
Time (months)	6	8	133,33%

Project A — physical execution milestone: 50%

Category	Projected	Actual	% actual
MH (R$)	303.223,00	457.470,47	150,87%
Material (R$)	84.061,15	33.111,30	39,39%
Service (R$)	212.858,00	97.339,80	45,73%
Financial expenses (R$)	0,00	506,35	n.a.
Travel (R$)	22.600,00	14.669,53	64,91%
Scholarships (R$)	96.000,00	146.459,40	152,56%
Operational support (R$)	159.863,85	150.516,87	94,15%
Time (months)	12	16	133,33%

Project A — physical execution milestone: 100%

Category	Projected	Actual	% actual
MH (R$)	606.446,00	953.445,47	157,22%
Material (R$)	168.122,30	75.608,53	44,97%
Service (R$)	425.716,00	162.320,53	38,13%
Financial expenses (R$)	0,00	1.063,87	n.a.
Travel (R$)	45.200,00	24.434,14	54,06%
Scholarships (R$)	192.000,00	192.033,60	100,02%
Operational support (R$)	319.727,70	440.160,56	137,67%
Time (months)	24	32	133,33%

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Contract amendment: There was 1 contract amendment to extend the duration from 24 to 32 months

Source: Prepared by the authors (2026)

Table 3 - Comparison between projected and realized values by execution milestone: Project B

Project B — physical execution milestone: 25%

Category	Projected	Actual	% actual
MH (R$)	99.896,25	345.859,09	346,22%
Material (R$)	63.250,00	40.624,98	64,23%
Service (R$)	121.750,00	296.085,00	243,19%
Financial expenses (R$)	0,00	232,80	n.a.
Travel (R$)	11.300,00	19.793,30	175,16%
Scholarships (R$)	24.000,00	127.170,00	529,88%
Operational support (R$)	55.912,75	156.487,75	279,88%
Time (months)	6	8	133,33%

Project B — physical execution milestone: 50%

Category	Projected	Actual	% actual
MH (R$)	199.792,50	721.385,09	361,07%
Material (R$)	126.500,00	52.332,64	41,37%
Service (R$)	243.500,00	424.750,15	174,44%
Financial expenses (R$)	0,00	521,00	n.a.
Travel (R$)	22.600,00	21.103,70	93,38%
Scholarships (R$)	48.000,00	138.050,00	287,60%
Operational support (R$)	111.825,50	214.487,75	191,81%
Time (months)	12	16	133,33%

Project B — physical execution milestone: 100%

Category	Projected	Actual	% actual
MH (R$)	399.585,00	813.626,09	203,62%
Material (R$)	253.000,00	53.790,28	21,26%
Service (R$)	487.000,00	477.955,95	98,14%

Category	Projected	Actual	% actual
Financial expenses (R$)	0,00	977,51	n.a.
Travel (R$)	45.200,00	21.616,70	47,82%
Scholarships (R$)	96.000,00	138.050,00	143,80%
Operational support (R$)	223.651,00	232.402,35	103,91%
Time (months)	24	33	137,50%

Contract amendment: There were 3 contract amendments to extend the duration from 24 to 33 months

Source: Prepared by the authors (2026)

Table 4 - Comparison between projected and realized values by execution milestone: Project C

Project C — physical execution milestone: 25%

Category	Projected	Actual	% actual
MH (R$)	604.340,88	319.948,00	52,94%
Material (R$)	55.653,75	8.133,76	14,61%
Service (R$)	237.085,63	150.305,60	63,40%
Financial expenses (R$)	0,00	184,70	n.a.
Travel (R$)	14.750,00	12.306,79	83,44%
Scholarships (R$)	160.000,00	86.000,00	53,75%
Operational support (R$)	78.895,75	74.716,00	94,70%
Time (months)	10	10	100,00%

Project C — physical execution milestone: 50%

Category	Projected	Actual	% actual
MH (R$)	1.208.681,75	663.130,00	54,86%
Material (R$)	111.307,50	71.350,84	64,10%
Service (R$)	474.171,25	554.932,64	117,03%
Financial expenses (R$)	0,00	456,10	n.a.
Travel (R$)	29.500,00	40.992,21	138,96%
Scholarships (R$)	320.000,00	166.000,00	51,88%
Operational support (R$)	157.791,50	125.133,22	79,30%

Category	Projected	Actual	% actual
Time (months)	21	21	100,00%

Project C — physical execution milestone: 100%

Category	Projected	Actual	% actual
MH (R$)	2.417.363,50	2.109.856,00	87,28%
Material (R$)	222.615,00	254.295,63	114,23%
Service (R$)	948.342,50	957.193,95	100,93%
Financial expenses (R$)	0,00	969,51	n.a.
Travel (R$)	59.000,00	47.914,26	81,21%
Scholarships (R$)	640.000,00	306.866,00	47,95%
Operational support (R$)	315.583,00	291.606,88	92,40%
Time (months)	41	41	100,00%

Contract amendment: None

Source: Prepared by the authors (2026)

Table 5 - Comparison between projected and realized values by execution milestone: Project D

Project D — physical execution milestone: 25%

Category	Projected	Actual	% actual
MH (R$)	78.705,75	102.501,00	130,23%
Material (R$)	25.250,00	33.153,37	131,30%
Service (R$)	84.250,00	1.250,00	1,48%
Financial expenses (R$)	0,00	97,24	n.a.
Travel (R$)	1.950,00	0,00	0,00%
Scholarships (R$)	30.300,00	26.386,00	87,08%
Operational support (R$)	52.767,90	34.296,52	65,00%
Time (months)	5	8	160,00%

Project D — physical execution milestone: 50%

Category	Projected	Actual	% actual
MH (R$)	157.411,50	186.161,00	118,26%

Category	Projected	Actual	% actual
Material (R$)	50.500,00	36.603,61	72,48%
Service (R$)	168.500,00	1.250,00	0,74%
Financial expenses (R$)	0,00	274,60	n.a.
Travel (R$)	3.900,00	0,00	0,00%
Scholarships (R$)	60.600,00	69.758,00	115,11%
Operational support (R$)	105.535,80	55.296,52	52,40%
Time (months)	10	16	160,00%

Project D — physical execution milestone: 100%

Category	Projected	Actual	% actual
MH (R$)	314.823,00	455.116,00	144,56%
Material (R$)	101.000,00	122.132,28	120,92%
Service (R$)	337.000,00	326.393,24	96,85%
Financial expenses (R$)	0,00	591,29	n.a.
Travel (R$)	7.800,00	4.661,93	59,77%
Scholarships (R$)	121.200,00	136.076,40	112,27%
Operational support (R$)	211.071,60	137.514,91	65,15%
Time (months)	20	32	160,00%

Contract amendment: There was 1 contract amendment

Source: Prepared by the authors (2026)

Table 6 - Comparison between projected and realized values by execution milestone: Project E

Project E — physical execution milestone: 25%

Category	Projected	Actual	% actual
MH (R$)	152.389,13	124.988,25	82,02%
Material (R$)	23.425,00	7.609,36	32,48%
Service (R$)	33.500,00	0,00	0,00%
Financial expenses (R$)	0,00	189,38	n.a.
Travel (R$)	5.250,00	800,00	15,24%
Scholarships (R$)	42.000,00	36.560,00	87,05%

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Category	Projected	Actual	% actual
Operational support (R$)	57.014,25	18.171,67	31,87%
Time (months)	6	8	125,00%

Project E — physical execution milestone: 50%

Category	Projected	Actual	% actual
MH (R$)	304.778,25	478.429,93	156,98%
Material (R$)	46.850,00	38.167,25	81,47%
Service (R$)	67.000,00	34.530,00	51,54%
Financial expenses (R$)	0,00	447,91	n.a.
Travel (R$)	10.500,00	13.396,23	127,58%
Scholarships (R$)	84.000,00	53.560,00	63,76%
Operational support (R$)	114.028,50	60.977,57	53,48%
Time (months)	12	15	125,00%

Project E — physical execution milestone: 100%

Category	Projected	Actual	% actual
MH (R$)	609.556,60	743.952,02	122,05%
Material (R$)	93.700,00	55.797,04	59,55%
Service (R$)	134.000,00	162.407,07	121,20%
Financial expenses (R$)	0,00	934,60	n.a.
Travel (R$)	21.000,00	30.158,35	143,61%
Scholarships (R$)	168.000,00	124.560,00	74,14%
Operational support (R$)	228.057,00	173.235,10	75,96%
Time (months)	24	30	125,00%

Contract amendment: There were 2 contract amendments

Source: Prepared by the authors (2026)

Table 7 - Comparison between projected and realized values by execution milestone: Project F

Project F — physical execution milestone: 25%

Category	Projected	Actual	% actual
MH (R$)	176.509,54	61.438,91	34,81%
Material (R$)	12.375,00	0,00	0,00%
Service (R$)	34.500,00	0,00	0,00%
Financial expenses (R$)	0,00	166,36	n.a.
Travel (R$)	1.300,00	0,00	0,00%
Scholarships (R$)	52.500,00	0,00	0,00%
Operational support (R$)	64.472,81	6.800,00	10,55%
Time (months)	8	10	133,33%

Project F — physical execution milestone: 50%

Category	Projected	Actual	% actual
MH (R$)	353.019,07	227.441,10	64,43%
Material (R$)	24.750,00	16.594,48	67,05%
Service (R$)	69.000,00	14.832,00	21,50%
Financial expenses (R$)	0,00	410,89	n.a.
Travel (R$)	2.600,00	36.986,53	1422,56%
Scholarships (R$)	105.000,00	82.750,00	78,81%
Operational support (R$)	128.945,63	8.500,00	6,59%
Time (months)	15	20	133,33%

Project F — physical execution milestone: 100%

Category	Projected	Actual	% actual
MH (R$)	706.038,14	944.915,21	133,83%
Material (R$)	49.500,00	40.045,03	80,90%
Service (R$)	138.000,00	44.874,80	32,52%
Financial expenses (R$)	0,00	1.313,41	n.a.

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Category	Projected	Actual	% actual
Travel (R$)	5.200,00	46.979,38	903,45%
Scholarships (R$)	210.000,00	229.750,00	109,40%
Operational support (R$)	257.891,25	131.051,23	50,82%
Time (months)	30	40	133,33%

Contract amendment: There were 2 contract amendments

Source: Prepared by the authors (2026)

Three categories concentrate recurring deviations; Financial Expenses records execution above expectations in all projects, while MH and Time show deviations in five of the six cases. The remaining four categories, Material, Services, Travel and Operational Support, exceed budget in only two projects each, without the same projects being repeated between them.

It can be seen, according to figure 1, that three categories stood out in this panorama: costs of financial expenses that were overrun in the six projects, MH and time, which were overrun in five of them each. In Man-Hour and Time, part of the projects were already being executed above what was predicted in the first milestone, at 25% of physical execution, which indicates a deviation present from the initial stages and not accumulated throughout the progress of the project. In the other categories, the scenario changes: the budget overrun occurs in, at most, four of the six projects and tends to be concentrated in intermediate or final milestones. This suggests a reaction by the project team, through reallocation of resources, rather than an initial failure in planning.

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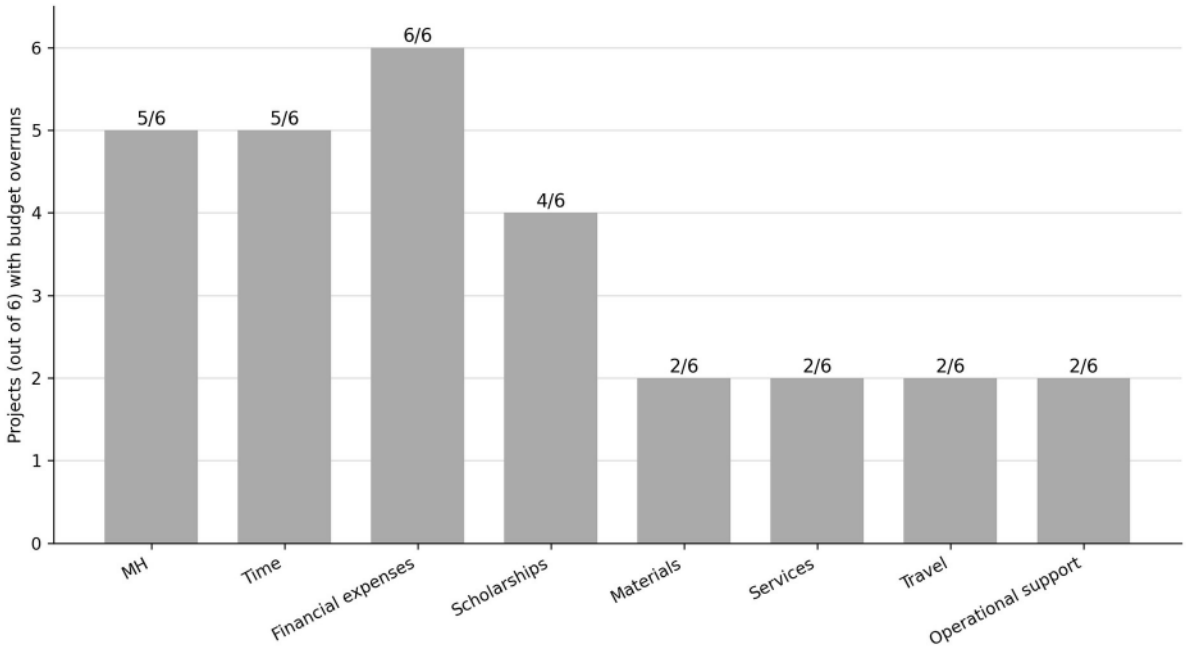

Figure 1 - Number of projects executed above budget by cost category. Source: Prepared by the authors (2026).

Given this distribution, the following sections deepen the analysis in the three most frequently occurring categories: Man-Hour (Section 4.2), Time (Section 4.3) and Financial Expenses (Section 4.4).

4.2 Man-Hour: Structural Overrun since the Proposal

The MH category presented execution above budget in five of the six projects analyzed, representing the item with the greatest financial impact among the deviations identified. In aggregate terms, the six projects estimated R$5,053,812.24 and executed R$6,020,910.79, a difference of R$967,098.55, equivalent to 19% above budget. Figure 2 shows the evolution of the ratio between realized value and projected value throughout the three execution milestones.

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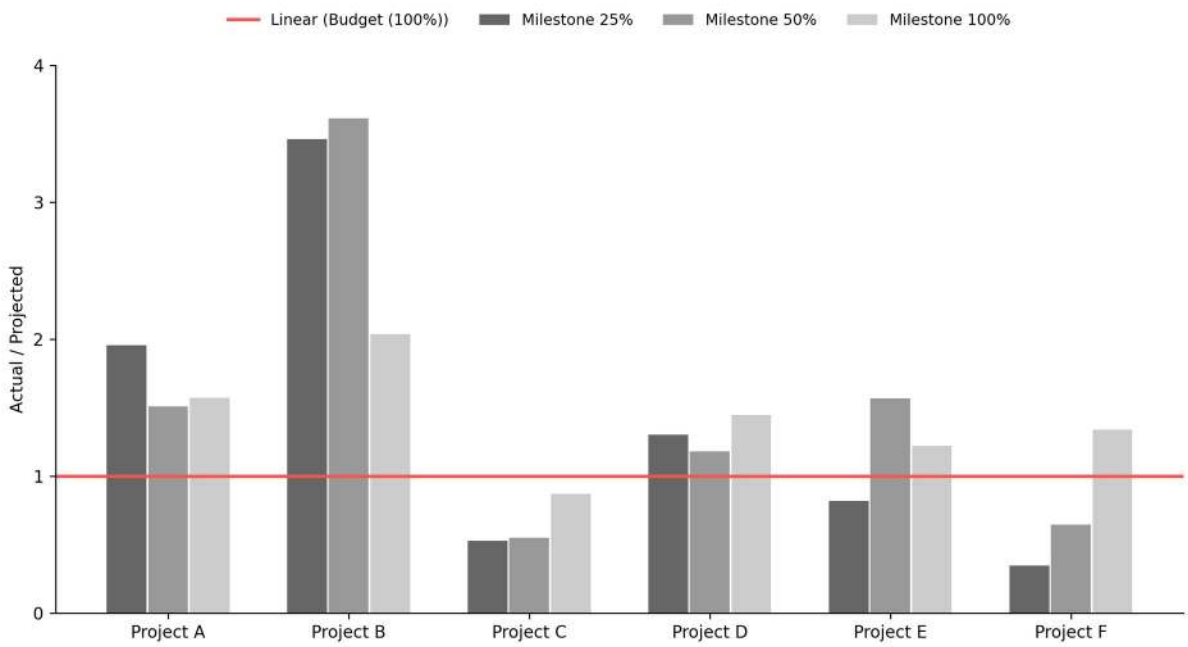

Figure 2 - Evolution of the ratio between realized value and projected value in the Man-Hour category by execution milestone. Source: Prepared by the authors (2026). Note: The reference line at 100% indicates equivalence between realized value and projected value. Values above the reference correspond to execution exceeding the budget.

The deviation manifested itself early. Three of the projects, A, B and D, were already executing above the expected 25% mark, with ratios of 195.5%, 346.2% and 130.2%, respectively. In these cases, overrun occurs when only a quarter of the scope had been completed, which indicates that the number of hours required for execution was underestimated when preparing the original proposal. The behavior is compatible with the systematic optimism bias described in the cost estimation literature (FLYVBJERG, 2008).

Project B constitutes an extreme case of the sample. At the 50% mark, it reached 3.6 times the budget and still remained at 2.0 times at the end of execution. In absolute values, R$813,626.09 was executed against R$399,585.00 forecast, a difference of R$414,041.09 in a project whose total investment is R$1,738,418.88.

Project C was the only one in the sample with execution below budget, ending at 87.3%, which represents R$2,109,856.00 executed against R$2,417,363.50 forecast, in addition to being the only project without an deadline extension amendment (Table 4). This coincidence reinforces the hypothesis that there is a relationship between deadline extension and MH overrun: when the deadline is extended, the consumption of hours tends to follow suit.

Finally, projects E and F had a different trajectory, starting below schedule and exceeding budget only at later milestones. Project E starts from 82.0% in the first milestone and

ends at 122.0%, while Project F starts from 34.8% and ends at 133.8%. In both cases, the deviation is consolidated throughout execution.

4.3 Time: delay present from the beginning, formalized after 50%

The Time category presented an extension of the deadline in five of the six projects analyzed. Table 8 presents the expected and actual deadlines, accompanied by the record of contract amendments.

Table 8 – Expected and actual deadlines and record of contract amendments per project

Project	Planned months	Actual months	Contract amendment
A	24	32	1 Additive term
B	24	33	3 Additive terms
C	41	41	None
D	20	32	1 Additive term
E	24	30	2 Additive terms
F	30	40	2 Additive terms
Total	163	208 45 months	additional (Aggregate)

Source: Prepared by the authors (2026)

This category showed a more consistent pattern across the three follow-up milestones. This behavior indicated that the delay did not accumulate progressively throughout the execution, but was already forming from the initial stages. This contrasts with cost categories, where this ratio tends to vary across milestones.

Although there was a constant standard, the contract amendments, however, were not signed at the 25% mark; contractual extensions were only formalized after 50% of physical execution. It was evident that the delay in relation to the original schedule had already been accumulating proportionally since the first months of the project, but its contractual recognition through the signing of the addendum only occurred when the project was already halfway

through physical execution. So, there was a delay between the moment in which the delay actually exists and the moment in which it is officially recognized.

In aggregate, the six projects total 163 months planned against 208 months realized, an additional 45 months, or 27.6% above forecast. Project D is the furthest from the original deadline, with 60% additional time, regularized in a single contract amendment. In Project C, the only one without a deadline, there was no delay to be recognized.

4.4 Financial Expenses: absence of heading

The Financial Expenses category showed the most uniform behavior of the entire sample. In the six projects analyzed, the amount foreseen in the budget was equal to R$0.00, while all recorded effective execution under the heading throughout the three monitoring milestones (Tables 2 to 7). The absence of a projected value made it impossible to calculate the ratio between what was realized and what was projected, which is why the category is analyzed qualitatively (Section 3). The values executed were reduced and showed few variations between projects. At the end of execution, Project D recorded the smallest amount, R$591.29, and Project F the largest, R$1,313.41. In the sample as a whole, the item totals R$5,850.19. Execution occurs from the first milestone in all projects and grows throughout physical progress, a behavior compatible with bank fees and financial charges on the movement of resources.

The absence of a budget forecast can be associated with the difficulty of anticipating this type of expenditure when preparing the proposal, coupled with the low impact on the financial result of the project as a whole. Unlike the other categories analyzed, the deviation observed in Financial Expenses is not characterized as a sizing error nor as a response to events that occurred during execution. This is the absence of the item in the original budget, a condition verified in all projects regardless of technical sector, size or duration.

4.5 Comparative Analysis: Structural and Reactive Deviations

The categories analyzed showed different behavior in terms of when the deviation manifested itself throughout the execution. Table 9 summarizes this behavior and allows us to identify two main patterns.

Table 9 – Consolidation of budget deviations by cost category

Category	Overrun by 100% completion	Already over budget at 25%?	Projects with overruns	Observed pattern
MH	5 of 6	3 of 6	A, B, D, E, F	Structural: undersized since the original proposal
Time	5 of 6	5 of 6	A, B, D, E, F	Structural: identical ratio in the 3 milestones (formalized via amendment)
Financial Expenses	6 of 6	does not apply	A, B, C, D, E, F	Total absence of the item in the original budget
Scholarships	4 of 6	2 of 6	A, B, D, F	Mixed: peaks at the beginning, convergence at the end
Materials	2 of 6	1 of 6	C, D	Reactive: appears throughout execution
Services	2 of 6	1 of 6	C, E	Reactive: appears throughout execution
Travel	2 of 6	2 of 6	E, F	Volatile: small and sensitive budget base
Operational Support	2 of 6	1 of 6	A, B	Reactive: appears throughout execution

Source: Prepared by the authors (2026)

The first pattern identified were the structural deviations that already appeared in the initial stages of execution and originate from the sizing of the proposal. Furthermore, these deviations tend to grow on their own, because longer deadlines end up requiring more months of work from the team. This is the case of MH and Time, categories that exceeded their budgets in five of the six projects.

The second pattern was reactive deviation, which emerged throughout the project in response to execution occurrences. Characterized in the Material, Services and Operational Support categories, which showed overrun in only two of the six projects each, with predominantly late manifestation. The affected projects are not repeated among the three categories, which reinforces the reading of specific occurrences associated with the particularities of each execution, compatible with the reallocation of resources by the team.

Two categories do not fit either type. Scholarship costs exceeded the budget in four projects, two of them as early as the first milestone, with initial peaks and convergence toward

completion, while expenditure in the remaining projects stayed below budget. The absence of a common trajectory indicates a mixed pattern. Travel, in turn, showed large variations because its budget base was small: Project F spent R$46,979.38 against R$5,200.00 budgeted, whereas Project A spent just over half its budgeted amount.

The Financial Expenses category, as discussed previously, did not result from a sizing error or execution events, but from the absence of the item in the original budget.

When comparing MH and Time, a relevant relationship between the two categories was revealed. Project C was the only one completed without a deadline extension and the only one with MH execution below budget. The other five presented an extended deadline and higher MH execution than expected. The association consists of the nature of the costs involved, after all, MH is an expense that depends on the duration of the project. Thus creating a cascade effect between the extension of deadlines and personnel costs, in which the deviation from one category feeds into that of the other. It should be noted that the association does not establish a causal relationship. There was no technical justification for each extension, which prevents it from being determined whether the extension of the deadline generated additional consumption of hours or whether both resulted from a common prior cause. What the data allows us to state is that the two conditions occurred together and their absence was also joint.

5. Final considerations

The results indicated that the budget deviation is not uniform in nature across cost categories. Man-Hour and Time present structural deviation, with deviation identified at the beginning of execution and associated with the sizing carried out in the proposal phase. In the five projects extended, the extension of the deadline occurred together with the increase in Man-Hour, indicating a cascading effect. Service, material and operational support presented reactive and punctual deviations. Financial expenses indicate a limitation of the budget instrument itself and not an estimation error. Based on the identified standards, it is recommended to prepare future budgets:

• Separate a specific safety margin for working hours, taking

• as a reference the deviation observed in the analyzed projects (around 19%), instead of applying a generic percentage to the total budget;

• Ensure that any extension of time in the contract is accompanied

• by a mandatory review of the working hours budget, so that the extension of deadlines is not treated in isolation, without considering the impact this has on the team's costs;

• Monitor project execution through intermediate milestones, following a

• model similar to EVM (Earned Value Management), from the beginning. Thus, deviations can be identified in the initial stages, and not just at the end.

As a limitation, the sample brings together six projects from a single organization, selected according to exclusion criteria, value range and funding modality, preventing generalizations. Even so, the results can guide the budget preparation of organizations that carry out RD&I projects with a similar cost structure.

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