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THE FUTURE OF THE APPLIED RESEARCH ENVIRONMENT IN BRAZIL: A FORESIGHT ANALYSIS

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ABSTRACT

This Paper aims to identify, describe and analyze possible future scenarios for the applied research environment in Brazil using Foresight Management methods. It also seeks to identify the main factors influencing this environment and to explore the evolution of these factors to outline strategies for action in each of these scenarios. For this analysis, we used the Scenario Thinking Technique, which consists of detecting influential uncertainty factors and using them to create and compare possible future scenarios. Through the analysis of the research environment in Brazil, we identified two megatrends with a high degree of impact and uncertainty: state participation in R&D and companies' interest in R&D. The combination of the possible variations of these megatrends allowed us to draw four scenarios for the future, which were named "Spoiled Baby", "Supernova", "Cash Cow" and "Pineapple". The knowledge and analysis of these possible scenarios will allow better preparation for the challenges that the future will bring to this environment.

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INTRODUCTION

At this moment in the history timeline (characterized by volatility, ambiguity and uncertainty), technological, social and cultural changes occur with much more speed and intensity than at any other time. In this sense, people, companies and governments need to modify behaviors to adapt to this new reality. It is necessary to look to the future in a critical and structured way, considering various possibilities and a large amount of information. On the other hand, traditional planning tools are not able to adequately meet these new needs. It is in this context that we saw the emergence of Foresight Management, a new area of knowledge, which aims to detect and understand future trends. Foresight can be defined as "the ability to cope with the future and to make sense of it" (Rohrbeck, 2010). Foresight understands the future as an emerging entity that's only partially visible in the present, not a predetermined destiny that can be fully known in advance (OECD, 2021). The objective is not to 'get the future right', but to expand and reframe the range of plausible developments that need to be taken into consideration. Von der Gracht *et al* (2010) report that, mainly due to the ease of access to information and knowledge, the economy has been moving rapidly from an industry-driven economy to a knowledge-based economy.

In this new reality, even public institutions, which belonged to a traditionally stable and predictable environment, need to learn to live with the complexity and uncertainty about the future. A combination of well-developed corporate foresight and innovation management is a key success factor in the knowledge economy (Von der Gracht *et al.*, 2010).

Conceptualization of Research and Applied Research: In a general way, Research can be defined as "a detailed study of a subject, especially in order to discover new information or reach a new understanding" (Cambridge, 2021). According to OECD Frascati Manual (2015), Research is "creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge". Baimyrzaeva (2018), in turn, conceptualizes research in a complementary way, as being "the process of gathering and investigating information about a subject, in order to understand it". Research is an essential activity for the construction of human knowledge, and consequently for the development of society. (Baimyrzaeva, 2018). For an activity to be classified as a Research and Development (R&D) activity, five core criteria have to be jointly satisfied (OECD, 2015). These criteria are:

- To be aimed at new findings (novel);
- To be based on original, not obvious, concepts and hypotheses (creative);
- To be uncertain about the final outcome (uncertain);
- To be planned and budgeted (systematic);
- To lead to results that could be possibly reproduced (transferable and/or reproducible).

According to UNESCO data, global spending on Research and Development amounted to nearly US\$ 2.23 trillion in 2018. An important division among the types of research is according to its nature. Which this criterion, research is divided into Basic Research (or foundational/academic research) and Applied Research. Still according to OECD Frascati Manual (2015), Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. Applied research, on the other hand, is an original investigation undertaken in order to acquire new knowledge, directed primarily towards a specific, practical aim or objective. Basic Research has as purpose to uncover universal laws that explain the nature of things or how they work or relate to each other and various kinds of consequences.

further claim that the excellence of Brazilian research is concentrated in fields that receive sectoral investments, with great emphasis on Clinical medicine, Agriculture, and Physics and Space Science. The capacity to generate science, technology and innovation of a country or region cannot be seen as an isolated phenomenon. Cassiolato&Lastres (2017) state that such capacity is, in fact, the result of relations between economic, political and social actors, and therefore, reflects its own cultural and historical conditions. In this sense, Cassiolato & Lastres (2017) also report that it is only since the beginning of the 21st century that the theme acquired unanimity and has gained a central role in the country's productive and industrial development policy. In this period, the Brazilian government begins a process of significant expansion of public investments for the consolidation of the national system of science and technology, articulating the strategy with other federal policies (especially industrial policy). One of the main practical initiatives implemented by the government in this process was the expansion of teaching and research institutions. This expansion occurred through the creation of public universities in regions far from the major economic centers (18 new public universities were created in regions of the country where such institutions did not exist until then); and through the significant expansion of federal technical schools, such as IFMA and the other IFs (more than 280 federal institutes of education, science and

Table 1. Gross Domestic Expenditure in R&D (as a percentage of GDP)

#	Country	Time					
		2013	2014	2015	2016	2017	2018
1st	Israel	4,10	4,17	4,27	4,51	4,82	4,94
2nd	Republicof Korea	3,95	4,08	3,98	3,99	4,29	4,53
3th	Sweden	3,26	3,10	3,22	3,25	3,36	3,31
4th	Japan	3,31	3,40	3,28	3,16	3,21	3,28
5th	Austria	2,95	3,08	3,05	3,12	3,05	3,17
6th	Germany	2,84	2,88	2,93	2,94	3,07	3,13
7th	Denmark	2,97	2,91	3,05	3,09	3,05	3,03
8th	United States of America	2,71	2,72	2,72	2,76	2,82	2,83
9th	Belgium	2,33	2,37	2,43	2,52	2,66	2,77
10th	Finland	3,27	3,15	2,87	2,72	2,73	2,76
(...)							
29th	Brazil	1,20	1,27	1,34	1,26	1,09	1,16

Source: own illustration with UNESCO Institute for Statistics data.

Typically, this type of research begins based on the researcher's own knowledge, research skills, and interest. Funding is available from the government, universities, and private foundations in the form of research grants, and has usually longer timeframes. Applied research is designed and conducted to answer practical questions to address real-world problems and the needs of a particular client. This client initiates research based on the need for information, in response to a specific situation, problem, or opportunity. The client is primarily responsible for funding the research, usually much smaller than necessary for full research, and has significantly shorter deadlines than researchers would ideally need. Basic research and applied research are also complementary. While basic research generates universal knowledge, applied research usually applies this knowledge to solve specific problems. Research has always been an essential activity for the social and economic development of humanity, and its importance has grown substantially as the world becomes increasingly uncertain, complex and ambiguous. "R&D is increasingly viewed as an input to innovation in the context of the overall efforts made in a knowledge-based global economy, but continues to play a crucial part and is a major focus of government policies because of its unique features." (OECD, 2015).

Research and applied research in Brazil: Currently, Brazil is the 13th in the world in terms of the number of peer-reviewed papers, having produced 250,680 papers between 2011 and 2016. The majority of these papers result R&D conducted at publicly funded universities. The global leader (USA) produced over 2,500,000 papers in the same period. (CROSS et.al, 2018). concerning citation impact (The number of citations a paper receives), Brazil has historically been below the world average. However, Brazil's impact has increased from 2011 to 2016 a rise of 18%. Cross et.al (2018)

technology were created across the country). However, despite such initiatives, it is noticeable that Brazilian investment in R&D is still below what is desirable. To illustrate this perception, we will use the UNESCO Institute for Statistics data on Gross Domestic expenditure on R&D (GERD). According to OECD (2015), GERD is total intramural expenditure on R&D performed in the national territory during a specific reference period. Besides, according to OECD (2015), GERD is the primary indicator for international comparisons of R&D activity. In the table below, we present the GERD data, expressed as a percentage of Gross Domestic Product (GDP), from the countries that occupy the top ten places in this statistic in 2018, compared to Brazil:

With annual spending of US\$ 36,315 billion (equivalent to just 1.16% of your GDP) in R&D, Brazil ranks 29th in a list with 82 countries with 2018 data. The global leader, Israel, invests a percentage four times higher of your GDP in R&D, compared to Brazil. It is possible, then, to conclude that Brazil is a country that does not invest sufficiently in research, innovation, and development. This low investment in R&D is a historical trend, which brings us, as the main consequence, a lack of competitiveness. According to Coutinho (2017), Brazil presents "mediocre competitive performance and commercial fragility in all segments with high added value and high technological content." Companies may prefer to gain rents by avoiding competition through legal protection rather than by gaining a competitive edge through innovations (OECD, 2020). In fact, Brazil only ranks 71st in The Global Competitiveness Index, which measures parameters from 141 countries. Some of the parameters in which the country presents the worst results, and therefore most contribute to the bad position in the Index, are Innovation capability (40th position), ICT adoption (67th position), Infrastructure (78th position), and Product market (124th position).

In the upcoming future, this trend of a scarcity of resources for R&D in Brazil shows no signs that it could be reversed. The country goes through successive periods of economic stagnation, and the amount of resources from the public budget allocated to research decreases each year. Brazilian research institutions need to increase the effectiveness of their work, which includes optimizing methods and processes, in addition to diversifying funding sources.

Foresight Analysis: The scenario technique: The analysis of the framework of research and applied research in Brazil allows us to identify an important trend: decrease in resources for research funding. This is a vital issue since the absence or insufficiency of financial resources can make it unfeasible or even interrupt the carrying out of research activities. For adequate monitoring of this threat, a necessary question is: is this a passing or lasting trend? In addition, other trends may emerge that are also worthy of monitoring. This gives rise to other important questions, such as: What other factors are likely to influence this environment in the near future? How might these factors behave? What are the impacts and consequences arising from the varied behaviors of these factors?

The relevance of these questions demonstrates the degree of uncertainty contained in this environment. At the same time, it highlights the need to look to the future in a critical and structured way, considering various possibilities and a large amount of information. This is what we intend to accomplish with the Foresight Analysis performed here with the Scenario Technique.

As a disadvantage, high insecurity with individual assumptions. The Foresight analysis that we will carry out in this chapter will follow the 2x2 Matrix Method, a six-step scenario planning method proposed by Chermack (2011):

- Identify the driving forces affecting the futures;
- Cluster the driving forces in groups of driving forces with mutual impact;
- Determine the extreme behaviors of clusters, called factors;
- Rank these factors on impact and uncertainty;
- Locate two factors on a 2x2 matrix, creating four corresponding scenarios;
- Create scenario narratives based on the constraints of the produced matrix.

Foresight Analysis: Detecting influential uncertainty factors: The first task of the scenario technique is to scan the environment in order to detect a wide variety of uncertainty factors, possessing the potential to have a significant impact on this environment in future scenarios. The correct naming and analysis of these factors is fundamental for the development of adequate future scenarios, allowing launching reliable forecasts in the future. After the detecting of uncertainty factors, the second step consists on to cluster the factors in groups of driving forces, with a high mutual impact on each other. These groups should be arranged in such a way that it is possible to describe their behavior going up or down towards two extremes (which corresponds to the third step).

Table 2. Influential uncertainty factors in Brazilian research environment

influential uncertainty factors	Groups of driving forces
Creating competitive advantage Adoption of Information and Communications Technology Qualification of the structure for research	Technological Development
Political orientation and positioning Role of the State in Research & Innovation Educational situation	State participation
Business mortality Demand for more quality in products and services Capacity building of the workforce	Companies Interest
Access to information Cultural changes Climate and environmental change Influence of religious groups and leaders	Interest of the Society
Open Foreign Trade Environment Closed Foreign Trade Environment Degree of macroeconomic stability	Economic conjuncture

Source: own elaboration.

The Scenario Technique (also called Scenario Thinking or Scenario-based Planning) is one of the most important Foresight Management methods. It can be conceptualized as a structured process of thinking about and anticipating the unknown future, without pretense of being able to predict the future or being able to influence the environment in a major way. Instead, it navigates through the uncertainties and large-scale driving forces that are impacting on the future (van der Heijden, 2005). The objective is to examine possible future developments that could impact on individuals, organizations or societies, in order to find directions for decisions that would be most beneficial no matter how the future unfolds. The philosophy is to proactively think and plan for future developments instead of being a passive victim of change. (scenariothinking.org, 2006). The analysis of alternative scenarios of future is important to help planning and decision-making by describing future conditions in which an organization may have to operate. They also can help to break out of the idea that the future will be a continuation of the past and help identify critical decisions that must be made for an organization, company, or a technology system (van der Heijden, 2005). Scenarios have been used for different governments or companies, in areas such as formulating strategy, policy development, conflict resolution, group learning, and rehearsing management decisions. According to Nagel & Faix (2013), this method has as main advantage to become apparent the trendsetting perspectives, allowing to wrong planning can be identified.

Through environmental observation and literature review, it was possible to identify and select the main uncertainty factors that will impact the environment of applied research in Brazil in the future. The table 2 below presents these factors, divided into the respective groups of driving forces.

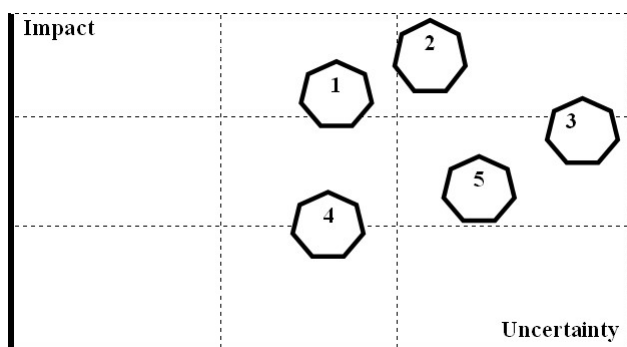
Below, we will list and discuss such groups of driving forces, in order to understand how they could behave and how they would impact the R&D environment:

- 1) Technological development – It is a high impact factor on the research environment. As new technologies are adopted in conducting research, the quality of their development and results achieved also increases. These results are applied and lead to a better qualification in the structure for the research environment, generating a virtuous circle of creating competitive advantages and adding value to the environment as a whole.
- 2) State participation in R&D – according to the political and economic position that the country adopts, the government can assume different roles concerning research. A fosterer's role demonstrates a more proactive stance, where the state assumes the condition of the main investor and financier of R&D activities. Meanwhile, a regulator's role corresponds to a more reactive stance. It would be essential for the future of the R&D environment to have a clear definition of which role

is intended to be adopted. However, this depends significantly on political orientation and positioning. The option for a more conservative political direction, as an example, may lead the government to favor research with a certain ideological bias, leaving scientific objectivity in the background. This would mainly impact educational institutions, which are also the main research centers in the country. The increase in investments in Education also benefits research, while its decrease also reduces the field of research.

- 3) Companies' interest in R&D – is also a factor with a high impact on the R&D environment. Companies are one of the stakeholder groups with the greatest interest in scientific and technological development, in order to improve the quality of their products and services, and thus maximize their profit possibilities. In the Brazilian business market, however, there is a lack of interest in research & innovation, one of the main reasons for a high rate of business mortality. As access to information becomes more and more popular, consumers tend to become more demanding about the quality of products and services. This movement may have, as one of its consequences, an increase in the demand for innovation.
- 4) Interest of the society – the Brazilian people are marked by cultural traits averse to innovation, such as pragmatism, conservatism and religiosity. As an example, we observed recently religious leaders occupying prominent positions in the government and forming a bench in the national congress. Some fundamentalist religious interests' conflict with scientific interests, when their beliefs and doctrines are contrary to science. In this sense, a profound cultural change would be needed to increase society's interest in R&D. Cultural change would be beneficial to arouse appreciation for development, and to put pressure on the government and companies for innovation. However, they do not happen quickly.
- 5) Economic conjuncture – the degree to which the economic environment is open or closed to foreign trade is an important influencing factor. An economic environment open to free trade can be a great stimulant to R&D development. Initially, there may be some negative effects, due to market exposure to foreign products, with higher quality and more competitive prices than local products. However, if accompanied by incentives for R&D, they can start a process of continuous improvement of local companies. By contrast, Economic Protectionism gives the false impression of being beneficial to a country, as it proposes to avoid the entry of foreign competitors (with higher quality products and more competitive prices) in the local market. However, customers in this market are harmed, as they do not have access to qualified products. In the long run, the absence of qualified competition can lead to stagnation in this market, making efforts in R&D unnecessary.

The next step is to rank these groups of driving forces according to two measures: impact and uncertainty. According to these criteria, Technological development (group 1) was ranked as high impact and medium uncertainty. State participation (group 2) was ranked as high impact and high uncertainty.



Source: own illustration.

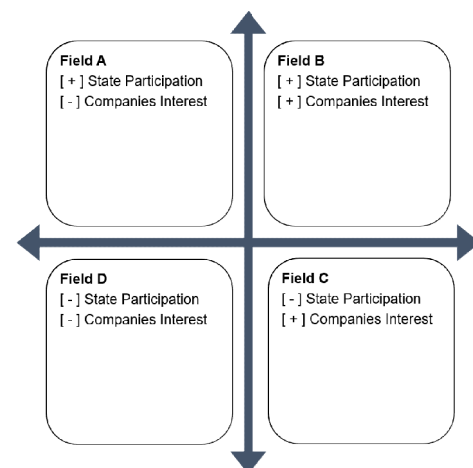
Figure 1. Impact and Uncertainty of driving forces

Companies interest (group 3) was ranked as high impact and high uncertainty. Interest of the society (group 4) was ranked as medium impact and medium uncertainty. And Economic conjuncture (group 5) was ranked as medium impact and high uncertainty. We can better visualize the result of this assessment in the Figure above:

We can perceive that State participation (group 2) and Companies interest (group 3) are the two most impactful and uncertain groups of driving forces. Therefore, these will be used for the construction of the scenarios, which will be carried out in the following subtitle.

Foresight Analysis: Thinking and Elaborating Scenarios: For the generation of the scenarios, the two most impactful groups of driving forces (chosen on the previous subtitle) are arranged on a vertical axis and a horizontal axis crossed, forming a 2x2 matrix. In our case, State Participation will be on the vertical axis, and Companies Interest will be on the horizontal axis. The intersection of these two axes generates four fields, which correspond to the four scenarios of different performances of the groups of driving forces. Thus, field A corresponds to a scenario with higher State Participation and lower Companies Interest; field B corresponds to a scenario with higher State Participation and higher Companies Interest; field C corresponds to a scenario with lower State Participation and higher Companies Interest; field D corresponds to a scenario with lower State Participation and lower Companies Interest.

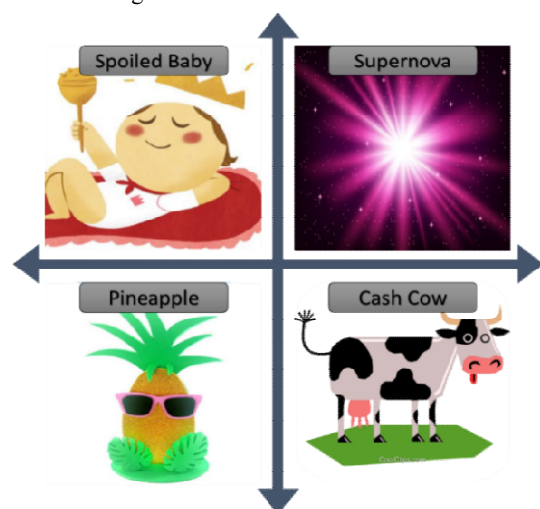
The figure below illustrates the construction of these scenarios:



Source: own illustration.

Figure 2. Scenarios' Construction

The next step is to "bring the scenarios to life", which we do initially by naming and illustrating them with neutrality and Scenario D, "Pineapple". The result of the naming and illustration of the scenarios can be seen in the figure below:



Source: own illustration.

Figure 3. Future scenarios for Research in Brazil

Foresight analysis: Describing and analyzing scenarios: The last step of our Foresight Analysis is the description of the scenarios created in the subtitle above, through scenario narratives created using elements of the external environment, called here story dimensions. For each scenario, we will describe six story dimensions, namely: the World, the People, the Economy, the Government, the Companies and the Customers. We show the results of this in-depth analysis in the following topics:

Scenario A – “Spoiled Baby”

In this scenario, research is treated by the government as a key sector for the country's development, with constant investments (vertical axis). However, with the domestic market marked by strong protectionist clauses, and local companies earning well because of the improved economy, the market does not share the same enthusiasm for investing in research & development (horizontal axis). The research is then restricted to sectors chosen by the government. These sectors receive all the resources and attention; however, without the counterpart of the market, they end up not reaching the expected development (like a spoiled baby!)

products (horizontal axis). With the efforts of both, Brazilian Applied Research has become the main driver of the country's development, ready to bring it to the brightest points on the world stage (as a supernova!)

Scenario C – “Cash Cow”

In this scenario, the economy is still stagnant, which is why the government is not yet able to invest adequately in research & development (vertical axis). However, with the opening of the economy to free trade, Brazilian companies were “forced” to modernize, if they wanted to survive competitively. As a result of long and constant investments in research & innovation, Brazilian companies and their products have achieved a prominent worldwide position, bringing them excellent and constant good results. Like a cash cow!

Scenario D – “Pineapple”

In this scenario, applied research completely loses its importance for the country.

Table 3. Story dimensions of the “Spoiled Baby” scenario

The World...	... is divided into large geopolitical blocks in the leadership of the great powers. Nationalism is prominent, despite movements for globalization. In trade relations, protectionism and free trade share opinions, with an advantage for protectionism;
The People...	... prevails with a paternalistic culture. They live in a society that is still very dependent on government actions;
The Economy...	... is growing. GDP expands and the country can increase investment rates in research & innovation. Despite market optimism and confidence, investors are still wary;
The Government...	... maintains a guarantee posture. Research resources increase in sectors chosen by the government, or considered strategic for the country;
The Companies...	... benefit from the heated economy and the absence of competition to close the domestic market. They achieve good profit rates without the need to invest in innovation. Little interest in applied research;
The Customers...	... are undemanding in relation to product quality, but are satisfied with the increase in purchasing power;

Source: own illustration.

Table 4. Story dimensions of the “Supernova” scenario

The World...	... is totally globalized, interconnected and technological. Trade barriers have been almost eliminated, and Free trade is prevalent in trade relations;
The People...	... have radically changed the mentality in the country, and are now oriented towards the future, value knowledge and innovation and always wish to evolve as individuals and in society;
The Economy...	... is becoming one of the strongest in the world! Thanks to a radical change in mentality, the country has been experiencing years of sustainable GDP growth, with largely favorable trading conditions;
The Government...	... adopted a posture in support of innovation and sustainable development. With the continued increase in resources for education and research, the quantity and quality of research has increased significantly;
The Companies...	... strongly value research & innovation, thanks to strong competition and the need for innovation. The markets are marked by high diversification, verticalization and added value. With this stance and government support, many of them are a worldwide highlight in their area of operation;
The Customers...	... do not give up high quality and fair price on the products they consume. With the opening of international trade, they have bigger and better options. Environmentally responsible, they are concerned with the outcome of their choices.

Source: own illustration.

Table 5. Story dimensions of the “Cash Cow” scenario

The World...	... witnesses increasingly fierce power disputes between the great powers. In trade relations, protectionism and free trade share opinions, with a slight advantage for free trade;
The People...	... developed a practical, independent and results-oriented mentality. There are many defenders of the minimal state and economic liberalism
The Economy...	... is slowly recovering. The market shows confidence in the country's growth capacity, but despite this, GDP growth rates are still not ideal. The country invests in research & innovation, but still less than desirable;
The Government...	... had to adapt to a scenario of scarcity of resources. He adopted a more regulatory stance, instead of being an executor. The number of public-private partnerships has increased considerably. The promotion of research & innovation was restricted to a few strategic sectors;
The Companies...	... has a high interest in research & innovation, thanks to an open market for competition. The need for innovation has increased the quality and competitiveness of the country's products, which are now also able to compete in international markets. Relative investment diversification;
The Customers...	... are much more demanding, because contact with products from other markets, with higher quality and more competitive price, raised their level of demand. They compare national and imported products, and only consume national products that reach the expected quality level.

Source: own illustration.

Scenario B – “Supernova”

In this scenario, the slight improvement in the economic situation, coupled with a radical change in mentality, caused the government to invest more and more in research & development (vertical axis). With an open and competitive market, companies also follow this movement, seeking more quality and competitiveness in their

Still experiencing an economic recession, the government is unable to increase the promotion of research, so resources have been reduced year after year, reaching rates similar to those of the last century (vertical axis). One of the measures taken was to increase the protectionism of the economy, preventing more competitive foreign products from taking over the market.

Table 5. Story dimensions of the “Pineapple” scenario

The World...	... has become extremely nationalist and politically polarized. Protectionism is prevalent in trade relations;
The People...	... value pragmatism. There is a strong religious and conservative influence on customs. Wide use of fake news and post-truths;
The Economy...	... is in a state of stagnation. GDP growth rates close to zero bring instability and uncertainty to the scenario. The country is unable to invest in research & innovation;
The Government...	... disseminated conservatism as a strategy. With the reduction of resources for research, only research with an ideological bias is encouraged;
The Companies...	... do not show interest in research & innovation. Without external competitors, there is no need for innovation and quality improvement. Only the traditional economic sectors stand out;
The Customers...	... practically gave up looking for better options for their needs for consumption desires. They are resigned to the quality and price of the products available.

Source: own illustration.

Local companies, seeing that they had a guaranteed market, saw no need to invest in research & innovation (horizontal axis). Research, then, ended up becoming an extremely difficult activity to be carried out in the country, without government or market support (like a pineapple!)

CONCLUSION

The “Spoiled Baby” scenario would enable the consolidation of the country's public research institutions. The improved economic situation could generate many opportunities, provided that the public authorities understand the importance of investing in R&D. However, the insufficient investment offered by the private sector would make it difficult to carry out applied research, which would hinder the achievement of objectives. The “Supernova” scenario would put the country's public research institutions in a prominent position, achieving excellence and fulfilling the objective of inducing sustainable development. The active participation of the private sector, combined with government investment, has the power to bring with it many excellent opportunities for research and innovation. The “Cash Cow” scenario would bring challenging changes for the country's public research institutions. If the country's economic situation does not show consistent improvements immediately, an expected consequence will be a gradual decrease in resources for research and development. So, if research entities want to move forward, they will be “forced” to seek other sources of funds, such as private companies. They would also be “forced” to get closer to the productive sectors of the communities where they operate, which is a desirable goal but has not yet become a reality. The “Pineapple” scenario would bring to the country's public research institutions the challenge of surviving in very adverse conditions. The decrease in investments in research & innovation, whether public or private, can have negative consequences for the economy and society, therefore, the knowledge of the challenges that this scenario can bring is essential.

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