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Prospective Scenario Analysis: An Approach Using System Dynamics

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RESUMO
Uncertainties are inevitable and need to be accepted as part of business life. However, to deal with them, it is necessary to improve the planning arsenal for strategic decision making. Thus, from the examination of the characteristics of scenario analysis techniques and system dynamics, an opportunity was perceived for combining these, in order to pave a path that was not predominantly qualitative, as with scenario analysis, nor as complex and quantitative as systems dynamics appears to be. This work aimed to produce a methodology of combination between these techniques, based on an in-depth theoretical review. As a test field, a case study was conducted for an anesthesiology company, aiming to investigate the future of medical remuneration amid the numerous possibilities of political, economic, technological, social and competitive transformations. As a result, it was possible to obtain quantitative analyses that are not shown in this paper, but was the foundation to built interpretations and qualitative data in the decision making process. By using both quantitative and qualitative important qualitative aspects of scenario analysis wasn't abandoned, what improved the preparation of leaders for questioning and reviewing their mental models. It was concluded that the combined use of the two techniques amplifies the research horizons of the system under study and make possible the identification of relevant indicators for monitoring the scenarios.

Keywords: *Scenario analysis. Systems dynamics. Strategic Management. Planning - Uncertainty.*

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I. Introduction

The more dynamic the environment, the more unpredictable and uncertain it will be, making the task of creating strategies more arduous (D'AVENI; DAGNINO; SMITH, 2010). One of the methodologies developed to deal with uncertainties in decision making is scenario analysis, being an important tool to question the premises on which decision makers see the environment (CHERMACK, 2011).

Phadnis *et al.* (2014), when presenting the axiomatic foundations for the development of scenarios, warns about the lack of a systematic approach to its development, and indicates the existence of 23 different techniques of scenario analysis. In addition, it points out that there are inconsistencies in the terms used interchangeably even among the seminal authors of the theme. Chermack (2011) confirms the statements of Phadnis et al. (2014) by stating that there are no texts that provide an explanation of the theoretical structure of how scenario analysis works. At the same time, Chermack (2011) demonstrates the evolution and prominence that this technique gained in the works of Pierre Wack, Peter Schwartz, Kees van der Heijden, Godet, Porter, among others, as well as in the corporate world from the 1990s.

Berger (2004) asserts that the prospective attitude is an intuitive human act, that is, it is inseparable to planning, thinking, both in the past and in the future. However, the trap of prospecting lies in the inclination to the present as a reference for the future, that is, to make future predictions based on the present (CHERMACK, 2011). In this sense, there seems to be unanimity between Chermack (2011); Phadnis *et al.* (2014); Berger (2004); Kelly, Sirr and Ratcliffe (2004); and Schwartz (1995); that scenario analysis is not about predicting the future, but of imagining it. Thus, Porter (1985) defined scenario analysis as: "A consistent view of how the future can unfold – not a prediction, but a possible future."

To accomplish this goal, it is necessary to form a shared understanding by the engagement of multiple stakeholders in what Van der Heidjen (2005) calls strategic conversation. This conversation, also present both in scenario analysis and in system dynamics, facilitates the process of information transfer and helps in the construction of new mental models. Similarly, Featherston and Doolan (2013) claim that system dynamics is not a prediction methodology, but an approach to exploring the current structure of a system and the reasons for its behavior. Complementing this idea, Sterman (2000) states that the dynamics of systems arises from the need for tools to simulate complex systems in the presence of uncertainties.

Therefore, system dynamics and scenario analysis seem to fulfill an equal purpose, as Schwartz (1991) assures us that scenario analysis is the world's most powerful vehicle to challenge mental models, as it enables the combination of complex factors that affect decision making. Cavana (2010); Featherston and Doolan (2013); Nakajima; Yasui and Ohkami (2012) also reaffirm the complementarity between these two techniques in the production of more robust scenarios.

Looking to these issues, this article seeks to present a methodological framework for the application of scenario analysis with the use of system dynamics in such a way that its application is possible in the real business world avoiding oversimplification, the idea of prediction and the lack of further studies on the behaviors of variables at stake. To achieve this objective, research was carried out together with an anesthesiology company interested in tracing future strategies. The results of the research are presented, as well as the methodology resulting from this study.

II. Theoretical Background

Heijden et al. (2002) propose that most organizations manifest deficit in the capacity of scenario analysis, resulting in companies constantly caught by surprise by the environment, without preparing resources and capabilities to be able to strengthen their position. Take, for example, the effect of the COVID-19 pandemic on global production chains, especially on the semiconductor industry which was unable to imagine the increase in the global demand provoked by people working remotedly from home.

In this sense, the dynamics of systems can bring great contributions to the analysis of scenarios, since from their use it is possible to identify causal relationships, identify critical forces that act on the system and nonlinearities. Moreover, as White (2011) recommends: "the predictive power of models characterized by strong human intervention is lower than those of engineering systems models". However, they can still be considered great sources of insight due to the understanding of relationships it entails. Thus, several authors have contributed to the realization of systems dynamics with the analysis of scenarios such as: Dolado (1992); Cavana and Manni (2000); Homer and Oliva (2001); Luna-Reyes and Andersen (2003); Cavana and Clifford (2006); Warren (2004, 2005); Burt (2007); Cavana (2010); Nakajima, Yasui and Ohkami (2012); Bala, Arshad and Noh (2017).

Once that the critical objective of scenario analysis is the revelation of mental premises and models, individuals when confronting the scenarios reinterpret and reconstruct the meaning, or more precisely, review its premises. This is in line with Chermack (2011); Senge (2002); Schwartz (1991); van der Heijden (2005); Bradifield et al. (2005) and Kahane (2012); applications highlighted by each of these authors in Chart 1.

Chart 1 – Scenario anlysis applications

Author	***Utility of Scenario Analysis***
Dorner, 1996	Scenarios have utility in reducing the bounded rationality of humans. Research shows that scenarios are effective because they are highly memorable and narrative in nature.
Weick (1979, 1985, 1990)	Mental models guide, provide the basis on which individuals interpret and understand organizational life.
Senge (1990)	Scenario analysis holds connections and contributes to systemic thinking.
Schwartz (1991)	Scenarios influence the company's decision making and implementation process, even more so when the names given to them are vivid and memorable.
Van der Heijden (2005)	Scenario planning begins with mapping the organization as a system. The systems view, incorporates consideration of internal and external variables and focuses on how these variables interact with the system.
BRADFIELD et al., 2005	Scenario analysis can reduce the cost of information. The creation of shared mental models facilitates the information transfer process and thereby reduces the cost of information transfer.

Source: Prepared by the author, 2021.

VAN DER HEIJDEN (2000) argues that planning using scenario analysis creates a conversation between the internal organizational system and the external environment. Thus, organizational learning must be able to achieve perceptions of changes in the external environment as if these two systems were interdependent. For Schoemaker (1993) scenario analysis is based mainly on the narrative approach, uncertainty permeating models and complex futures decomposed into discrete states. These fundamentals would generate psychological benefits of counteracting potential biases. Biases, according to Sterman (2000), affect mental models, generating distortions and incorrect judgments.

However, scenario building, using system dynamics or otherwise requires the participation of key organizational actors linked to the issue (GOOYERT; ROUWETTE; VAN KRANENBURG, 2013). Therefore, Beall and Ford (2010) state that participatory environmental modeling using system dynamics is an effective

process for facilitating the integration of ecosystem science and social concerns as it facilitates model building by the art of facilitation, creating a common language that integrates various types of information into simulation models.

If on the one hand system dynamics requires mathematical and computational experts for the elaboration of the simulations, the formulation of the systems, the discussion of causal relations and feedbacks can be elaborated by the group of stakeholders without major difficulties. In these cases, we should observe the recommendations of Luna-Reyes and Andersen (2003). Also, according to these authors, it is possible to use a series of qualitative assessments of the model, such as interviews, focus groups, Delphi studies, and participant observation. After all, according to Sterman (2000): "omitting structures or variables that are known to be important because data are not available is less scientific and accurate than using best judgment to estimate their values".

One can also ally the suggestions of Luna-Reyes and Andersen (2003) to Rangel's (2012) proposal, which uses qualitative analysis, but interpreting historical data, both in the assembly phase of the system, and in the future perception of its movements. However, in doing so, Burt's (2007) suggestions can be added to Rangel's (2012) model, seeking to identify potential nonlinearities and possibilities for disruption in the system, with evaluation using the qualitative techniques proposed by Luna-Reyes and Andersen (2003).

Every strategic assessment considers a set of internal and external variables and seeks to reconcile them (GRANT, 2010). Some external variables can be controlled, others can be influenced, others are totally beyond the organization's control. The variables that affect all companies in all industries are the political, economic, social, technological, and legal variables. Grant (2010) calls these variables PESTL. Porter (1985) on the other hand, exacerbates the variables closest to the firm related directly to its competition, its suppliers, customers, substitute products, and new entrants. Porter's (1985) model became known as Porter's 5 forces.

It is important for modeling that these variables are discussed with the work group, avoiding complexities at first. In addition to evaluating behaviors and imagining trends, the working group can separate the variables as: predictable and uncertain ones. This distinction is supported by Schwartz (1995) and Phadnis *et al*. (2014).

Finally, Cavana and Maani (2000), provide a methodological model for interventions using modeling and system dynamics. According to the authors, the macro stages of this methodology incorporate: i) problem structuring; ii) modeling of causal diagrams; iii) dynamic modeling; iv) modeling and scenario planning and; v) implementation and organizational learning.

In the problem structuring phase, one seeks to clearly state the issue to be worked on, its scope (study boundaries) and the stakeholders to be involved. At this stage the collection of information begins, whether historical, reports, previous studies and even interviews that relate to the issue under study.

In the causal diagram formulation stage, the knowledge base about the problem is established. This is done by: identifying key variables, the behavior over time of these variables, developing the causal diagram illustrating the relationship between the variables, discussing the behavior of the variables over time, identifying models that describe the cause-and-effect behaviors, identifying the leverage points of the system, and developing intervention strategies. After these steps Cavana and Maani (2000) suggest modeling, followed by data survey and consistency tests to verify results, and finally scenario planning, which consists of variations in the model and verification/analysis of results with the recording of a report for discussion.

III. Methodology

This research can be classified as applied, since it aims to generate knowledge for the practical application of scenario analysis and system dynamics. Furthermore, it uses a practical case study to address the proposal. As to the approach, it can be considered qualitative and quantitative since it seeks to interpret phenomena and attribute meaning to them but combines mathematical and modeling to create information which will also be interpreted and combined with the qualitative results.

For all these reasons, the methodology employed in this study is considered Flexible Design as defined by Robson (2011) and employing case study as prescribed by Yin (2009). That is, the model was developed by collecting and testing direct and indirect data, i.e., using all available strategies, such as: available documents, reports, interviews, direct observation, and other forms that enable the formation of the data set required for analysis of the models produced.

By means of a real case of strategic planning of a company in the medical field located in Belo Horizonte/MG, the future of medical compensation was investigated, more specifically, the compensation of anesthesiologists in Brazil. The answer to this question was essential in the context of determining the physicians' state of readiness for new paths, that is, for the decision making of new investments for the company. Thus, it was sought to identify the critical variables internal and external to the business. For these variables, data was collected, and their possible future behaviors were verified.

From then on, a model was built using system dynamics and the variables were classified according to Feartherston and Doolan (2013) in: internal, predictable and uncertainty. Then this model was validated by means of a survey questionnaire submitted to the company's board. For the internal and predictable variables, data was collected for modeling in system dynamics. These data were discussed with the physicians and specialists with the purpose of increasing learning about the system. In the discussion sessions, the loops and potential disruptions of the system and their effects were discussed. The scenarios were then presented to and discussed with the company's board, generating new knowledge regarding the concepts covered in the literature.

IV. Results And Discussions

Background of the study

The company that is the object of this study provides anesthesiology services and is linked to a large network of hospitals. Its growth currently depends on the growth of the hospital, and even though its revenues have increased in the last few years, the physicians' compensation remain stagnant with signs of decrease and threatened by environmental factors. Despite this, the company is part of an ecosystem with the following characteristics:

- 25,484 anesthesiologists according to CFM/CREMESP (2020);
- according to Silva (2020), a safe surgical procedure requires anesthetic procedure. In Brazil, there are about 12 million procedures per year (base: 2016). According to this source, the need for the anesthesiologist physician grew sharply between 2006 and 2016 and tends to grow further with the growth of employment and income;
- 286 billion annual market with growth of 7.5% y.y. and undergoing consolidation (EMIS INSIGHTS, 2020a, 2020b);
- demographic and epidemiological factors indicating increased demand on the one hand and supply bottlenecks on the other (BRAZIL, 2019; THE ECONOMIST INTELLIGENCE REPORT, 2021);
- as a middle-income country, Brazil has the potential to quadruple the number of surgeries per inhabitant (NOORDERMARKETING, 2019; PRYDZ and WADHWA, 2019; ANAHP, 2021);
- Only 28.5% of people in Brazil have health insurance. Of that total, 44.5% depend on their jobs to maintain their plans (SILVA, 2020);
- competitive factors are pressuring cost reduction (ANAPH, 2021).

Identification of variables

After forming the working group and discussing the objectives, a search was conducted for the environmental variables looking for that could most strongly affect the business, using the PESTL and Porter's 5 forces models, that is, referring to the macro and micro environment. As a result, 18 environmental factors were identified, and for each one the potential behavior was discussed. To fulfil this task, sources such as IBGE, Ministry of Health, EMIS, Euromonitor, Marketline, and other relevant sources were used, showing the current market profile and forecasts until 2025.

Discussion of the variables

a) Political-legal

Political-legal variables have the power to influence economic variables and interfere directly in the system, generating reactions of all kinds and can be favorable or unfavorable to growth in the number of people with health insurance plans or in the private health network. Therefore, they influence the market, investor confidence, and the country's economic growth itself. In this sense, the adoption of government policies can encourage, slow, or reduce GDP growth. GDP growth is vital for the growth of per capita income and investment, which, in turn, influence consumption, generating further growth. This part of the model, while impossible to predict, can be evaluated in terms of the possible directions and their impact on the model.

In relation to the legal limitations for the formation of large economic groups, it is understood that the industry will become increasingly consolidated. Therefore, with a greater tendency for M&A movements, isolating or making the small disappear. This impacts the capacity of the anesthesiology company to negotiate with the market and may jeopardize contract negotiations.

In relation to public-private partnerships (PPP) and social health organizations (OSS), the odds are on an increase in the frequency of management of public assets by private institutions, generating market growth for companies specialized in health management and opening a strategic option for the company.

b) Economic

In the economic sphere, the following variables were considered: interest rates, tax burden and new medical compensation models. Regarding interest rates, a gradual increase in the rate was considered. This would have the effect of increasing the cost of raising funds in the company, but without a highly detrimental effect, since it

would be the new rule for the entire market. The tax burden, on the other hand, could generate a high negative effect, since the remuneration of physicians is made in the form of profit distribution, which would be burdened by the taxation of dividends.

The new compensation models also encompass the lines of care. The group discussed the tendency of remuneration by the patient's clinical status and the remuneration by packages. The former would generate the need for the company to develop competencies to monitor the patient's clinical status, which will certainly generate an increase in costs. The package remuneration would negatively affect the prices charged. It is also worth mentioning that the formation of large groups reinforces the probability of the two pricing modalities demonstrated above.

c) Social

In relation to the social variables, it was considered relevant to portray the GDP/Economic Crises and the Health Operator Structure Change. For the GDP/Economic Crises, one can consider the "V" recovery profile and the after-effects: unemployment and hunger. This entails, at least in the short term, a smaller number of patients in the supplementary health network. This reduction was estimated by the team at five million lives. After all, according to data from Coelho (2021), only 28.5% of the Brazilian population has health insurance, and 45.4% of the people who have health insurance depend on their jobs to finance these plans.

In relation to the change in the structure of the operators, one can see a tendency to reduce surgical procedures in hospital units, in a movement of decentralization to day hospitals and specialized clinics. This could lead to a reduction in procedures and, consequently, a reduction in the company's revenues.

d) Technological

Technology would bring the greatest risks of disruption, causing as an immediate effect the reduction in the need for anesthesiologist professionals. Automated anesthesia is a necessity for large networks to reduce operational costs. With this, close loop systems to control the anesthetic act would generate efficiency gains for repetitive acts and complex analysis. The only barrier would be the investment in technology and training.

Another relevant point is technology as an enabler of growth and simplification of billing services, associated with disintermediation. This wave would cause the billing service provider to lose bargaining power with the carriers, reducing the supposed strategic benefit. With these trends, the company could take over the billing service by reducing its deductibles and adding commission revenue from individual physicians without major investment and cost requirements.

One should also note the uberization of anesthesiology services. Once an anesthesiologist application is created in a lower cost model and if this service can maintain its quality level, companies could migrate to this type of contracting, even reducing fiscal and labor risks. Another side of the applications would be the improvement in the operational management of the medical act. In this sense, the company that offers the monitoring of the medical act would come out ahead, even more if associated with the improvement of multidisciplinary assistance.

e) Customers

The mainstream related to customers would be technology for humanization and removing barriers from the whole process. Thus, customization and tracking of the customer journey could be an avenue for understanding, evaluating, and developing new products geared toward people's well-being.

f) Suppliers

Regarding suppliers, the variable post-pandemic world was verified. In this aspect, the exit of companies from China and the regionalization trends of services, could open space for the development of new partnerships. However, it was verified that this variable would generate low impact, since agreements and partnerships are already possible to execute. On the other hand, the possibility of variation in equipment costs remains on the radar.

g) Competitors

Since it is the second largest specialty and with a high degree of competition, it is not difficult to imagine the emergence of new anesthesiology companies with differentiated value proposals or with more competitive prices that could attract the attention of the large networks. The working group then saw a possible pressure for low prices associated with movements to increase quality. In both cases, there would be pressure on margins.

Thus, a strategic alternative would be to grow by subletting labor to serve other market niches. This increase in competitiveness among companies would lead to the end of the cooperative negotiation and remuneration model, generating greater pressure on medical fees for operators.

h) New Entrants

Among the M&A movements in the market, Hospital Orizonti/Rede D`or/Hapvida deserve attention. These two players apparently could reduce demand and accelerate new remuneration models.

i) Substitute products

Among the substitute products, nurse anesthetists and robotic anesthesiology call attention. The first one could reduce the number of anesthesiologists needed, at least for post-surgical assistance. The second, although less likely, would generate the need to implant a technological branch in the company, but certainly with reduced demand for professionals.

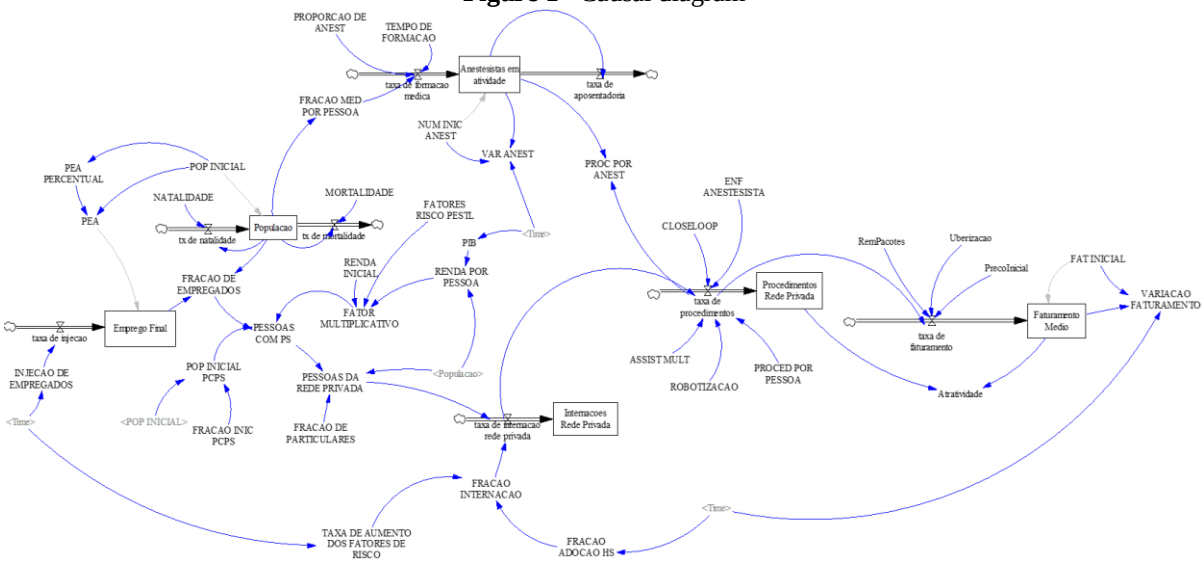
Causal loop design and results

Considering the discussions regarding external variables, one can identify several causal relationships with positive and negative effects on the business. One can also observe the direct impact of several variables on the price and on the demand, which would impact the company's revenues and, consequently, the physician's remuneration.

In the elaboration of the model, it was perceived, besides the items previously explained in the discussion of the variables, that: i) the population and its habits needed to be represented as a promoter of the demand for medical procedures; ii) a possible decrease in medical remuneration would affect the attractiveness of the sector, affecting the training of physicians.

The diagram was elaborated and discussed with the Strategic Work Group (SWG). Then, this group was informed that they would receive a research questionnaire that would seek not only to validate the relationships, but also to establish the current and future importance of these relationships. The causal loop diagram is shown in Figure 1.

Figure 1– Causal diagram



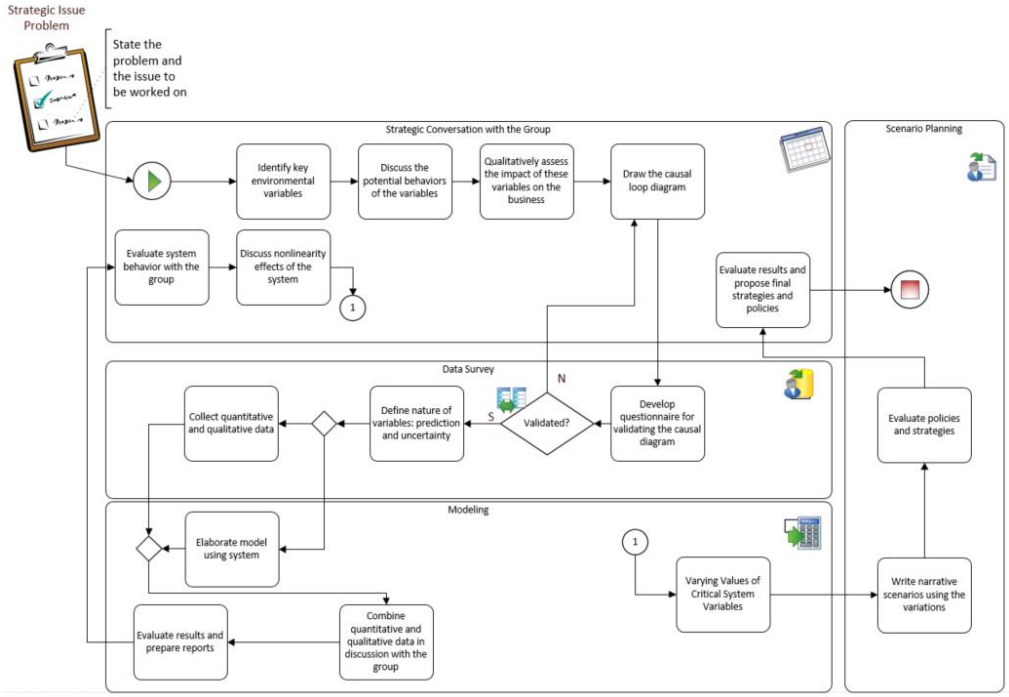
Source: Prepared by the author, 2021. (Portuguese)

After the causal diagram was drawn up, we moved on to data collection. Interviews and qualitative data were used to validate the causal diagram. Once validation was done, modeling was performed with new data surveys, equation adjustments, and model consistency checks. For the modeling, reports from several sources were used. Thus, the modeling was done in the Vensim software and quantitative data was produced, but they are not presented, since the interest of this article is to demonstrate the methodology for decision making. Thus, the data analyzed and interpreted by the work group according to the methodology proposed in Figure 2 were presented in the form of qualitative data in Figure 4.

The feedback effects of the system were also evaluated according to Figure 3. Thus, it was perceived that the repressed demand for procedures, the reduction of unemployment, and the growth of GDP are driving factors for the increase in the number of procedures. Initially, the anesthesiologist training rate follows its

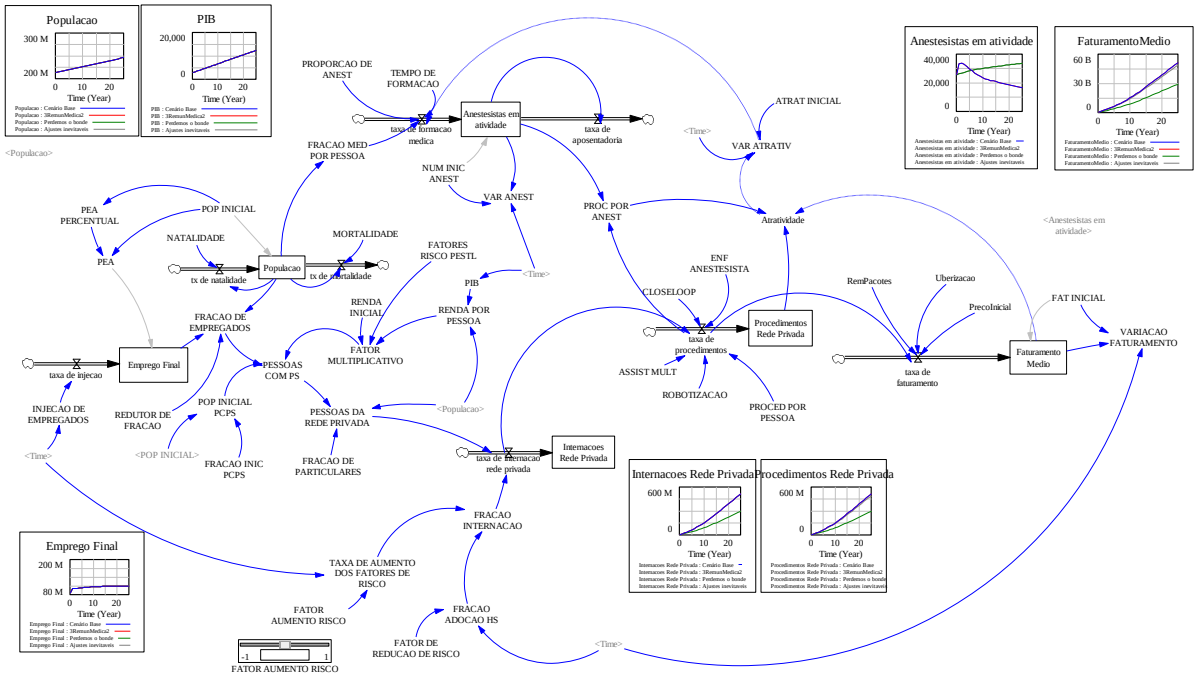
normal course. However, market pressures, such as consolidation and lack of public sector investment, force the large networks to lower their costs and increase their revenues. Eventually, this pressure reduces the interest of doctors in the profession, which, demands a lot of work, but at lower prices. This hypothesis was tested by the model, producing four scenarios. These four scenarios, produced from quantitative data, were synthesized in a qualitative way in Figure 4. This qualitative approach facilitated the transfer of information to new participants as the work evolved.

Figure 2 - Scenario analysis methodology and system dynamics



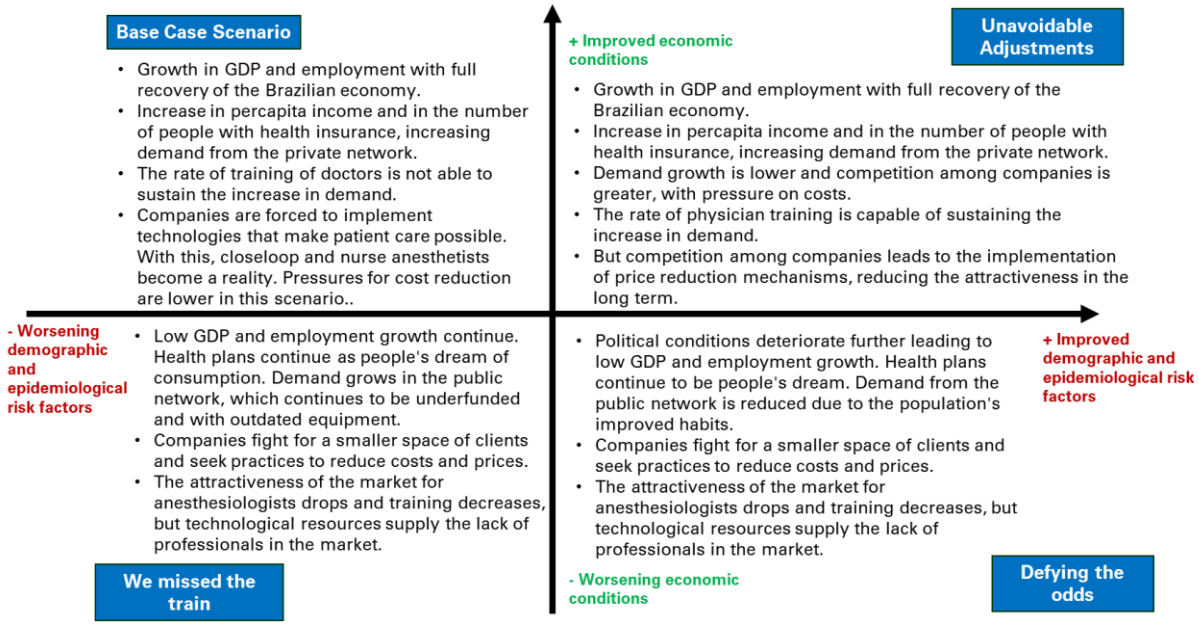
Source: Prepared by the author, 2021.

Figure 3 - Representation of the nonlinearity in the system



Source: Prepared by the author, 2021. (Portuguese).

Figure 4 – Possible scenarios



Source: Prepared by the author, 2021.

Thus, scenario planning produced quantitative data that assisted in the preparation of the company's strategic planning, helping it to consider distinct horizons (KACHANER; KING; STEWART, 2016), which fulfilled an essential role for managers to delve into realities that go far beyond today's concerns. Indeed, the modeling produced four distinct realities. The scenario challenging the odds was considered the least likely because, although improving people's health status by adopting healthy habits is desirable, it requires great effort from public policies, which have been the subject of much debate (REIS, 2021; BARNETT et al., 2012). Even so, the "inevitable adjustments" scenario shows that even under extremely favorable conditions, the system would generate adjustments and the need for internal strategic adjustments.

V. Conclusions

It is concluded, in line with the literature by Cavana, 2010; Cavana; Clifford, 2006; Cavana; Maani, 2000; Chermack, Thomas, 2011; van der Heijden, 2002; Phadnis et al., 2014; Schoemaker, 1993; Sterman (1994, 2000, 2002), that both methodologies assist in challenging mental models by creating depth about future possibilities. However, the combined use of the two techniques allows one to go further, paving a clear methodological path that covers the inconsistencies reported primarily by Chermack (2011), Phadnis et al. (2014), and Mackay and Tambeau (2013).

Measuring the system allowed to find and resolve inconsistencies in reasoning, both in identifying relationships that initially made sense, or that dimensionally cannot be practiced. In addition, it required an in-depth study of the data, with the use of modeling and statistics. During this investigation new relationships were discovered that were shared with the strategic working group. For the data that were not found, it required extending the strategic conversation of qualitative analysis, either through the use of stories or other qualitative techniques, as suggested by Luna-Reyes and Andersen (2003). This, in turn, increases the degree of participation of people in the search for alternative solutions for the future and allows the group to be more committed to change, as stated by Van der Heidjen (2005). This leads to the conclusion that the use of scenario analysis with system dynamics creates an approach for exploring the current structure of the system and the reasons for its behavior confirming the statements of Featherston and Doolan (2013), enabling the group a more complete understanding of the relationships between variables and allowing this art to be transformed into science. In this sense, this study contributes to the techniques proposed by Cavana (2010), Nakajima; Yasui and Ohkami (2014) by incorporating qualitative analysis into the models. It was also verified that the technique is powerful to organize the narrative scenarios to the extent that it is possible to organize a huge range of variables, generating several quantitative data, each one at its own time, or simultaneously, verifying the results of the system and its interpretation for the generation of the narratives.

For the company, the application of the technique contributed to the sedimentation of the strategic proposals, once it was realized that the market will suffer inevitable adjustments, either by the increase in demand, or by the pressure to reduce prices and costs. With this, it became clear to the company the need to

review its business model, to allow the diversification of the portfolio and the construction of a more competitive growth model. It also became clear the need to anticipate the generation of value, with a more effective performance in patient monitoring. Finally, it became clear the need to develop technological partnerships to provide services in the market, in order to have lean costs, maintaining and improving the physicians' profit margins. It also showed the need to break the paradigm around remuneration per procedure, which must migrate to an effective profit distribution model, based on the business results and not on the work performed.

Although this work is not free of limitations, such as the absence of a structured database on the private health network in Brazil, the unwillingness of associations representing the sector to contribute by providing information, and the very limitation related to a single case study, the methodology suggested here is considered replicable. We conclude, therefore, that the analysis of scenarios combined with the dynamics of systems according to the methodology proposed here uses and combines the strongest points of both methodologies, while maintaining a degree of simplicity and adequate cost for implementation in companies.

Finally, the analysis allowed for the identification of strategic environmental indicators to be monitored by the company, which can assist in the necessary state of environmental vigilance. From a practical point of view, it allows the company to act in advance of external factors. From the theoretical point of view this covers a gap announced by Chermack (2011) in reference to the monitoring of scenarios

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