



Pro-innovation restructuring strategy: case study of a multipurpose public organization in health

Patrícia Santos Cavaleiro Silva ^[a], Marcos Filgueiras Jorge ^[b], Branca Regina Cantisano dos Santos e Silva Riscado Terra ^[c], Jorge de Abreu Soares ^[d], João Alberto Neves dos Santos ^[e], Marcelino José Jorge ^[f]

^[a] MSc in Accounting Sciences, Rio de Janeiro State University (UERJ). Research Assistant, Laboratory for Research in Economics of Healthcare Organizations (LAPECOS) of the Evandro Chagas National Institute of Infectious Diseases (INI) at Oswaldo Cruz Foundation (Fiocruz), Rio de Janeiro, RJ – Brazil, email: psc.cavaleiro@gmail.com

^[b] DSc Student in Science, Technology and Innovation in Farming and Cattle-raising, Federal Rural University of Rio de Janeiro (UFRRJ), Technical Director, Monitore ambiental – Water Resources and Environment, Rio de Janeiro, RJ – Brazil, email: filgueiras_jorge_marcos@hotmail.com

^[c] DSc in Production Engineering, Alberto Luiz Coimbra Institute of Post-Graduation and Research in Engineering (COPPE), Federal University of Rio de Janeiro (UFRJ). Professor, Rio de Janeiro State University (UERJ), Rio de Janeiro, RJ – Brazil, email: brancaterra@gmail.com

^[d] DSc in Systems and Computing Engineering, Federal University of Rio de Janeiro (UFRJ). Professor, Rio de Janeiro State University (UERJ). Professor, Celso Suckow da Fonseca Federal Center for Technological Education (CEFET/RJ), Rio de Janeiro, RJ – Brazil, email: jasoares@uerj.br

^[e] DSc in Production Engineering, Pontifical Catholic University of Rio de Janeiro (PUC-Rio). Professor, Fluminense Federal University (UFF), Niterói, RJ – Brazil, email: joaoalbertoneves@gmail.com

^[f] DSc in Production Engineering, Alberto Luiz Coimbra Institute of Post-Graduation and Research in Engineering (COPPE), Federal University of Rio de Janeiro (UFRJ). Coordinator, Laboratory for Research in Economics of Healthcare Organizations (LAPECOS) of the Evandro Chagas National Institute of Infectious Diseases (INI) at Oswaldo Cruz Foundation (Fiocruz), Rio de Janeiro, RJ – Brazil, email: marcelino.jorge@ini.fiocruz.br

Abstract

The aim of this article is to measure the effect on performance, of the innovation in the organizational structure of the laboratories for clinical research associated with healthcare in infectious diseases of the Evandro Chagas National Institute of Infectious Diseases (INI) at Fiocruz in 2007, an

effect herein identified as representative of the corporate intangible assets resulting from such restructuring strategy. The method consists, first, in the analysis of the literature about the measurement of intangible assets and organizational innovation, the potential effects of organization's structure in performance, and the assessment of multipurpose public organizations in health, as sources of the basic notion on relations between intangible assets, organizational structure and performance which is used in this research. Next, the empirical research involves: (a) characterizing the change in organizational structure of 8 INI laboratories; (b) quantifying variables on the use of consumer goods and specialized personnel and on the production of teaching, research and health care; (c) calculating indicators about the development of relative technical efficiency of INI laboratories in the period 2002-2014, through Data Envelopment Analysis (DEA); and (d) using these indicators to compare the performance of these laboratories before and after the organizational innovation associated with the adoption of the Innovative Structure in their restructuring. As a contribution to knowledge, opens up prospects of collaborative research in Administration, Accounting and Economics for the development of a metric for organizational innovation. As management contribution, confirms the association between restructuring of INI laboratories as Innovative Organizations and their improvement in performance. Although the case study method imposes limitations to the generalizability of these results, mainly because there are no sufficient multipurpose organizations that use this methodology in performance assessment, it brings evidence on the potential benefit of the entrepreneurial-oriented innovation for the expansion and improvement of multipurpose public organizations.

Keywords: Efficiency, Innovation, Competitive advantage.

Introduction

A public organization's knowledge is associated with its strategic positioning, as attested by the literature, thus raising interest in innovation as a key focus of organizational assessment, including efforts at innovation measurement and diffusion. Accounting Sciences in particular define knowledge as an intangible asset (CONSELHO FEDERAL DE CONTABILIDADE, 2013) whose value may even exceed the book value of a company's hard assets (SVEIBY, 1998).

Studies in Business Administration on the measurement of intangible assets recognize knowledge as a key factor for competitive advantage and propose its assessment as a source of innovation.

Given the need for measurement in innovation assessment, the Oslo Manual defines innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method, in workplace organization or external relations" (ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, 2005, p. 47).

As an interesting example for innovation assessment studies, the Evandro Chagas National Institute of Infectious Diseases (INI) of the Oswaldo Cruz Foundation (Fiocruz), a Brazilian multipurpose public organization in health, with activities in research, teaching, and patient care, adopted a strategy of change in 2006 in the organizational structure of its clinical research laboratories associated with patient care in infectious diseases. The aim was to promote innovative orientation internally to enhance the strategic positioning of the Institute's research activity in health starting in 2007.

This article thus aims to contribute to knowledge on the measurement of public organizations' intangible assets through a case study that assesses the effect of implementing the strategy of change in the INI structure, based on the notion shared by Business Administration, Accounting Sciences, and Economics on the importance of organizational innovation for adding value to productive organization.

In order to assess the positive effect of the organizational innovation implemented at INI, the frame of reference involved the measures for implementing organizational structural change in the Fiocruz institutes, resulting from the strategy approved by the Fiocruz Internal Congress in September 2006, i.e., a transition from a divisional to an innovative structure, inspired by the concepts of Mintzberg et al (2006), and under the hypothesis of further enhancing the Foundation's development.

The results-based management of clinical research at INI, the management model adopted in 1999, aimed to monitor the Institute's research activities with performance indicators measured since 2002. Using these indicators, the article assesses the performance evolution of the clinical research laboratories as a whole and associates the evolution with the effect of intangible assets accumulated as part of restructuring.

The article includes four sections in addition to this Introduction. The first develops the theoretical basis for addressing the theme. The second discusses the case study method and research design. The third presents the analysis of the results and the fourth the principal contributions of the analysis and the study's limitations.

Theoretical framework

To choose the measure of the effect of restructuring on the organization's efficiency in this assessment of the organizational innovation, we drew on: (a) models from the literature in Business Administration, Accounting Sciences, and Innovation Economics that assess the organization's intangible assets and organizational innovation, based on measures of its effect on the organization's performance; (b) the relationship between structure and innovative behavior in Mintzberg's organizational structure theory; and (c) the concepts of endogenous growth theory as applicable for elucidating the guiding principles of innovation in a multipurpose public organization in health.

Metric for intangible assets

The combination of resources to organize production in a competitive environment results from the configuration of the company's assets: "(a) a resource controlled by an entity as the result of past events and (b) of which future economic benefits are expected to result" (CONSELHO FEDERAL DE CONTABILIDADE, 2013, p.5).

The strategic nature of the assets accumulated by the company to determine its competitive positioning in the market explains the importance assigned by Accounting Sciences to measurement of intangible assets. Assets' tangibility is an important criterion for distinguishing among them, since assets have a visible side, represented by the tangibles, and an invisible side, represented by the intangibles, and both have value for the company (HENDRIKSEN; BREDA, 1999). Cavalcanti & Gomes (2000) contend that the knowledge economy shifts the axis of wealth and development to technology- and knowledge-intensive sectors, transforming the intangible's value into a major differential between companies.

Hendriksen and Breda (1999, p. 388) emphasize the difficulty in measuring intangible assets due to the subjectivity involved in their recognition is highlighted, i.e., that intangible assets form one of the most complex areas in accounting theory, due partly to difficulties in defining them, but mainly because of uncertainties in measuring their values and estimating their lifespans.

Given recognition of intangible assets' importance, the underlying notion in designing models for analyzing intangible capital in Edvinsson & Malone, Jóia, and Stewart is that the effect of the structural and organizational component of intellectual capital incorporated by the organization is decisive for its relative performance in a competitive environment. Indeed, according to Edvinsson & Malone (1998, p.31-33), structural capital represents everything that supports human capital: organizational capital, including systems, instruments, and organizational philosophy; innovation capital, or the capacity for renewal and the results of innovation; and processes capital, comprised of processes and techniques that expand the organization's efficiency. According to Jóia (2000), structural capital involves the company as a whole, or that which it mobilizes to generate knowledge, encompassing internal processes, relations with suppliers, clients, and service providers. Innovation capital is defined by Jóia (2000, p.56) as "a direct consequence of the company's culture and its capacity to create new knowledge based on existing knowledge", hence expressing the need for an adequate structure that fosters the full development of its human competencies. According to Stewart (1997, p. 79), "Intellectual capital is not created from discrete wads of human, structural, and customer capital, but from the interplay among them."

Thus, the methods for measuring intellectual capital used in the Skandia Navigator (1998), the Balanced Scorecard (1998), and the heuristic model proposed by Jóia (2000) adopt the perspective of the observed result, i.e., considering the effect on the organization's performance associated with the available intangible resources.

The Skandia Navigator was presented by Edvinsson & Malone (1998, p.61) as an index showing the organization's direction and velocity, expressed as the mean of the measures of the organization's efficacy, obtained by assessing the effects of activities with the potential to generate company value in the five areas that, according to the authors, orient the company's actions: financial, client, processes, renewal and development, and human resources.

Under the premise that "what is not measured is not managed", in Kaplan & Norton (1998, p. 21) the authors of the *Balanced Scorecard* (BSC) propose mapping a set of performance measures for the company's strategic objectives, consisting of indicators that also aim to represent the effects of intellectual capital assets. Combined according to a balanced perspective and aligned with organizational strategy, the BSC indicators for the organization's results from the financial focus and that of the client, internal processes, and learning and growth seek to represent, elucidate, communicate, and manage the organizational strategy through tangible objectives and measures.

The heuristic model for measurement of intellectual capital in Jóia (2001) disaggregates the completion of the corporate mission into the execution of broad programs and respective specific action programs and considers the fulfillment of these programs as a function of indicators of each program's relative importance for achieving the mission. The indicators are conceived as resulting from the comparison of observed actions through benchmark analysis, for example, with Data Envelopment Analysis (DEA), (JÓIA, 2001, p.58). In other words, Jóia (2000) adds considerations on prioritization to the method for calculating intellectual capital in Edvinsson & Malone (1998), such that its contribution to the measurement of intangible capital also measures intellectual capital from the perspective of the actions' result for organizational performance.

Metric for organizational innovation

According to the Oslo Manual, the organization's objectives when pursuing innovation "may involve products, markets, efficiency, quality or the ability to learn and to implement changes", which defines organizational innovation as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method, in workplace organization or external relations", and associates it with the result of strategic decisions (ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, 2005, p.20, 47)

According to Lam (2004), technological innovations, which include product and process innovation, can result from organizational innovation, and organizational innovation can be assessed according to three principal aspects: (a) the relationship between structural forms of organization and innovative capacity; (b) innovation as a process of organizational learning and knowledge creation; and (c) the organizational capacity for change and adaptation. Teece (1996) thus argues that organizational structures act on both innovation and products and processes, emphasizing the relevance of measuring organizational involvement in the innovation process.

According to Tushman, Newman & Romanelli (1986), an organization's capacity for change and adaptation results from the fact that the organization's market is dynamic, so that changes are seen by successful organizations as a necessary alignment for sustaining the pace dictated by competition. As for innovation as a process of organizational learning, Takeuchi & Nonaka (2008, p. 41) contend that the organization is moved by knowledge, and that innovation can emerge from explicit or tacit forms of knowledge and their interaction. Meanwhile, Mintzberg et al (2006) identifies five structural forms of organization and highlights the efficacy of the innovative organizational configuration in a complex and unpredictable environment, since it promotes an entrepreneurial orientation, with incentives for (and diffusion of) innovative capacity throughout the organization.

In the literature on innovation, factors related to the objectives and effects of organizational innovation and those that hinder its diffusion serve to orient studies on its measurement. In other words, the observation of innovation in response to a new management strategy requires the result's measurement in the organization: "Organizational aspects are receiving growing attention as key factors for adequate innovative management in private enterprises, so it is essential to consider them in future surveys in the region" (JARAMILLO; LUGONES; SALAZAR, 2001, p.54).

As for measurement of organizational innovation, the Oslo Manual does not prescribe a method, but gives examples of its objectives, "for example, reducing costs, improving production capabilities", and recommends collecting data on the objectives and effects of innovation: "While objectives concern enterprises' motives for innovating, effects concern the actual observed outcomes of innovations." (ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, 2005, p.90, 106).

Organizational structure and innovative performance

According to Tushman & Romanelli (1986), organizational evolution is an incremental change involving various areas of adjustments and convergence between strategy, structure, persons, and processes. According to Lam (2004), the relationship between organization and

innovation occurs with the mediation of the organization's structural forms. On this point, "A firm's organizational structure can affect the efficiency of innovation activities, with some structures better suited to particular environments" (OECD, 2005, p. 38).

With regard to the logic of the organization's structure, Mintzberg et al (2006, p.185) contend that there is no one single way to plan an organization and its coordination, and that the structure also represents situational factors that affect the organization. However, the structural models are shaped in internally consistent clusters of the six following basic components: the operational core, consisting of the operators that perform the basic work of manufacturing products and providing services; the top strategy, which is at least a manager that supervises the system; the middle line, consisting of managers that form a hierarchy of authority between the operational core and top strategy; the technostructure, consisting of analysts that perform administrative jobs like formally planning and controlling the work done by others; the support team, consisting of auxiliary units that provide internal services; and the ideology, the component that encompasses the organization's traditions and beliefs and that differentiates it from other organizations.

According to organizational structure theory in Mintzberg et al (2006), the arrangement of these six basic components of the organization obeys the requirements of a division of labor in tasks to be performed and a coordination mechanism between these tasks (MINTZBERG et al, 2006, p. 186). The basic mechanisms of coordination are: mutual adjustment, a process of simple informal communication; direct supervisions by a group leader; standardization of work processes through programming of the work content by the technostructure; standardization of results, dealing with specification of the results; standardization of skills, in which workers are standardized according to some knowledge or skills set transmitted to them in order to apply it on the job; and standardization of norms, according to which the workers share a common set of beliefs, based on which the coordination is established.

The five resulting configurations according to Mintzberg et al (2006, p.195) vary as to different combinations of the coordination mechanism, designation of the main basic component, and degree of decentralization. The five configurations are Simple Structure, Machine Bureaucracy, Professional Bureaucracy, Divisional (Diversified) Organization, and Innovative Organization.

Based on the literature, the reason for adopting the innovative structure can involve incorporation of organizational innovation to solve problems of coordination and commitment resulting from the strategic objective of adaptation to the organization's expectations concerning the knowledge society, and to the response to its implications for the choice of assets: "to innovate means to break away from established patterns" (MINTZBERG et al, 2006, p.197), and in this sense coordination needs to be flexible.

Relevant to this analysis, the Divisional Organization structure consists of various divisions with a certain degree of autonomy, but united by a central office. Division managers are responsible for the respective divisions' results and thus detain a certain level of autonomy. The central office is responsible for the overall corporate strategy and uses the technostructure to plan and operate the performance system, designate division managers, and provide common support services to all the divisions, exerting control over their performance. Thus, the advantages – and limits – of the Divisional Organization structure are: incentive for efficient capital allocation; assistance to the central office in choosing the best form of resource

allocation and training of general managers; risk diversification; and adherence to strategic orientation.

By comparison, coordination of the Innovative Organization structure has little formalization or job specialization via training specialists. The latter are organized in project teams to do the basic innovation work, or multidisciplinary teams that seek to solve problems directly on behalf of clients. The strategy results from specific actions taken in many places in the organization, such that the strategy takes shape along with the project's development. Efforts cannot be routine, and the coordination mechanism is mutual adjustment. Decision-making power is distributed across the organization as needed, based on expertise, not authority. The manager needs to know how to channel conflicts for productive purposes. Dynamic and complex environments are more appropriate for this structure.

Multipurpose public organization in health: innovation and assessment

In public administration, cost-efficient management allows assessing administrators' performance with predefined indicators. Considering the role played by correct cost appropriation as in incentive in management decisions, effective cost information is an important indicator for characterizing performance and backing organizational assessment.

The use of information on effective cost for assessment and incentive pertains to a specific approach to organizations' performance. This approach tends to assume that there is a benchmark that can be calculated accurately and that should serve for comparison with the cost actually observed in the organization. This is the so-called cost function, which depicts the cost at which an ideal organization should operate when it is devoted to cost minimization and relies on complete information *a priori* about the best technology and the prices of all the recommended production factors according to possible technical combinations. Any organizational deviation from the cost function is interpreted as a performance deficiency.

However, the assumption of the manager's command of complete information, incorporated into neoclassical company models in perfect competition, is no longer unanimous in Economic Analysis: the effective cost indicator is insufficient for confirming the underlying principle of innovation (DJELLAL & GALLOUJ, 2005).

Varian (2006) incorporates the hypothesis of information asymmetry into the description of the interaction between the agent of production and the manager. This results in interest in models that adopt the informational hypothesis on the existence of inefficiencies beyond the manager's control to explain the productive organization and its rationality through the search for relative performance efficiency (LEIBENSTEIN, 1966). Recognition of inefficiencies and incomplete information in endogenous growth theory also distinguishes the axioms of models for determination of enterprises in imperfect competition (ROMER, 1994). Meanwhile, the basic notion of the Learning Curve Model is that knowledge accumulation in the innovative organization is incremental in the short term (ROSEMBERG, 1976).

The approach to the study of the productive organization vis-à-vis the hypothesis of the pursuit of relative efficiency oriented by observation of peers' performance has awakened interest in the use of the data envelopment analysis (DEA) model for calculating the frontier in the set of production possibilities that are observed empirically among the peers known to the index organization (MANTRI, 2008).

In particular, the multipurpose public organization in health, defined here as a production unit that provides comprehensive health care services in association with teaching and

research, is a public organization subject to internal conflicts of interest and which uses specialized resources, many of which are commercialized in incomplete markets, to produce public goods whose assessment is subject to experience with their use: (a) it involves multiple activities competing for available resources; (b) it belongs to a large family of health services units; and (c) it depends on internal structures to solve mutual adjustment problems (MINTZBERG et al., 2006).

Adoption of the expansion strategy, as characterized by Rovere (1997) and Bisang & Katz (1996), through the promotion of mission-oriented research for solving of coordination and commitment problems in public organizations in strategic health research, like Fiocruz, thus justifies posing the problem of performance assessment at INI as one of assessing the efficiency of its clinical research laboratories associated with patient care to obtain gains in efficiency in the use of specialized resources over time.

Research methodology

This study's basic tenet is that the positive effect of the organizational innovation consisting of the pro-entrepreneurial structural change on the performance of the multipurpose public organization in health is associated with accumulation of the organization's intangible assets and can be confirmed quantitatively with the aid of the following concepts from the literature: measurement of intangible assets; public management; incomplete information; measurement of organizational innovation; structure; entrepreneurial orientation; and efficiency.

The research uses the case study method and can be classified as exploratory, in the sense used by Marconi & Lakatos (2003, p. 188), because it investigates the hypothesis of the organizational structure's influence on performance, aimed at contributing to measurement of organizations' intangible assets, clarification of the underlying concepts, and more precise research on measuring innovation, and descriptive, in the sense used by Gil (2002, p.42), since it analyzes secondary quantitative data, aimed at defining, quantifying, and confirming the association between the structure and efficiency variables.

The research question is the following: how to assess the efficacy of the organizational innovation that consisted of the structural change oriented towards the adoption of the Innovative Organization configuration (Mintzberg, 1995) at INI. The overall objectives are to measure the effect of the innovation through the structural change in the laboratories conducting integrated research, teaching, and patient care in infectious diseases at INI in 2007, an effect identified as incorporation into the Institute's intangible assets, and to verify whether the efficiency of these substructures increased over time.

The INI laboratories are diversified organizational substructures regulated by Brazil's prevailing legislation on public administration, and as such their performance is conditioned by problems of coordination and commitment involved in the internal resources earmarked yearly in the Institute's public budget, given the goals – potentially competing for resources – of their research, teaching, and patient care activities. Therefore, the study's first specific objective is to calculate indicators on comparative performance trends for the INI laboratories as production units, before and after the promotion of coordination mechanisms by mutual adjustment, empowerment of the operational core, and decentralization of the Fiocruz institutes, and the second is to assess the overall effect of restructuring the INI laboratories.

The laboratories' performance is expressed as an overall mean value, which compares the weighted mean of outputs with the weighted mean of inputs and in which the weights represent the relative importance of each output and input. Assessment of the INI organizational innovation strategy first involves designing an indicator for the joint performance of its eight laboratories, equal to the annual mean of the quotients between the weighted sum of outputs and weighted sum of inputs in the production at each laboratory during the target period, and next to compare the trend in the indicator in the periods prior to and following the restructuring.

The study tests the following null hypothesis: that the adoption of the Innovative Organization configuration for restructuring clinical research laboratories associated with patient care in infectious diseases does not result in improved overall performance in research, teaching, and patient care at INI.

The study's data analysis method consists of calculating the annual summary scores on relative technical efficiency and an efficiency frontier for the observed performance of the eight INI laboratories in 2002-2014, used for comparison to hierarchically order their relative performance. The DEA method was chosen, since it was considered in studies by J6ia (2000) on Brazilian public organizations, by Marinho (2003) on public organizations in health in Rio de Janeiro, and by Cinca, Molinero & Queiroz (2003) on public organizations in Spain.

Data envelopment analysis (DEA) for efficiency analysis

In any given production process, the organization that produces the most outputs with the same resources is considered relatively more efficient. Analogously, the organization that produces the same using the least resources is also considered relatively more efficient.

In performance analysis, technical efficiency reflects the organization's ability to obtain maximum yield from its production technology (COELLI et al., 1998). The problem of selecting a standard for comparison between organizations is treated by identifying the efficiency frontier, defined as representing the set of organizations under analysis that cannot have their production increased given the resources they use, or which, given their production level, cannot reduce their use of resources.

Based on the above argument, the administrator does not have access to the theoretical transformation function and/or to the organization's true cost function. Thus, the efficiency frontier calculated with non-parametric adjustment represents the production frontier for the revealed best practices, i.e., the maximum empirically observed production by any productive organization in the study population, obtained from its actual supply of inputs.

This has sparked interest in the DEA model for assessment of comparable decision-making units (DMU) that use different amounts of inputs to produce different amounts of outputs. The aim is to obtain a production frontier given the following assumptions: there are inefficient and efficient producers; efficient producers are on an efficiency frontier given by their production; and inefficient producers are close to the frontier, and their inefficiency are defined as the distances from the inefficient producer's production level to the frontier (COELLI et al., 1998).

The DEA model can be visualized as follows: there are K productive organizations under analysis (U_1, U_2, \dots, U_K); organization I produces M outputs ($O_{1I}, O_{2I}, \dots, O_{MI}$); and organization U_i uses N inputs to produce these M outputs ($I_{1I}, I_{2I}, \dots, I_{NI}$). Given, *a priori*, the weighting criterion for each of these inputs and outputs for obtaining the aggregate produc-

tion YI and total inputs XI used by organization UI , e.g., by a complete price system for these M outputs and N inputs, it would be possible define the efficiency EI of UI as below, in which AHI is the weight of a unit of output OH in production YI of UI , and BJI is the weight of a unit of input IJ in the breakdown of total resources XI used by UI to produce YI :

$$EI = \frac{YI}{XI} = \frac{A1I.O1I + A2I.O2I + \dots + AMI.OMI}{B1I.I1I + B2I.I2I + \dots + BNI.INI}$$

Identification of the efficient frontier in a large number of K organizations considered all the volumes produced OH , as well as all inputs IJ used by each of K organizations. In addition, if all the weights AHI and BJI are known, an observable efficient frontier may exist, including all the L organizations, which among the K organizations under analysis, operate the best practices, i.e., the maximum empirically observed production by any organization in the target population, obtained from its effective allocation of inputs. In addition, it would be justified as specification of a standard for comparison that for all these L organizations situated on the frontier, $EL = YL/XL = 1$.

However, AHI and BJI are often not known to the observer, and it is hardly likely to extract them from the market's functioning or even from a process of coordination of preferences by vote. The DEA model's original solution to the problem as formulated was that if organization UL belongs to the efficient frontier, it is because there will be some set of weights (AHL and BJL) such that EL is the highest. In other words, a set of weights to be revealed, to which $EL = YL/XL = 1$ attests the greatest efficiency of organization UL in the use of the inputs actually chosen to produce the resulting outputs.

Having identified all the organizations UL that apply the best empirically observed practices, one obtains simultaneously the relative situation of all the others, i.e., those not belonging to the efficient frontier. This problem is solved once for each DMU, thus finding its summary relative efficiency score, i.e., how efficiently it is turning its inputs into outputs when compared to the other observed organizations.

DEA-CCR models are two linear programming models: input-oriented DEA-CCR (DEA-CCR-I) seeks to minimize consumption of inputs in order to produce at least the observed level of production; and the output-oriented CCR model (DEA-CCR-O) aims to maximize production, using at most the observed consumption of inputs. As for the DEA-BCC models, both those oriented towards decreasing inputs (DEA-BCC-I) and those oriented to increasing outputs (DEA-BCC-O), display a frontier surface with variable returns to scale and are relevant, since they allow assessment of DMUs with different scales (COELLI et al., 1998).

Premises and limitations of the DEA Model

The DEA model's solutions to the problems faced by external evaluators justify the method's choice to assess the efficacy of the organizational structure in the INI laboratories: (a) the model can simultaneously use multiple outputs and inputs, each considered in differ-

ent measurement units; (b) the model's objective of calculating a summary assessment score for each DMU under analysis resolves the evaluator's limitation in making a conclusive assessment given the scattering of the DMUs' performance results in different activities; (c) as a byproduct, calculation of this summary efficiency score furnishes the appropriate weight for weighting each product and service produced or input used in the multipurpose DMU, given the habitual difficulty in assigning values to products and services in the absence of a complete price system; (d) the model meets the criterion of strict equity in each DMU's relative assessment; and (e) it focuses on individual observations, not on averages for the target population (MANTRI, 2008).

Meanwhile, the limitations identified by the literature in the DEA model mainly involve: (a) the fact that it is a deterministic model, not allowing treatment of uncertainties; (b) it does not allow cause-and-effect relations between variables; (c) it is highly sensitive to measurement errors, which can comprise the analysis; and (d) it does not estimate the organization's absolute performance (OZCAN, 2009).

Finally, an operational limitation to the DEA model, in terms of presenting consistent results to discriminate and order observations, is that the number K of DMUs analyzed must be at least triple the number of outputs (M) and inputs (N) used, i.e., $K \geq 3(M + N)$ (DE NEGRI, 2003).

Universe, sample, and data collection

The INI currently develops thirteen different integrated actions in research, teaching, and patient care in infectious diseases: Chagas disease; acute febrile diseases/dengue; infectious and parasitic diseases; human T-lymphotropic viruses (HTLV); American tegumentary leishmaniasis (ATL); meningitis; mycoses; paracoccidioidomycosis (PCM); toxoplasmosis; tuberculosis; HIV; sporotrichosis; and other infectious diseases.

The current study analyzed the evolution of eight laboratories in 2002-2014, considering that these were the INI laboratories that completed the integration of research, teaching, and patient care activities in infectious diseases covered in the thirteen areas, namely the following eight laboratories: Chagas disease, acute febrile diseases, HTLV, leishmaniasis, mycoses, toxoplasmosis, tuberculosis, and HIV laboratories.

The data collection process used a structured spreadsheet for compilation in the INI files and processing the necessary data for quantification of the input and output variables and summary scores, respectively, to calculate the laboratories' DEA-efficient frontier, using it as a benchmark to assess their performance over time from 2002 to 2014.

The amounts of activities in diagnosis, patient treatment at different levels of care, research, and teaching for each year in 2002-2014 were considered: (a) from the angle of annual expenditures on these activities by the laboratory, in amounts and at values in current prices, corresponding to the inputs of the respective laboratories in the Institute in the year analyzed; and (b) from the angle of the annual result obtained per laboratory, the amounts of which correspond to the laboratories' outputs during the period.

Selection of the model's variables

The choice of variables resulted from the discussion with the INI medical staff on the analytical representation of the clinical research laboratories associated with patient care in infectious diseases, and met the following requirements: (a) the data on the selected variables could be measured; (b) they contained pertinent information for use of the DEA model not included in other variables; (c) this information could contribute to the objective of performance assessment of the selected DMUs; and (d) the resulting number of variables was adequate for the number of DMUs (FAÇANHA; JORGE, 2004). Eight variables were quantified (SILVA, 2015).

The input variables were selected for their relevance to expenses: (a) physician-hours, or time dedicated by medical professionals to each laboratory and (b) costing, except personnel, annual expenditure on medicines, test reagents, and hospital material per laboratory. Outputs were chosen for their importance to the laboratory's output: (a) number of tests performed per laboratory; (b) number of patient consultations provided per laboratory; (c) number of hospitalization days per laboratory; (d) scientific research output, measured as the number of articles published per laboratory; (e) cohort, or number of new patient research subjects per laboratory; and (f) teaching, or number of Master's and PhD theses per laboratory.

Tests for Checking the Statistical Precision of the Results

Since the available sample comes from a population with an unknown distribution of probabilities, nonparametric tests are recommended to analyze the summary scores calculated with DEA and deal with the problem of indetermination of the inherent calculation error in the chosen deterministic method (JORGE *et al.*, 2006).

Results

According to the reports by the Fiocruz Internal Congresses, which have decision-making power on the foundation's mission and organization, the structure of its institutes corresponded to the Professional Bureaucracy under the taxonomy proposed by Mintzberg in 1995. In 1988, the diagnosis of the 1st Regular Internal Congress attributed the limitations on the foundation's development to this structure: deficiency in promoting interaction between researchers and their peers and with professionals in support and operational activities; and incentive for standardization of skills (FUNDAÇÃO OSWALDO CRUZ, 1988).

In 1994, the 2nd Regular Internal Congress identified the absence of pro-effectiveness and pro-efficacy plans in the work by Fiocruz, resulting in the transition to the Divisional Organization structure in 1996, which consolidated the foundation's strategic plan and increased the management autonomy of the institutes' administrators, with the objective of developing strategic health research activity through: promotion of results-oriented management; qualitative and quantitative adjustment of human resources; and investment in technical change and its material base. However, the transition was conditioned on the strategic plan's definition, agreed on with the technostructure under this configuration, so that autonomy in research activity, associated with the foundation's strategic positioning, but subject to

uncertainties and conducted dynamically in a complex and difficult-to-assess environment, still remained limited (FUNDAÇÃO OSWALDO CRUZ, 1994).

In the 5th Internal Congress in late 2006, the strategy of reconfiguring the Fiocruz institutes was promoted according to the Innovative Organization structure, in search of mechanisms for division of labor and research coordination that evolved continuously, in keeping with the existing projects, aimed at integrating the patient care activities structured according to the respective modalities (inpatient, day hospital, and outpatient), lines of care (e.g., infectious diseases), support activities (e.g., clinical pathology), and theoretical support (e.g., clinical epidemiology) to the clinical research laboratories associated with patient care (FUNDAÇÃO OSWALDO CRUZ, 2006).

The approach to test the study hypothesis was: (a) to consider each laboratory's annual situation in 2002-2014 as an independent DMU from the others; (b) to calculate its summary scores in relation to a unique frontier, over time, of production possibilities for the set of laboratories in each year from 2002-2014, with 104 observation units; (c) to calculate the laboratories' mean annual score; (d) to use the appropriate non-parametric tests to verify the statistical significance of differences between scores; and (e) to verify whether the trend in the laboratories' mean annual scores in 2007-2014 represented gains in efficiency.

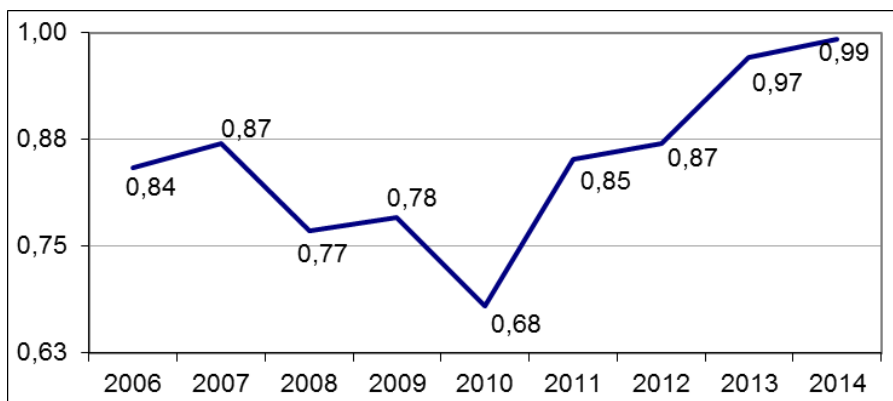
Table 1 and Graph 1 show the laboratories' annual scores for relative technical efficiency in 2006-2014, calculated with the DEA-BCC-O model.

Table 1 – Evolution in the efficiency scores of the INI laboratories: 2006-2014

Laboratory	2006	2007	2008	2009	2010	2011	2012	2013	2014
Chagas disease	0.71	0.71	0.65	0.60	0.46	0.70	0.68	0.84	0.94
Acute febrile diseases	0.97	1.00	0.94	0.94	0.61	0.92	1.00	1.00	1.00
HTLV	0.63	0.77	0.72	0.66	0.46	0.79	0.77	1.00	1.00
Leishmaniasis	0.91	0.79	0.57	0.64	0.90	0.91	0.98	1.00	1.00
Mycoses	0.83	1.00	0.84	1.00	1.00	1.00	1.00	1.00	1.00
Toxoplasmosis	0.82	0.84	0.76	0.73	0.48	0.78	0.77	0.98	1.00
Tuberculosis	0.87	0.91	0.78	0.70	0.54	0.73	0.77	0.95	1.00
HIV	1.00	0.94	0.91	1.00	1.00	1.00	1.00	1.00	1.00
Mean score	0.84	0.87	0.77	0.78	0.68	0.85	0.87	0.97	0.99

Source: Elaborated by the authors.

Graph 1 – Evolution in the mean annual score of the INI laboratories: 2006-2014



Source: Elaborated by the authors.

The table and graph portray the effectiveness of the strategy to increase the outputs obtained per unit of inputs in the laboratories following a period of absorption of the pro-entrepreneurial innovation in the three-year period 2008-2010. The use of non-parametric tests to measure the statistical precision of the results of the analysis using this model in Jorge, Carvalho & Jorge (2012) confirmed that the variation in the relative technical efficiency summary scores are statistically significant.

The study allowed rejecting the null hypothesis: that the adoption of the Innovative Organization configuration for restructuring the clinical research laboratories associated with patient care in infectious diseases does not result in overall performance improvement in the research, teaching, and patient care activities at INI. The overall performance improvement may be associated with improvements in problem-solving in coordination and commitment - and mutual adjustment - between expert professionals in the INI laboratories' research teams, which resulted from internalization of the incentive for innovative orientation through increased decision-making autonomy for the laboratories.

Conclusions

In order to assess the strategy of adopting the Innovative Organization structure in the Fiocruz institutes in 2007, this case study was based on the underlying notion that the effect of this change represents the incorporation of organizational innovation into the intangible assets of INI. The article aimed to measure the effect of pro-entrepreneurial innovation on the performance of INI laboratories in charge of integrated research, teaching, and patient care activities in infectious diseases in 2007. As a result, the empirical study confirmed the increase in efficiency in the laboratories assessed since restructuring.

The survey of the restructuring measures at Fiocruz in light of the conceptual framework proposed in Configuration Theory of Mintzberg et al (2006) elucidated the approach for characterization of the pro-entrepreneurial innovation strategy adopted in the case study. The use of a DEA-BCC-O model, specified for measuring overall efficiency in the INI laboratories' use of resources, allowed calculating the laboratories' individual relative performance indicators for the period 2002-2014. The non-parametric analysis technique chosen for constructing a single efficiency frontier allowed identifying the restructuring strategy's pro-efficiency effect, resulting in a metric for this organizational innovation identified as adding value to the organization's intangible assets in the Accounting Sciences literature.

As for adding knowledge to Administration Theory, the article helps elucidate the potential effect of the strategy of organizational restructuring herein assessed as a problem-solving mechanism in coordination and commitment in the multipurpose public organization working in research, teaching, and patient care. As a contribution to Economics, the article offers evidence to support the hypothesis of the pursuit of relative efficiency - peer performance emulation - as a guiding principle of innovation in these organizations. As for empirical research in Accounting Sciences, the article presents an alternative for the assessment of intangible assets from the perspective of innovation results.

The article thus adds knowledge on the effect of decentralization with mutual adjustment and empowerment to promote an entrepreneurial attitude in innovation activities, illustrates the use of a potentially useful basic notion for empirical research on innovation measurement, and contributes to the formulation of the research problem in Accounting Sciences,

still dependent on efforts under way for the use of multivariate analytical methods in the measurement of the organization's intangible assets.

As a management contribution, the article confirms the association between the new organizational structure of patient care associated with clinical research and the result of the pro-entrepreneurial restructuring strategy in the laboratories, providing evidence on the potential benefit of its replication for the expansion and improvement of comprehensive care in infectious diseases. The case study method limits generalization of the results, mainly because there are no other multipurpose institutions that use this approach for measurement and analysis, and the Efficiency Analysis is thus limited to benchmarking among the organization's own laboratories. However, the effect of organizational innovation on innovative orientation and the laboratories' performance was empirically demonstrated. The research effort can serve as the basis for future studies and for orienting correlated performance monitoring measures in other multipurpose organizations, thereby allowing comparison of results and measurement of efforts.

References

- BISANG, R; KATZ, J. **Eficacia y eficiencia microeconómica en instituciones no sujetas a reglas convencionales de mercado**. Buenos Aires: [s.n.], 1996. Mimeo.
- CINCA, C. S; MOLINEIRO, C. M; QUEIROZ, A. B. **The measurement of intangible assets in public sector using scaling techniques**. Journal of Intellectual Capital, v. 4, n. 2, p. 249 – 275, 2003.
- COELLI, T. J. et al. **An introduction to efficiency and productivity analysis**. New York: Springer, 1998.
- CONSELHO FEDERAL DE CONTABILIDADE. **Pronunciamentos técnicos contábeis**. 2012. Brasília, 2013. 1202 p.
- DE NEGRI, J. A. **Desempenho exportador das firmas industriais no Brasil: a influência da eficiência de escala e dos rendimentos crescentes de escala**. Brasília, DF: IPEA, 2003 (Texto para discussão n. 997).
- DJELLAL, F; GALLOUJ, F. **Mapping innovation dynamics in hospitals**. Research Policy, v. 34, p. 817-835, 2005.
- EDVINSSON, L; MALONE, M. S. **Capital intelectual**. São Paulo: Makron Books, 1998.
- FAÇANHA, L. O; JORGE, M. J. **Projeto de avaliação e acompanhamento de desempenho do IPEC: uma proposta para o SEMOC/IPEC: PAA-IGs**. Rio de Janeiro: IPEC/Fiocruz, 2004. Mimeo.
- FUNDAÇÃO OSWALDO CRUZ. **I Congresso interno: relatório final da plenária extraordinária**. Diretrizes para a adequação da estrutura organizacional da Fiocruz. Rio de Janeiro, 1988.
- _____. **II Congresso interno: relatório final da plenária ordinária**. Autonomia, flexibilidade e qualidade. Rio de Janeiro, 1994.
- _____. **V Congresso interno: relatório final da plenária extraordinária**. Diretrizes para a adequação da estrutura organizacional da Fiocruz. Rio de Janeiro, 2006.
- GIL, A. C. **Como elaborar projetos de pesquisa**. São Paulo: Atlas, 2002.
- HENDRIKSEN, E. S; BREDÁ, M. F. V. **Teoria da contabilidade**. São Paulo: Atlas, 1999.

JARAMILLO, H; LUGONES, G; SALAZAR, M. **Normalización de Indicadores de Innovación Tecnológica en América Latina y el Caribe** - Manual de Bogotá. 2001. Available online: <http://www.mct.gov.br/upd_blob/0026/26035.pdf>. Retrieved: 10 Jul 2015.

JOIA, L. A. **Medindo o capital intelectual**. RAE - Revista de Administração de Empresas, São Paulo, v. 41, n. 2, p. 54-63, abr./jun. 2001.

JORGE, M. J. et al. **Efetividade em custo e análise de eficiência de programas em organizações complexas**: a experiência do IPEC/Fiocruz. Ciudad de México: FUNSALUD, 2006.

JORGE, M. J; CARVALHO, F. A. A; JORGE, M. F. **Diversificação como estratégia de expansão em uma instituição pública de pesquisa**: uma avaliação utilizando o modelo DEA de análise de eficiência. Organizações & Sociedade, Salvador, v. 19, n. 60, p. 35-49, mar. 2012.

KAPLAN, R. S; NORTON, P. D. **A estratégia em ação**: Balanced Scorecard. Rio de Janeiro: Campus, 1997.

LAM, A. **Organizational Innovation**. Available online: <http://mpra.ub.uni-muenchen.de/11539/1/MPRA_paper_11539.pdf>. Retrieved: 10 Jul 2015.

LEIBENSTEIN, H. **Allocative Efficiency vs. 'X'**: Efficiency. American Economic Review, v. 56, p. 392 - 415, jun. 1966.

MANTRI, J. K. (Ed.) **Research methodology on Data Envelopment Analysis (DEA)**. Boca Raton, FL: Universal Publishers, 2008.

MARCONI, M. A; LAKATOS, E. M. **Fundamentos da metodologia científica**. São Paulo: Atlas, 2003.

MARINHO, A. **Avaliação da eficiência técnica nos serviços de saúde nos Municípios do Estado do Rio de Janeiro**. Revista Brasileira de Economia. Rio de Janeiro, v. 57, n. 3, set. 2003.

MINTZBERG, H. **Criando organizações eficazes**: estruturas em cinco configurações. São Paulo: Atlas, 1995.

MINTZBERG, H. et al. **O processo da estratégia**. 4. ed. Porto Alegre: Bookman, 2006.

ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT. Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data. 3rd Edition. 2005. Available online: <<http://www.oecd.org/sti/inno/oslomanualguidelinesforcollectingandinterpretinginnovationdata3rdedition.html>>. Retrieved: 15 apr 2016.

OZCAN, Y. A. **Quantitative Methods in Health Care Management**. San Francisco: Jossey-Bass, 2009.

ROMER, P. M. **The origins of endogenous growth**. Journal of Economic Perspectives, v. 8, n. 1, p. 3-22, 1994.

ROSEMBERG, N. **Perspectives on technology**. New York: Cambridge University Press, 1976.

ROVERE, M. **Políticas y gestión en las organizaciones de ciencia y tecnología en salud**. Washington, D.C.: OPAS, 1997. (OPS/HDP/HDR/97.05). Mimeo.

SILVA, P. S. C. **O impacto do ativo intangível medido pelo efeito da inovação organizacional em instituição pública multipropósito**: o caso do Instituto Nacional de Infectologia Evandro Chagas - INI da Fiocruz. 2015. 122 f. Dissertação (Mestrado em Ciências Contábeis) - Universidade do Estado do Rio de Janeiro, Rio de Janeiro, 2015.

STEWART, T. A. **Intellectual Capital**: The new wealth of organizations. New York: Doubleday, 1997.

SVEIBY, K. E. **A nova riqueza das organizações**: gerenciando e avaliando patrimônios do conhecimento. Rio de Janeiro: Campus, 1998.

TAKEUCHI, H; NONAKA, I. **Gestão do Conhecimento**. Porto Alegre: Bookman, 2008.

TEECE, D. J; PISANO, G; SHUEN, A. **Dynamic capabilities and strategic management**. Strategic Management Journal, v. 18, n. 7, p. 509-533, aug.1997.

TUSHMAN, M. L; PHILIP, A. (Ed.) **Managing Strategic Innovation and Change**: A Collection of Readings. 2. ed. New York: Oxford University Press, 2004.

VARIAN, H. R. **Microeconomia**: princípios básicos. Rio de Janeiro: Campus, 2006.

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