Fiscalização a serviço da sociedade

REVISTA do TCU

Federal Court of Accounts Journal • Brazil • year 48 • Issue nº 135 • January/April 2016 • English version

The future of external control

Federative Republic of Brazil

Federal Court of Accounts

MINISTERS

Aroldo Cedraz de Oliveira, Presidente
Raimundo Carreiro, Vice-Presidente
Walton Alencar Rodrigues
Benjamin Zymler
Augusto Nardes
José Múcio Monteiro
Ana Arraes
Bruno Dantas
Vital do Rêgo

SUBSTITUTE MINISTERS

Augusto Sherman Cavalcanti
Marcos Bemquerer Costa
André Luís de Carvalho
Weder de Oliveira

PUBLIC PROSECUTION OFFICE OF TCU

Paulo Soares Bugarin, Prosecutor General
Lucas Rocha Furtado, Assistant Prosecutor
Cristina Machado da Costa e Silva, Assistant Prosecutor
Marinus Eduardo de Vries Marsico, Prosecutor
Júlio Marcelo de Oliveira, Prosecutor
Sérgio Ricardo Costa Caribé, Prosecutor

Fiscalização a serviço da sociedade

REVISTA do TCU

Federal Court of Accounts Journal • Brazil • year 48 • Issue nº 135 • January/April 2016

The concepts and opinions expressed in signed doctrinal works are the sole responsibility of the authors.

www.tcu.gov.br

Mission Statement
Improving the Public Administration for the benefit of society through external oversight

Vision Statement
To be a reference in promoting an effective, ethical, agile and responsible Public Administration

Federal Court of Accounts – Brazil Journal, v.1, n.1 (1970) - . – Brasília : TCU, 1970- .
v.
From 1970 to 1972, annual; from 1973 to 1975, triannual; from 1976 to 1988, biannual; from 1990 to 2005, quarterly; 2006, annual; as of 2007, triannual

ISSN 0103-1090

1. Oversight of public expenditure- Brazil Journal, v.1, n.1 (1970) - . – Brasília : TCU, 1970-

Catalogued by Biblioteca Ministro Ruben Rosa

TRIBUNAL DE CONTAS DA UNIÃO

FOUNDER
Minister Iberê Gilson

EDITORIAL COUNCIL SUPERVISOR
Minister Aroldo Cedraz de Oliveira

EDITORIAL COUNCIL
Substitue-Minister Augusto Sherman Cavalcanti
Prosecutor General Paulo Soares Bugarin
Eduardo Monteiro de Rezende
Rainério Rodrigues Leite
Flávia Lacerda Franco Melo Oliveira

EDITORIAL RESPONSIBILITY
Serzedello Corrêa Institute
Documentation Center

CONTRIBUTORS
Biblioteca Ministro Ruben Rosa

TRANSLATION
Department of International Relations

Images
iStock

DESIGN
Pablo Frioli

Editorial Design and photomontage
Vanessa Vieira F. da Silva - ISC/Seducont

Documentation Center
SAFS Quadra 4 Lote 1
Edifício Anexo III - Sala 21
Brasília-DF
70.042-900
revista@tcu.gov.br

Printed by Sesap/Segedam

Letter to the Reader

Dear reader,

This issue of the *TCU Journal*, in line with the current situation of the country, covers the trending topic of the last few weeks, that is: fighting corruption, for corruption is responsible for affecting society's self-esteem, for infecting the political system and sweeping the economy.

Misuse of public resources, a well-known fact by all of us, does not only affect us today, but also influences the future of the generations to come, because it takes away the basic conditions for a long lasting and socially sustainable development. According to the latest studies, the average cost of corruption, every year, is between 1.38% and 2.3% of Brazil's GDP.

To this end, it became relevant to mention how the Supreme Audit Institutions (SAI) actions impact on the development of mechanisms that may inhibit unsound practices to the Public Administration and, subsequently, harmful to society.

Audit institutions, as we all know, already show in their reports verification regarding aspects that, somehow, show evidence of procedures and practices that might lead to any potential misuse of public resources. Although, it is important to always seek improvement of the oversight methods and techniques adopted, so we can detect mismanagement of public funds before it happens.

The Federal Court of Accounts of Brazil (TCU) has invested continuously in initiatives in this direction. In October of 2015, TCU started the "Fight against Misappropriation and Irregularities" Project, within the General Secretariat of External Control (Segecex), which purpose is to disseminate good practices in facing fraud and corruption in the Public Administration and, as part of the second phase of the project, to elaborate guidelines on how to act focusing on fighting such irregularities.

More recently, in last January, we created the Department of Special Operations for Infrastructure (Seinfra-Operações), responsible for the oversight and other activities related to the "Operação Lava Jato" (Operation Carwash) investigation, and the following up on the Leniency Agreements signed with the Comptroller General of Brazil (CGU), according to the statement of the head of the Department, Rafael Jardim Cavalcante.

It is also important to mention the article by SAI Portugal, "the external control as a tool for fighting corruption – the role of the Supreme Audit Institutions", written by Portugal's government auditor Ruth Serra, in which, after writing on the characteristics of the different types of audits, she demonstrates the importance of forensic audit for preventing and detecting fraud.

However, to achieve agility and efficiency of procedures and optimization of results, it is essential the use of new technologies and paradigms associated with the intensive use of electronic data.

An important condition to leverage oversight activities in an increasingly connected society is the extraction of information and knowledge from the abundant sources of data available today. TCU, aware of this reality, and in order to make our performance even more focused, timely and efficient, has encouraged the use of the data applied science to the External Control. That is the scope of the article "Computational Intelligence applied to the external control: pattern classification using artificial neural networks".

Similarly, TCU has invested in advanced data analysis, seeking to build predictive models. Techniques such as deep learning, presented in the article of the federal government auditor, Luis Andre Dutra e Silva, are among those used in the Court. Segecex, through the Department of Information Management for the External Control (Seginf), has coordinated initiatives for developing structuring corporate solutions, such as "e-contas" and "e-TCU", as well as elaborate predictive models to support planning and implementation of actions, such as the risk rankings in voluntary transfers and in public procurement. The Court, however, still has a long way to go.

This vision of the future is confirmed on the interview of the Chief Scientist of the US Government Accountability Office (GAO), Timothy Persons, in which he expressed his position on the use of data analysis in the activities of External Control. According to him, information processing is not going anywhere, and it is a mistake to consider it as a trend. In the interview, the scientist explained the various uses of this tool and stated that the SAIs, that have fight against corruption among their challenges, would reach better results if they include advanced technologies to their resources.

Enjoy the reading!

Bruno Spada

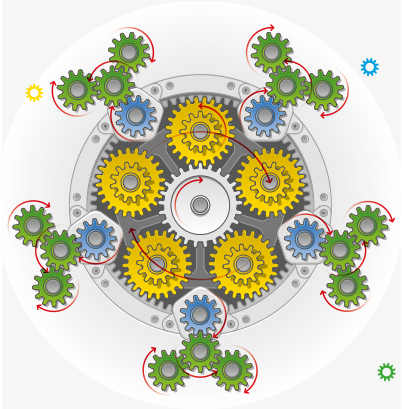
Aroldo Cedraz de Oliveira
President of the Federal Court of Accounts – Brazil and Supervisor of the Editorial Council of the TCU Journal

Table of Contents

Interview 8

Opinion 12

Highlights 14



Articles 18

Index and addresses

Articles

Data analytics and the fight against corruption

Until a few years ago, public institutions had to struggle with the problem of access to information. Apparently, the efforts to overcome such situation generated another problem. Nowadays, there is a vast array of information available and, consequently, the need to find the needle in the haystack. In this context, what is the importance and the benefits of data analytics?

This is really an evolutionary issue for public institutions. Although it is indeed the case that there were prior problems, I don't think the advent of Big Data in and of itself will eliminate every access and data quality issue faced by the institution. What has changed is the relative abundance of data, the dramatic reduction of the cost of storage and computation, and new ways of thinking and methods associated with efficiently extracting value from the data. As such, data analytics has rightly become very important to the business of public institutions, especially for those who employ creative, problem-solving approaches to their mission challenges

Timothy Persons
Chief Scientist of the United States Government Accountability Office (GAO)

Dr. Timothy M. Persons is a member of the Senior Executive Service of the U.S. federal government and was appointed the Chief Scientist of the United States Government Accountability Office (GAO) in 2008. In this capacity, he serves to direct GAO's Center for Science, Technology, and Engineering (CSTE), a group of highly specialized scientists, engineers, and operations research staff. In these roles he directs science and technology (S&T) studies and is an expert advisor and chief consultant to the GAO, Congress, and other federal agencies and government programs on cutting-edge S&T, key highly-specialized complex systems, engineering policies and best practices, and original research studies in the fields of engineering, computer, and the physical and biological sciences to ensure strategic and effective use of S&T in the federal sector.

During this interview to ***Revista do TCU*** Dr. Persons talked about the importance of data analytics to the work carried out by an audit institution, especially when it comes to curbing corruption and fraud. In his opinion, a Supreme Audit Institution (SAI) who remains behind on implementing data analytic approaches will face limitations in its effectiveness in finding and fighting fraudulent activities. Although believing that the future of auditing will be almost entirely data analytic in nature, he emphasizes that technology will never replace the collective wisdom of experienced professionals.

coupled with a subtle, but important shift in their view of data as an expense/problem to be managed to data as an asset/opportunity to create value.

Is data analytics just a temporary trend or the key to solve from basic to sophisticated problems?

There's nothing temporary about data analytics. For example, here in America we utilize the word "Google" as a verb (I 'googled' TCU to learn more about it as an institution). Although it will certainly not be the answer or approach to all problems, data analytics done well does broaden the available solution space for certain types of problems which involve goals such as improving efficiency, providing more incisive insight on root causes, and supporting more informed decision making.

Corruption and fraud are major problems faced by Brazil and, therefore, major challenges presented to the Brazilian Court of Accounts. In your opinion, how data analytics may be used by the Court in order to tackle fraud and corruption?

From my perspective, fraud and corruption are effectively cost-benefit analyses done by people who might fall into the temptation of bettering themselves at the expense of others. As such, the rise and proliferation of effective anti-fraud data analytics approaches has increased the risk and cost of being discovered doing nefarious things and subsequently being prosecuted thus effectively suppressing fraudulent behavior. In this same manner, I imagine that the Brazilian Court of Accounts would very much benefit from fraud analytic approaches

"I believe SAIs who are faced with significant corruption-fighting challenges would do well to leverage existing technologies and approaches as part of their arsenal of methods."

such as linking software for social network/tracking funds kind of analyses, geospatial analysis, text mining of large datasets for sense-making purposes, among others.

How important is it for Supreme Audit Institutions (SAIs) of countries in great need of fighting corruption to invest in projects related to data analytics?

SAIs who remain behind on implementing approaches will face limitations in their effectiveness at finding and curbing fraudulent activities. It is indeed possible for a given SAI to preserve a business model which uses conventional methods alone, but I wouldn't expect it to be as effective as those SAIs which add to conventional methods augmented or assisted by newer data analytics approaches (some of which have reported dramatic improvements in the effectiveness of their revised and updated business model). As such, I believe SAIs who are faced with significant corruption-fighting challenges would do well to leverage existing technologies and approaches as part of their arsenal of methods.

Could you mention a case/situation in which data analytics made the difference in curbing corruption and promoting transparency?

The U.S. Department of Agriculture (USDA) saw a dramatic drop in fraudulent claims for crop insurance after they implemented data analytics approaches. Their Crop Insurance Program Compliance and Integrity Data Warehouse utilized multiple datasets to prevent fraudulent claim payments which resulted in billions of dollars in savings. Specifically, USDA data analysts utilized access to 170 data sources - including several terabytes of policy information, 120 terabytes of weather, satellite and other remotely sensed data, and 1.3 million crop insurance policies across 3,200 counties – to look for atypical patterns among insurance claims, cross-checking them with data from high-solution satellite images and weather records. Their approach involved both conventional prosecution activities as well as newer, "softer" approaches where letters of inquiry were sent to claimants who were suspected of fraud. This latter method resulted in a subsequent dramatic drop in claims simply because the participants in the program quickly became aware of USDA's new ability to detect fraud or suspected fraudulent activities.

The use of information obtained by means of data analytics may be limited to either open or shape an investigation or do you believe it could be used as a piece of formal evidence?

I believe that these new methods will need to be court tested in time such that they will evolve to where they can be utilized as

formal evidence in a trial. That said, I believe they can and should be utilized to shape or inform investigations. Once the newer methods are tested and refined through many cases for tipping and cueing kind of tasks, I think we will begin to see them introduced in due time as formal evidence in court cases. (*cf.*, Daubert standards utilized here in the U.S.)

One of the duties of the Brazilian Court of Accounts is to assess whether a governmental body is achieving economy, efficiency and effectiveness in the employment of available resources. How data analytics could be used to the benefit of a performance audit and help to shape public policies.

In my view, performance auditing practice and methods are prime candidates for exploration and piloting of advanced analytics. Here at GAO, we are well known for our conventional analytic methods and we are in the process of considering and piloting some of the newer approaches to see what, if any, things we might be able to do to support the economy, efficiency, and effectiveness of various public sector operations…including our own. As in other problem sets, data analytics methods may or may not add value to various activities of an SAI. Even so, in my experience, when such methods have added value they usually do so in a transformative manner. Once again, I think we'll need to keep track of how SAIs are using new analytics approaches and remain connected and share lessons learned about what works and what doesn't as we walk this path together.

"The rise and proliferation of effective anti-fraud data analytics approaches has increased the risk and cost of being discovered doing nefarious things and subsequently being prosecuted thus effectively suppressing fraudulent behavior."

Could you mention a practical example?

One of our earliest pilots involved text mining of a thousand documents to sort and cluster them according to a pre-defined taxonomy based on the audit objectives. By having an algorithm sort the documents according to topic (for example, some documents of this federal grant program were related to funding, some were technical in nature, and some contained geospatial information). As a result, a large amount of analytic time was saved by using this newer approach since, based on the questions of the audit, the analysts could read only that subset of all the documents that were relevant to them. Our pilot demonstrated that this approach (tested on a previously completed job using conventional methods) resulted in a reduction of weeks to hours of analytic time to achieve the same results.

Is data analytics the future of auditing? Would you define it as a decision-making system or a decision supporting system?

I believe the future of auditing will be almost entirely data analytic in nature. Specifically, data analytics will transform the accountability business wherever "gut" instincts or audit process inefficiencies lay. That said, I don't believe data analytics will ever be a decision-making system in and of itself (i.e., it will never replace the collective wisdom of experienced people), but will remain a decision supporting system (i.e., it will support more efficient and more effective data driven operations.)

What are today's cutting-edge technologies that a SAI must have in order to perform its duties?

From my perspective, SAIs who wish to conduct advanced analytics would do well to utilize data visualization, statistical computation, link and network analysis, geospatial analysis, text mining, document clustering, and optical character recognition software packages. Supporting infrastructure for data analytics involves the use of structured and unstructured databases as well as cloud and/or Hadoop architectures (depending on your data access and management policies). As always, the technologies should serve the mission elements and not vice versa.

Could you mention any limitations that still need to be overcome in order for data analytics to provide better results for a SAI?

Although there are technical (i.e., ICT architecture) and methodological (i.e., data reliability) challenges which would need to be addressed by an SAI desiring to develop and operationalize data analytic approaches, the primary limitation I have noted is cultural in nature. This is to say, institutio-

nal culture might resist new methods because, for example, they are unfamiliar (or may have been developed externally), they often require working dynamic, socially-integrated teams, and are likely to have a high rate of failure when attempting to evolve new analytic methods. The solution to such cultural barriers involves strong, consistent leadership supporting the new methods (i.e., "tone at the top"), the enablement of creative, problem-solving kind of thinking (often found in the more junior staff who are likely to be more open to the new methods), and a willingness to experiment and be wrong at times, but to learn quickly from each failure such that lessons learned are incorporated into the next iteration. Building symbiotic relationships with mission partners within an institution is also a *sine qua non* of data analytics.

Which SAIs are presently more advanced in the use of data analytics? What did they do differently than others that are not so advanced?

Although I'm not familiar with all SAIs, much less the extent to which they utilize data analytics, the ones who participated in the recent joint GAO (USA)/CNAO (China)-hosted event included (in addition to the hosts), Brazil, UK, Canada, the Netherlands, Norway, South Korea, and New Zealand. Indications from the conference were that many of these SAIs are building capacity and creatively enhancing their baseline capabilities to enhance the performance of their institutions. What struck me as a common theme from the proceedings was their willingness to think in an innovative context by essentially asking themselves the following question: "*How might we dramatically improve or add to our baseline capabilities with these new methods and tools?*" Some are succeeding because they have to… they don't have an abundance of staff to employ more manual or labor intensive methods. Others have been allowed to innovate through exploration of methods and a greater openness to what the new methods (including having a high tolerance for trying things that don't work, but adapting quickly and incorporating lessons learned in an agile process of continuous testing and development.)

> *"I have been impressed with what TCU has been doing in data analytics and regard much of their efforts as pioneering for the global accountability community."*

How important is the role of Chief Data Officer (CDO) in a SAI? What should be expected from such desk?

I think the INTOSAI community will see an increase of SAI CDOs over time, especially as the community evolves to recognize, embrace, and deploy the new approaches. In that way, I think the role of the CDO will be seen as increasingly important, even necessary, for more efficient and effective operations of SAIs. One critical distinction will involve making sure that the CDO isn't confused with or subsumed under the CIO. CIOs have a very important role for the management and security and ICT infrastructure and should be integrally partnered with the CDO, but is generally not designed to perform the functions of a CDO in terms of analytics with the data. The CDO should be expected to develop functional, symbiotic relationships with the desired mission elements of the SAI and should be allowed to work in an innovation context which allows them to safely fail, but learn and adapt to find workable operational solutions.

Considering your knowledge of the work performed by the Brazilian Court of Accounts, would you say the Court is in the right path when it comes to data analytics? What would you evaluate as a good move and in what areas the Court is still lagging?

I have been impressed with what TCU has been doing in data analytics and regard much of their efforts as pioneering for the global accountability community. Given the top-level support from the President and the extensive research into developing and deploying capabilities (including travels and interviews with experts), and the success of some early pilots which they shared at a recent conference, I believe TCU is exhibiting the elements of long-term, sustainable success in the use of data analytics in support of their various missions. As I understand the way forward for TCU, I applaud the institution's embrace of the overall datafication of Brazil something that, if leveraged properly through appropriate data analytics, should yield ongoing benefits to the Brazilian taxpayer. The challenge then will be to address the data reliability and methodological verification of the analytics in order to increase confidence, assurance, and efficacy of the new methods.

Opinion

The role of courts of accounts in the fight against corruption

The exact delimitations of the role of the Federal Court of Accounts in fighting corruption are still under discussion. In its duty to carry out the external control of the Public Administration, the "network of Courts of Accounts", hand in hand with the legislature, is the eyes of society for the sound management of public funds and policies. Because of its increasingly specialized role - in each part/context/situation of the complex state activity - the Courts translate for the citizens, in an analytical manner, the adequacy of the administrative freedom of managers regarding the respective suitability of the acts in the strict interest of society.

In the case of the eternal economic dilemma of scarce resources, it is compelling that the State acts economically, efficiently and effectively in a governance to produce the best possible results for society. The Courts of Accounts act, after all, to enhance the latter objectives: roughly, whether showing to the administrators the risks, opportunities and recommendations once the favorable conditions to amplify more efficient and effective action are identified; whether in a compliance bias, demonstrating (and punishing) behavior, processes and decisions made on the wrong side of the law and the principles governing public administration.

The corruption of public officials, in this sense, is an intrinsic factor of state inefficiency. While bleeding resources that otherwise would make the public policies and spending more efficient and effective, the State political legitimacy itself is compromised in an unrest that antagonizes "social peace", idealized in the old days when the Republic was established. Thus, the Courts of Account, as institutions established to monitor broadly the adherence to these Republican interests, control the Public Administration in view of its improvement, being invariably entangled in this whole context of "fighting corruption".

In fact, corruption is always the result of a failure in the State governance. If public managers must work for citizens - the golden rule of public governance - corruption is the classic management by self-interest or that of third parties.

The issues are: is the state apparatus enough to fight such corruption? Are the control structures efficient? Where are the main risks? Is the regulatory framework consistent with the control needs, without sacrificing efficiency? How to strengthen the control measures to make all this apparatus more efficient?

In the international literature on the subject, the fight against corruption can be summed up in the triad of **prevention**, **detection** (oversight) and **accountability** (punishment) .

In compliance with the constitutional role of the Courts of Accounts and according to the time of its performance - in concurrent and ex post audits – it is paramount to meditate (and account for results) on the role of TCU in these variables.

Aware of the demands of society for those responses, in terms of strategic initiatives, TCU took two key steps:

• Established the Project Fighting Embezzlment and Irregularities (Projeto Combate a Desvios e Irregularidades);

• Established the Extraordinary Department of Special Operations in Infrastructure - (Secretaria Extraordinária de Operações Especiais em Infraestrutura-SeinfraOperações).

The project **Fighting Embezzlement and Irregularities** - created in October 2015 - is headed by the Office of the Coordinator-General for Core Public Management Services and has the support of the Department of Methods and Support to External Control. This action intends to both provide answers to the Public Administration itself in setting a reference to fight fraud and corruption in the management and internal audit area, as well as identify opportunities for improvement of External Control in this area.

Igo Estrela

Rafael Jardim Cavalcante
Secretary
Extraordinary Department of
Special Operations in Infrastructure

More specifically, the reference aims to map and disseminate best practices in fighting fraud and corruption in the Public Administration. The purpose is to provide answers and optimal activity actions related to the management of ethics and top management position; transparency and accountability of its activities; to the complaints services and investigation procedures, implementation and review of preventive and detective controls; to the role of internal audit and risk management unit, to the punishment of those responsible for fraud and correction of damage; among other actions. In a second stage, the project intends to prepare, under the External Control, regulatory guidelines for conducting control actions focused on fighting fraud and corruption.

Seinfra Operations, likewise, came in a very specific context. Established in January 2016 with 20 admittedly experienced auditors, their first responsibility was to prioritize the inspections and instructions related to "Lava Jato" Operation, which already has more than 50 cases.

The works in the department currently cover Petrobras contracts in the refineries of Comperj, Abreu e Lima and Paraná Refinery (Repar); in addition to the public works, purchases and services of Eletronuclear in the mega project of Angra III. Also included in the scope of Seinfra Operations are investments in thermal companies, probes, international platforms and contracts directly involved with "Lava Jato" Operation.

The audits in these ventures differ from the others not only due to the peculiar social appeal of the matters discussed, but mainly because of the type of information that is the facts to be tried in the proceedings. The different context is reflected in the fact that the judge responsible for conducting the "Lava Jato" Operation shared with TCU information from the investigations. In this background, it is necessary to evaluate how to extract the most out of these processes aimed at the triad of fighting corruption: **prevention, detection** and **accountability**.

Also, in view of the natural experience in the handling of "unconventional" documents (largely secret), Seinfra Operations is responsible for all the follow up in the infrastructure area, the Leniency Agreements that might be in negotiation with the Office of the Comptroller General, pursuant to Law No. 12846 / 2013 (Anticorruption Law).

Naturally, before this immersion of information applied to external control, it is urgent to build solid mechanisms, in possession of such data, to perform in a predictive and preventive manner, maximizing the efficiency of control resource allocation based on previously identified risks, in close synergy with the performance of other core business departments of TCU.

For this purpose, the Department was divided into three subunits: a typical Division for analyzing and conducting audits; an information Service for collecting and handling such information; and a Work Group for the specific application of selected information in external control processes.

From the perspective of performance, if in a "traditional" action of control –where there is access to the usual administrative documentation - specialized auditors can eventually identify overpricing and overbillings that can constitute "fuel" for illicit payments, "privileged" documents that both leverage the possibility of identifying such "excess" and enable recognition of those accountable and other irregularities that, otherwise, would missed.

The establishment of knowhow - and a legal framework to collect and treat such information - extends the bias of "detection" and accountability of fraud. It leverages a broader view (fairer and more effective) of "governance of corruption" where possibly certain public officials are deliberately appointed to produce disastrous results.

With "special" information, sometimes produced by "four hands" with other control institutions - in a sum of expertise – we aim to achieve a gray mass of responsibilities that was formerly impossible. The wide accountability of this network, of course, is far more effective for the Republic, for it catalyzes the extraction of the true roots of governance (corruption or governance) built to produce spurious results.

An example of the potential of such information was demonstrated by the TCU in Judgment 1,990/2015-Plenary, reported by the Hon. Minister Benjamin Zymler in the trial of the Delayed Cracking Unit (UCR) from the Abreu e Lima refinery of Petrobras in Pernambuco. In that case, a loss which at the time was of around R$ 150 million, given the treatment of tax information obtained with authorization from the court responsible for conducting the "Lava Jato" Operation, became (still perfunctorily!) an overpricing of almost R$ 700 million in just one contract.

Similarly, in Judgment 2960/2015-Plenary, the Atmospheric Distillation and Diesel Hydrotreating Units, both from the Abreu e Lima Refinery, a latent loss of R$ 1.07 billion would be impossible to be meticulously designed without the information collection so authorized by law.

In the Paraná Refinery (Repar), the hon. Substitute Minister André Luís de Carvalho announced to the Plenary of the TCU, in Judgment 2163/2015-Plenary, R$ 1.3 billion in losses, after re-examining the facts in the face of the "new "procedural context verified with new elements from the processes shared by the "Lava Jato" Operation.

Understanding the need for obtaining and processing information associated with the massive investment in information technology also enabled the production of Judgment 3089/2015-Plenary, reported by the Hon. Minister Benjamin Zymler. With statistical and computerized handling of all contracts from Petrobras involving more than R$ 100 million, in the Supply Department, the Court warned the agencies responsible for conducting the Leniency Agreements in "Lava Jato" Operation that "the most likely amount" from the loss of cartels in Petrobras was of 17%; or R$ 8.8 billion in the Supply Department; or, extrapolating to the other contracts, a potential R$ 29 billion in total losses.

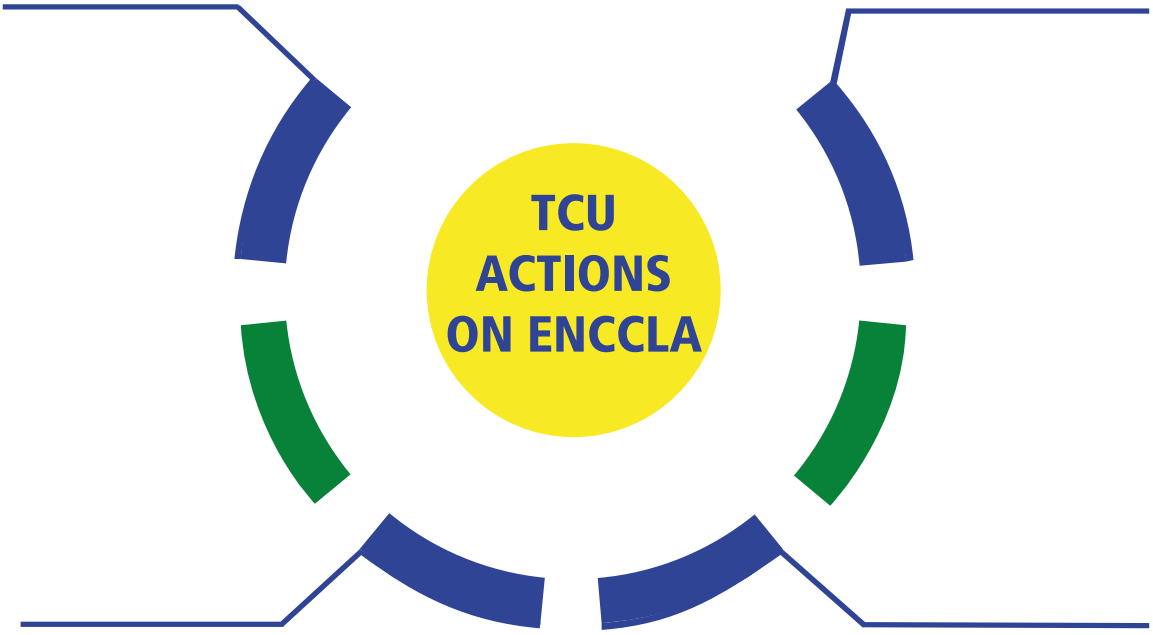
The expectation, with these strategic initiatives, is to offer society measures that have been taken in external control in view of the social and political moment in the country. It is known that it is necessary to account for the possible "reinvention" of control, which is capable of making it more in line with the demand to take action against the pillars of corruption. This issue must be studied and offered to citizens without prejudice of learning from the results presented. Not so much in view of the structural measures already taken, as demonstrated, but mainly in terms of the learning obtained from the results already achieved.

Partnership Against Corruption

The Federal Court of Accounts of Brazil (TCU) participates in the Nacional Strategy to combat Corruption and Money Laundering (Enccla) since its creation, in 2003. It is an initiative that consists in the articulation of various agencies from the three branches of the Republic, public ministries and civil society that act, directly or indirectly, in preventing and combating corruption and money laundering. During this long partnership with Enccla, TCU has contributed actively to the implementation and coordination of actions deliberated by the group..

Establishment of an articulated strategy of fomentation, monitoring and collection of compliance with the Access to Information Law, in relation to active and passive transparency. The participating agencies of the action have developed a unified methodology to evaluate active transparency, which was applied by the Federal Public Ministry in more than 5000 cities around the country, making the creation of the national rank of transparency feasible.

Elaboration and discussion of a document that guides agencies and entities in all the powers of the federal, state, municipal and district spheres to evaluate the integrity programs of medium and large companies under the administrative responsibility process (PAR) scope, or according to leniency, both predicted by Law n° 12.846 of 2013 (Anticorruption Law). The mentioned Law provides for the civil and administrative responsibility of legal entities for practicing acts against public, national or foreign administration and establishes other provisions. Besides this document, the sixteen assessment parameters of integrity programs are defined in article 42 of Decree n° 8.420 of 03/18/2015; the participant bodies are detailing the effectiveness criteria, good practices and what shouldn't be accepted in each parameter.



Conception and proposal to the internal and external control bodies and antitrust bodies of mechanisms to enable access to the base of the electronic invoice and digital bookkeeping of the Public System of Digital Bookkeeping (Sped).

Continue to develop the System of Consultation and Analysis of Contracts with the Public Power and propose a rule for its implementation in all courts of accounts around the country. Under the scope of this action, TCU elaborated and made available for homologation, an interface, which provides to the courts of accounts information related to the Integrated System of General Services Administration data (Siasg).

General Secretariat of Government Audit

Framework for Fighting Fraud and Corruption

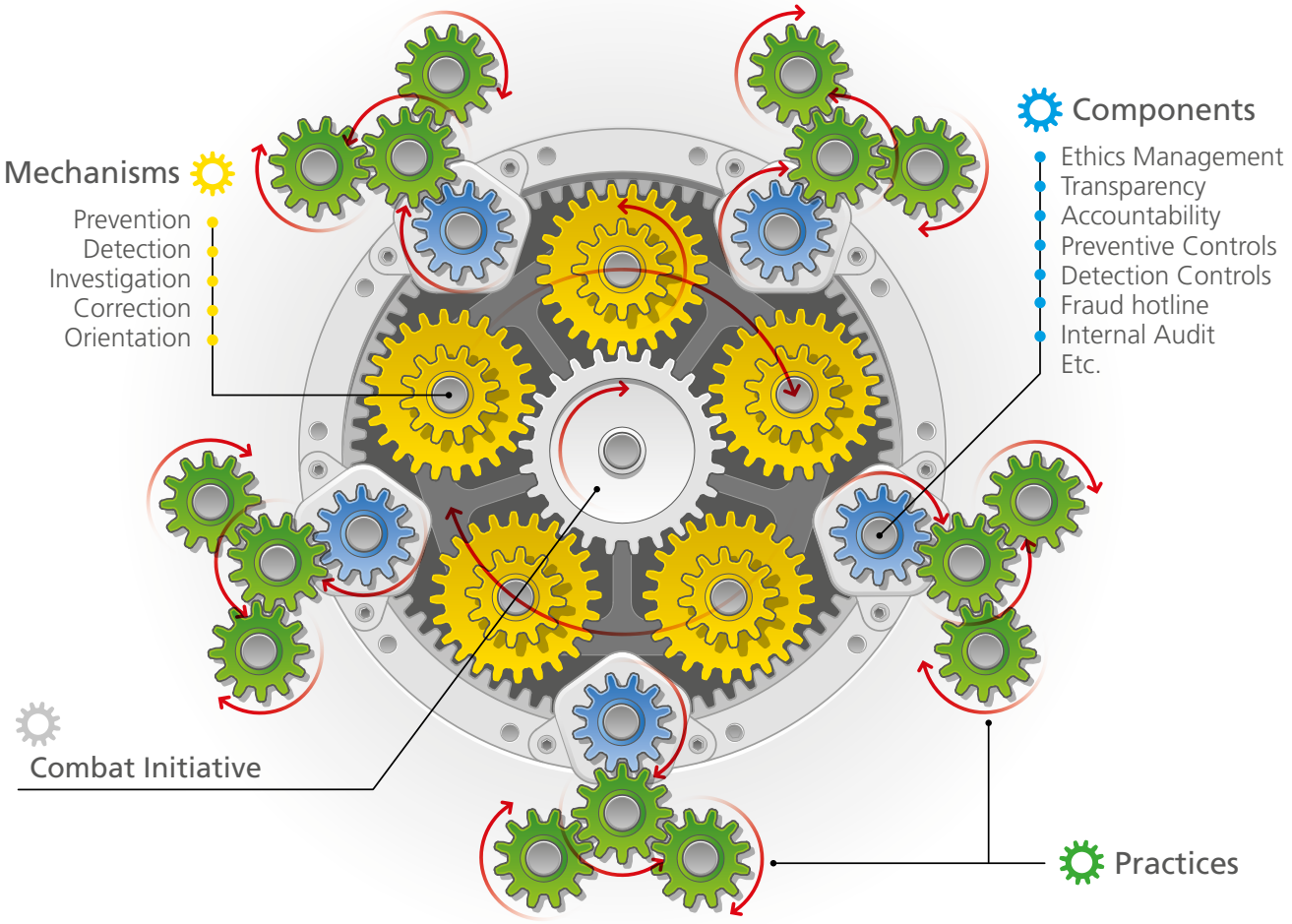
Where: Application in any type of federal, state, and municipal public organization

Who: Managers of public organizations and their internal audit

How: Managers who adopt the suggested practices will be contributing to the fight against fraud and corruption

Why: Fraud and corruption sabotage the quality and result of public services and any attempt to improve them

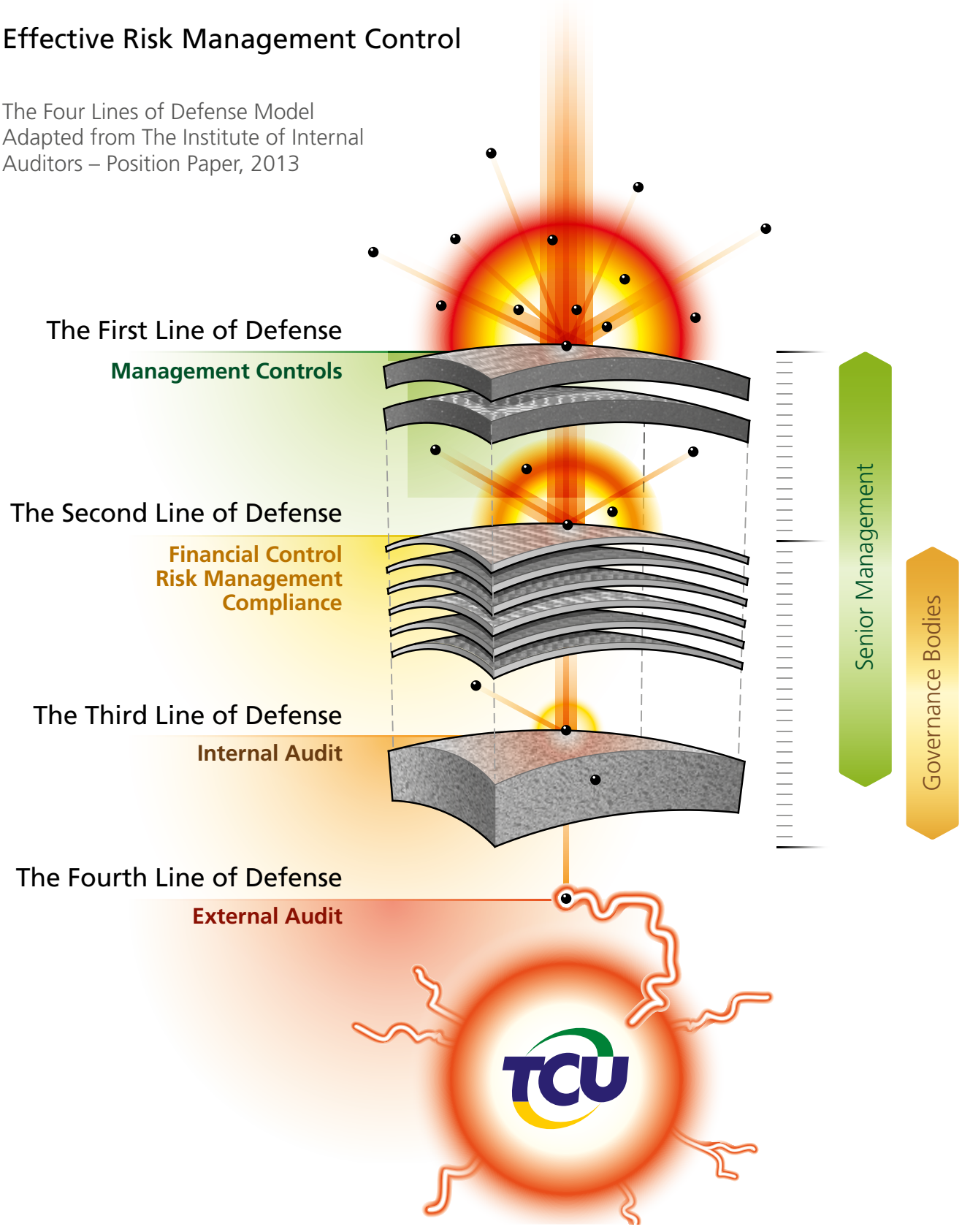
When: In progress



General Secretariat of Government Audit

Effective Risk Management Control

The Four Lines of Defense Model
Adapted from The Institute of Internal Auditors – Position Paper, 2013



General Secretariat of Government Audit

Information Management for External Control

Use of *Deep Learning* in Oversight

Luís André Dutra e Silva is a public servant at the Federal Court of Accounts in Brazil, Bachelor in Computer Science from Uniceub, with a certification in Software Engineering from IEEE and in Projects Management from Stanford University.

ABSTRACT

This article describes how the deep learning technique may be applied to actions of external control and the fight against corruption. Historic facts, which show the evolution of this technique, are presented in this article, as well as the functioning of the artificial and biological neural networks and a set of application examples.

Keywords: machine learning, deep learning, neural networks, fight against corruption, control actions, algorithms.

1. INTRODUCTION

Among the Machine Learning techniques (subject of the body of knowledge on Artificial Intelligence based on algorithms that use a large number of examples for the training of computer models), *Deep Learning* has been highlighted in recent years. A set of techniques that utilizes deep artificial neural networks with many intermediate layers between the input and the output layers (LECUN et al, 2015).

The technological edge of this approach is the excellent results obtained in problem solving, results that exceed even the performance of the best specialists in certain areas of knowledge such as the recognition of locations and semantic features in images;

victory in strategy games more complex than chess; and human beings overcoming verbal comprehension psychometric tests.

The following is a brief history of this technique and its application in oversight and the fight against corruption, as well as a description of the functioning of neural networks.

2. HISTORY

The connectionist models of automatic learning were initially implemented by the industry during the 1950s, due to the emergence of large computer systems. The first attempts to implement these models, however, were not successful, due to limitations of the processing power of computers at that time, coupled with the lack of theoretical foundation that supports the execution of the technique. Among the failed initiatives, we can mention the simulation of "electronic brains" by Nathanial Rochester of IBM's research labs.

Another factor that contributed to reduce interest of the scientific community in this issue was the publication in 1969 of an article by American scientist Marvin Minsky. The article showed that the perceptron, the most primitive artificial neuron, would be inappropriate to reproduce all the basic logic operations like, for example, the "exclusive or" logic function essential for solving Boolean equations.

Despite the difficulties experienced, in the mid-1970s, with the improved processing power of computers, a new algorithm called *backpropagation* (WERBOS, 1974), which demonstrated the possibility of connectionist models to faithfully reproduce all logic operations performed by the human mind, depending only on the number of artificial neurons used and the number of layers designed for specific purposes.

Parallel to the efforts of scientists and engineers to mimic the biological mechanisms of intelligence, in the late 1970s, neuroscientist Vernon Benjamin Mountcastle reached a fundamental discovery in this matter. He demonstrated that the neocortex has a single learning algorithm, which is repeated in all regions of the brain in columnar structures (MOUNTCASTLE, 1978).

Despite the availability of neural network algorithms during the 1980s, only in the mid-1990s came the first research using this technique applied to the analysis of corporate fraud. Kurt Fanning (1995) showed that self-organizing neural networks might be used to predict frauds in the financial reporting by companies.

During the following decade, there were significant advances in low cost parallel computing devices, a fact that enabled the training of highly complex models in infinitesimally less time than previously available by sequential means. In 2004, Jeff Hawkins, a former engineer at Intel and founder

of Palm Inc., argued that the structures discovered by Mountcastle function as small pattern recognizers, whichcan be interconnected in order to learn any concept and even to perform predictions and generalizations about something not experienced (HAWKINS, 2004). In addition, in this decade, new forms of boot parameters caused great enthusiasm among proponents of *Deep Learning*, a technique seen before only as limited to data storage and unable to generalize its predictions.

After 2010, numerous scientific papers were written demonstrating the applicability of neural models that assist large organizations in their corporate governance actions through fraud detection in financial transactions.

A few years later, in 2012, Kurzweil reinforced Hawkins' theory. He has shown that connectionist models, when combined with statistical models, detect temporal patterns and implement the central idea of the organization in hierarchical layers, necessary to pattern recognizers similar to those discovered by Mountcastle.

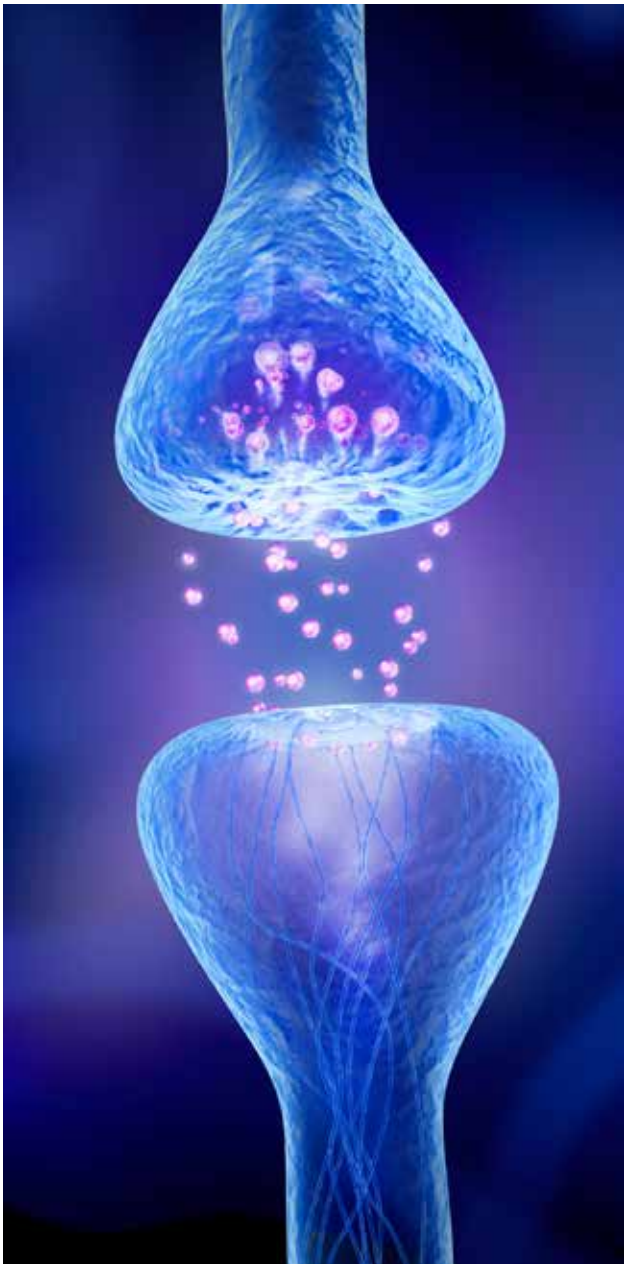
For the purpose of the prediction of irregular activities, the training of artificial models based on their biological counterparts most often occurs without supervision. Thus, the active neurons, which represent the learned concepts, are determined competitively and cannot be directly translated into something that is already known, but need the help of experts to determine the emerging meanings of such a learning process.

Therefore, its most direct applications are in the online form of anomaly detection and in the development of concepts that would traditionally be based on the Artificial Intelligence methods, available on a large scale since the 1960s, to combat corporate fraud, and not in Deep Learning techniques based on a large number of actual and continuous examples.

More recently, in 2014, there were random connection disposal methods, which inserted the noise required for the non-occurrence of simple memorization, allowing the construction of models with exponentially higher than the previous performance, in terms of generalization of behavior (HINTON et al, 2014). The motivation of this connection disposal method is the process that occurs in sexual reproduction, wherein the couple's genes are combined with a small random mutation in the genetic code transmitted by heredity, this being the more efficient means in the evolution of more advanced organisms.

3. OPERATION

In 1981, Mountcastle received the Nobel Prize for Medicine for his discovery (considered the Rosetta Stone of neuroscience) that the fundamental structure of the cerebral neocortex is a minicolumn with about a hundred neurons arranged in six distinct layers and that the human brain has about 100 million of these small structures throughout its



extent (MOUNTCASTLE, 1978). There are connections in both directions, which means, therefore, that the basic unit of our brain is a recurring and modularized network because each of the minicolumns connects to hundreds of other similar ones, forming a column of up to 70,000 neurons whose approximate size is comparable to that of a pinhead. The columns are grouped to form specialized tissues in a given cognitive function, and these tissues, in turn, can be connected to any other module, regardless of the distance that separates them, because there are axons that can go from one extreme to another in the brain.

According to Hawkins (2004), the lower layer of the neocortex has a much larger number of connections (synapses) with terminals originating from axons from other regions of the nervous system than connections that originate from this layer. In this manner, the level representation that the first layer offers is connected to temporal events from the senses. From the second layer, however, progressively persistent concepts and independent of temporal changes are formed. Finally, the neuron activation of the sixth layer occurs whenever patterns are present in the input connections and such activations persist for the duration of the exposure to these standards.

In accordance with a persistent cognitive function of representing concepts, the sixth layer has a much larger number of terminals coming out than the number of synapses connected to dendrites, which are connected to this layer. In addition, a very small number of sixth layer neurons is activated for a given concept and, empirically, it has been proven that always the same neurons are activated for any particular concept (ZADOR, 2000). This demonstration was carried out in a scientific experiment in which persons subject to monitoring of the brain by magnetic resonance imaging, upon displaying the picture of a specific person, always had the same activation of the sixth layer neurons.

Moreover, the simultaneous presence of different patterns in different regions of the neocortex in the first layer makes these patterns enhance the weights (synapses) that associate them. Thus, the neocortex functions as an associative memory in which a pattern or part of it, activates neurons which represent related standards. According to this associative architecture, the function of the sixth layer neurons connections to the others is to make predictions about which standards will succeed those which are present in the immediately inferior connections, reinforcing the sequence of predicted events that were learned by experience.

It is also important to consider the fact that the hierarchical structure of the layers of the visual cortex inspired the creation of convolutional neural networks (CNNs). This type of implementation has proven to be the most suitable for visual pattern recognition (LECUN, 1995). There is nevertheless a fundamental difference between CNNs and biological neural networks: CNNs are generally unidirectional (FFNs), while the natural neural networks are recurring (RNNs).

On another research front, related to an architecture closer to reality, the recurring artificial neural networks, as well as the neocortex, are stimulated primarily by temporal patterns (GRAVES, 2012). Thus, the sequence of successive stimuli allows them to be classified automatically so they can be associated to other sequences previously learned. It is a proven fact, in this case, that the need that the human mind has to learn sequential patterns. For example, the sequence of notes of a melody can be easily remembered. However, our mind can hardly recall the reverse sequence of musical notes.

This limitation does not occur on artificial neural networks, since recurring two-way models (BRNN) can learn any temporal or spatial sequence in both directions. Such models are proven to be more efficient in recognition sequences such as speech, writing and successive events that may be related to any irregularities or unlawful activity.

4. APPLICATIONS IN OVERSIGHT

As an example of an application in textual bases, a simple traditional neural network (*Multi Layer Perceptron*) with few intermediate layers is able to classify high precision types of decisions contained in judgments of the Court. This classification is fundamental for defining a context for the subsequent extraction of attributes (named entities) of the various deliberations that need to be continuously monitored by specialists.

Considering the other extreme, an application on photographic bases, in order to cover a large number of audited public works, convolutional neural networks can be used to monitor, using images obtained by remote sensing, the progress of project implementation. This type of application can perform the comparison of images related to the various stages of each project and indicate possible delays or technical non-conformities with the specifications.

When it comes to detecting anomalies applied to fraud discovery in agreements, for example, an artificial neural network, in unsupervised mode, may recognize abnormal situations in its execution after receiving as input thousands of normal situations that do not represent irregularities. Therefore, if there is a discrepancy between the realized resource flows and the expected execution of the projects, this method can indicate, with high probability, the occurrence of illicit activities.

In the case of treatment sequences, a recurrent network can be trained with the temporal series of price offers and attributes of objects of bids, learning to identify sequences that represent irregularities in the bidding process. This is possible thanks to the large number of examples of previous sequences, which were classified as irregular or not by experts. Therefore, this type of solution would contain the consolidated knowledge of many professionals over decades of experience.

Neural networks can also be used for routing and the classification of irregularities in the Special Rendering of Accounts processes through the recognition of textual and logical patterns in documents from different sources of unstructured data. This process consists in performing unsupervised training, carried out in a large quantity of documents with the purpose of finding semantic clusters that can later be associated with groups of irregularities in these processes. After the association of such groups to the meanings identified by experts, it is possible to create neural models supervised able to perform the same type of classification and routing of new documents, which were not part of the initial training.

5. CONCLUSION

Therefore, the use of Deep Learning solutions to aid in the fight against corruption can cause a gain of sufficient scale to cover a much greater number of cases of irregularities than what is possible to achieve today by a simple sampling related to the materiality of the resources involved. However, of course, the role of the experts of each area involved cannot be discarded, since the situations found automatically do not represent deterministic indications, but indications with a probability associated with the greater or lesser degree of certainty that represent important findings to be overseen by TCU and other oversight bodies.

REFERENCES

MINSKY, Marvin; PAPERT, Seymour. Perceptrons: An Introduction to Computational Geometry. Cambridge: The MIT Press, 1969.

WERBOS, Paul J. Beyond Regression: New Tools for Prediction and Analysis in the Behavioral Sciences. Cambridge MA: Harvard University Press, 1974.

MOUNTCASTLE, Vernon B. An Organizing Principle for Cerebral Function: The Unit Model and the Distributed System. Cambridge: MIT Press, 1978.

LECUN, Y; BENGIO, Y. Convolutional Networks for Images, Speech, and Time-Series. The Handbook of Brain Theory and Neural Networks. Cambridge: MIT Press, 1995.

FANNING, K.; COGGER, K.O.; SRIVASTAVA, R. Detection of Management Fraud: A Neural Network Approach. Nova York: IEEE, 1995

ZADOR, Anthony. Neural Representation and The Cortical Code. San Francisco: Annual Reviews, 2000.

HAWKINS, Jeff; BLAKESLEE, Sandra. On Intelligence. Nova York: Times Books, 2004.

LIVNAT, A; PAPADIMITRIOU, C.; PIPPENGER, N., FELDMAN, M.W. Sex, mixability, and modularity. Proceedings of the National Academy of Sciences. Redwood City: Highwire Press, 2010. Volume 107. p. 1452–1457.

KURZWEIL, Ray. How to Create a Mind: The Secret of Human Thought Revealed. Nova York: Viking Books, 2012.

GRAVES, Alex. Supervised Sequence Labelling with Recurrent Neural Networks. Nova York: Springer 2012.

HINTON, Geoffrey; SRIVASTAVA, Nitish; KRIZHEVSKY, Alex; SUTSKEVER, Ilya; SALAKHUTDINOV, Ruslan. Dropout: A Simple Way to Prevent Neural Networks from Overfitting. Journal of Machine Learning Research. Brookline: Microtome Publishing, 2014. Volume 15. p. 1929-1958.

LECUN, Y; BENGIO, Y; HINTON, G. Deep learning. Nature. Nova York: Macmillan Publishers Limited, 2015. Volume 521. p. 436-444.

External public audits as an instrument in the combat against corruption: The role of the Supreme Audit Institutions

Rute Alexandra de Carvalho Frazão Serra
has a Master's Degree in Law – Legal and Political Sciences from the Autonomous University of Lisbon and a post-graduate in Public Management from the Superior Management Institute of Lisbon. Currently, she is working with external public audit functions, at the Federal Court of Accounts in Portugal.

ABSTRACT

The political and financial external control of the management of – public funds is a mission entrusted to the State under the democratic Rule of Law. In the present, tax-paying citizens who require more and more accuracy, responsibility and transparency in the management of public resources zealously demand its fulfillment. Citizens examine these qualities to have the necessary trust in the institutions that undertake external control.

The Court of Accounts of Portugal (Tribunal de Contas) has the constitutional mandate of carrying out the external control of public management. A sovereign institution supervises the economic and financial management of the Federal Administration, its jurisdiction covers all actors that in any way manage public funds. It acts as a guardian on behalf of the original holders of the right to these funds.

The aim of this article is to analyze public auditing in its condition of an instrument of control *par excellence*, used by the Portuguese Court of Accounts both as a dissuasive and investigative instrument against corruption, particularly by the specific techniques of forensic auditing. Even though forensic audits are not encompassed by the fundamental role and primary aim of the Supreme Audit Institutions, a result of their usefulness is that they are now internationally recognized as a valuable contribution in the combat against corruption.

Keywords: Public audits; Supreme Audit Institutions; Corruption; Forensic audits.

1. INTRODUCTION

The issuance of Act 98/97 on August 26th, 1997, regarding the Organization and Process of Portugal's Court of Accounts [in its original acronym, LOPTC], established audits as the fundamental technique of the Court of Accounts to control public financial activities. However, since the 1980s, the Court has approved a number of individual audit rules while seeking to develop and to apply the norms of its support services [Serviços de Apoio], in conformity with the highest current standards of technical quality and efficiency.[1]

In a context of severe economic and financial crisis such as the present one, public audits will be put to test in their capacity to serve as effective tools to guarantee transparency in public management (Cabeza del Salvador, 2009).[2] The economic and social transformations that have occurred doubtlessly reflect themselves in the way the concept of audit is defined. From a definition based on the reconstitution of past facts, analysts gradually came to emphasize the *preventive and guiding* functions of audits as a field of knowledge.

The importance of auditing public accounts is recognized since the ancient times of the Babylonians, Greeks, Romans and Egyptians. One can actually find a reference to the clear need for the role of auditors in society in Aristotle's treatise on *Politics*. He states the need for a magistrate to be placed above all other magistrates who manage public money, "whose manages nothing for himself and makes others account for their management and corrects it […]".[3]

McMickle (1978)[4] also refers to the writings of Aristotle, who described that the Senate of Athens was constituted by 500 persons who selected a Council of 10 *Logistae* and 10 *Euthuni* to verify the accounts of the public officials with the particular aim of detecting fraud.

2. EXTERNAL PUBLIC AUDITS

For the purpose of brevity, let us now turn to the current definitions of *public audit* and *auditor*, and to how they are characterized, in order to examine the external control exercised by the Court of Accounts.

Despite its initial purpose of verifying accounts and accounting acts, the object of the external audits of public institutions evolved as a result of what Pollit *et al* (1999) called the "machinery of democratic accountability", referring to the Supreme Audit Institutions.[5]

There are several definitions of public audit both from an internal and external perspective. Bearing in mind the aim of this article, I shall focus on the definition of *external public audit*, that is, public audits performed by the Court of Accounts.

INTOSAI defines an audit as a "review of a body's activities and operations to ensure that these are being performed or are functioning in accordance with objectives, budgets, rules and standards".[6]

In turn, the European Court of Auditors (ECA) adopted the following definition[7]: "The objective of an audit of financial statements is to enable the auditor to express an opinion on whether the financial statements

are prepared, in all material aspects, in accordance with an identified reporting framework. The objective of an audit of compliance is to enable the auditor to conclude as to whether the activities, financial transactions, and information comply, in all material respects, with the applicable legal and regulatory framework".[8]

In its Manual of Audit and Procedures, Vol. I, the Portuguese Court of Accounts presents a definition of audit similar to that of INTOSAI: "An audit is a review or verification of a particular matter, in order to analyze its compliance with specific rules, standards or objectives. It is accomplished by a reputable and technically prepared person according to generally established principles, methods and techniques that may enable auditors to form an opinion and issue a report on the matter".[9]

The LOPTC establishes audits[10] - of any type or nature regarding acts, procedures or other aspects of financial management - as the fundamental method of the Court of Accounts for carrying out its control activities.

However, according to Article 55 of the LOPTC and considering the guidance of the Court of Accounts toward integrated control, *all types* of audits are accepted.[11]

The Portuguese Court of Accounts closely follows the classification presented by INTOSAI in the International Standards of Supreme Audit Institutions (ISSAI)[12] and carries out financial audits (ISSAI 1000 to 2999),[13] compliance audits (ISSAI 4000 to 4200)[14] and performance audits, or value-for-money audits (ISSAI 3000 to 3999).[15]

Regarding financial audits, their main scope is to analyze the regularity, legality and reliability of the audited accounts. In conformity with the INTOSAI definitions,[16] independent analyses are carried out and objective opinions are written on the reliability of the accounts and financial statements and on the use of resources by the audited institutions, thus meeting the applicable standards of accounting and financial reporting to which they are subject.

On their turn, compliance audits have the goal of ensuring the degree of fulfillment of the applicable internal and juridical standards, internal policies (established, for instance, by codes of ethics and conduct), and cover a vast array of issues. Compliance audits are developed according to two fundamental criteria: a) *Regularity* – to ensure that the activities, transactions and information presented in the financial statements of the audited institution are in conformity with the applicable legal provisions; and b) *Property* [*or adequacy*] – an analysis of the compliance of the management exercised by the public officials with the applicable principles of public financial management.[17]

Finally, performance audits, or value-for-money audits, are independent analyses of the efficiency, effectiveness and economy regarding how the audited institutions use their resources.[18]

Based on this three-fold classification and on the provisions of article 55 of the LOPTC, the Court of Accounts may also undertake integrated audits[19] or comprehensive audits to attain an integrated view of the audited institution. Consequently, the Portuguese Court of Accounts is not as restricted as other Supreme Audit Institutions, which experience constraints such as limits to their independence, poorly trained personnel, the lack of follow-up on previous recommendations, and limits to the scope of their audits.*20*

Audits can detect *anomalies* when properly conducted by using methods, techniques, tests and samples, and after their distinct stages are concluded (preliminary study, production and approval of a global audit plan, the audit itself [including a concrete assessment and evaluation of the controls of the audited institution, production of a work plan, of audit dossiers and field work], evaluation [production of the audit report and notification to the audited institution, which has the right to object to it] and production of the report.

Such *anomalies* can range from *simple mistakes and irregularities* to cases of *financial violations* or even *criminal violations* (unlawful acts). Therefore, it is fundamental that the work plan of an audit reasonably ensure the detection of anomalies. Depending on their legal status, such anomalies may have to be communicated by the Public Prosecutor's Office to the applicable judicial instances.

If an *error*, an *irregularity* or even a *violation* is detected during the audit, the auditor can change the audit program. The auditor must meet all evidentiary requirements possible, obeying the applicable rules for testimonials, while bearing in mind that both from a material and formal perspective, the evidence produced by the audit can be used in judicial procedures.

Thus, the work documents of auditors are indispensable *means of evidence* for any lawsuits that may arise.[21]

The *errors* can be omission, duplication, compensation, imputation or an error of principle. Upon their detection, auditors must produce audit recommendations to the audited institution so they can correct them. In turn, an *irregularity* can be an intentional or unintentional violation of a law, or of an accounting or administrative standard or principle. If an error is not corrected in a timely manner, it can become an irregularity in the form of a *systematically recurrent error*. Errors, as much as irregularities, can lead to financial consequences.[22]

An irregularity can be characterized as a *fraud* when the applicable juridical requirements are present in relation to both the objective and subjective elements of an audit.

A *fraud* is generally present in cases of manipulation of the law, falsification, modification or voluntary omission of entries and/or supporting documents with the intention of producing an incorrect record of the financial data or a misappropriation of assets or embezzlement of funds for purposes other than those for which they were assigned.[23]

3. EXTERNAL PUBLIC AUDITS AND THE COMBAT AGAINST CORRUPTION: FORENSIC AUDITING

Preventing corruption is not a direct objective of the Supreme Audit Institutions. Nonetheless, it is during the process of audits that most frauds and evidences of corruption are detected.[24] Furthermore, as Dye (2007) affirms, SAIs cannot remain indifferent to the intrinsic difficulties of legislators in the field of combat against corruption, especially in the contexts of less developed countries.[25]

In 2013, INTOSAI issued the international standards ISSAI 300 and ISSAI 400 on the fundamental principles of performance auditing and compliance auditing. Both standards specify the type of information to be included in audit reports, which must *accurately* describe their audit objectives, the *evidences* collected during the audit process and its *results*. Audit reports must also accurately describe their *subject matter, criteria, methodology, sources of data* and any limitation to the data used, along with the audit *findings*.[26]

Around the year 2000, because of the widely recognized importance of the concept of *accountability* for the future of democracies, a new way of thinking began to emerge regarding the future role of audits and of the Supreme Audit Institutions, in view of the t social, economic and financial transformations taking place in an at an unstoppable pace.[27]

In this context, it is evident that all governance instances must contribute to an effective transparency at the political, legal and financial levels. In the words of Dobrowolski (2013) the SAIs must "contribute to combating corruption through their audit work".[28]

Several studies[29] have pointed out limitations in the mandates of the SAIs in relation to all types of audits. However, none of them has mentioned the Portuguese Court of Accounts.[30] In this specific case, there are no legal obstacles to audits with a different scope from the traditional scopes of financial audits, performance audits and compliance audits. Nor is the mandate of the Portuguese Court restrictive in this regard.

In addition to the traditional types of audits carried out by the SAIs, Dye (2007) identifies a new type of audit, namely *forensic audit*. In this type of audit, "auditors design their audits to gather evidence to prove the existence of fraud and/or corruption. The skills required to do this exceed the audit skills necessary to conduct a financial or compliance audit".[31]

In the present, the SAIs of countries of Anglo-Saxon tradition frequently carry out this type of audit.[32]

In 2005, Brazil's Court of Accounts [Tribunal de Contas da União-TCU] requested information to the Office of the Auditor General of Canada with a view to creating a department identical to the Canadian Forensic Audit Unit.[33] Also in 2005, the Comptroller General of the Republic of Costa Rica started a similar process as a joint venture with the same goal, in liaison with the Canadian Office of the Auditor General.[34]

The debate about whether or not it is opportune for SAIs to develop forensic audits in addition to the traditional audits has not been a pacific one. However, in 1997, during the 4th Triennial Congress of the Caribbean Organization of Supreme Audit Institutions (CAROSAI) in Georgetown, Guyana, World Bank consultant James P. Wesberry Jr. affirmed that "in a world which is being devastated by collapsing morals, […] there will be no other alternative to SAIs than to man the front lines in the battle against corruption by rapidly developing a special group of forensic auditors capable of performing *independent investigatory audits* [emphasis added] wherever corruption is alleged".[35]

As to the Portuguese case, Lopes (2003) asserted that the competence and jurisdictional powers of the Court of Accounts suffice for efficaciously combatting corruption.[36]

International organizations have not refrained from approaching this subject. INTOSAI itself clearly addressed the issue of cooperation among SAIs and internal audits in the public sector, and stated that in addition to performance and compliance audits, SAIs must also carry out *special examinations and forensic audits*.[37]

This concern by the international organizations is by no means recent. In 1998, the 16th International Congress of Supreme Audit Institutions (INCOSAI) held debates regarding the role of SAIs in the prevention and detection of fraud and corruption, and the adequate methods and techniques to attain this aim.[38] On its turn, the 21st United Nations / INTOSAI Symposium held in Vienna in 2011 on "Effective practices of cooperation between Supreme Audit Institutions and citizens to enhance public accountability" resulted in the conclusion, *inter alia*, that citizens have the duty to warn SAIs about situations of fraud and corruption, whereas SAIs must create mechanisms to manage this type of information. The SAIs of Mexico and the USA are mentioned in connection with this discussion, due to the mechanisms that they have established to receive and deal with citizen denunciations.[39]

In 2013, the United Nations and INTOSAI undertook a joint project focused on the role of the SAIs

in the combat against corruption.[40] After collecting data on the theme, this project published a first document with its conclusions.[41] The same concern was reflected by the OECD, which confirmed the need for SAIs to dedicate themselves to *new types of audits* that may allow the identification of situations of corruption and fraud.[42] The European Court of Accounts is providing guidance on its website regarding how to collect audit data and to conduct audit interviews, along with guidelines for auditors on the issue of fraud.[43]

According to the definition of Singleton (2006), a *forensic audit* is a process to detect, prevent and correct fraudulent activities. Therefore, forensic auditors must be capable of preventing a reasonable hypothesis of fraud.[44]

Ayala (2008) also defines a forensic audit as a type of audit that may emerge whenever a fraud is detected during another type of audit. In this regard, the investigation of a financial fraud depends on the type of fraud, the environment in which it was committed (that is, public or private sector) and the applicable legislation. On the other hand, a forensic audit can start directly without a previous audit of another type, for instance, in specific cases of *denunciation*.

Forensic audits can be either *preventive* or *reactive*. A *preventive*[45] forensic audit has the objective of providing assurance to organizations regarding their ability to dissuade, prevent and react against financial frauds. It may include previous consultancy tasks to implement anti-fraud programs and controls, along with mechanisms of alert in case of irregularities, and a complaint management system. This first approach is preventive inasmuch as it comprises actions and decisions in the present to avoid frauds in the future. On its turn, the goal of a *reactive* forensic audit is to iden-

tify financial frauds by undertaking a deep investigation to provide clarifications on the amounts involved in a fraud, along with its direct and indirect effects, its legal status and its presumable authors and accomplices. The *destination* of the conclusions of this type of forensic audit are the judicial authorities, in particular the criminal authorities. Their approach is reactive inasmuch as they comprise actions and decisions in the present as a response to facts that occurred in the past. Finally, there may arise the need to perform a *comprehensive forensic audit* – that is, a forensic audit at once preventive and reactive.[46]

In the context of the Portuguese Court of Accounts, forensic audits are linked to evidence collection techniques specifically adapted to sustain the collected evidence, and to the appointment and preparation of auditors to testify in trials.[47] On the other hand, the process of establishing a specific department with the adequate analytic *tools* to receive and deal with fraud complaints from a forensic perspective, while providing *expert training* to the auditing personnel of the Court of Accounts, may enable a situation in which an autonomous department, or a number of *expert auditors* integrated to the work of the regular audit teams can undertake forensic audits whenever the evidence of fraud is found in other types of audits.

The resulting *advantage* of such an innovation[48] is that it would pave the way for audits specifically aimed at *routine evaluations of risk* and *detection of financial fraud*, in line with the rationale expressed by the above-mentioned international organizations as reasons for concern and action by the SAIs.[49] It would strengthen the *efficiency* of the Public Prosecutor's Office in its roles of filing financial liability lawsuits and referring cases that involve audits to the appropriate authorities upon the discovery of criminal activity.

Therefore, this solution would enable *gains of efficiency* in lawsuits filed by the Public Prosecutor's Office.

4. CONCLUSION

Audits are now definitively accepted by Portugal's Court of Accounts as the fundamental technique of control of public financial activities. Considering the Court of Accounts' current trend toward integrated control, Act 98/97 regarding its Organization and Process has proved to include all types of audits, even though financial, performance and compliance audits still play the central role among its activities. This fact is in line with the orientations of the international instances of which the Court of Accounts is a member.

Whenever an error, irregularity or violation is detected during an audit, the auditor in charge must take all necessary steps regarding the collected evidence and meet the applicable rules for testimonials, while ensuring that the evidence provided by the audit is sufficient and appropriate for judicial use both in material and formal terms.

Several international organizations are currently concerned and express converging views regarding the usefulness of the Supreme Audit Institutions as actors that can play a leading role in the combat against fraud and corruption by carrying out specific types of audits in order to detect such violations.

The Portuguese Court of Accounts can actively contribute to the prevention of fraudulent acts by public managers and other officials responsible for public affairs by carrying out *forensic audits*. Forensic audits can be either preventive or reactive, and the legal mandate of the Court of Accounts does not pose any obstacle to their practice.

In the context of the Portuguese Court of Accounts, forensic audits are linked to evidence collection techniques specifically adapted to sustain the collected evidence, and to the appointment and preparation of auditors to testify in trials.

On the other hand, the process of establishing a specific department with the adequate analytic *tools* to receive and deal with fraud complaints from a forensic perspective, while providing *expert training* to the auditing personnel of the Court of Accounts, may enable a situation in which an autonomous department, or a number of *expert auditors* integrated to the work of the regular audit teams can undertake forensic audits whenever the evidence of fraud is found in other types of audits.

The resulting *advantage* of such an innovation is that it would pave the way for audits specifically aimed at *routine evaluations of risk* and *detection of financial fraud*, in line with the rationale expressed by the above-mentioned international organizations as reasons for concern and action by the SAIs. It would strengthen the *efficiency* of the Public Prosecutor's Office in its roles of filing financial liability lawsuits and referring cases that involve audits to the appropriate authorities upon the discovery of criminal activity.

Therefore, this solution would enable *gains of efficiency* in lawsuits filed by the Public Prosecutor's Office.

NOTES

1 *Manual de auditoria e procedimentos do Tribunal de Contas*, Vol. I, p. i.

2 CABEZA DEL SALVADOR, Ignacio, "Reflexiones sobre la crisis económica y el papel de la auditoría pública", in *Auditoría Pública*, nº 47, pp. 27-45, apud HERNANDÉZ, Antonio M. López, "Control e Auditoria del sector público en un escenario de crisis económica", in *Revista Auditores*. Instituto de Censores Jurados de Cuentas de España, nº 15, Mayo de 2011.

3 ARISTÓTELES, *Tratado da Política* [Aristotle's *Politics*], Publicações Europa-América, 2000, p. 102.

4 MCMICKLE, P., 1978, "The nature and objectives of auditing: A unified rationale of public, governmental, and internal auditing", United States of America: UMI Dissertation Services, *apud* TARA, Ioan Gheorghe, SIMONA, Gherai Dana, *Historical analysis on the appearance of the Supreme Audit Institutions in the European Union*, p. 708. Available at *http://steconomiceuoradea.ro/anale/volume/2014/n1/077.pdf* (Access on Feb. 2, 2015).

5 See POLLIT, C. / SUMMA, H., "Performance audit and public management reform", p. 1, in POLLIT, C., et al (1999), *Performance or compliance? Performance audit and public management in five countries*. Oxford: Oxford University Press, 1999. Available at: http://fdslive.oup.com/www.oup.com/academic/pdf/13/9780198296003.pdf (Access on February 2, 2015).

6 See the definition of the Court of Accounts' publication *Manual de auditoria e procedimentos do Tribunal de Contas*, Vol. I, p. 23.

7 This definition regards audits of financial statements and compliance audits.

8 See European Court of Accounts, "Financial and compliance audit manual", p. 266. Available at http://www.eca.europa.eu/Lists/ECADocuments/FCAM_2012/FCAM_2012_EN.pdf (Access to the Portuguese version of the Manual on February 2, 2015).

9 See *Manual de auditoria e procedimentos do Tribunal de Contas*, Lisboa, Abril 1992, Vol. 1, Annex 1, item 11.

10 According to article 55 of the LOPTC.

11 This is confirmed by subparagraph c) item 2, article 3 of the Regulations of the 2nd Section of the Court of Accounts [Regulamento da 2ª Secção (RSS) do Tribunal de Contas], approved by Resolution 3/98 – 2ª S., June 4th, amended by Resolution 2/2002 of January 17th and Resolution 3/2002, of June 5th.

12 http://www.issai.org/about-the-issai-framework/ (Access on January 17, 2015).

13 http://www.issai.org/media/13509/financial_audit_guidelines_e.pdf (Access on January 17, 2015).

14 http://www.issai.org/media/13513/compliance_audit_guidelines_e.pdf (Access on January 17, 2015).

15 http://www.issai.org/media/13517/performance_audit_guidelines_e.pdf (Access on January 17, 2015).

16 See the "Glossary of terms to the INTOSAI financial audit guidelines", p. 56. Available at http://www.issai.org/media/13509/financial_audit_guidelines_e.pdf (Access on January 17, 2015).

17 *Idem*, p. 55 (Access on January 17, 2015).

18 *Idem*, p. 58 (Access on January 17, 2015).

19 Or "integrais", according to COSTA, Paulo Nogueira da, *op. cit*. p. 68.

20 In this regard, see STAPENHURST, Rick, in "Features and functions of Supreme Audit Institutions", The World Bank, #59, October 2001. Available at: http://web.worldbank.org/WBSITE/EXTERNAL/EXTABOUTUS/ORGANIZATION/EXTPREMNET/0,,contentMDK:22454972~pagePK:64159605~piPK:64157667~theSitePK:489961,00.html (Access on January 17, 2015).

21 See ISSAIs 1230, 1500 and 1501, which emphasize the importance of the collected means of evidence during audits, especially for the Supreme Audit Institutions with jurisdictional powers, such as in the case of the Portuguese Court of Accounts. Available at http://www.issai.org/4-auditing-guidelines/general-auditing-guidelines/ (Access on January 17, 2015).

22 See *Manual de auditoria e procedimentos do Tribunal de Contas*, Vol. I, p. 72.

23 See *Manual de auditoria e procedimentos do Tribunal de Contas*, Vol. I, p. 73.

24 See BORGE, Magnus, "The role of Supreme Audit Institutions (SAIs) in combating corruption". Paper presented at the workshop Public Sector Financial Transparency and Accountability: The Emerging Global Architecture and Case Studies. 9th International Anti-Corruption Conference. Durban, October 1999.

25 "Corruption and fraud detection by Supreme Audit Institutions", apud SHAH, Anwar, *Performance accountability and combating corruption*. Public Sector Governance and Accountability Series, World Bank Publications, 2007, p. 305.

26 See GONZÁLEZ, Elena Herrero, in "Las limitaciones en auditoría pública", in *Revista Auditoría Pública*, nº 63, 2014, pp. 21-28.

27 See, for instance, *Código de boas práticas em matéria de transparência das finanças públicas*, published in 1998 (republished in 2007), by the IMF. Available at: http://www.imf.org/external/np/fad/trans/code.htm (Access on January 23, 2015). Or the *Sun City Declaration* issued at the 17th Commonwealth Auditors General Conference, which took place on October 10-13 in South Africa. The Sun City Declaration laid the foundations for the SAIs regarding issues such as the value of the product of audits and the role and the responsibilities of the SAIs in this regard; the importance of the SAIs in the promotion of environmental audits; and the importance of the audits of information technology systems (in relation to this final issue, see *International Journal of Government Audit*, January 2000, Vol. 27, #1, pp. 7-10).

28 DOBROWOLSKI, Z., in "The role of the Supreme Audit Office in combating corruption", Ljubljana, Slovenia, 2011, apud INTOSAI, *Guideline for the audit of corruption prevention in government agencies*. Bona, February 26th, 2013, p. 7.

29 By means of example, see STAPENHURST, Rick, *op. cit*.

30 See subparagraph c), item 2, art. 3 of Resolution 3/98 – 2ª S. June 4th, Regulations of the 2nd Section [Regulamento da 2ª Secção].

31 "Corruption and fraud detection by Supreme Audit Institutions", apud SHAH, Anwar, *Performance accountability and combating corruption*. Public Sector Governance and Accountability Series, World Bank Publications, 2007, p. 313.

32 The Supreme Audit Institution of the USA – Government Accountability Office (GAO) – has a specific unit for this type of audit: the Forensic Audits and Special Investigation Unit. The main objectives of this unit are to "conduct complex investigations […] and analysis of federal government programs and processes; interview witnesses, subjects and informants to solicit information and collect data; distinguish between relevant and irrelevant evidence, and prepare analyses and recommendations; perform undercover work and surveillance using a variety of equipment to collect and document evidence; collaborate with other auditors, analysts, attorneys and investigators; develop and maintain relationships with the federal government […] law-enforcement agencies; and to prepare technical reports, […] testimony and reports of investigations". Available at: *http://www.gao.gov/careers/criminal.html* (Access on January 23, 2015).

33 Subsequently to this request, a synthesis-report was produced by MODENA, Carlos César "Implementing an anti-fraud/anti-corruption strategy in the Brazilian Court of Accounts". Available at: http://portal2.tcu.gov.br/portal/pls/portal/docs/2053600.PDF (Access on January 23, 2015).

34 See the final paper produced by FALLAS, José Alpízar, "Implementing the forensic audit capability of the Contraloría General de la República de Costa Rica". Available at https://www.ccaf-fcvi.com/index.php?option=com_k2&view=item&id=19:mproving-he-orensic-audit-capability-of-the-contralor%C3%ADa-general-de-la-rep%C3%BAblica-de-costa-rica&Itemid=334&lang=en (Access on January 23, 2015).

35 See WESBERRY, James P., Jr., *in 21st century challenge to Supreme Audit Institutions*, 4th Triennial Congress of the Caribbean Organization of Supreme Audit Institutions (CAROSAI), Georgetown, Guyana, March 18, 1997, pp. 6-7.

36 See LOPES, Helena Abreu, "O papel do Tribunal de Contas português na prevenção da corrupção", in *Revista do Tribunal de Contas*, n.º 40, 2003, pp. 113- 128.

37 See INTOSAI, "Coordination and cooperation between SAIs and internal auditors in the public sector", p. 4. Available at: http://www.issai.org/media/13353/intosai_gov_9150_e_.pdf (Access on 24.01.2015).

38 As to the essential issues of the Sun City Declaration on this matter, the mandate of SAIs is not restrictive in relation to this type of audits. However, the methodologies in this field need to be enhanced in their ability to encourage public management to establish (both proactive and reactive) internal controls in order to prevent and detect fraud. On the other hand, it is necessary to establish legal mechanisms to preserve sensitive computational data. The current techniques of forensic audits will help improve the expectations of citizens in relation to the auditors' work of preventing and detecting frauds. Finally, when producing audit programs, auditors must envisage the most diligent methods capable of ensuring the detection of a fraud whenever it occurs.

39 Such mechanisms include, among other features, denunciation hotlines and computer programs for detecting financial frauds. See United Nations, Economic & Social Affairs, "Citizen engagement practices by Supreme Audit Institutions – Compendium of innovative practices of citizen engagement by Supreme Audit Institutions for public accountability". January 15, 2014, p. 9.

40 The name of the project is "INTOSAI Platform for Cooperation with the United Nations".

41 This document is available at Http://workspace.unpan.org/sites/Internet/Documents/A_UN-INTOSAI_Joint_Project_For_Digital%20Book.pdf (Access on 6.2.2015).

42 See, in this regard, the document available at: http://www.intosai.org/fileadmin/downloads/downloads/3_committees/4_goal4/FAC_TFSP_OECD_Partners_Good_Governance_Mapping_Role_SAI.pdf (Access on 6.2.2015).

43 Information available at: http://www.eca.europa.eu/pt/Pages/AuditMethodology.aspx (Access on 2.2.2015).

44 See SINGLETON, Tommie, SINGLETON, Aaron, BOLOGNA, Jack, LINDQUIST, Robert, *Fraud auditing and forensic accounting*. New Jersey, USA: John Wiley & Sons, Inc., 3rd edition, 2006, p. 55.

45 Or proactive.

46 See AYALA, Jorge Badillo, "Auditoría Forense – Más que una especialidad profesional una misión: prevenir y detectar el fraude financiero", Mayo de 2008, V.2.0, p. 5. Available at https://na.theiia.org/translations/PublicDocuments/Auditoria_Forense_Una_Misi%C3%B3n_JBadillo_Mayo08%2814023%29.pdf (Access on 24.01.2015).

47 In this regard, the criminal procedure rules related to the means of evidence (articles 124-170 of the Portuguese Code of Criminal Procedure) and evidence collection (articles 171-190 of the Code) play a fundamental role. The auditors and technicians who carry out verifications belong to the special inspection staff of the Court of Accounts, and are not considered criminal police officials (such a qualification is not necessary, since the scope of their activities is distinct from that of criminal investigations *tout court*). Yet, either in relation to the current legal prerogatives, or to the international standards applicable to public audits – in particular, the audits carried out by the SAIs –, it would be convenient for the inspection staff of the Court of Accounts (or for a part of it) to receive special training in these criminal investigation techniques that have become useful for forensic audits. Auditors would doubtlessly play the role of official experts (which is formally accepted nowadays, but has not yet been recognized in material terms) whenever required. On the other hand, when collecting evidence – especially testimonials and documents – considering the current criminal legislation, the Public Prosecutor's Office would guarantee a more efficient audit process for the purposes of financial liability lawsuits. In this sense, Antônio Cluny states: "(…) during an audit, upon the evidence of a financial violation that could harm good management practices and the proper use of public funds, it would be important to count with a prompt judicial proceeding that could be independent from the audit at issue, and capable of carrying out a routine evaluation of its evidences, underlying risks and of the usefulness of

a timely consideration of the public interest with efficient and adequate means" (CLUNY, *Responsabilidade financeira e tribunal de contas. Contributos para uma reflexão necessária*, Coimbra Editora, 1ª Ed. Dezembro 2011, p. 242). On the other hand, Helena Ferreira Lopes affirms that "(…) the overall evidence comprises the audit evidence, that is, the documents that provide a basis for the reported conclusions regarding a specific set of facts – authentic, authenticated and specific documents, including the exams, inspections, evaluations and declarations signed by the responsible officials or other responsible parties", and that "(…) an audit is an activity marked by the perception and valuation of a specific reality of facts by individuals with special technical and scientific knowledge – namely, auditors. This means to say that we do stand before an inspection-activity, and that an audit is indeed an inspection", thus recognizing an equivalence between auditors and inspection experts, in accordance with the Code of Criminal Procedure, and the importance of the means of evidence during an audit. LOPES, "O valor probatório do relatório de auditoria em juízo", in II *Encuentro de los Tribunales de Cuentas de España y Portugal*. León, 23 y 24 de septiembre de 2004 – Madrid, 2005, pp. 297-318. In any case, it would not be totally senseless if the general definitions of evidence provided by articles 513 to 522-C of the Civil Procedure Code could underlie the evidence-collection methodology to be used in this type of audit.

48 This would necessarily result in specific modifications to the organic statute of the General Direction of the Court of Accounts.

49 See ISSAI 1240 issued by INTOSAI, which deals particularly with the responsibilities of auditors in relation to fraud during financial audits. Available at: http://www.issai.org/media/13096/issai_1240_e_.pdf (Access on 24.01.2015).

BIBLIOGRAPHICAL REFERENCES

AYALA, Jorge Badillo, "Auditoría Forense – Más que una especialidade profesional, una misión: prevenir e detectar el fraude financiero", May 2008, v.2.0. Available at: https://na.theiia.org/translations/Public Documents/Auditoria_Forense_Una_Misi%C3%B3n_JBadillo_Mayo08%2814023%29.pdf

ARISTÓTELES, *Tratado da política* [Aristotle's *Politics*]. Publicações Europa-América, 2000, p. 102.

CABEZA DEL SALVADOR, Ignacio, "Reflexiones sobre la crisis económica y el papel de la auditoría pública", in *Revista Auditoría Pública*, nº 47.

CLUNY, António, *Responsabilidade financeira e Tribunal de Contas – Contributos para uma reflexão necessária*. Coimbra Editora, 1ª Ed., Dezembro 2011.

DYE, Kenneth M., "Corruption and fraud detection by Supreme Audit Institutions", apud SHAH, Anwar, *Performance accountability and combating corruption*. Public Sector Governance and Accountability Series, World Bank Publications, 2007, p. 305.

DOBROWOLSKI, Z., "The role of the Supreme Audit Office in combating corruption". Ljubljana, Slovenia, 2011, in *Guideline for the audit of corruption prevention in government agencies*. Bona, February 26, 2013.

MCMICKLE, P., 1978, "The nature and objectives of auditing: A unified rationale of public, governmental, and internal auditing". United States of America: UMI Dissertation Services, *apud* TARA, Ioan Gheorge, SIMONA, Gherai Dana, in *Historical analysis on the appearance of the Supreme Audit Institutions in the European Union*", p. 708. Available at: *http://steconomiceuoradea.ro/anale/volume/2014/n1/077.pdf* .

POLLIT, C., GIRR X., LONSDALE, J., MUL, R., SUMMA, H. & WAERNESS, M., (1999), *Performance or compliance? Performance audit and public management in five countries*. Oxford: Oxford University Press.

LOPES, Helena Abreu, "O papel do Tribunal de Contas português na prevenção da corrupção", in *Revista do Tribunal de Contas*, n.º 40, 2003, pp. 113- 128.

LOPES, Helena Ferreira, "O valor probatório do relatório de auditoria em juízo", in II Encuentro de los Tribunales de Cuentas de España y Portugal. León, 23 y 24 de septiembre de 2004 – Madrid, 2005.

SINGLETON, Tommie, SINGLETON, Aaron, BOLOGNA, Jack, LINDQUIST, Robert, *Fraud auditing and forensic accounting*. Jonh Wiley & Sons, Inc, 3rd edition, 2006.

Computational Intelligence Applied to Audits: Pattern Classification Using Artificial Neural Networks.

Renan Martins de Sousa
is a public servant at the Federal Court of Accounts in Brazil, with a degree in Electrical Engineering from Ceará State University and has a specialist degree in regulation of telecommunications services from the National Institute of Telecommunications (Inatel) and from the International Union of Telecommunications (UIT)..

ABSTRACT

The rise in the demand for greater transparency of information held by the public bodies has been leading to an increased availability of various databases. This fact, allied with the advances on the processing capacity, has been promoting interest in the use of computational intelligence in less explored areas, such as the audit activities related to public administration control. The ability of the artificial neural networks to classify patterns may help control agencies to perform their duties more efficiently. Typical applications of classification standards in auditing are related to fraud detection, auditing of financial statements and risk assessment, among others. The Federal Court of Accounts of Brazil (TCU), aware of this reality, has been carrying out several actions to develop skills associated with data analysis.

Keywords: Applied Computational Intelligence. Neural Networks. Pattern Classification. Audit. Federal Court of Accounts.

1. INTRODUCTION

The technological advances made in recent decades, both regarding computer processing and to data storage capacity, combined with the increasing availability of information, pose a great challenge for those who need to treat them and issue an opinion based on such treatment.

According to Byrnes *et al* (2014), data science, likewise, has advanced enormously, incorporating theories, techniques and software applications from many disciplines, including data analysis, business intelligence, mathematics and probability, statistical learning (including pattern recognition), data visualization and analysis and treatment of large data sets, such as data mining and visualization.

The application of these theories may be used by control bodies, so that they may present new types of evidence and conduct more focused audits, and may result in more reliable opinions on the audit objects, even when subjected to high performance requirements, such as time, accuracy and cost.

This article conceptualizes pattern classification as an applied computational intelligence tool and briefly outlines the origins, features and training of artificial neural networks, especially the multilayer perceptron (MLP) network, illustrating its use in auditing. Moreover, it shows how the Federal Court of Accounts (TCU) has encouraged the treatment of information databases to render its performance more effective, timely and intelligent.

2. WHAT DOES PATTERN CLASSIFICATION MEAN?

Automatic recognition, description, grouping and pattern classification are very important tools for a wide range of engineering and sciences disciplines, such as biology, psychology, medicine, computer vision, artificial intelligence and remote sensing, among others.

However, what are patterns? Jain, Duin and Mao (2000 apud Watanabe, 1985) define pattern as "the opposite of chaos; an entity to which a name may be assigned". For example, a pattern may be a voice signal, a DNA sample, a text document, a video clip, a fingerprint, a handwritten word etc.

Once there is a pattern, its recognition (or classification) may be carried out with or without supervision. Without supervision, the pattern is associated with a class unknown until then, a technique known as clustering. In this case, the problem lies in categorization, in which classes are defined by the system designer or are learned based on the similarity of patterns. With supervision, of greater interest to this paper, the pattern is identified as part of a predefined class. The separation of patterns among classes may be carried out by a discriminant analysis.

Examples of applications in this field include data mining, document classification, financial forecasts, organization and search in multimedia databases and biometrics, among many others.

In short, pattern recognition consists in studying how machines can observe the environment, learn to distinguish patterns of interest and make reliable and reasonable decisions about the categories of these patterns.

The design of a pattern recognition system involves three basic macro steps: (i) data acquisition and preprocessing; (ii) data representation and (iii) decision-making. In general, the problem domain determines the choice of the

method applied in each of these steps. The models most commonly used to make decisions on pattern recognition are: template matching, structural matching, statistical classification and artificial neural networks.

3. ARTIFICIAL NEURAL NETWORKS

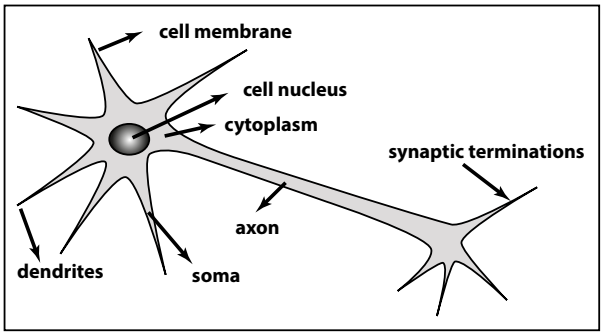
Artificial neural networks are numerical processing systems, and consist in connecting a large number of simple processors. These interconnections have biological origin, namely, the nervous system of living things. The concept underlying these systems is that complex processing may be obtained when many simple, highly interconnected processors are combined, and such concept is referred to in literature as connectionism.

Connectionism, which employs distributed and parallel processing, as opposed to centralized processing, represents with certain ease the features of cognitive processes, such as the ability to simultaneously consider a number of restrictions or combine various sources of knowledge. It is also able to represent the ability to generalize.

In spite of their biological inspiration, the current models of neural networks do not represent the aspects and structures widely known to brain physiology, such as the spatial organization of neurons and interconnections and the existence of various types of signals between these "processors". This is due to the search for balance between the biological plausibility of such models and their mathematical treatment.

The figures below illustrate the schematic view of a typical neuron (Figure 1) and an abstraction for computational purposes (Figure 2):

Figure 1:
A typical neuron



Source: http://blogdopetcivil.com/2013/07/05/redes-neurais-artificiais/

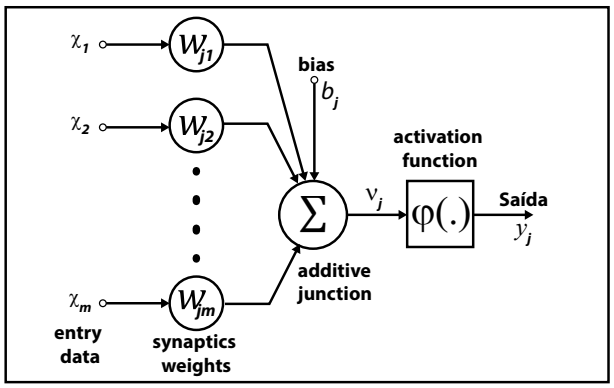
The fundamentals of the current neuron model and the principle of association were set out in the late nineteenth century, in the works of James (1890). However, the first major studies about the mathematical ability of networks of neuron-inspired processing elements were only outlined in the first half of the twentieth century. McCulloch and Pitts (1943) showed that associations of such artificial neurons could implement any finite logical function, and this may be considered the first theoretical success on connectionism.

However, the most important step on the subject was taken when Rosenblatt (1958) introduced the first concrete neural model, called the perceptron, which initially had only two layers: input and output. This model was able to classify patterns from examples, but its use was hampered by some limitations exposed in the work of Minsky and Papert (1969), which led the research to be discontinued. The interest in connectionism was revived with the use of the error backpropagation training algorithm, presented by Rumelhart and McCelland (1986),which extended Rosenblatt's perceptron to multiple layers (multi-layer perceptron - MLP), overcoming the limitations of the original model and enabling the development of applications in various branches of knowledge.

After this brief history, we find it important to place the artificial neural networks in the universe of methods applicable to pattern recognition and describe some of their main features.

While there are several approaches to pattern recognition, this paper is only interested in the statistical and neural approaches. The latter has different opera-

Figure 2:
Nonlinear model of a neural network node



Source: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1806-11172011000100009

ting principles, although it uses models that are equivalent to those of the latter.

In the statistical approach, each pattern is represented by a set of "n" features–or measures–and viewed as a point in an *n*-dimensional space. According to Jain, Duin and Mao (2000), the purpose of this representation is to choose the features so that the patterns (feature vectors) belonging to different classes occupy compact, well-ordered regions of then-dimensional space of features. Thus, the effectiveness of this choice is greater the easier it is to separate the patterns belonging to different classes.

Based on a subset of patterns of various classes (training set), the purpose of the statistical approach is to define decision boundaries in the *n*-dimensional space of features capable of separating patterns belonging to different classes. In the statistical approach, decision boundaries are determined by the pattern probability distributions, which must be known or learned *a priori*.

The neural approach, on the other hand, uses a nonlinear discriminant analysis, namely, a geometric analysis. The discriminant functions are constructed by a linear combination of basic nonlinear functions, and have the following form:

$$g(\boldsymbol{x}) = \sum_{i=1}^{m} w_i \varphi_i(\boldsymbol{x}, \boldsymbol{u_i}) \quad (1)$$

The combination of x and parameter vector $\boldsymbol{u}$ results in a scalar product, i.e, $\phi_i(\boldsymbol{x}, \boldsymbol{u_i}) = \phi_i(\boldsymbol{x}^T \boldsymbol{u_i})$. The form of the nonlinear function ϕ, referred to as the activation function, is chosen *a priori* and the optimization procedure determines, simultaneously, the w_{ij} and $\boldsymbol{u_i}$ parameters. In other words, the basic functions are selected previously, but their parameters are adaptable during the optimization phase.

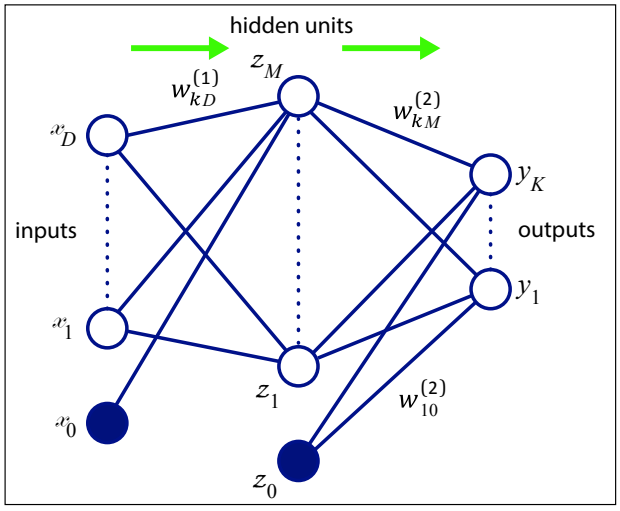
In sum, the main features of neural networks are: (i) the ability to learn nonlinear relationships between inputs and outputs; (ii) the use of sequential training procedures and (iii) the ability to adapt to the given data.

4. MULTILAYER PERCEPTRON NETWORK, LEARNING AND THE ERRORBACKPROPAGATION ALGORITHM

According to Bishop (2006), the most successful model using the neural approach, within the scope of pattern recognition, is the multilayer perceptron (MLP) neural network, of interest to this paper. A neural network is mainly specified by its topology, the features of its nodes and training rules.

MLP networks are organized in layers, linked by unidirectional connections as shown in Figure 3.

Figure 3:
Architecture of an MLP network with one hidden layer and an output layer.



Source: Bishop (2006)

The mathematical model of an MLP network, such as the one shown in Figure 3, may be represented by the following formula:

$$y_k(\boldsymbol{x},\boldsymbol{w}) = \sigma\left(\sum_{j=0}^{M} w_{kj}^{(2)}\, h\left(\sum_{i=0}^{D} w_{ji}^{(1)} x_i\right)\right) \quad (2)$$

In equation (2), the activation functions σ(*)and h(*) usually take the shape of the sigmoid function, since they represent a nonlinear mapping between input and output and may be differentiated, although other shapes are admitted, depending on the application.

The linear combination $\sum_{i=0}^{D} w_{ji}^{(1)} x_i$, after undergoing nonlinear h(*) transformation, serves as input to the neurons of the hidden layer. This result is linearly combined with weights $w_{kj}^{(2)}$ and subject to further nonlinear σ(*) transformation, resulting in output y_k.

In summary, the MLP network is a nonlinear mapping from a set of input variables $\{x_i\}$ to a set of output variables $\{y_k\}$ controlled by a vector of adjustable parameters, known as synaptic weights.

The learning procedure (optimization) involves updating parameters $w_{kj}^{(2)}$ and $w_{ji}^{(1)}$, so that the neural network is able to efficiently perform the classification task. Regarding the MLP network, the most used and widespread optimization rule is the one defined by the error backpropagation algorithm.

During training with this algorithm, the network operates in a two-stage sequence. First, a pattern – a set of variables $\{x_i\}$ – is introduced to the network's input layer. The processing is performed through the network, layer by layer, until the output layer produces the response in an iterative process.

Thus, the initial step of the first stage comprises calculating the activation level and the outputs of all neurons in the hidden layer and output layer. The outputs of the hidden layer neurons are the input for the output layer neurons. Subsequently, the outputs of the output layer neurons are computed.

In the second stage, the obtained output is compared to the desired output for the presented pattern, since the desired output is known *a priori*. If the output obtained is not correct, the error (the difference between the desired and obtained outputs) is computed, and such error is propagated from the output layer to the input layer in the opposite direction. The weights of the hidden layer connections are modified as the error is backpropagated using the generalized delta rule, which is not explained in details herein since it is out of scope of this paper.

This step involves calculating the local gradients of the output layer neurons – $\delta_k(t)$– and hidden layer neurons– $\delta_i(t)$ – and adjusting the weights of all neurons.

The second step involves updating the synaptic weights of the MLP network. Thus, regarding the hidden layer, the rule to update weights $w_{ji}^{(1)}$ for the next iteration is:

$$w_{ji}^{(1)}(t+1) = w_{ji}^{(1)}(t) + \nabla w_{ji}^{(1)}(t) = w_{ji}^{(1)}(t) + \alpha\delta_i(t)x_i(t) \quad (3)$$

Regarding the output layer, the rule to update weights $w_{kj}^{(2)}$ is:

$$w_{kj}^{(2)}(t+1) = w_{kj}^{(2)}(t) + \nabla w_{kj}^{(2)}(t) = w_{kj}^{(2)}(t) + \alpha\delta_k(t)y_k(t) \quad (4)$$

In equations (3) and (4), "α" is one of the input parameters of the algorithm, and is known as the learning rate.

To summarize, when a pattern is initially introduced to the network, it produces an output. After measuring the distance between the current and

desired response (error), the appropriate adjustments are made to the weights of the connections to reduce this distance. After the network is trained and the error achieves a satisfactory level, it may be used as a tool to classify new data.

The design of a neural network and the operation of this algorithm involve specifying a number of parameters, which decisively influence their performance, their convergence and the network generalization capability. These considerations do not fall within the scope of this paper.

The following example illustrates, in a very intuitive way, what problems MLP artificial neural networks, such as pattern classifiers, seek to solve. Consider a database containing information on a particular flower genus called Iris. This database consists of the following characteristics (features) of this flower genus: petal width, petal length, sepal width and sepal length. Depending on the values of these features, the flower is classified into one of three species (classes): *iris virginica, iris setosa* or *iris versicolor*. The database has various entries and each one of them associates the set of features of a certain flower to its respective species, as shown in the table below:

The MLP neural network is trained as part of these randomly selected entries (training set), i.e., the input data set (characteristics) and its respective flower class are introduced to the network, with the purpose of having the neural network learn from these data. After training, the neural network is able to classify, among one of the flower species, a new pattern (the set containing four characteristics of the flower), introduced to such network with a certain success rate.

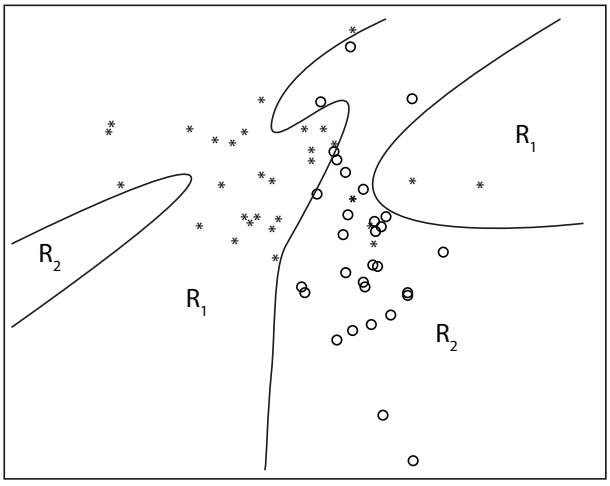
To have a graphical visualization of a MLP neural network classification solution, Figure 4 shows the optimal separation boundaries for two classes of patterns represented by the symbols "*" and "o".

5. APPLYING PATTERN CLASSIFICATION THROUGH ARTIFICIAL NEURAL NETWORKS IN THE AUDIT DOMAIN

Although it is not as frequent when compared to other branches of knowledge, the use of neural networks in the audit field is mentioned several times in the scientific literature, although the references cited herein are not the result of a comprehensive review.

Calderon and Cheh (2002) analyze papers published in some categories: risk assessment (three pa-

Figure 4 – Decision boundaries (R_1 and R_2) of an MLP neural network to classify patterns from two classes



Source: Jain, Duin e Mao (2000).

Table 1: Example of only three entries from an input database used by a MLP neural network

sepal		petal		Species
length (cm)	width (cm)	length (cm)	width (cm)	
4,8	3,4	1,6	0,2	*Iris setosa*
6,2	2,2	4,5	1,5	*Iris versicolor*
6,9	3,1	5,4	2,1	*Iris virginica*

Source: prepared by the author

pers), fraud and error identification (six papers), issue of going concern[I] opinion (three papers), identification of situations where there is too much exposure to financial risks (three papers) and bankruptcy forecast (twelve papers). These authors state that neural networks may be superior to other techniques when data is available in large samples, the scale of values to be analyzed is large and associations among data are poorly defined and barely noticeable.

Garrity, O'Donnell and Sanders (2006), when defending continuous auditing and the use of computational intelligence, also highlight applications of artificial neural networks in the same areas mentioned by Calderon and Cheh (2002) and Koskivaara (2003).

Cerullo and Cerrullo (2006) analyze the use of neural networks to predict fraud in financial statements, by using coefficients and information on resulting from analyses of the accounting statements themselves. The authors state that neural networks process large amounts of data to solve problems by recognizing trends and complex relationships, which are barely noticeable to other computational methods.

Taha (2012) justifies the use of neural networks in auditing and concludes that such neural networks are better than statistical methods for planning and conducting audits. From his perspective, neural networks may indicate which financial statements are most likely to contain substantial errors, guiding the auditor in relation to how in-depth audit tests are and providing further conditions to issue a more accurate opinion on these financial statements.

Pourheydari, Nezamabadi-Pour and Aazami (2012) used four pattern classification techniques to identify modified[II] and unmodified[III] audit opinions on financial statements. Although their study shows other very interesting findings, its results showed that the MLP neural network proved to have high ability to identify different types of audit opinions on the financial statements, achieving a success rate of over 87%, jointly considering modified and unmodified opinions.

Finally, Byrnes *et al* (2014) defend the appropriation of data analysis techniques by auditing standards. From their perspective, technological developments, such as cloud computing, and the advances of data science contribute to enhance the effectiveness and efficiency of the audit work. They argue that the incorporation of computational intelligence enables continuous and predictive audits, more effective fraud detection and the safer issue of opinions.

These authors also point out several opportunities that are enhanced by the use of data analysis in financial audits, such as: the identification of risks associated with audit contracts (risks of bankruptcy and senior management fraud); the identification of risks of material errors and the performance of substantive tests and the identification of non-conformities in financial statements due to fraud.

These applications support, almost entirely, the works carried out by the control bodies. In addition, pattern recognition using artificial neural networks, may be used in many other audit problems. Some examples are the identification of fraud in bidding and procurement public processes and the granting of benefits from government programs, the identification of personnel admission or pension registration deeds not qualified for such, as well as a tool for continuous and predictive audit of the Government's Accounts, part of the annual review of the President's government accounts. Therefore, the use of neural networks may be an important tool to improve the effectiveness, efficiency and even the economy of the works carried out by these institutions.

6. FOSTERING THE USE OF COMPUTATIONAL INTELLIGENCE IN AUDITS

It has been well established that it is the duty of the Federal Court of Accounts (TCU) not only to control legality and compliance, but also to control efficiency, economy, efficacy and effectiveness of management actions in relation to individuals who use, collect, keep, manage or administer public monies, values and goods.

To perform an audit in all its dimensions, the TCU has been granted several duties by constitutional and infra-constitutional norms, which, over time, have become quite complex and varied, demanding a timely, focused and intelligent action, in order to optimize the resources made available to it.

Society, by becoming increasingly connected and aware of the need for greater transparency in the use of public resources, has increasingly demanded that government databases be made available. In this context, the TCU has often faced the need to properly handle this information and use it to assist its mission to improve the Government to benefit society.

In this scenario, the Presidency of the TCU, during the administration of Minister Aroldo Cedraz, decided to undertake actions to encourage the use of computational intelligence applied to audits.

Two strategic guidelines, which were outlined for TCU's 2015-2021 Strategic Planning and approved by TCU Order 141 from April 1st, 2015, stand out in this context: (i) using control intelligence to identify on a large scale the risks of nonperformance or inadequate implementation of products and services and inducing such practices to other parties subject to jurisdiction; and (ii) developing comprehensive organizational competence to work with emerging technology resources and analyzing large databases (Big Data).

At the tactical level, the 2015-2017 Audit Plan defines a line of action, which takes part in this movement, i.e., continuously monitoring, from the treatment of information databases, the use of public funds, in order to timely detect and correct possible diversions.

An outstanding initiative associated with this movement was the launch, on September 28th, 2015, of the TCU Center for Research and Innovation (CePI). This unit, which had already begun its activities in January 2015, aims to promote applied research in the TCU and coordinate the Innovation and Co-participation Lab (coLAB-i).

The coLAB-i aims to support innovative projects, ensure the knowledge management of developed solutions, coordinate cooperation activities and promote training activities and events in relation to topics at the frontier of knowledge. In addition, the coLAB-I, the first innovation laboratory in a control body, had the privilege of joining the select group included in Nesta's map of global laboratories (http://www.nesta.org.uk/) in its first year operating.

In addition, the TCU has promoted seminars and training courses on data analysis and given awards, through the *Reconhe-Ser* program, to several projects applying data science tools.

7. CONCLUSION

The rapidly growing capacity of computer processing and the availability of large databases made it easier to use more sophisticated data analysis and classification methods. In this context, pattern recognition techniques, such as artificial neural networks, gained prominence in applications in various branches of knowledge.

Artificial neural networks are number processing systems formed by highly connected processing units and able to map nonlinear relationships present in large databases. Using the nonlinear discriminant analysis theory and the error backpropagation algorithm for training and optimizing their parameters,

the multilayer perceptron neural networks are able to generalize the acquired knowledge and classify patterns with high success rates.

Classification patterns with the use of neural networks may help control bodies at all audit stages, whether in the planning, execution or report stage. Several studies have presented applications for risk assessment, fraud and error identification, continuing assessment (going concern opinion), identification of situations where there is too much exposure to financial risk, bankruptcy forecast, and identification of modified and unmodified audit opinions on financial statements, among others. This is a vast and yet little explored scope of application.

The audit activity, in particular, understands information and knowledge as input and product, and such elements increasingly depend on information technology. Data processing to extract information is, therefore, indispensable to leverage control activities in an increasingly connected society.

The TCU, aware of this reality and the need to conduct increasingly focused, timely and intelligent actions, has encouraged the use of data science applied to audits, through various actions contained in its Strategic Plan and Audit Plan. We highlight the launch, on September 28th, 2015, of the Center for Research and Innovation (CePI).

NOTES

I Also known as continuity evaluation, it consists in analyzing short and medium term cash flow of an operation, business or company. It sustains short-term strategic decisions based on cash generation and business liquidity, revealing the financial strength of a company for the following months and deciding on fundings, refundings, investments and other strategic, operational and financial elements.

II An opinion with reservations, adverse opinion and abstention of opinion on financial statements, necessary when: (a) the auditor concludes, based on the obtained audit evidence, that the financial statements as a whole present relevant misstatements; or (b) the auditor is able to obtain appropriate and sufficient evidence to conclude that the financial statements as a whole do not present relevant misstatements.

III The opinion given by the auditor when he concludes that the financial statements, in all relevant respects, were prepared in accordance with the applicable financial statement structure.

REFERENCES

BISHOP, Christopher M. Pattern Recognition and Machine Learning. Springer, October 2006.Availableon<http://www.rmki.kfki.hu/~banmi/elte/Bishop%20-%20Pattern%20Recognition%20and%20Machine%20Learning.pdf>. Accessed on: Aug 10. 2015.

BYRNES, Paul., CRISTE, Tom., TREVOR, Stewart., VASARHELYI, Miklos. Reimagining Auditing in a Wired World. AICPA White Paper, August2014.Available on: <https://www.aicpa.org/InterestAreas/FRC/AssuranceAdvisoryServices/DownloadableDocuments/Whitepaper_Blue_Sky_Scenario-Pinkbook.pdf >. Accessed on:Nov 11. 2015.

CALDERON, Thomas G., CHEH, John J. A roadmap for future neural networks research in auditing and risk assessment. International Journal of Accounting Information Systems, Volume 3, Issue 4, December 2002, Pages 203-236. Available on: <http://www.sciencedirect.com/science/article/pii/S1467089502000684>. Accessed on: Jan 18. 2016.

CERULLO, Michael J., CERULLO, Virginia. Using Neural Network Software as a Forensic Accounting Tool. Information Systems Control Journal, ISACA, 2006. Available on: <https://www.google.com.br/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiGn6W76OvKAhULGpAKHV6UCGQQFggdMAA&url=http%3A%2F%2Fwww.isaca.org%2FJournal%2Farchives%2F2006%2FVolume-2%2FDocuments%2Fjpdf0601-using-neural-network.pdf&usg=AFQjCNGLi7Omn2qs3hPy4lqcuxU_AYAmoA>. Accessed on: Dec 15. 2015.

GARRITY, Edward J., O'DONNELL, Joseph B., SANDERS, Lawrence. Continuous auditing and data mining. Idea Group Inc., 2006. Available on: <http://www.igi-global.com/chapter/continuous-auditing-data-mining/10596?camid=4v1>. Accessed on: Jul 7. 2015.

JAIN, Anil K., DUIN, Robert P. W., MAO, Jianchang. Statistical Pattern Recognition: A Review. IEEE Transactions on Pattern Anaçysis and Machine Intelligence, Vol. 22, nº 1, January 2000. Available on: <http://www.cs.indiana.edu/~predrag/files/jain_2000.pdf >. Accessed on: Jul 22. 2015.

KOSKIVAARA, Eija. Artificial Neural Networks in Auditing: State of the Art. TUCS TechnicalReport 509, 2003. Available on: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.67.459&rep=rep1&type=pdf >. Accessed on: Oct 10. 2015.

POURHEYDARI, Omid., NEZAMABADI-POUR, Hossein., AAZAMI, Zeinab. Identifying qualified audit opinions by artificial neural networks. African Journal of Business Management, Vol 6, p. 11077-11087, 7 November 2012. Available on: <http://www.academicjournals.org/app/webroot/article/article1380541005_Pourheydari%20et%20al.pdf >. Accessed on: Feb 2. 2016.

TAHA, Reem O. Hussein. The possibility of using Artificial Neural Networks in Auditing - Theoretical Analytical Paper. European Journal of Economics, Finance and Administrative Sciences, Issue 47, 2012. Available on: <http://www.academia.edu/1634776/The_Possibility_of_using_Artificial_Neural_Networks_in_Auditing_-Theoretical_Analytical_Paper >. Accessed on: Jan 30. 2016.

Information Science and Public Administration: an approach to Information Governance using the Mediation Law as a facilitator in improving the efficiency of information management

Domingos Savio Evandro da Silva
is an accountant, with expertise in Information Security, and is a public servant at the National Civil Aviation Agency (ANAC) where he works as a specialist in Civil Aviation Regulation.

Gerusa Vieira Barata Silva Cardoso
is an attorney and member of the Mediation and Arbitration Committee of the Brazilian Bar Association, Federal District and Territories Section, with expertise in Litigation and Public Law from the School of Magistrates of the State of Espírito Santo.

ABSTRACT

Information is an essential element in the formulation of organizational policies to obtain favorable economic results. This article aims to review, in the Public Administration, some aspects of Information Governance and Information Science, with which methods of mediation can be used among users of information, including for the conflict resolution addressed by Brazilian Law 13,140/2015, in order to improve the Information Management process.

Keywords: Governance; Information Science; Information Management; Mediation; Law.

1. INTRODUCTION

For the study of sciences, information is a meaning transmitted to a conscious being by a message inscribed in a time-space material support, which can be printed, electromagnetic signals, and sound wave. To this end, signs and symbols are used to associate a concrete element, the signifier, to a representative element, the signified.

This article aims to review some aspects of Information Governance and Information Science in the Public Administration. Methods of mediation

can be used with these aspects among users of information to improve the Information Management process, including for conflict resolution, as established by the Mediation Law (13,140/2015) and by the new Civil Procedure Code (Law 13,105/2015).

2. INFORMATION SCIENCE – PUBLIC ADMINISTRATION

One observed in the Brazilian Public Administration that every governmental action for implementing and developing policies is strictly related to the use of technology resources. This enables , among other things, efficient information management, reducing operational costs and improving the control of processes and activities whose results seek the wellbeing of society.

This way, the importance of streamlining state administrative actions increases, which encourages the conscious use of information resources by regulating and standardizing procedures.

In this context, information science appears as an assistant in understanding those aspects related to information management in the Public Administration, as it can be understood as an interdisciplinary area by nature, with investigative and analytical purposes. Its objective is to study the phenomena correlated to information production, organization, dissemination, and use in all fields of knowledge.

For Information Science, the use of the word "information" indicates a specific perspective based on which the concept of communication of knowledge has been determined. This perspective comprises characteristics such as innovation and relevance, that is, it refers to the process of transformation of knowledge and, particularly, to its selection and interpretation within a specific context.

In Capurro's perspective (2003), the concept of information as we use it in everyday English in the sense *knowledge communicated* plays a central role in today's society... "it is commonplace to consider information as a basic condition for economic development together with capital, labor, and raw material;". However, when quoting Bogdan (1994), we see that the concept of "information" goes beyond the field of sciences, that is:

> (...) The notion of information has been taken to characterize a measure of physical organization (or decrease in entropy), a pattern of communication between source and the receiver, a form of control and feedback , the probability of a message being transmitted over a communication channel, the content of a cognitive state, the meaning of a linguistic form, or the reduction of an uncertainty. There seems to be no unique idea of information upon which these various concepts converge and hence no proprietary theory of information (CAPURRO, 2003)

Nonetheless, "information" is better defined when one understands its useful character for human beings. In this sense, Capurro (2003) writes about Machlup and Mansfield (1983). In "The study of information: interdisciplinary messages", they collect views on the interdisciplinary controversy in computer science, artificial intelligence, library and information science, linguistics, physics, and in the social sciences. The controversy is inferred from the use of the information concept in the context of signal transmission, when stating that the basic sense of information is directed to and received by human minds. Hence, all other senses, including its use with regard to nonhuman organisms as well as to society as a whole, are metaphoric and, as in the case of cybernetics, anthropomorphic. In short, for Machlup, information is "a human phenomenon. It involves individuals transmitting and receiving messages in the context of their possible actions".

On the other hand, Buckland (1991) presents three meanings for the term "information" in Information Science, distinguishing with regard to:

- Information-as-process, where the act of informing changes initial knowledge;
- Information-as-knowledge: where the communicated knowledge concerning some particular fact, subject, or event, having the characteristics of being intangible and hard to measure, as it is personal and conceptual;
- Information-as-thing: this is used attributively for objects, such as data and documents that are referred to as "information" because they are regarded as being informative.

Hence, he reaffirms the concept of documents (information-as-thing), indicates the subjective nature of information, and supports the idea that anything can be informative within a context for representative use. Figure 1 shows these relations that information assumes in four aspects.

According to the definition set forth in Law 12,527/2011 – Law of Information Access, information is "data, processed or not, in any media, support or format, that may be used for production and transmission of knowledge".

It is verified, therefore, that for an information system, "data" are raw elements represented by symbols that may be quantified, structurally organized, and mathematically described.

When focusing on these concepts, we verify the importance of information as an indispensable object in the production and transmission of knowledge, which, in turn, has become essential for the formation of a person and of the society with which they relate.

3. GOVERNANCE – INFORMATION MANAGEMENT

The Federal Public Administration has attempted to develop their actions within a managerial framework in order to contribute to the efficient and economic use of resources and to reach a higher number of beneficiaries. That means that society's consciousness is more and more notorious, participative and demanding so that public assets can be accessible and used for everyone's benefit. This challenges public managers to be more qualified and engaged in the search for improvements in processes for which they are responsible.

The issue that the Administration currently faces is how to overcome the barriers to the implementation of the Public Management's managerial model and to support the initiatives to develop an efficient information and communication structure, without compromising the necessary state controls

Figure 1: Four Aspects of Information

Intangible	Tangible
Information-as-knowledge - knowledge	Information-as-thing – Data, Documents
Information-as-process – Effect of transmitting knowledge, becoming informed	Information processing – treatment of data, documents

Source: Buckland (1991)

that ensure that there is no embezzlement when applying public policies and resources.

According to an article by Borges and Serrão (*apud* Romilson Pereira) published in the Journal of the Federal Court of Accounts – TCU, the origin of governance is attributed to the movement that happened in the United States in the 1980s. Big investors were against corporations that were being managed in a way that did not meet the interest of shareholders. "The subject would become notorious with the financial scandals that broke in several corporations of that country" (Magazine TCU, no. 122, page 120, 2011).

Jessop (*apud* Pereira) clarifies that the term was already used in the 1940s and that governance arose from the need, attempt and hope to minimize risks, reduce the inherent complexity, in other words, to govern and control phenomena and events in the real world, which would naturally be necessary and contingent. Therefore, what happened in the mid-80s was the discovery of governance by corporations.

Thus, we can consider that governance in the public sector is founded basically on the principles of transparency, integrity and accountability, the same ones suggested for corporate governance. Due to its particularities, governance in the public sector must be connected to behavioral patterns, well-defined organizational processes and structures, control networks, and management reports intended for the external public.

These concepts are connected to those of governance, including corporate and information governance. They comprise several fields of interest, such as technology, security, communication, and knowledge, and require constant improvements and maturity in the Public Administration before becoming effective and permanent.

Therefore, as a development of governance, information governance may be established consisting of aspects of leadership, organizational structure, and processes that ensure that the duties/responsibilities of information management support and improve the organization's objectives and strategies.

In this sense, the management and formation of knowledge are closely linked to information management itself. Among others, the aspects of security and resource control inherent to the knowledge dissemination process must be observed, constituting an integrated and harmonic system.

According to Simch and Tonetto (2007), other aspects that are part of an Information System environment and are disseminated by professional practices classify the information by priority levels. They respect the needs of each company, as well as the importance of information classification, for the maintenance of the company's activities.

For Eluzia (SILVA, 2009), the importance of the information systems available in the Public Sector is intended to support their operational conditions and, at the same time, they are also used "to support the sector activities in agencies and entities, becoming more objective, complete, fast, and transparent".

Although this kind of management is similar to what is called corporate governance in the private sector, there is still a lot to improve in the public sector, especially regarding information management. The main agents, responsible for making decisions, generally have little knowledge of the technical aspects that this type of management comprises, even though information must necessarily be the intrinsic and indispensable element throughout the formal process that enables making the right decision.

In this context, it is emphasized that the decisions made must target the inherent role of the Public Administration or of the State itself, which is to meet the needs of society and citizens, given that it is this same society that establishes the conditions and limits for the State to exercise its power.

Nevertheless, the conflict of interests is also present in this relation, as this is a characteristic element in human beings that intend to constantly satisfy their needs while also observing the limits established by social interaction.

In this aspect, in a systemic view, the organization must consider the constituent parts of the entire organizational framework, as well as the relationship between these parts, so that conflicts may be satisfactorily resolved. For this purpose, it will be necessary to use structured methods and objective techniques that may be applied whenever different interests arise when serving citizens. One example is alternative dispute resolution methods, that is, mediation and conciliation used as facilitators in the dialogue between the interests of the Administration and service users.

4. MEDIATION IN INFORMATION SCIENCE

According to Almeida Junior (2009), mediation can be understood as "every action of interference taken by the information professional, whether it is direct or indirect, conscious or unconscious, singular or plural, individual or collective, which enables the appropriation of information to fully or partially meet an informational need".

Considering the scope of information treatment, going from storage to dissemination, such mediation has started to play not a supporting role in Information Science, but it effectively interferes in its own object – information.

Practically speaking, mediation of information is only understood as linked to the information service or, more specifically, to spaces and actions that target customer services. However, it is implicitly present in some other actions, even though by guiding and directing all activities being conducted. This makes the idea of work that is not directed to satisfying information needs unconceivable. In these cases, the following can be mentioned: information storage, which is updated according to users' interests and demands; the selection policy, discussed in the development of informational collections, which has the final user as supporting ground. The same applies to the works of information processing: its actions aim to recover information that meets and satisfies the users' needs.

Still according to Almeida Junior (2009), there is a distinction between implicit and explicit mediation. The former is held in spaces with informational equipment, where actions are developed without the immediate presence of users. In these spaces, are information selection, storage and processing. On the other hand, the explicit mediation occurs in spaces where the presence of users

is inevitable, "even if this presence is not physical, such as in long distance accesses in which a concrete and on-site interference of a professional is not required".

In this context, it is established that mediation comprises consciously developed actions that are based on knowledge dominated and externalized with reasonable control. It also includes actions that allow unconscious knowledge to emerge, which cannot be controlled and is interconnected with conscious knowledge.

> (…) the mediation of information enables users to be the protagonist in the appropriation process, as they determine the existence or not of the information that arises from knowledge modification, reorganization, re-structuring, and transformation. Ultimately, the one who determines the existence of the information is the user, that person who uses the contents of information supports (ALMEIDA JUNIOR, 2009).

Another aspect highlighted by Information Science is that neutrality and impartiality, although sought, are not accomplished in the mediation process because information itself is not neutral, it is immersed in ideologies and in several interests, such as economic, political, cultural, and formation interests.

Therefore, we notice that information is not simply transferred and transmitted, which would imply an exchange, a change of place. Information is present in supports and needs to be appropriated by interested parties that is when it will begin to belong to the reconstructed knowledge.

This understanding is especially important for the Public Administration. It enables the increase of efficiency in information services and resource management, as the process of receiving information is no longer addressed as a simple activity of transference, dissemination and availability; it becomes embedded in and interdependent of a wider process, that is, information mediation.

In this sense, taking into account that appropriation and interference occur in various fields, from information production to its final destination, going through informational support (media, equipment, tools) and agents to the citizen-user, managers and agents are no longer seen as direct trustees of information, but they play the role of mediators. They interfere in the entire process of information appropriation of citizen-users in an undoubtable and determining manner and allow them to become active parts in this mediation.

Seen this way, as an object of interest to parties, information is the basis of knowledge reconstruction as it deals with uncertainties and, as a

substitute, it begins to generate conflicts between these same parties.

5. MEDIATION LAW – ALTERNATIVE DISPUTE RESOLUTION IN PUBLIC ADMINISTRATION

In the conception of Luiz Guilherme (Marinoni et al., 2015), mediation consists of "the inclusion of a neutral third person to assist in the negotiation between the parties. The intention is to collaborate so that the parties may reach an agreement on their own".

According to Rodrigo Cardoso Magno (2013), the reputable mediation characteristics may "point to an apparent conflict with the principles of administrative law, which lays down its roots on state sovereignty and on the vertical relation between State and those being administered – historically known as subject". In mediation, the parties are placed in a horizontal position and seek to meet their needs and interests in a harmonic manner, upholding a customized way of justice".

Nevertheless, it is verified that when the public interest is above private interest, the promotion of individual rights must be observed with proportional consideration, guided by the principle of human dignity.

Within the juridical scope, legality would comprise both an imperative action from the administration as a consensual performance. The principle of legality does not hinder managers from adopting consensual solutions for dispute resolution. Therefore, "it must be assessed if the selected option – whether imperative or consensual – may result in maximum effectiveness of the principle of efficiency, thus respecting the fundamental rights" (MAGNO, 2013).

Law 13,140/2015 (Mediation Law) provides for mediation between private parties as a way of dispute resolution and for the alternative dispute resolution in the public administration. Article 1, sole paragraph, defines mediation as "the technical activity conducted by a neutral third person without any decision-making power, who, after being chosen or accepted by the parties, assists them and encourages the identification or development of consensual solutions for the dispute".

This law is extremely relevant as it regulates out-of-court mediation and also has some aspects of court mediation. That is why it is important to interpret it along with the Civil Procedure Code – CPC, which introduces public mediation and conciliation that are being used in direct and indirect Public Administration.

In these terms, the New Civil Procedure Code sets forth the following in its Article 174:

> The Federal Government, States, Federal District, and Municipalities shall create mediation and conciliation councils with the following duties related to the consensual resolution of disputes at administrative level: I – settle conflicts involving public administration bodies and entities; II – assess the admissibility of conflict resolution requests in the public administration by conciliation; III – promote the execution of the Conduct Adjustment Term (TAC), when applicable. (Law 13,105/2015)

In the Public Administration, it is possible to apply alternative dispute resolution methods, such as mediation and conciliation, but they are subject to the possibility of using such methods in the area of public interests. It is also possible to apply other techniques when alternative dispute resolution methods are not feasible, such as the execution of the Conduct Adjustment Term – TAC, in case of conflicts involving Public Administration bodies and entities.

The parties are not restricted to only mediation and conciliation. Based on each case, the judge may grant to the involved parties the possibility of using other alternative dispute resolution techniques.

According to Law no. 13,140/2015, the mediation and conciliation procedure is permeated with norms, rules, and principles that must be informed to the parties at the beginning of a session. Other constitutional principles of Brazilian proceedings must also be observed:

- Independence – freedom to act, without being internally or externally pressured, being allowed to reject, suspend or interrupt the session if the conditions required for a good progression are lacking;

- Isonomy – equal treatment of parties, prevailing the random distribution of proceedings to mediators and conciliators;

- Freedom of will – respect to the parties' different points of view, ensuring they make a voluntary and non-coercive decision, with freedom to make their own decisions during or at the end of the proceedings, or even to interrupt it at any time;

- Search for consensus – maintenance of a favorable environment so that the parties may reach a satisfactory agreement;

- Confidentiality – non-disclosure of any information obtained in the session, unless explicitly authorized by the parties, required by law, or necessary for honoring the agreement reached by the mediation;

- Orality and informality – maintenance of the cohesion with objectivity and avoidance of unnecessary formalities and excess of bureaucracy;

- Informed decision – to keep the parties fully informed as to their rights and the factual context they are in; and

- Impartiality – lack of favoritism, preference, or prejudice, ensuring that personal values and concepts do not interfere in the result.

Impartiality permeates the entire mediation and conciliation procedure. Mediators and conciliators are subject to this, which is also mandatory in conciliation and mediation in private councils (Article 170, 172, and 173 of CPC).

In this sense, mediation in the scope of administrative law can still be held in the administrative dispute phase – administrative mediation, in which the administrative authority elects the cases eligible for mediation and proposes to the parties the adoption of an alternative solution (out of court). It can also be held in the judicial phase, in which there is the commencement of proceedings at court; this is called mediation "attached to the court". Therefore, the phase in which mediation will be proposed and used depends on the administrative and judicial procedures adopted by the Public Sector.

According to Magno (2013), when quoting Brazilian scholars, the principles of consensus and efficiency in the Public Administration as well as the interest for adopting a "Preventive Advocacy" have become more important in Administrative Law. It endows, thus, the "State attorney with a proactive attitude that seeks conflict resolution".

6. APPLICATION OF CONFLICT RESOLUTION

Some aspects may arise when evaluating an internal environment of a public body that provides services to society related to delivery and provision of information or products such as transparency and effectiveness regarding the obligation of making information accessible to the public, as per Law 12,527/2011 (Law of Information Access).

It should be noted that an internal environment is influenced by the relationship between people, who are responsible for the performance of activities that contribute to the efficacy of business.

Therefore, for mediating the information and the conflicts resulting from the relation between people, one can infer a model of event application that may be used in the Public Administration as basis for the improvement of information management and its connection with good governance. The use of models helps in the comprehension and scaling of actions that enable efficiency in resource allocation. It is also a relative parameter of a situation lived in the organizational environment and directs the efforts towards the improvement of the institutional performance when achieving established goals.

When observing some departments of a typical public institution that have specific characteristics when dealing with information (such as the document registration and distribution department), as well as those departments that have relationships with external users (with typical customer service activities), one can verify the possibility of conflicts. This includes conflicts resulting from mistakes in the institution's internal management, which generates resistance and compromises the service quality. One example is when a public servant must treat some information deemed important, but does not have the knowledge nor the proper tools to do so. The trend, in this case, is to be resistant in face of the risk of having to accounted for possible damages caused to the institution because of inadequate use of the information they had access to.

In this context, considering that the level of demand of people is variable due to the influence of their culture, history, beliefs, ideology, and experiences - which affect the relations developed in customer service and in information service provision to citizen-users - it is appropriate to understand that when providing a service to society, the "service" concerns the satisfaction of demands for information, product, and service of the citizen. On the other hand, "treatment" concerns the way the user is received and served. These integrated and complementary actions make up a service of excellence.

Thus, a good "service" refers to quality, which includes a good "treatment" and the sufficient and timely satisfaction of the demands for information, product, and service.

Thus, it is possible to imagine a situation in which the user is not satisfied with the results obtained from the service. One example is when the user requests information on public services concessions aiming to obtain a detailed analysis of the financial and economic status of the concessionaire companies, as well as the registry data of their co-owners. In this situation, the Public Admi-

nistration denies the request explaining that this information is exclusive to the government entity connected to its administrative performance.

It may be inferred that when an information request is denied, the citizen-user tends to depreciate the service received from the Administration, even if this denial has been legally justified. This may figure as a conflict between the involved parties with consequences, sometimes unpredictable, to the Public Administration. In any case, however, the treatment provided to the citizen must always be respectful and helpful, regardless of being considered satisfactory in the citizen-user's opinion.

A good practice adopted as a measure for efficiency and quality in order to monitor the range and the impact of the service provided by the Administration is to implement communication channels so that citizen-users may record their demands, whether for information or products, as well as their opinion about the service.

In the case of the example above, the user, unhappy with the rejection from the Administration, may claim his rights to have access to that information based on the democratic principles of transparency and publicity of administrative acts, which are essential for the exercise of social control.

Suppose that, in this situation, the user appeals against the decision to the competent department. There will be a bureaucratic procedure, such as the completion of forms and submission of copies of the documents containing the notification and formalization of the administrative proceedings. The user will have the impression that his request will follow a more strict process, and will be better reviewed and certainly granted. Nevertheless, should the request be once again denied, the user's dissatisfaction will be so deep that he will be constrained to appeal to court against the administrative decision.

In the hypothetical situation above, one notices that the efficiency and economy in public management acts tend to be compromised, as the Administration will be obligated to allocate resources for its representation in court. On the other hand, the court will put in efforts to satisfy society's desire before a governmental entity.

Situations that involve conflicts to be analyzed and deliberated in court are recurrent in the Public Administration and many initiatives of out-of-court settlements are undertaken in several public sector institutions. This seeks economy when using resources as well as to expedite the proceedings.

In this sense, Law 13,105/2015 (New Civil Procedure Code) brings important guidance for the structure and management of state activities. Article 174 indicates the Public Administration as the protagonist in the resolution of conflicts between parties by creating mediation and conciliation councils with duties related to the consensual resolution of disputes at administrative level. This guidance is specified in Law 13,140/2015 (Mediation Law), listing activities regulated and supervised by the Public Entity, and enables the reduction of bureaucracy by allowing the use of technology as a conflict resolution instrument

> Article 43. The public administration institutions and entities may create councils to resolve disputes between private parties, if conflicts are related to the activities regulated or supervised by them.
>
> Article 46. Mediation may be held over the Internet or through other communication channels that enable this to be long distance, provided that the parties agree with such.
>
> Sole Paragraph. The party residing overseas may choose to be subject to the mediation as per the provisions of this Law. (Law 13,140/2015)

Given the above and taking into consideration the example presented, one can provide a possible solution for the conflict that led the citizen-user to seek court to have his demand satisfied. Firstly, this solution would comprise the creation of a mediation and conciliation council in the respective public institution, with duties related to the consensual resolution of disputes at the administrative level. Alternately and without compromising the functions of this council, the Administration can seek assistance from the existing Mediation and Conciliation Centers at Courts through a covenant or a cooperation term.

In any case, with the Mediation Law, it is necessary to train servants regarding the conciliation and mediation techniques so they may be able to resolve the conflicts that arise in the everyday life of existing relations with society in state activities. Some entities have provided this capacity building,

such as the National Mediation and Conciliation School (ENAM), of the Judicial Renovation Secretariat, Ministry of Justice (SRJ/MJ), and the National Justice Council (CNJ).

7. CONCLUSION

In the Brazilian Public Administration, the importance of streamlining information management is connected to the conscious use of information resources and aims to improve the efficiency and results when providing services to society.

In this context, information science appears as an assistant in understanding those aspects related to information management in the Public Administration, as it can be understood as an interdisciplinary area by nature. Its objective is to study the phenomena correlated to information production, organization, dissemination, and use in all fields of knowledge.

Through aspects of leadership, organizational structure and processes, governance enables the information management responsibilities to support and improve the organization's objectives and strategies. However, when dealing with the needs of society and citizens, one must be aware of the conflicts of interests that are a characteristic element in human beings who constantly intend to satisfy their needs while observing the limits established by social interaction.

In order to resolve conflicts in a satisfactory manner, it is necessary to use structured methods and objective techniques, among which there are alternative dispute resolution methods (mediation and conciliation).

With the Mediation Law, alternative dispute resolution method have become important in the public administration, as it re-establishes communication and trust between the parties, who have a collaborative attitude towards an agreement or social pacification of the conflict. In this sense, mediation can still be held in the administrative dispute phase – administrative mediation, in which the administrative authority elects the cases eligible for mediation and proposes to the parties the adoption of an alternative solution (out of court). It can also be held in the judicial phase, in which there is the commencement of proceedings at court.

This article aimed to present the reasonableness of applying adequate conflict resolution to improve information management as a good practice towards governance in the Public Sector. It took into account that the level of demand from people is variable and this is reflected in the relations developed in customer service and when the Administration provides information services.

In this sense, Law 13,105/2015 (New Civil Procedure Code) and Law 13,140/2015 (Mediation Law) bring important guidance for the structure and management of state activities. They indicate the Public Administration as the protagonist in the resolution of conflicts between parties by creating mediation and conciliation councils with duties related to the consensual resolution of disputes at administrative level. This improves resource management and the satisfaction of society's needs.

Finally, it has been verified that the analysis performed refers to one of the immensurable aspects of the information mediation process. It is necessary to improve this practice with new studies and guidance.

REFERENCES

ALMEIDA JÚNIOR, Oswaldo Francisco de. Mediação Da Informação e Múltiplas Linguagens. Universidade Estadual de Londrina / Universidade Estadual Paulista Júlio de Mesquita Filho, Campus de Marília. Revista Pesquisa Brasileira Ciência da Informação, Brasília, v.2, n.1, p.89-103, jan./dez. 2009.

BRASIL. LEI nº 12.527, de 18 de novembro de 2011. Dispõe sobre os procedimentos a serem observados pela União, Estados, Distrito Federal e Municípios, com o fim de garantir o acesso a informações, e dá outras providências. Diário Oficial da União - DOU, ed. extra, 18 de novembro de 2011.

BRASIL. LEI nº 13.105, de 16 de março de 2015. Institui o Código de Processo Civil. Diário Oficial da União - DOU, 17 de março de 2015, P.1

BRASIL. LEI nº 13.140, de 26 de junho de 2015. Dispõe sobre a mediação entre particulares como meio de solução de controvérsias e sobre a autocomposição de conflitos no âmbito da administração pública; altera a Lei no 9.469, de 10 de julho de 1997, e o Decreto no 70.235, de 6 de março de 1972; e revoga o § 2o do art. 6o da Lei no 9.469, de 10 de julho de 1997. Diário Oficial da União - DOU, 29 de junho de 2015, P.4.

BRASIL. TRIBUNAL DE CONTAS DA UNIÃO – TCU. Revista do Tribunal de Contas da União, número 122, p 120. 2011. Disponível em: http://portal.tcu.gov.br/publicacoes-institucionais/periodicos-e-series/revista-do-tcu/revista-do-tcu.htm Acessado: Dez/2015.

BUCKLAND; Michael K. Artigo: Information as thing. Journal of the American Society for Information Science; v. 42, p.351-360, Jun 1991.

CAPURRO, R.; HJØRLAND, B. O conceito de informação. Perspectivas em Ciência da Informação, v.12, n. 1, p. 148-207, jan/abr 2007. Capitulo publicado no Annual Review of Information Science and Technology. Ed. Blaise Cronin. V.37, cap.8, p.343-411, 2003.

MAGNO, Rodrigo Cardoso. Mediação na administração pública: direito comparado. Revista Jus Navigandi, Teresina, ano 18, n. 3801, 27 nov. 2013. Disponível em: <https://jus.com.br/artigos/25947>. Acesso em: jan. 2016.

MARINONI, Luiz Guilherme; ARENHART, Sérgio Cruz; MITIDIERO, Daniel. Novo Código de Processo Civil comentado. Editora Revista dos Tribunais, São Paulo. 2015.

SILVA, Eluzia Ferreira da. Sistemas de informações aplicados ao processo orçamentário do SERPRO: estudo de caso. 2009. 57 f. Monografia (Especialização em Orçamento e Finanças). Universidade de Brasília, Brasília, 2009. Disponível em: http://bdm.unb.br/handle/10483/1627 Acessado: Dez 2015.

SILVA SAVIO. (Domingos Savio Evandro da Silva). Administração pública e Governança: conscientização e maturidade da cultura de segurança da informação / Domingos Savio Evandro da Silva – Brasília. Trabalho de Conclusão de Curso (Especialização em Segurança da Informação) SENAC/DF, 2012.

SIMCH, Maicom Rafael Victor; TONETTO, Tiago Squinzani. Artigo: Auditoria dos Sistemas de Informação Aliada à Gestão Empresarial. Universidade Federal de Santa Maria - RS/ UFSM. Revista Eletrônica de Contabilidade. 2007. Disponível em: http://cascavel.ufsm.br/revistas/ojs-2.2.2/index.php/contabilidade/article/download/39/3525 - Acessado: Dez 2015.

A Metric of Software Size as a Tool for IT Governance

Marcus Vinícius Borela de Castro
is a public servant of the Federal Court of Accounts in Brazil, graduated in Computer Science from the Federal University of Viçosa, with a specialist degree in Information Technology Governance from the University of Brasilia and certified in metric function points (CFPS).

Carlos Alberto Mamede Hernandes
is a servant of the Federal Court of Accounts in Brazil, graduated in Data Processing from the University of Brasilia and with a Master's Degree in Knowledge Management and Information Technology at the Catholic University of Brasilia.Católica de Brasília.

ABSTRACT

This paper[1] proposes a new metric for software functional size, which is derived from Function Point Analysis (FPA), but overcomes some of its known deficiencies. The statistical results show that the new metric, Functional Elements (EF), and its submetric, Functional Elements of Transaction (EFt), have higher correlation with the effort in software development than FPA in the context of the analyzed data. The paper illustrates the application of the new metric as a tool to improve IT governance specifically in assessment, monitoring, and giving directions to the software development area.

Index Terms: Function Points, IT governance, IT performance, Software engineering, Software metrics.

1. INTRODUCTION

1.1 RESEARCH SUBJECT

Organizations need to leverage their investments in technology to create new opportunities and produce change in their capabilities [RUBIN 1993, p. 473]. According to ITGI [2007, p. 7], information technology (IT) has become an integral part of business for many companies with key role in supporting and promoting their growth. In this context, IT governance fulfills an important role of directing and boosting IT in order to achieve its goals aligned with the company's strategy.

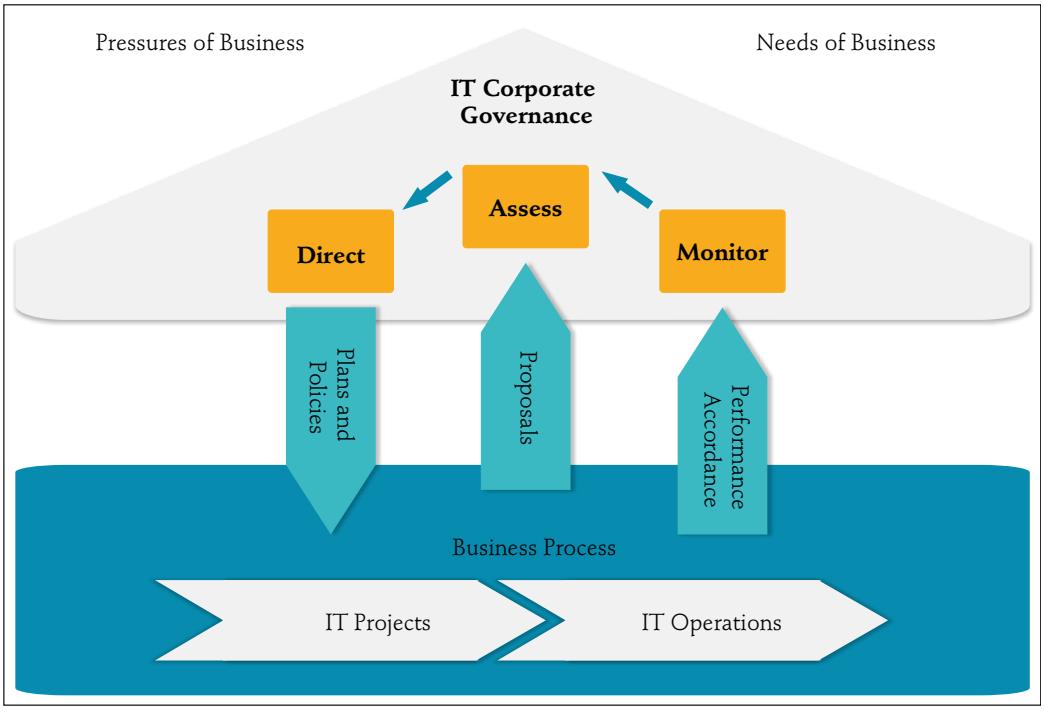


Figure 1: Cycle Assess-Direct-Monitor of IT Governance

Source: ISO 38500 [3, p. 7]

In order for IT governance to foster the success of IT and of the organization, ISO 38500 [ISO, IEC, 2008, p. 7] proposes three main activities: to assess the current and future use of IT; to direct the preparation and implementation of plans and policies to ensure that IT achieves organizational goals; to monitor performance and compliance with those policies (Fig. 1).

A metric of software size can compose several indicators to help reveal the real situation of the systems development area for the senior management of an organization, directly or through IT governance structures (e.g., IT steering committee). Measures such as the production of software in a period (e.g., measure of software size per month) and the productivity of an area (e.g., measure of software size per effort) are examples of indicators that can support the three activities of governance proposed by ISO 38500.

For the formation of these indicators, one can use Function Point Analysis (FPA) to get function points (FP) as a metric of software size. Created by Albrecht [1979], FPA has become an international standard for measuring the functional size of a software with the ISO 20926 [ISO; IEC, 2009] designation. Its rules are maintained and enhanced by a nonprofit international group of users called International Function Point Users Group (IFPUG), responsible for publishing the Counting Practices Manual (CPM), now in version 4.3.1 [IFPUG, 2010].

Because it has a direct correlation with the effort expended in software development [ALBRECHT; GAFFNEY, 1983; KEMERER, 1987], FPA has been used as a tool for information technology management, not only in Brazil but worldwide. As identified in the *Quality Research in Brazilian Software Industry report*, 2009 [BRASIL, 2009, p. 93], FPA is the most widely used metric to evaluate the size of software among software companies in Brazil, used by 34.5% of the companies. According to a survey carried out by Bundschuh and Dekkers [2008, p. 393], 80% of projects registered on the International Software Benchmarking Standards Group (ISBSG), release 10, which applied metric used the FPA.

The FPA metric is considered a highly effective instrument to measure contracts [VAZQUEZ et al., 2011, p. 191]. However, it has the limitation of not treating non-functional requirements[2], such as quality criteria and response-time constraints. Brazilian federal government institutions also use FPA for procurement of development and maintenance of systems. In addition to the several decisions[3] by the Brazilian Federal Court of Accounts (TCU) that point out FPA as an example of metric to be used in contracts. the *Metrics Roadmap* of SISP [BRASIL, 2012], a federal manual for software procurement, recommends its application to federal agencies.

Despite the extensive use of the FPA metric, a large number of criticism about its validity and applicability, described in Section 2.2, put in doubt the

correctness of its use in contracts and the reliability of its application as a tool for IT management and IT governance.

So the question arises for the research: is it possible to propose a metric for software development, with the acceptance and practicality of FPA, that is, based on its concepts already widely known, without some of the flaws identified in order to maximize its use as a tool for IT governance, focusing on systems development and maintenance?

1.2 RESEARCH RATIONALE

The rationale for the research can be analyzed based on the interest of several players involved in the context of software development and maintenance:

1. governance committees: metric can derive indicators that will enable greater IT governability;

2. IT manager[4]: metric can allow for better control towards achieving the goals set by upper administration;

3. suppliers from the private market and public agencies: metric can increase objectivity of the relationship, enabling contracts with a lower probability of causing problems, with payment per results and fair prices;

4. oversight bodies, such as TCU: the metric can support evaluation, on a more objective basis, of software development public contracts (e.g. evaluations on IT planning, contract planning and contract management);

5. research institutions: the study proposed can serve as the foundation for new studies, after all, the field of metrics does not have many good research papers. A survey by Jörgensen and Shepperd (2007, p. 36) shows that most of the research of software costs does not take into consideration articles that have already been published and criticizes the obsolescence of the data used.

1.3 CLASSIFICATION OF METHODOLOGY

This paper can be classified as a practical research, according to the Demo classification (*apud* ANDRADE, 2002, p.4) since it aims at solving problems related to actual application, as mentioned in section 1.2.

According to Andrade (2012, p. 5-6), with regard to the objectives, the article is exploratory because it proposes a new approach to metric. It is also descriptive because it presents concepts, such as software metric, and illustrates its application in IT governance. As for the approach to achieve the objectives, the paper can be classified as deductive (ANDRADE, 2002, p. 11) since it proposes a new metric based on theoretical concepts. As for the procedures adopted, the paper uses the statistical method (ANDRADE, 2002, p. 14) to build and evaluate the results.

1.4 SPECIFIC OBJECTIVES

The specific objectives of this paper are:

1. to present an overview of software metrics and FPA;

2. to present the criticisms to the FPA technique that motivated the proposal of a new metric;

3. to derive a new metric based on FPA;

4. to evaluate the new metric against FPA in the correlation with effort;

5. to illustrate the use of the proposed metric in IT governance in the context of systems development and maintenance.

Each of the specific objectives is dealt with in its own subsection under the topic Development below.

2. DEVELOPMENT

2.1 SOFTWARE METRICS

2.1.1 Conceptualization, categorization, and application

Bundschuh and Dekkers [2008, p. 180-181] describe various interpretations for metric, measure, and indicator found in the literature. Concerning this study, no distinction is made among these three terms. We used Fenton and Pfleeger's definition [1988, p. 5] for measure: a number or symbol that characterizes an attribute of a real world entity, object or event, from formally defined rules[5].

Table I:
Examples Of Categories Of Software Metrics

Criterion	Category	Source
Entity	Process Product Resource	[13, p. 74]
Number of attributes involved	Direct Indirect	[13, p. 39]
Target of differentiation	Size Quality	[15, p. 32]

According to Fenton and Pfleeger [1998, p. 74], software metrics can be applied to three types of entities: processes, products, and resources. The authors also differentiate direct metrics, when only one attribute of an entity is used, from indirect metrics, the other way around [FENTON; PFLEEGER, 1998, p. 39]. Indirect metrics are derived by rules based on other metrics. The speed of delivery of a team (entity type: resource) is an example of indirect metric because it is calculated from the ratio of two measures: size of developed software (product) development and elapsed time (process). The elapsed time is an example of direct metric. Moser [1996, p. 32] differentiates size metrics from quality metrics: size metrics distinguish between the smallest and the largest whereas quality metrics distinguish between good and bad. Table I consolidates the mentioned categories of software metrics.

Moser [1996, p.31] notes that, given the relationship between a product and the process that produced it, a product measure can be assigned to a process, and vice versa. For example, the percentage of effort in testing, which is a development process attribute, can be associated with the generated product as an indicator of its quality. Additionally, the number of errors in production in the first three months, a system attribute (product), can be associated to the development process as an indicative of its quality.

Fenton and Pfleeger [1998, p. 12] set three goals for software metric: to understand, to control, and to improve the targeted entity. They call our attention to the fact that the definition of the metrics to be used depends on the maturity level of the process being measured: the more mature, more visible, and therefore more measurable [FENTON; PFLEEGER, 1998, p. 83]. Chikofsky and Rubin [1999, p. 76] highlight that an initial measurement program for a development and maintenance area should cover five key dimensions that address core attributes for planning, controlling, and improvement of products and processes: size, effort, time, quality, and rework. The authors remind us that what matters are not the metric itself, but the decisions that will be taken from them, refuting the possibility of measuring without foreseeing the goal [CHIKOFSKY; RUBIN, 1999, p. 75].

According to Beyers [2002, p. 337], the use of metric in estimates (e.g., size, time, cost, effort, quality, and allocation of people) can help in decision making related to software development and to software projects planning.

2.1.2 FPA overview

According to the categorization in previous section, FPA is an indirect measure of product size. It measures the functional size of an application (system) as a gauge of the functionality requested and delivered to the user of the software. This is a metric understood by users, regardless of the technology used[6].

It is worth mentioning that, in addition to FPA, there are four other functional metrics considered ISO standard of functional metric since they follow the rules defined in the six norms of the series ISO 14143 (ISO; IEC, 2002a, 2003, 2004, 2006, 2007, 2011a): MKII FPA (ISO; IEC, 2002b), COSMIC-FFP (ISO; IEC, 2011b), FiSMA (ISO; IEC, 2010) e NESMA (ISO; IEC, 2005). According to Gencel and Demirors (2008, p.4), ISO standard functional metrics estimate software size based on the function delivered to users, with a difference in counted objects and in the way they are counted[7].

Functionalities can be of two types: transactions, which implement data exchanges with users and other systems, and data files, which indicate the structure of stored data. There are three types of transactions: external inquiry (EQ), external outputs (EO), and external inputs (EI), as the primary intent of the transaction is, respectively, a simple query, a more elaborate query (e.g., with calculated totals) or data update. There are two types of logical data files: internal logical files (ILF) and external interface files (EIF), as their data are, respectively, updated or just referenced (accessed) in the context of the application.

Figure 2:
Visualization of the five types of functions in FPA

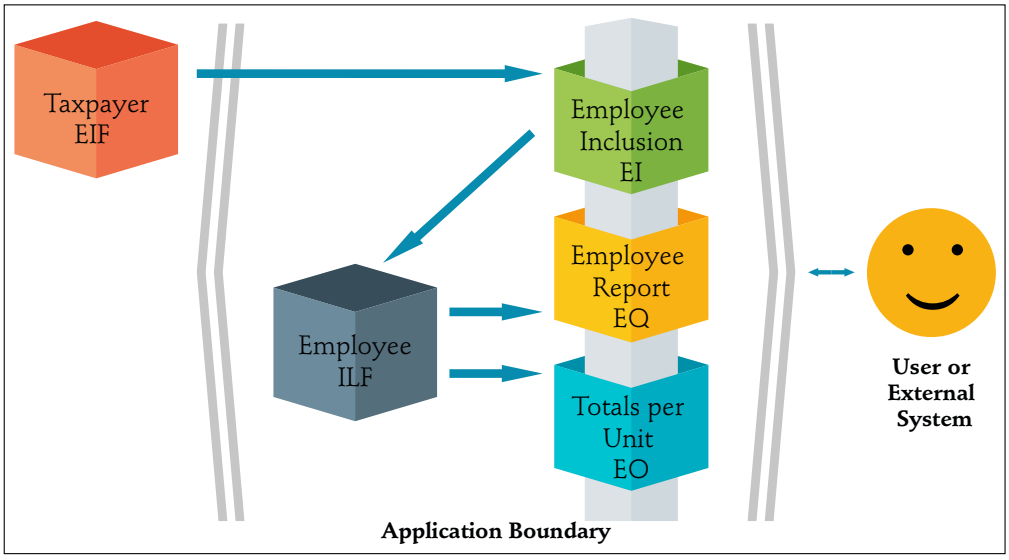


Fig. 2 illustrates graphically these function types. To facilitate understanding, we can consider an example of EI as an employee inclusion form which includes information in the employees data file (ILF) and validates the tax code informed by the user accessing the external file taxpayers (EIF), external to the application, which contain Federal Revenue CPF data. Also in the application we could have, hypothetically, an employee report, a simple query containing the names of the employees of a given organizational unit (EQ) and a more complex report with the number of employees per unit (EO).

In the FPA calculating rule, each function is evaluated for its complexity and takes one of three classifications: low, medium or high complexity. Each level of complexity is associated with a size in function points. Table II illustrates the derivation rule for external inquiries, according to the number of files accessed (File Type Referenced - FTR) and the number of fields that cross the boundary of the application (Data Element Type - DET).

As for EQ, each type of functionality (EO, EI, ILF, and EIF) has its specific rules for derivation of complexity and size, similar to Table II. Table III summarizes the categories of attributes used for calculating function points according to each type of functionality.

The software size is the sum of the sizes of its functionalities. This paper is not an in-depth presentation of concepts associated with FPA. Details can be obtained in the Counting Practices Manual, version 4.3.1 [IFPUG, 2010].

Table II:
Derivation Rule For Complexity And Size In Function Points Of An External Inquiry (Eq)

FTR (file) \ DET (field)	1 a 5	6 a 19	20 or more
1	low (3)	low (3)	medium (4)
2 a 3	low (3)	medium (4)	high (6)
4 or more	medium (4)	high (6)	high (6)

Table III:
Categories Of Functional Attributes For Each Type Of Functionality

Function	Functional Attributes
Transactions: EQ, EO, EI	referenced files (FTR) and fields (DET)
Logical files: ILF, EIF	logical registers (Record Element Type - RET) and fields (DET)Campos (ou TD – tipos de dados)

2.2 CRITICISMS TO THE FPA TECHNIQUE THAT MOTIVATED THE PROPOSAL OF A NEW METRIC

Despite the extensive use of the metric FPA, mentioned in Section I, there are a lot of criticism about its validity and applicability that call into question the correctness of its use in contracts and the reliability of its application as a tool for IT management and governance (ABRAN; ROBILLARD, 1994; FENTON; PFLEEGER, 1998; KITCHENHAM, 1997; KITCHENHAM; KÄNSÄLÄ, 1993; KITCHENHAM *et al.*, 1995; KRALJ *et al.*, 2005; PFLEEGER *et al.*, 1997; TURETKEN *et al.*, 2008; XIA *et al.*, 2009).

Several metrics have been proposed taking FPA as a basis for their derivation, either to adapt it to particular models, or to improve it, fixing some known bugs. To illustrate, there is Antoniol *et al.* [2003] work proposing a metric for object-oriented model and Kralj *et al.* [2005] work proposing a change in FPA to measure more accurately high complexity functions (item 4 below).

The objective of the metric proposed in this paper is not to solve all faults of FPA, but to help to reduce the following problems related to its definition:

1. low representation: the metric restricts the size of a function to only three possible values, according to its complexity (low, medium, or high). But there is no limit on the number of possible combinations of functional elements considered in calculating the complexity of a function in FPA;

2. functions with different functional complexities have the same size: as a consequence of the low representation. Pfleeger *et al.* [1997, p. 36] say that if H is a measure of size, and if A is greater than B, then H_A should be greater than HB. Xia *et al.* [2009, p. 3] show examples of functions with different complexities that were improperly assigned the same value in function points because they fall into the same complexity classification;

3. abrupt transition between functional element ranges: Xia *et al.* [2009, p. 4] introduced this problem. They present two logical files, B and C, with apparent similar complexities, differing only in the number of fields: B has 19 fields and C has 20 fields. The two files are classified as low (7 fp, function points) and medium complexity (10 fp), respectively. The difference lies in the transition of the two ranges in the complexity derivation table: up to 19 fields, it is considered low complexity; from 20 fields, it is considered medium complexity. The addition of only one field leading to an increase in 3 pf is inconsistent, since varying from 1 to 19 fields does not involve any change in the function point size. A similar result occurs in other transitions of ranges;

4. limited sizing of high complexity functions: FPA sets an upper limit for the size of a function according to its type. Kralj *et al.* [2005, p. 83] describe the situation of functions that are improperly classified as being of high complexity. They call attention to the need to have higher numbers for greater complexities and propose a change in the calculation of FPA as a solution[8];

5. operation on ordinal scale: as previously seen, FPA involves classifying the complexity of functions in low, medium or high complexity, as a ordinal scale. These labels in the calculated process are substituted by numbers. An internal logical file, for example, receives 7, 10 or 15 function points, as its complexity is low, medium or high, respectively. Kitchenham [1997, p. 29] criticizes the inadequacy of adding up values of ordinal scale in FPA. He argues that it makes no sense to add the labels *low complexity* and *high complexity*, even if using labels 7 and 15 respectively as synonyms;

6. inability to measure changes in parts of the function: this characteristic, for example, does not allow to measure function points of part of a functionality that needs to be changed in one maintenance operation. Thus, a function addressed in several iterations in an agile method or other iterative process is always measured with full size, even if the change is considered small in each of them.

Given the deficiencies reported, the correlation between the size in function points of software and the effort required for the development tends not to be appropriate, since FPA has these deficiencies in the representation of the real functional size of software. If there are inaccuracies in the measuring of the size of what must be done, it is impossible to expect a proper definition of the effort and therefore accuracy in defining the cost of development and maintenance. The

mentioned problems motivated the development of this work, in order to propose a quantitative metric, with infinite values, called Functional Elements (EF).

2.3 DERIVATION PROCESS OF THE NEW METRIC

The proposed metric, Functional Elements, adopts the same concepts of FPA but changes the mechanism to derive the size of function[9].

The reasoning process for deriving the new metric, as described in the following sections, implements linear regression similar to that seen in Graph 1. The objective is to derive a formula for calculating the number of EF for each type of function (Table VII in Section 2.3.4) from the number of functional attributes[10] considered in the derivation of its complexity, as indicated in Table II in Section 2.1.2.

The marked points in Graph 1 indicate the size in fp (Z axis) of an external inquiry derived from the number of files (X axis) and the number of fields (Y axis), which are the attributes used in the derivation of its complexity (see Table II in Section 2.1.2). The grid is the result of a linear regression of these points, and represents the value of the new metric.

2.3.1 Step 1 - definition of the constants

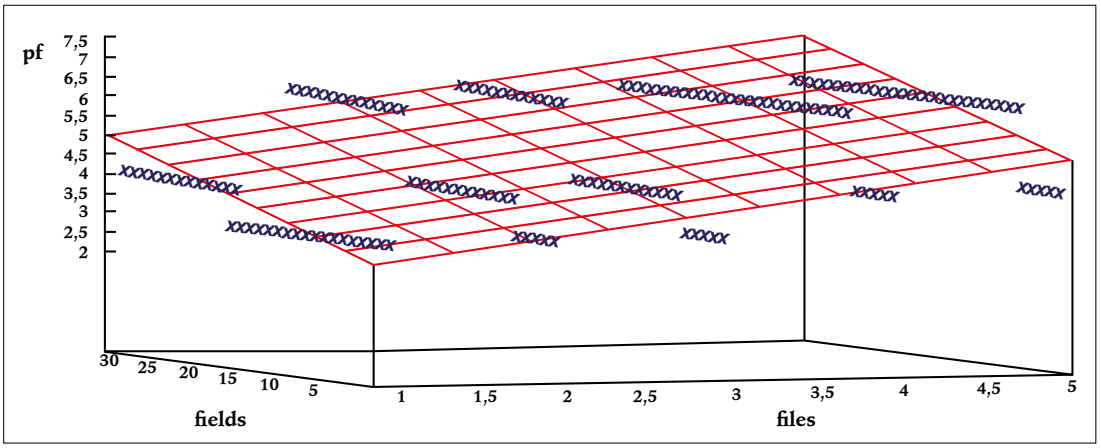
If the values associated with the two categories of functional attributes are zero, the EF metric assumes the value of a constant. Attributes can be assigned value zero, for example, in the case of maintenance limited to the algorithm of a function not involving changes in the number of fields and files involved. In the context of the new metric, the dimension of operation to exclude a functionality takes on the value of the constant, since there are no attributes specifically impacted by this operation.

The values assigned to these constants come from the NESMA, ISO standard of functional measurement, functional metric for the cases with zero-value attributes, as documented in *Function Point Analysis For Software Enhancement* (NESMA, 2009). FPA itself (IFPUG, 2010, v. 4, p. 94) indicates NESMA as an alternative for maintenance measurements due to its capacity to deal with the 6th criticism of section 2.2. NESMA scales maintenance by multiplication of the original size of the function by an impact factor of the alteration. The impact factor derives from the proportion between the volume of attributes (e.g. fields) included, altered or excluded and their original volume in the function. The adjustment factor takes on values that are multiples of 25%, up to the limit of 150%.

For each type of functionality, the proposed metric uses the smallest possible value by applying NESMA, that is, 25% of the number of fp of a low complexity function of each type: EIF - 1.25 (25% of 5); ILF - 1.75 (25% of 7); EQ - 0.75 (25% of 3); EI - 0.75 (25% of 3), and EO - 1 (25% of 4).

2.3.2 Step 2 - treatment of ranges with unlimited number of elements

In FPA, each type of function has its own table to derive the complexity of a function, in a similar way to Table II in Section II-A-2, which presents the values of the ranges of functional attributes for the derivation of the complexity of external inquiries. The third and last range of values of each functional element of the



Graph 1: Derivation of number of fp of an external inquiry from the attributes used in the calculation

derivation tables of all types of functions is unlimited, as we see *20 or more* TD in the first cell of the fourth column of the same table, and *4 or more* ALR in the last cell of the first column.

In order to create a finite set of data for regression, a superior limit was set for these ranges with a number of elements equivalent to that of the greatest precedent range[11]. In the case of ranges for external inquiries, the number of fields was limited to 33, a result of defining 14 as the number of elements of the third range (*20 to 33*), which is the same size of the largest range (*6 to 19 – 14 elements*). The number of referenced files was limited to 5, using the same reasoning. The limitation of the ranges is a mathematical artifice to prevent imposing an upper limit for the new metric (4th criticism in Section 2.2).

2.3.3 Step 3 - generation of points for regression

The objective of this phase was to generate, for each type of function, a set of data records with three values: the values of the functional attributes and the derived fp, already decreased from the value of the constant in step 1. Table IV illustrates some points generated for the external inquiry.

An application developed in MS Access generated a dataset with all possible points for the five types of functions, based on the tables of complexity with bounded ranges developed in the previous step. Table V shows all considered combinations of ranges for EQ.

2.3.4 Step 4 - linear regression

The several points obtained in the previous step were imported into Excel 2007 for linear regression between the size of FP and the functional attributes, using the Ordinary Least Squares Method (OLS) held constant with value zero, since these constants were already defined in step 1 and decreased from the expected value in step 3.

The statistical results of the regression are shown in Table VI for each type of function.

Table VII shows the derived formula for each type of function with coefficient values rounded to two decimal place values. Each formula calculates the number of functional elements, which is the proposed metric, based on the functional attributes impacting the calculation and the constants indicated in step 1. The acronym EFt and EFd represent the functional elements associated with transactions (EQ, EI, and EO) and data (ILF and EIF), respectively.

The functional elements metric, EF, is the sum of the functional elements transaction, EFT, with the functional elements of data, EFd, as explained in the formulas of Table VII. So the proposed metric is: EF = EFt + EFd.

The EFt submetric does not count logical files (ILF and EIF) in separate as in the EFd submetric, but only as they are referenced in the context of transactions. Files are also not counted in other ISO standard metrics of functional size [BUNDSCHUH; DEKKERS, 2008, p.

Table IV: Partial Extract Of The Dataset For External Inquiry

FTR	DET	PF (decreased of constant of step 1)
1	1	2,25
1	2	2,25 (...)
1	33	3,25
2	1	2,25 (...)

Table V: Combinations Of Ranges For Calculating Fp Of Eq

Function type	Initial FTR	Final FTR	Initial DET	Final DET	Original FP	PF decreased of constant
EQ	1	1	1	5	3	2,25
EQ	1	1	6	19	3	2,25
EQ	1	1	20	33	4	3,25
EQ	2	3	1	5	3	2,25
EQ	2	3	6	19	4	3,25
EQ	2	3	20	33	6	5,25
EQ	4	5	1	5	4	3,25
EQ	4	5	6	19	6	5,25
EQ	4	5	20	33	6	5,25

388]: MKII FPA [ISO; IEC, 2002b] and COSMIC-FFP [ISO; IEC, 2011b].

When evaluating the metric, in the next section, two of them were tested, EF and EFt, counting and not counting the logic files, and the results show that EFt has a better correlation with effort[12]. Although it was not assessed, submetric EFd has its worth because it reflects the structural complexity of the data of an application.

2.4 EVALUATION OF THE NEW METRIC

The new EF metric and its submetric EFt were evaluated for their correlation with effort in comparison to the FPA metric. The goal was not to evaluate the quality of these correlations, but to compare their ability to explain the effort[13].

We obtained a spreadsheet from a federal government agency with records of Service Orders (OS) contracted with private companies for coding and testing activities[14]. An OS

Table VI: Statistical Regression - Comparing Results Per Types Of Functions

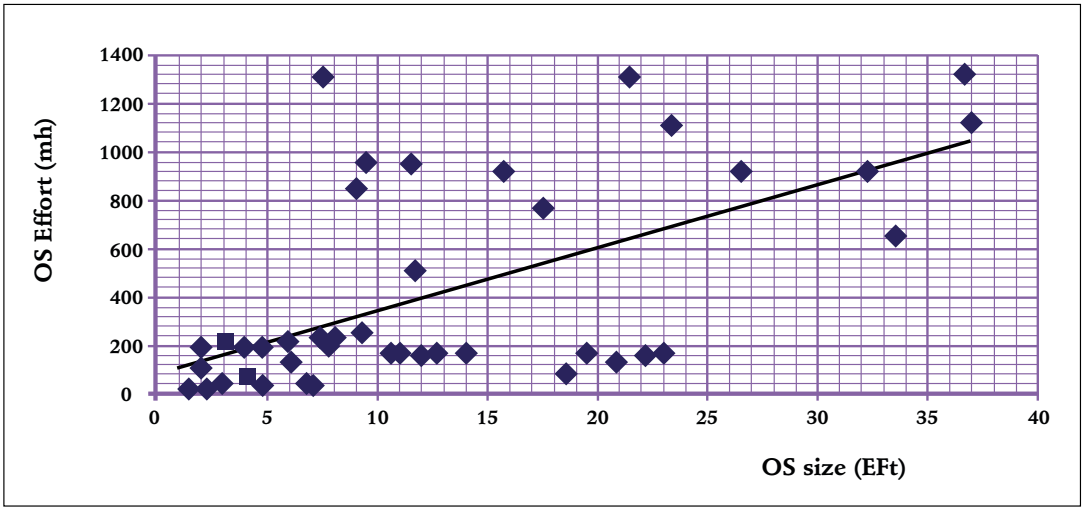
	ILF	EIF	EO	EI	EQ
R^2	0,96363	0,96261	0,95171	0,95664	0,96849
Records	729	729	198	130	165
Coefficient *p-value* (FTR or RET)	3,00E-212	1,17E-211	7,65E-57	1,70E-43	4,30E-60
Coefficient *p-value* (DET)	2,28E-231	2,71E-225	1,44E-59	2,76E-39	2,95E-45

Table VII: Calculation Formulas Of Functional Elements By Type Of Function

Function type	Formula
ILF	$EFd = 1.75 + 0.96 * RET + 0.12 * DET$
EIF	$EFd = 1.25 + 0.65 * RET + 0.08 * DET$
EO	$EFt = 1.00 + 0.81 * FTR + 0.13 * DET$
EI	$EFt = 0.75 + 0.91 * FTR + 0.13 * DET$
EQ	$EFt = 0.75 + 0.76 * FTR + 0.10 * DET$

Table VIII: Structure Of The Received Data To Evaluate The Metric

Abbreviation	Description	Domain
OS	Identification Number of a service order	up to 10 numbers
Function	Identification Number of a function	up to 10 numbers
Type	Type (categorization) of a functionality according to FPA	EQ, EI, EO, ILF or EIF
Operation	Operation performed, which may be inclusion (I) of a new feature or change (A) of a function (maintenance)	I or A
Final FTR RET	Value at the conclusion of the request implementation: if the function is a transaction, indicates the number of referenced logical files (FTR); if it is a logical file, indicates the number of logical records (RET)	up to 3 numbers
Operation FTR RET	Number of FTR or RET that were included, changed or deleted in the scope of a maintenance of a functionality (only in change operation)	up to 3 numbers
Original FTR RET	Number of FTR or RET originally found in the functionality (only in change operation)	up to 3 numbers
Final DET	Number of DET at the conclusion of the request implementation	up to 3 numbers
Operation DET	Number of DET included, changed or deleted in the scope of a functionality maintenance (only in change operation)	up to 3 numbers
Original TD	Number of DET originally found in a functionality (only in change operation)	up to 3 numbers
FP	Number of function points of the functionality at the conclusion of the request	up to 2 numbers
%Impact	Percentage of the original function impacted by the maintenance, as measured by NESMA [27]	25, 50, 75, 100, 125, 150
PM	Number of maintenance points of the functionality handled, as measured by NESMA [27]	up to 4 numbers
System	Identification of a system	one char
Hours	Hours dedicated by the team to implement the OS	up to 5 numbers
Team	Number of team members responsible for the implementation of the OS	up to 2 numbers



Graph 2: Dispersion of points (OS) of H system: effort (man-hour) x size (Functional Element of Transaction)

contained one or more requests for maintenance or development of functions of one system, such as: create a report, change a transaction. The spreadsheet showed for each OS the real allocated effort and, for each request, the size of the function handled. The only fictitious data were the system IDs, functionality IDs and OS IDs, as they were not relevant to the scope of this paper. The spreadsheet showed the time spent in hours and the number of people allocated for each OS. The OS effort, in man-hours, was derived from the product of time by team size. Table VIII presents the structure of the received data.

Data from 183 Service Orders were obtained. However, 12 were discarded for having dubious information, for example, undefined values for function type, number of fields, and operation type. The remaining 171 service orders were related to 14 systems and involved 505 requests that dealt with 358 different functions. To achieve higher quality in the correlation with effort, we decided to consider only the four systems[15] associated with at least fifteen OS, namely, systems H, B, C, and D. Table IX indicates the number of OS and requests for each system selected.

The data were imported into Excel 2007 to perform the linear regression[16] using the ordinary least squares method after calculating the size in EF and EFt metrics for each request in an MS-Access application developed by the authors: between the effort and the size, calculated in the FP, EF and EFt metrics. The linear regression was carried out considering the constant with value zero, since there is no effort if there is no size[17]. The operation was done through a system because the variability of the factors that have an influence on effort are reduced within a single system[18]. Graph 2 illustrates the dispersion of points (OS) on the correlation between size and effort in EFt (man-hour) and the line derived by linear regression in the context of system H.

The coefficient of determination R^2 was used to represent the degree of correlation between effort and size calculated for each of the evaluated metrics. According to Sartoris [2008, p. 244], R^2 indicates, in a linear regression, the percentage of the variation of a dependent variable Y that is explained by the variation of a second independent variable X. Table IX shows the results of the linear regressions performed.

From the results presented on Table IX, comparing the correlation of the metrics with effort, we observed that:

1. correlations of the new metrics (EF, EFt) were considered significant at a confidence level of 95% for all systems (*p-value* less than 0.05[19]). However, the correlation of FPA was not significant for system B (*p-value* 0.088 > 0.05);

2. correlations of the new metrics were higher in both systems with the highest number of OS (H and B). A better result in larger samples is an advantage, because the larger the sample size, the greater the reliability of the results, since the *p-value* has reached the lowest values for these systems;

3. although no metric got a high coefficient of determination ($R^2 > 0.8$), the new metrics achieved medium correlation ($0.8 > R^2 > 0.5$) in the four systems evaluated, whereas FPA obtained weak correlation (0.2 > R2) in system B, considering the confidence level of 91.2% in this correlation (*p-value* 0.088);

4) correlations of the new metrics were superior[20] in three out of the four systems (H, B, and D), that is, in 75% of the systems.

Table IX: Results Of Linear Regressions - Effort Versus Metrics Of Size

System		H	B	C	D
Quantity of OS		45	25	21	15
Quantity of Requests		245	44	60	20
FP	R^2	59,3%	11,2%	67,7%	51,8%
	***p-value* (teste-f)**	4,6E-10	8,8E-02	3,3E-06	1,9E-03
EF	R^2	65,1%	60,3%	53,0%	54,7%
	***p-value* (teste-f)**	1,5E-11	2,3E-06	1,4E-04	1,2E-03
	Proportion to FP's R^2	+10%	+438%	-22%	+5%
EFt	***R2***	66,1%	60,3%	53,0%	54,7%
	***p-value* (teste-f)**	8,5E-12	2,3E-06	1,4E-04	1,2E-03
	Proportion to FP's R^2	+11%	+438%	-22%	+5%

Table X: Justifications Of How The New Metrics Address The Critiques Presented In Section 2.2

Criticism	Solution
Low representation	Each possible combination of the functional attributes considered in deriving the complexity in FPA is associated with a distinct value.
Functions with different complexities have the same size	Functionalities with different complexities, as determined by the number of functional attributes, assume a different size.
Abrupt transition between functional element ranges	By applying the formulas of calculation described in Table VII in Section 2.3.4, the variation in size is uniform for each variation of the number of functional attributes, according to its coefficients.
Limited sizing of high complexity functions	There is no limit on the size assigned to a function by applying the calculation formulas described in Table VII in Section 2.3.4.
Undue operation on ordinal scale	The metrics do not have a ordinal scale with finite values, but rather a quantitative scale with infinite discrete values, which provide greater reliability in operations with values.
Inability to measure changes in parts of the function	Enables the measurement of changes in part of a functionality considering in the calculation only the functional attributes impacted by the amendment.

Given the observations listed above, we conclude that the metrics proposed, EF and EFt[21], have better correlation with effort in comparison to FPA for the analyzed data[22].

Table X contains the explanation of how the proposed metrics, EF and EFt, address the criticisms presented in Section 2.2.

2.5 ILLUSTRATION OF THE USE OF THE NEW METRICS IN IT GOVERNANCE

Kaplan and Norton [1992, p. 71] claim that what you measure is what you get. According to COBIT 5 [ISACA, 2012b, p. 13], governance aims to create value by obtaining the benefits through optimized risks and costs. In relation to IT governance, the metrics proposed in this paper not only help to assess the capacity of IT but also enable the optimization of its processes to achieve the results.

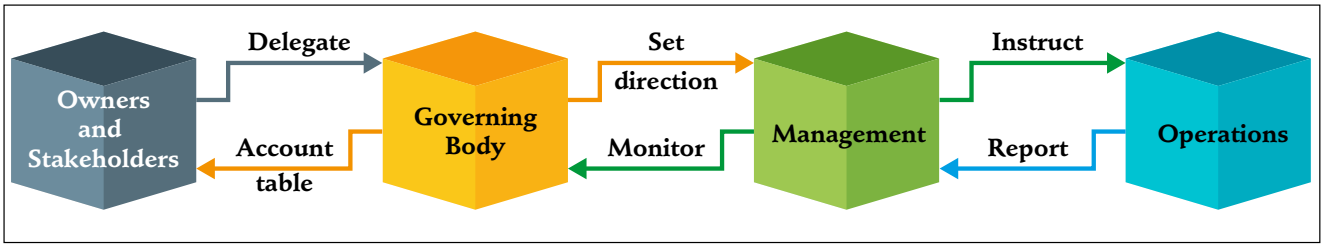
Metrics support the communication between the different actors of IT governance (see Fig. 3) by enabling the translation of objectives and results in numbers. The quality of a process can be increased by stipulating objectives and by measuring results through metrics [MOSER, 1996, p. 19]. So, the production capacity of the process of information systems development can be enhanced to achieve the strategic objectives with the appropriate use of metrics and estimates.

Software metrics contribute to the three IT governance activities proposed by ISO 38500, mentioned in Section 1.1: to assess, to direct and to monitor. These activities correspond, respectively, to the goals of software metrics mentioned in Section 2.1.1: to understand, to improve, and to control the targeted entity of a measurement.

Regarding the directions of IT area, Weill and Ross [2006, p. 188] state that the creation of metrics for the formalization of strategic choices is one of four management principles that summarize how IT governance helps companies achieve their strategic objectives. Metrics must capture the progress toward strategic goals and thus indicate if IT governance is working or not [WEIL; ROSS, 2006, p. 188].

Kaplan and Norton [1996, pp. 75-76] claim that strategies need to be translated into a set of goals and metrics in order to have everyone's commitment. They claim that the Balanced Scorecard (BSC) is a tool which provides knowled-

Figure 3:
Roles, activities and relationships of IT governance



Adapted from ISACA [2012a, p. 24]

ge of long-term strategies at all levels of the organization and also promotes the alignment of department and individual goals with those strategies. According to ITGI [2007, p. 29], BSC, besides being a holistic view of business operations, also contributes to connect long-term strategic objectives with short-term actions.

To adapt the concepts of the BSC for the IT function, the perspectives of a BSC were re-established [VAN GREMBERGEN; VAN BRUGGEN, 1997, p. 3]. Table XI presents the perspectives of a BSC-IT and their base questions.

According to ITGI [2007, p. 30], BSC-IT effectively helps the governing body to achieve alignment between IT and the business. This is one of the best practices for measuring performance [ITGI, 2007, p. 46]. BSC-IT is a tool that organizes information for the governance committee, creates consensus among the stakeholders about the strategic objectives of IT, demonstrates the effectiveness and the value added by IT and communicates information about capacity, performance and risks [ITGI, 2007, p. 30].

Van Grembergen [2000, p.2] states that the relationship between IT and the business can be more explicitly expressed through a cascade of scorecards. Van Grembergen [2000, p.2] divides BSC-IT into two: BSC-IT-Development and BSC-IT-Operations. Rohm and Malinoski [2010], members of the Balanced Scorecard Institute, present a process with nine steps to build and implement strategies based on scorecard. Bostelman and Becker [1999] present a method to derive objectives and metrics from the combination of BSC and the Goal Question Metric (GQM) technique proposed by Basili and Weiss [1984]. This association between BSC and GQM is consistent to what ISACA [2010, p. 74] says: good strategies start with the right questions. The metric proposed in this paper can compose several indicators that can be used in BSC-IT-Development.

Regarding the activities of IT monitoring and assessment [ISO; IEC, 2008, p. 7], metrics enable the monitoring of the improvement rate of organizations toward a mature and improved process [RUBIN, 1993, p. 473]. Performance measurement, which is object of monitoring and assessment, is one of the five focus areas of IT governance, and it is classified as a driver to achieve the results [ITGI, 2007, p. 19].

To complement the illustration of the applicability of the new metric for IT governance, Table XII shows some indicators based on EF. The same indicator can be used on different perspectives of a BSC-IT-Development, depending on the targeted entity and the objective of the measurement, such as the following examples. The productivity of a resource (e.g., staff, technology) may be associated with the *Future Orientation* perspective, as it seeks to answer whether IT is prepared for future needs. The same indicator, if associated with an internal process, encoding, for example, reflects a vision of its production capacity, in the *Operational Excellence* perspective. In the *Customer Orientation* perspective, production can be divided by client, showing the proportion of IT production to each business area. The evaluation of the variation in IT production in contrast to the production of business would be an example of using the indicator in the *Contribution to the Business* perspective.

The choice of indicators aimed to encompass the five fundamental dimensions mentioned in Section

Table XI:
Perspectives Of A Bsc-It

Source: inspired in ITGI [2, p. 31]

Perspective	Base question	BSC corporative perspective
Contribution to the business	How do business executives see the IT area?	Financial
Customer orientation	How do customers see the IT area?	Customer
Operational excellence	How effective and efficient are the IT processes?	Internal Processes
Future orientation	How IT is prepared for future needs?	Learning

Table XII: Description Of Illustrative Indicators

Metric	Unit	Dimension	Description of the calculation for a system
Functional size	EF	Size	sum of the functional size of the functionalities that compose the system at the end of the period
Production in the period	EF	Effort	sum of the functional size of requests for inclusion, deletion, and change implemented in the period
Production on rework	EF	Rework	sum of the functional size of requests for deletion and change implemented in the period
Productivity	Functional Elements / Man–hour	Effort	sum of the functional size of requests implemented in the period / sum of the efforts of all persons allocated to the system activities in the period
Error density	Failures / Functional Element	Quality	number of failures resulting from the use of the system in a period / size of the system at the end of the period
Delivery speed	Functional Elements / Hour	Time	sum of the size of the features implemented in the period / elapsed time
Density of the expected benefit	$ / EF	Expected benefit	benefit expected by the system in the period / system size

II.11: size, effort, time, quality, and rework. Another dimension was added: the expected benefit. According to Rubin [2003, p. 1], every investment in IT, from a simple training to the creation of a corporate system, should be aligned to a priority of the business whose success must be measured in terms of a specific value[23]. The dimension of each indicator is shown in the third column of Table XII.

Some measurements were normalized by being divided by the number of functional elements of the product or process, tactics used to allow comparison across projects and systems of different sizes. The ability to standardize comparisons, as in a BSC, is one of the key features of software metrics [HUFSCHMIDT , 2002, p. 493]. It is similar to normalize construction metrics based on square meter, a common practice [DEKKERS, 2002, p. 161].

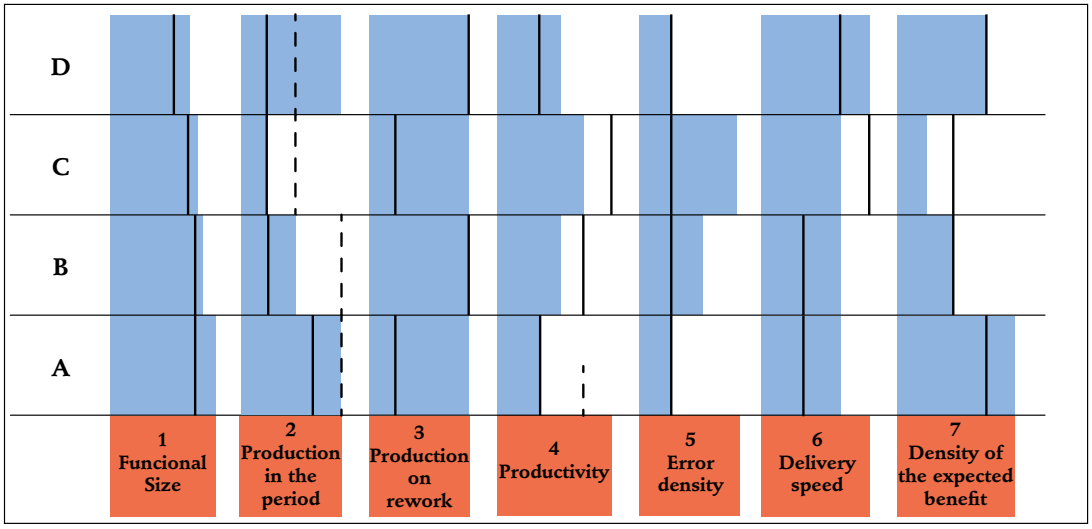
As Dennis argues [2002, p. 302], one should not make decisions based on a single indicator, but from a vision formed by several complementary indicators. As IT has assumed greater prominence as a facilitator to the achievement of business strategy, the use of dashboards to monitor its performance, under appropriate criteria, has become popular among company managers [ISACA 2010, p. 74]. Abreu and Fernandes [2009, p. 167] propose some topics that may compose strategic and tactical control panels of IT.

Graph 3 illustrates the behavior of the indicators shown in Table XII with annual verification for hypothetical systems. The vertical solid line indicates how the indicator to the system was in the previous period, allowing a view of the proportion of the increasing or decreasing of the values over the period. In the productivity column (column 4), a short line at its base indicates, for example, a pattern value obtained by benchmark. The vertical dashed line metric associated with the production in the period (2) indicates the target set in the period for each system: system A reached it, system D exceeded it, and systems B and C failed.

In one illustrative and superficial analysis of the indicators for system C, one can associate the cause of not achieving the production goal during that period (2) with the decrease of the delivery speed (6) and with the increase of the production on rework (3), resulted, most likely, from the growth in the error density (5). The reduction on the delivery speed (6) which can be associated with decreased productivity (4) led to a low growth of the functional size of the system (1) during that period. These negative results led to a decrease in the density of the expected benefit (7).

Graph 3 represents an option of visualization of the governance indicators shown in Table XII: a multi-metrics chart of multi-instances of a targeted entity or a targeted attribute. The vertical column width is variable depending on the values of the indicators (horizontal axis) associated with the different instances of entities or attributes of interest (vertical axis). The same vertical space is allocated for each entity instance. The width of the colored area, which is traced from the left to the right, indicates graphically the value of the indicator for the instance.

In the hands of the governance committee, correct indicators can help senior management, directly or through any governance structure, to identify how IT



Graph 3: Annual indicators of systems A, B, C and D

management is behaving and to identify problems and the appropriate course of action when necessary.

3. FINAL CONSIDERATIONS

The five specific objectives proposed for this work in Section 1.4 were achieved, albeit with limitations and with possibilities for improvement that are translated into proposals for future work.

The main result was the proposition of a new metric EF and its submetric EFt. The new metrics, free of some deficiencies of the FPA, metrics taken as a basis for their derivation, reached a higher correlation with effort than the FPA metric, in the context of the analyzed data.

The paper also illustrated the connection between metrics and IT governance activities, either in assessment and monitoring, through use in dashboards, or in giving direction, through use in BSC-IT.

There are possibilities for future work in relation to each of the specific objectives.

Regarding the conceptualization and the categorization of software metrics, a comprehensive literature research is necessary to the construction of a wider and updated categorization of software metrics.

Regarding the presentation of the criticisms to FPA, only the criticisms addressed by the new proposed metrics were presented. Research in the theme, as a bibliographic research to catalog the criticisms, would serve to encourage other propositions of software metrics.

Regarding the process of creating the new metric, it could be improved or it could be applied to other metrics of any area of knowledge based on ordinal values derived from tables of complexity as FPA (e.g., metric proposed by KARNER [1993]: Use Case Points). Future works may also propose and evaluate changes in the rules and in the scope of the EF. The creation process could be improved for example, by treating differently the unlimited ranges section (2.3.2). Weights could be attributed to sizes of the limited ranges, for example, according to the proportion of the functions that integrate such ranges in a sample with functionalities from several systems.

Regarding the evaluation of the new metric, the limitation in using data from only one organization could be overcome in new works. Practical applications of the metric could also be illustrated, for example, in contracts with an incremental delivery process. New works could compare the results of EF with the EFt submetric as well as compare both with other software metrics. Different statistical models could be used to evaluate its correlation with effort even in specific contexts (e.g., development, maintenance, development platforms). We expect to achieve a higher correlation of the new metric with effort in agile methods regarding to the FPA, considering its capacity of partial functionality sizing. (6th criticism in Section 2.2.)

Regarding the connection with IT governance, a work about the use of metrics in all IT governance activities is promising. The proposed graph[25] for visualization of multiple indicators of multiple instances through columns with varying widths along their length could also be standardized and improved in future work.

A suggestion for future work is noteworthy: the definition of an indicator that shows the level of maturity of a

company regarding to the use of metrics in IT governance. Among other aspects, it could consider in the composition of the indicator, the following are noteworthy: the breadth of the entities evaluated (e.g., systems, projects, processes, teams), the dimensions treated (e.g., size, rework, quality, benefits) and the effective use of the indicators (e.g., monitoring, direction).

Finally, we expect that the new metric EF and its submetric EFt help increase the contribution of IT to the business in an objective, reliable, and visible way.

NOTES

1 A version of this paper, in English, not including all the content here, was presented at the XXVII SBES (Brazilian Symposium on Software Engineering) promoted by SBC (Brazilian Computer Society) and was published in the IEEE Xplore: M. V. B. D. Castro and C. A. M. Hernandes, "A Metric of Software Size as a Tool for IT Governance", *Software Engineering (SBES), 2013 27th Brazilian Symposium on*, Brasilia, 2013, pp. 99-108. . doi: 10.1109/SBES.2013.13..

2 In its version, 4.3.1 (IFPUG, 2010), appendix C, there is a possibility of adjusting the functional size of a factor that reflects an assessment of the system in relation to 41 general non-functional characteristics. According to Fenton and Pfleeger (1998, p. 262), the determination is subjective and according to Kemerer (1987, p. 9), the adjustment does not increase the correlation of metric with effort. This part was separated from the standard rule of function points because FPA is an ISO standard of functional metric only without application of the adjustment.

3 There are several rulings on the subject: 1.782/2007, 1.910/2007, 2.024/2007, 1.125/2009, 1.784/2009, 2.348/2009, 1.274/2010, 1.647/2010, all of the Plenary of the TCU.

4 Also known as CIO – Chief Information Officer.

5 Kitchenham et al (1995) present a framework for the software metric in which they list the concepts associated with the formal model on which the metric is based (e.g. type of scale used).

6 The overview presented results from the experience with the FPA of Marcus, one of the authors. In 1993 he coordinated a program for implementation of the use of FPA in the development area of the Superior Labor Court (TST). At the TCU, he also works with metric.

7. Functional requirements are only one dimension of several impacting the effort. All of them have to be taken into account in estimates. Estimates and non-functional requirements evaluations are not the goal of this paper.

8. Functionalities with a very low level of complexity are also not dimensioned appropriately for FPA because they take on the minimum value when they should take on an even smaller value.

9. Because they are concepts that are widely known by the measurers, it is expected that the new metric will be accepted among the professionals of the field.

10 In this paper, these attributes correspond to the concept of functional elements, name of the proposed metric.

11 The alternative of attributing a third range to the sum of elements of the two first ranges was also assessed. However, this approach was less efficiant in the correlation with effort, for all data evaluated.

12 The choice was to distinguish the EFt metric for application in cases where the effort to treat data structures (Efd) is not the object of assessment or contract. Although it has not been assessed, the EFd submetric has its role in translating the structural complexity of data of an application

13 Kemerer (1987, p. 428) justified the use of linear regression as a means to evaluate the correlation of FPA metric with effort.

14 The agency that provides the data informed that each system was implemented in one language only: Java, DotNet or Natural.

15 The order of the systems follows the criterium of the quantity of OS.

16 A logistic non-linear regression was also carried out, with a constant, using the Gretl software, a free open code tool (http://www.simula.no/BESTweb), created as a result of the Jörgensen and Shepperd research (2007). However, the R2 factor proved that this alternative was worse than the linear regression for all metrics and, therefore, the nonlinear model correlation was discarded. R2 nonlinear regression reached the following values: (system R2_APF, R2_PM, R2_EF, R2_EFt) - (M, 0.316, 0.470, 0.434, 0.426); (B 0.013, 0.313, 0.442, 0.443); (C, 0.327, 0.262, 0.16, 0.152) and (D, 0.02, 0.127, 0.087, 0.087).

17 That is, the line goes through the origin of the axes.

18 This restriction is justified, for example, by the information given by the agency providing the data that the development language is only one per system and that the technical team is, as a general rule, also the same per system. The language and the team are factors that influence effort. The factors that influence effort and the degree of this correlation were discussed in several articles. For more details on the topic, we suggest accessing the articles in the base BestWeb (http://www.simula.no/BESTweb), created as a result of the Jörgensen and Shepperd research (2007).

19 In order to consider a correlation as statistically significant at a X% level of reliability, the p-value must be smaller than a 1 – X (ORLOV, 2996, p. 11). For a 95% level, the p-value needs to be smaller than 0,05.

20 The criterion used to consider the correlation C1 superior to correlation C2: C1 being significant and C2 not significant or, if both are significant, C1 having a larger R2 than C2.

21 We notice a greater correlation of the EFt metric in relation to EF in the H system, the only system that enabled a difference in the result of the two metrics by presenting commands related to the alteration of logic files in its OS. Thus, we notice a trend that is favorable for submetric EFt in relation to EF, reinforcing the hypothesis that submetric EFd which makes up the EF metric does not impact the coding and testing effort, tasks dealt with in the OS that were assessed.

22 A comparison between the correlation of the EF metric and the correlation of the PM metric (NESMA) was not the objective of the work. However, since the data also provided measures in PM, a metric used in contract of the data provider, an assessment of the PM metric was also carried out.

System		H	B	C	D
PM	R^2	67,0%	48,1%	63,7%	60,4%
	p-value (teste-f)	4,7E-12	6,7E-05	1,1E-05	4,8E-04
	comparison R^2 PF	+13%	+329%	-6%	+17%

Comments

1. all correlations were considered significant at a confidence level of 95%;

2. as the new metric, PM achieved average correlations (0.8> R-squared> 0.5) for the four systems and a superior result than the FPA in the same three systems (H, B and D);

3. in the H system there was a equivalence of PM correlation with EFT correlation, with 0.9%, as the difference between the two correlations;

4. PM correlations were higher in 2 systems in relation to the new metric (C and D) and lower in a system (B).

5. in the context of the data assessed, the numbers show a slight superiority of PM in relation to the new metrics. However, we can foresee a potential of better results for EF, since PM has the first five flaws mentioned in section2.2.

6. PM has another conceptual flaw: in contrast with the FPA and EF, it dimensions in a different way software that is under development and software in maintenance, with different adjustment factors. The maintenance cost can actually be different with relation to development. Since it can also be different due to other factors (e.g. language used, methodology applied). Factors that do not alter the size of software, but the cost. Bringing concern with cost to the size of the software, as PM does, does not seem to be the best option because these are different concepts.

7. another disadvantage of PM in relation to the proposed metric is the counting cost. PM requires the length of the functionality before the maintenance, and no extra effort is required for the new metrics.

23 The scope of the work does not include investigating the concepts and processes associated to determining the value of a function or of a system or IT area. It is a complex topic that is still incipient.

24 The maximum value for each indicator in the period was associated to the maximum width defined for the column. The widths of the colored areas of the other systems were derived by using a simple rule of three.

25 At http://learnr.wordpress.com/ (access on Nov 4. 2012) there is a graph, which is functionally similar to what is proposed: *heatmap plotting*, however it is different as to format and possibilities of evolution. Since a similar graph was not found, the assumption is that it is a new format to visualize the behavior of multiple indicators in multiple instances in columns with variable widths in their extension (MIMICoVaWE - Multiple Indicators about Multiple Instances through Columns with Varying Widths along their Extension). Two examples among the several possible evolutions for a graph: an exchange in the position between the metrics and the instances, with these passing through the horizontal axis, a variation in the color tone of the cell that relates a metric to an instance according to some criterion (e.g. a regarding achievement of a specified goal).

REFERÊNCIAS

ABRAN, A.; ROBILLARD P. N. Function points: a study of their measurement processes and scale transformations. Journal of Systems and Software 25(2): 171-184. 1994.

ALBRECHT, A. J. (1979). "Measuring application development productivity." Proceedings of the Joint SHARE/GUIDE/IBM Application Development Symposium, SHARE Inc. and GUIDE International Corp. Monterey, CA.

ALBRECHT, A. J.; GAFFNEY JR. J. E. Software function, source lines of code, and development effort prediction: a software science validation. Software Engineering, IEEE Transactions on(6): 639-648. 1983.

ANDRADE, M. M. Como preparar trabalhos para cursos de pós-graduação: noções práticas, Atlas. 2002.

ANTONIOL, G. et al. Object-oriented function points: An empirical validation. Empirical Software Engineering 8(3): 225-254. 2003.

BASILI, V. R.; WEISS D. M. A methodology for collecting valid software engineering data. Software Engineering, IEEE Transactions on(6): 728-738. 1984.

BECKER, S. A. ; BOSTELMAN M. L. Aligning strategic and project measurement systems. Software, IEEE 16(3): 46-51. 1999.

BEYERS, C. P. Estimating software development projects. In: IFPUG. IT Measurement: Practical Advice from the Experts. Addison-Wesley Indianapolis. p. 337-362. 2002.

BRASIL. MCT - Ministério da Ciência e Tecnologia. Pesquisa de Qualidade no Setor de Software Brasileiro 2009. Brasília: Ministério da Ciência e Tecnologia.Secretaria da Política de Informática. 204p. Disponível em: <http://www.mct.gov.br/upd_blob/0214/214567.pdf>. Acesso em: 16 set. 2012. 2009.

BRASIL. SISP - Sistema de Administração dos Recursos de Tecnologia da Informação. Roteiro de Métricas de Software do SISP.Versão 2.0 Brasília: Ministério do Planejamento, Orçamento e Gestão.Secretaria de Logística e Tecnologia da Informação. Disponível em: <http://www.sisp.gov.br/ct-gcie/download/file/Roteiro_de_Metricas_de_Software_do_SISP_-_v2.0. pdf>. Acesso em: 31 out. 2012. 2012.

BUNDSCHUH, M.; DEKKERS C. The IT measurement compendium: estimating and benchmarking success with functional size measurement. Springer. 2008.

CHIKOFSKY, E. e RUBIN H. A. Using metrics to justify investment in IT. IT professional 1(2): 75-77. 1999.

DEKKERS, C. A. How and when can functional size fit with a measurement program? In: IFPUG. IT Measurement: Practical Advice from the Experts. Addison-Wesley Indianapolis. p. 161-170. 2002.

DENNIS, S. P. Avoiding obstacles and common pitfalls in the building of an effective metrics program. In: IFPUG. IT Measurement: Practical Advice from the Experts. Addison-Wesley Indianapolis. p. 295-304. 2002.

FENTON, N. E.; PFLEEGER S. L. Software metrics: a rigorous and practical approach. PWS Publishing Co. 1998.

FERNANDES, A. A.; ABREU V. F. Implantando a governança de TI: da estratégia à gestão de processos e serviços. Brasport. 2009.

GENCEL, C.; DEMIRORS, O. Functional size measurement revisited. ACM Transactions on Software Engineering and Methodology (TOSEM) 17(3): 15. 2008.

HUFSCHMIDT, B. Software balanced scorecards: the icing on the cake. In: IFPUG (2002). IT Measurement: Practical Advice from the Experts. Addison-Wesley Indianapolis. p. 491-502. 2002.

IFPUG - International Function Point Users Group. Manual de Práticas de Contagem de Pontos de Função, Versão 4.3.1 IFPUG. 2010.

ISACA - Information Systems Audit and Control Association. CGEIT Review Manual 2010. ISACA. 2010.

_____. COBIT 5: A Business Framework for the Governance and Management of IT. ISACA. 2012a.

_____. COBIT 5: Enabling Processes. Isaca. 2012b.

ISO - International Organization for Standardization; IEC -.International Electrotechnical Commission. 14143-4: Information Technology - Software Measurement – Functional Size Measurement - Part 4: Reference Model. 2002a.

_____. 20968: MkII Function Point Analysis - Counting Practices Manual. 2002b.

_____. 14143-3: Information Technology - Software Measurement – Functional

Size Measurement - Part 3: Verification of Functional Size Measurement Methods. 2003.

_____.14143-5: Information Technology - Software Measurement – Functional

Size Measurement - Part 5: Determination of Functional Domains for Use with Functional Size Measurement. 2004.

_____. 24570: NESMA functional size measurement method version 2.1 – Definitions and counting guidelines for the application of Function Point Analysis. 2005.

_____.14143-6: Guide for the Use of ISO/IEC 14143 Series and Related International Standards. 2006.

_____.14143-1: Information Technology - Software Measurement - Functional Size Measurement - Part 1: Definition of Concepts. 2007.

_____. 38500: Corporate governance of information technology. 2008.

_____. 20926: Software measurement - IFPUG functional size measurement method. 2009.

_____. 29881: FiSMA 1.1 functional size measurement method. 2010.

_____. 14143-2: Information Technology - Software Measurement - Functional Size Measurement - Part 2: Conformity Evaluation of Software Size Measurement Methods to ISO/IEC 14143-1. 2011a.

_____. 19761: COSMIC: a functional size measurement method. 2011b.

ITGI. IT Governance Institute. Board briefing on IT Governance. 2nd Ed. Isaca. 2007.

JORGENSEN, M.; SHEPPERD, M. A systematic review of software development cost estimation studies. Software Engineering, IEEE Transactions on 33(1): 33-53. 2007.

KAPLAN, R. S.; NORTON, D. P. The balanced scorecard - measures that drive performance. Harvard business review 70(1): 71-79. 1992.

KAPLAN, R. S.; NORTON D. P. Using the balanced scorecard as a strategic management system. Harvard business review 74(1): 75-85. 1996.

KARNER. G. Metrics for Objectory. Diploma thesis at the university of Linkoping, Sweden. No. LiTH-IDA-Ex-9344; 21. December 1993.

KEMERER, C. F. An empirical validation of software cost estimation models. Communications of the ACM 30(5): 416-429. 1987.

KITCHENHAM, B. et al. Towards a framework for software measurement validation. Software Engineering, IEEE Transactions on 21(12): 929-944. 1995.

KITCHENHAM, B. The problem with function points. Software, IEEE 14(2): 29-31. 1997.

KITCHENHAM, B.; KANSALA, K. Inter-item correlations among function points, Software Engineering, 1993. Proceedings., 15th International Conference on, Baltimore, MD, pp. 477-480, 1993.

KRALJ, T. et al. Improved standard FPA method - resolving problems with upper boundaries in the rating complexity process. Journal of Systems and Software 77(2): 81-90. 2005.

MOSER, S. Measurement and estimation of software and software processes, PhD Thesis, University of Berne, Switzerland. 1996.

NESMA. Netherlands Software Metrics Association. Function Point Analysis For Software Enhancement. Disponível em: <http://www.nesma.nl/download/boeken_NESMA/N13_ FPA_for_Software_Enhancement_(v2.2.1).pdf>. Acesso em: 16 out. 2012. 2009.

ORLOV, M. L. Multiple Linear Regression Analysis Using Microsoft Excel. Chemistry Department, Oregon State University. 1996.

PFLEEGER, S. L. et al. Status report on software measurement. Software, IEEE 14(2): 33-43. 1997.

ROHM, H.; MALINOSKI, M. Strategy-Based Balanced Scorecards for Technology. Balanced Scorecard Institute. 2010.

RUBIN, H. A. Software process maturity: measuring its impact on productivity and quality. In: Proceedings of the 15th international conference on Software Engineering, IEEE Computer Society Press: 468-476. 1993.

_____. How to Measure IT Value. CIO insight. 2003.

SARTORIS, A. Estatística e introdução à econometria. 2008.

TURETKEN, O. et al. The Effect of Entity Generalization on Software Functional Sizing: A Case Study. Product-Focused Software Process Improvement: 105-116. 2008.

VAN GREMBERGEN, W.; VAN BRUGGEN R. Measuring and improving corporate information technology through the balanced scorecard. The Electronic Journal of Information Systems Evaluation 1(1). 1997.

VAN GREMBERGEN, W. The balanced scorecard and IT governance.

Information Systems Control Journal, Vol 2, 40-43, 2000.

VAZQUEZ, C. E. et al. Análise de Pontos de Função: Medição, Estimativas e Gerenciamento de Projetos de Software. Editora Érica, São Paulo. 2005.

XIA, W. et al. Updating weight values for function point counting. International Journal of Hybrid Intelligent Systems 6(1): 1-14. 2009.

WEILL, P.; ROSS, J. W. Governança de TI, tecnologia da informação. São Paulo: M. Books do Brasil. 2006.

Theory of Change and its Potential Use in Performance Audits

Fábio Mafra
is a public servant at the Federal Court of Accounts in Brazil, graduated in Architecture and Urbanism from the Federal University of Santa Catarina, with a specialist degree in Public Bugdet from ISC/Cefor – Chamber of Deputies, with a Master's Degree in Economics, in business management, from the University of Brasilia.

ABSTRACT

In performance audits, one should seek to know the audited object with the support of diagnostics techniques. One of the techniques, which present the possibility of opening new horizons and bringing new solutions to the Federal Court of Accounts in Brazil (TCU) is the theory of change. The theory of change is a graphic representation of how the implementation of a project, program or policy leads to the expected results and impacts. The theory of change shows in a sequence the inputs that the project, program or policy will use, the activities the inputs will support, the outputs that the program wants to obtain, as well as the expected outcomes and impacts. Furthermore, it identifies events or conditions that may affect the achievement of the results and the subjacent suppositions on how changes should occur and about the cause and effect relationship involved. It is possible to see that the tool can add significant value to the results of audits, and may be used to comprehend the functioning mechanisms of the audited programs; define control points throughout the development process of actions undertaken; indicate factors that interfere with the results of this process; and visualize the effects of recommendations issued, considering the other factors involved. In view of the above, it is believed that the theory of change may constitute an important tool for TCU for conducting quality performance audits with high technical standard.

Keywords: Performance Audit. Diagnostic technique. Theory of change.

1. INTRODUCTION

Few things can be considered as fundamental to the success of an audit as knowing with the appropriate level of depth the audit object. This is well explained in the international auditing standards, which determine that auditors should understand the nature of the entity or of the program to be audited (INTERNATIONAL STANDARDS OF SUPREME AUDIT INSTITUTIONS, 2015)[1]. This requirement is especially important when dealing with performance audits, which due to being more flexible in the selection of subjects, audit objects, audit methods and criteria require greater dedication from the audit team in order to know the subject, the program and the auditees.

In the performance audits conducted by the Federal Court of Accounts of Brazil (TCU)it is recommended that this search for knowledge be carried out with the support of several diagnostic techniques. The TCU's *Manual de Auditoria Operacional* (Performance Audit Manual - 2010) mentions the Swot analysis, the risk analysis, the stakeholder analysis, the map of products and the process map. All these methods are studied and tested in audits and have specific technical documents to help auditors at the time of application. The use of these diagnostic techniques ensures the systematic and documented construction of knowledge about the audit object. Each of these methods comprises various capabilities and meets different needs, and is defined as tools available for use by auditors, depending on their need.

Accordingly, the introduction of new diagnostic techniques is generally welcome, to the extent that it opens up new possibilities for audit work, such as when the Ishikawa analysis or fishbone diagram was used for the first time in a performance audit. The technique was introduced because it provided a new perspective, by enabling the mapping of several causal factors, as well as their interrelations, which determined the origin of a particular problem situation, perfectly fitting the needs arising from the issue that had motivated such audit[2].

Between June and July 2015, I had the opportunity to attend a training, called the International Program for Development Evaluation (IPDET)[3], which is sponsored by the World Bank in partnership with Carleton University of Canada and was held in Ottawa. We had four weeks of intense training on the evaluation of projects, programs and policies, which involved presenting theory and tools, as well developing case studies and group discussions. One of the most interesting techniques showcased in the training, which seemed to provide a wide range of opportunities for opening new horizons and bringing new solutions to TCU's work, was the theory of change, which is the representation of the operating logics of programs

and public policies to achieve their expected results and impacts[4].

This paper aims to present the said technique and describe its purpose, as well as to evaluate how it could be adapted to the Court's needs and used in the development of performance audits.

2. DEFINITION AND USE OF THE THEORY OF CHANGE

The theory of change is a graphical representation of how the implementation of a project, program or policy leads to expected results and impacts, considering the underlying assumptions on how changes should occur. It is a tool that can be used to design and evaluate the initiatives that seek to promote social changes; a kind of "blueprint of the building blocks" required to achieve the long-term goals of any government initiative aiming to promote changes in society (ACTKNOWLEDGE AND ASPEN INSTITUTE, 2003).

A theory of change should (MORRA-IMAS; RIST, 2009, p. 151):

- describe the sequence of inputs that the project, program or policy will use, the activities that the inputs will support, the outputs that the program seeks to attain, as well as the expected outcomes and impacts;
- identify events or conditions that may affect the achievement of the outputs;
- identify the assumptions that the program is making about the cause and effect relationship;
- identify critical assumptions that should be examined in an evaluation, based on the program context and the literature review.

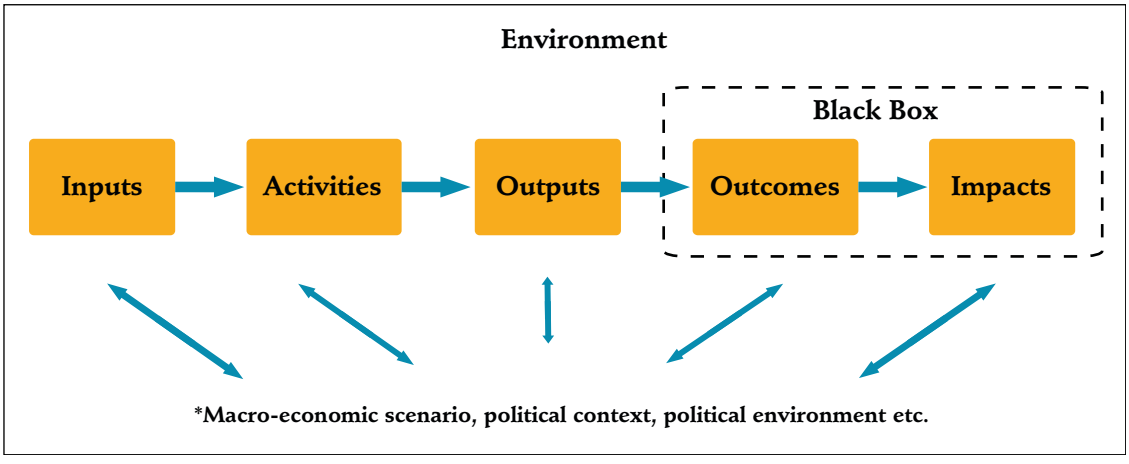
The theory of change reflects the beliefs about why the program should achieve its goals. It specifies the components of the programs and the relationships they hold. Therefore, the theory of change describes how resources are provided to enable an organization to implement activities for achieving specific goals, reflected as interrelated outputs, outcomes and impacts.

In addition, assumptions underlying the operational logic of the program should be identified. In a sense, the theory of change "opens the black box" to show how an intervention expects to convert inputs, activities and outputs into results and impacts (MORRA-IMAS; RIST, 2009).

The theory of change is quite often developed by government managers, as they produce the design for a given intervention, program or public policy. However, many government initiatives are developed without an explicit description of the theory of change.

Consequently, the theory of change frequently ends up being designed as part of a public policy evaluation. In an evaluation context,

Figure 1: From Inputs to Impacts



Source: PALUMBO, Salvatore (adapted from MORRA-IMAS; RIST, 2009, p. 152).

Note: Inputs are of financial, human and material resources. Activities are the actions performed. Outputs are services or goods produced. Results are the expected behavioral changes. Impacts are long-term improvements widespread in society.

the theory of change is usually developed at the end of the initial study on the evaluated program.

The use of the theory of change to describe an activity, program or public policy may provide several benefits, among which we highlight:

- enabling a clear view of how an intervention should work and the possibility of identifying potential design faults;
- enabling the identification of assumptions that may be associated with the risks of not achieving the expected results;
- making it easier to identify the issues to be evaluated;
- making it viable to reach a common understanding about how the program or the government activity works;
- helping to identify the program's key elements, which have a critical role in its success;
- making it easier to identify indicators for measuring the advances of the program or government activity; and
- enabling the presentation of results of a particular policy or program.

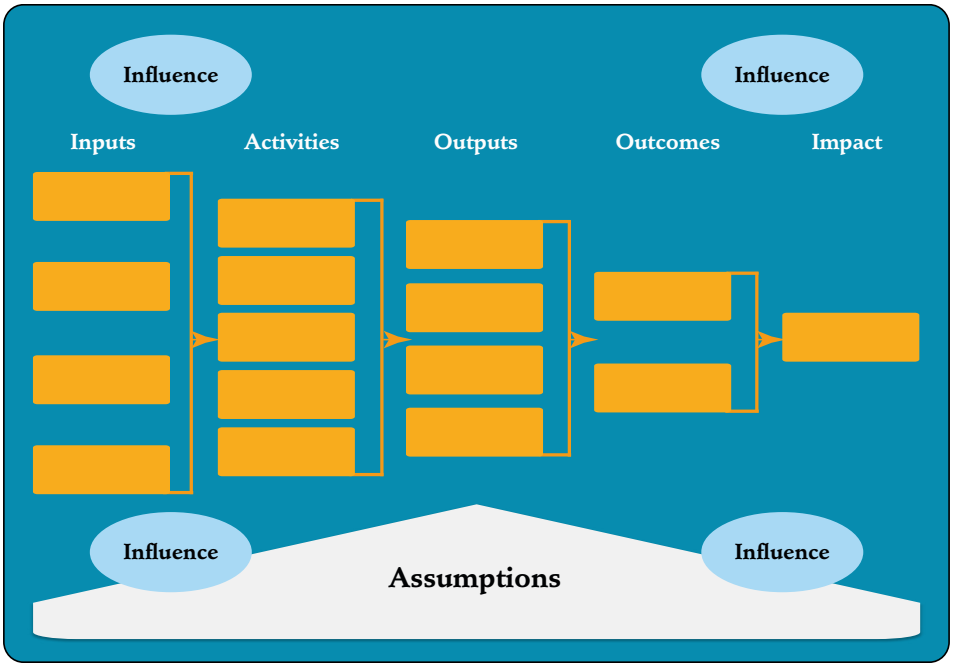
Prior to beginning the construction or revision of a theory of change, evaluators must have a clear understanding of the purpose and goals of the program, policy or activity involved. The following questions should receive special attention (INTERNATIONAL PROGRAM FOR DEVELOPMENT EVALUATIONS TRAINING, 2015):

- What knowledge supports the intervention?
- What is the rationale behind the intervention?
- What key assumptions are being considered?
- What other potential influences are operating in the context of the intervention?

Different models may be used to facilitate the construction of a theory of change. Figure 2 shows one of the flowcharts that adequately meets the technical requirements.

Figure 3, in turn, shows a finished example of a theory of change. Although it is not structured as the previous model, it provides a good idea of how the logic of a government initiative is supposed to operate.

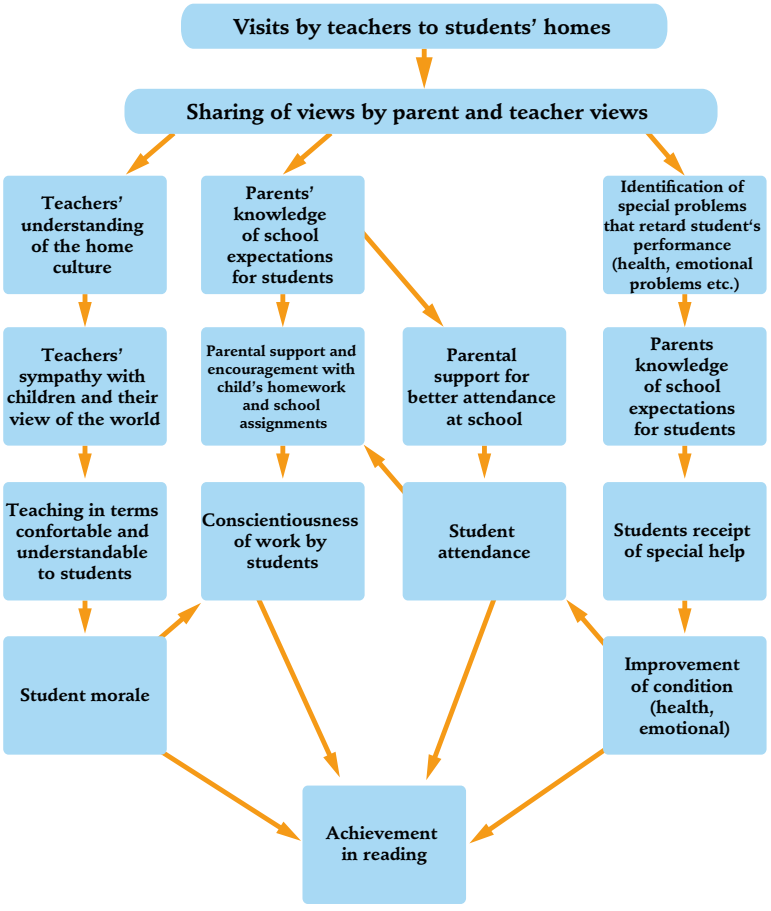
Figure 2:
Theory of Change Model



Source: IPDET, 2015

Figure 3:
Theory of Change
Examples

Note: This example does not explicitly identify the various components of the theory of change, which can be summarized as follows: teachers, students and students' households are inputs; visits are activities; conversations and parent awareness are products; greater empathy from teachers and the attendance of students are results; improved school performance is the impact.



Source: WEISS, 1972 *apud* MORRA-IMAS; RIST, 2009, with adaptations.

Assumptions:

- Parents are at home at the time of the visits.
- Teachers are willing to carry out the visits.
- Parents will welcome teachers into their homes.
- Parents will accept to discuss with teachers their view of educating their children.
- Teachers will better understand the culture of the families and will consequently be friendlier to their students.
- Teachers will adjust their way of teaching based on what they learned from the home visits.
- Parents wish to be involved in the process.

3. POSSIBLE WAYS TO USE THE THEORY OF CHANGE IN TCU'S PERFORMANCE AUDITS

As mentioned, given the variety of topics that are often subject to evaluation, the use of diagnostic techniques is quite common in performance audits to better understand their subject matter. Quite often, the methods employed derive from other areas of knowledge, especially social sciences, management and business management. Examples of such use are Swot analysis, which seeks to evaluate the strengths, weaknesses, opportunities and threats inherent in a project; process map, which seeks to understand the operation of work processes used by auditees and identify opportunities to streamline work routines; and stakeholder analysis, which aims to identify key stakeholders, their views and existing conflicts (THE FEDERAL COURT OF ACCOUNTS, 2010).

However, in order to fully employ methodological techniques derived from other fields of human activity in audits, they quite often need to be adapted to meet the specific needs of such audit modality.

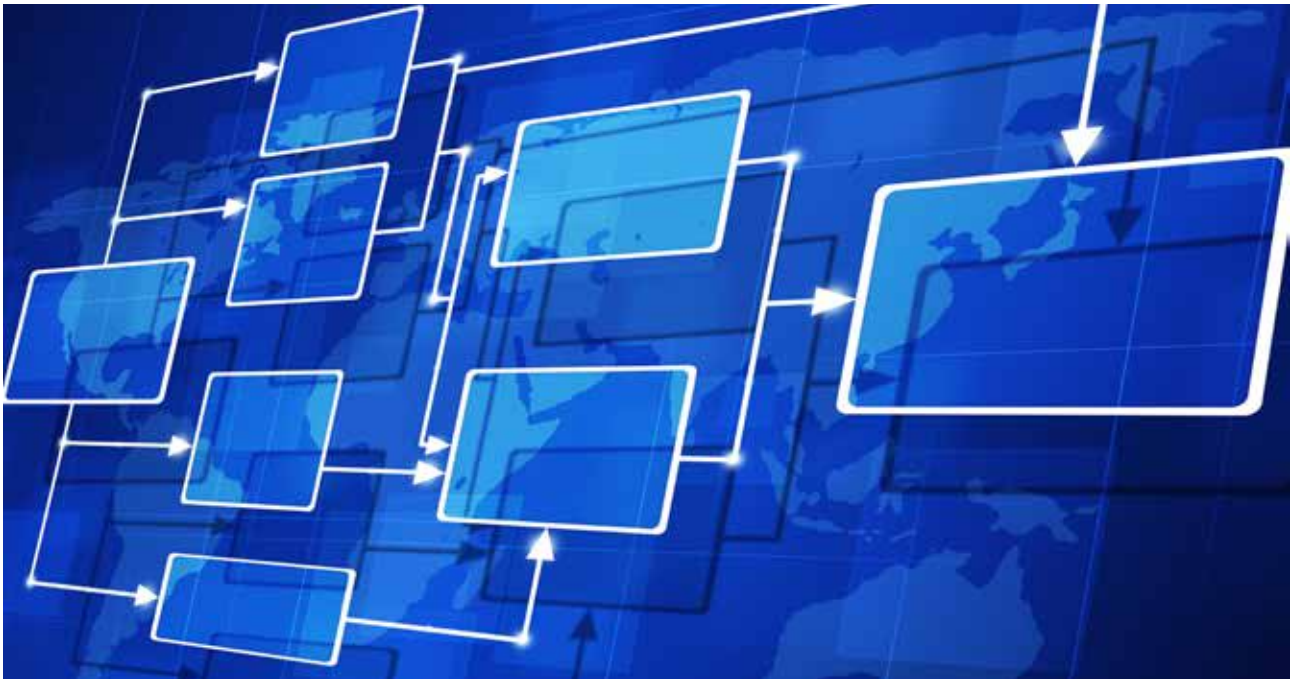
This was the case for the SWOT analysis, which, in the context of audits, has been used mostly as a diagnostic tool for identifying weaknesses and prioritizing aspects that need to be assessed during the development of the audit. To a degree that, in general, SWOT analyses are accompanied by risk analysis, in which weaknesses and threats unfold into corresponding risks. Within the scope of business management, on the other hand, Swot analyses have a more direct role in defining business strategies, providing elements to define a positioning for a certain company in the market. The idea is to take advantage of its strengths and opportunities, and at the same time protect it from the effects caused by it weaknesses and threats.

The Ishikawa analysis also falls into the same case. For the business environment, the designer of the technique, chemical engineer Kaoru Ishikawa, defined four fixed groups of problem sources (method; raw material; workforce; machinery) (DAYCHOUM, 2007). However, in the context of performance audits, the use of the "fishbone" was developed more freely, seeking to contemplate the groups of problems, which exist in the evaluated public policy.

Therefore, the theory of change technique, which is already being used within the international community of public policy evaluation, which involves several international organizations - especially the World Bank (IBRD), the Inter-American Development Bank (IDB), and the United Nations (UN) - may require adaptations to enter the field of performance audits.

However, we may already see that the tool can add significant value to the results of audits and may be used for the following purposes:

- understanding the operating mechanisms of audited programs, policies and government activities;
- identifying other factors that interact with the programs, policies and audited government activities and interfere in their results;
- defining control points throughout the development of the audited activity; and
- visualizing the effects of the recommendations made during the implementation of the audited activities.



The first approach mentioned corresponds to a more traditional use of the tool. It consists in using the theory of change as a diagnostic technique for audits to understand the structuring and functioning of audited government programs, policies and activities. In this sense, the mapping of the theory of change resembles two techniques that are already being used in performance audits, namely, the logical framework and the map of products.

By unawareness, the expressions theory of change and logical framework are frequently used as synonyms. The logical framework may be considered the first attempt to describe the components of government programs to demonstrate how activities lead to results. It also presents inputs, activities, outputs and outcomes. However, the theory of change, in addition to graphically laying out these components, is a causal model: it links the results to the activities to explain how and why the desired change will materialize. This is made possible by explaining the assumptions underlying the evaluated activity. In this sense, the logical framework comprises features that are more descriptive, while the theory of change comprises an explanatory feature (CLARK, H; ANDERSON, A. A., 2004).

The differences in relation to the map of products follow a similar rationale. This technique also identifies inputs, outputs and impacts. However, only the theory of change indicates assumptions involved, enabling the identification of beliefs that justify the chain of cause and effect defined for an evaluated object. These assumptions are key factors for the proper functioning of a program or activity under audit and the evaluation of the actual effects of the factors involved may be relevant to understand audit findings. Therefore, the theory of change provides an overview of the entire operational process of an audited activity, including assumptions about the cause and effect relationship, which is of great value for the perfect understanding by the audit team of the operational logic of the evaluated government initiative.

The second purpose mentioned also represents a unique feature of the theory of change in relation to other diagnostic techniques in use. It is justified by the possibility the theory of change has of indicating and considering other relevant factors - in addition to the audited policy or activity -with potential to influence the results that a certain policy seeks to achieve. Accordingly, the technique makes it possible to anticipate how external factors may contribute to or even hinder the achievement of defined goals.

As a third application, the theory of change tool may also be useful to identify control points throughout the development process of audited activities, which are significant for measuring performance indicators. In this sense, knowledge enabled by the theory of change may sustain the analysis of the quality of existing indicators and the formulation of recommendations to use indicators or improve the indicators already used by an auditee.

Finally, this new technique offers an opportunity to see how possible measures recommended

by the Court may be inserted into the chain of cause and effect relationship, which exists in a particular evaluated activity or public policy, and what consequences may result from this insertion. Thus, it would be possible to evaluate, through a qualitative analysis, which action could have a more beneficial potential effect, considering the context of the evaluated activity. Therefore, the use of the theory of change would represent an inventive initiative for the development of performance audits to the extent that currently, among the techniques used by TCU, there is not any a tool with such features.

The analysis developed so far seeks to evaluate, in theory, the potential benefits of this new methodology, considering a set of other tested techniques, which are available for this audit modality. However, when evaluating the possibilities of using the theory of change in performance audits, we must also consider to what extent there really is a demand for this methodology in the performance audits that are currently under development.

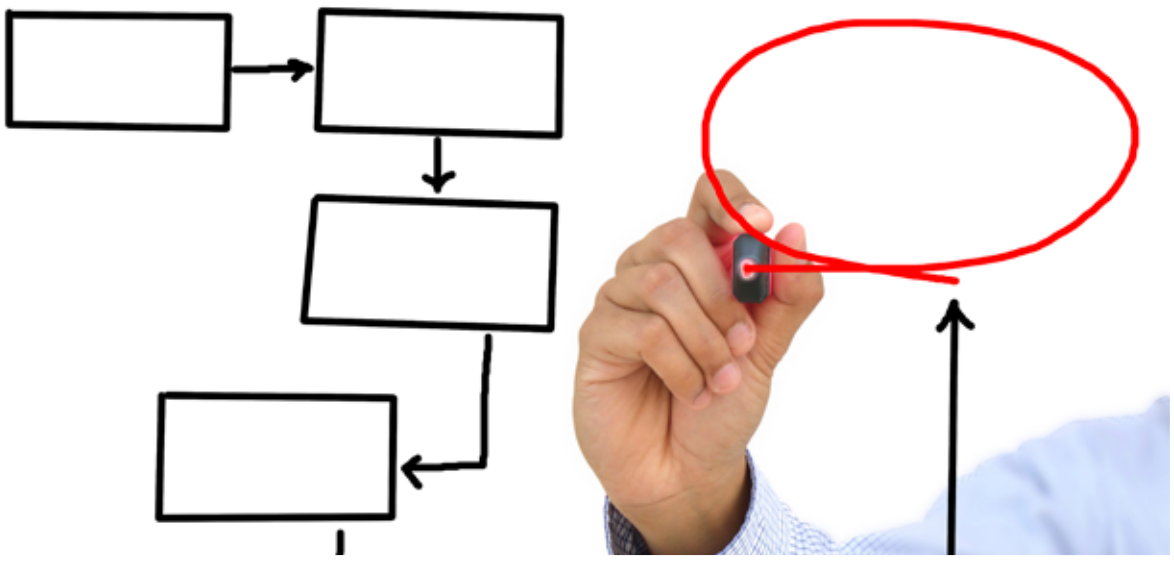
In this sense, the recent participation in a project developed by the TCU to measure the level of compliance of the procedures adopted by the Court to the international auditing standards gave me the opportunity to analyze a small random sample of six performance audits conducted by TCU in 2014. The analysis of the information gathered showed that this type of approach, defined by a detailed study of an audited object in the initial phase of an audit, which noticeably defined the audits carried out by the former Government Programs Audit and Evaluation Department (Seprog), is not being used a lot currently in the TCU. It was found that none of the six audits studied made use of diagnostic techniques.

Therefore, despite the potential of use of the theory of change technique in performance audit works, we have verified that demand for this new tool will probably be limited, being restricted to works that need a more in-depth study of the audited topics.

4. CONCLUSION

The theory of change is a qualitative technique with excellent potential for further improving the performance audits conducted by the TCU, to the extent that it enables a consolidated view of the full operation of the activity or public policy undergoing evaluation. The theory of change adds to the components that comprise to public policies information related to external influences and assumptions that sustain the cause and effect relationship, which, supposedly, lead to the expected results. For this reason, it allows for a very detailed and comprehensive analysis of the operational logics of an audited program or activity, and this may contribute to quality performance audits.

In addition, the technique provides an opportunity to assess the effects of possible recommendations and determinations by the Court within the set of factors found in the environment of the audited



object. This is not possible through other techniques that have been employed.

In spite of the potential shown, the current framework of performance audits under development in the TCU indicates that the demand for the use of this new methodological tool is limited, since many works related to performance have not used diagnostic techniques in the analysis of audited subject matters.

As a result, I recall the initial argument of this paper, which, based on the international auditing standards, emphasizes the importance of having adequate knowledge of the audited subject matters to develop high technical standard audits. In this sense, it is important to give greater emphasis to the study of audited programs and activities in the performance audits conducted by the Court. Therefore, it would be desirable for capacity-building activities for auditors begin to emphasize the need for diagnostic techniques in order to have a better understanding of the audited issues and bodies. I believe that, based on this new framework, the theory of change may constitute an even more important tool for conducting quality performance audits of high technical standard by the TCU.

NOTES

1 Fundamental Principals of Public Sector Auditing. International Standards of Supreme Audit Institutions(ISSAI 100/45).

2 This method was first used in 2008, in the audit to evaluate the concession and maintenance of sick pay benefits by the INSS (the Brazilian Social Security Institute). This audit sought to understand the reasons for the significant increase in the expenditures with this kind of benefit (TC 012.034/2008-7). Currently, the way the technique is used is explained in the TCU's technical document named *Técnicas de análise de problemas para auditorias* (Techniques to Analyze Audit Problems) (2013).

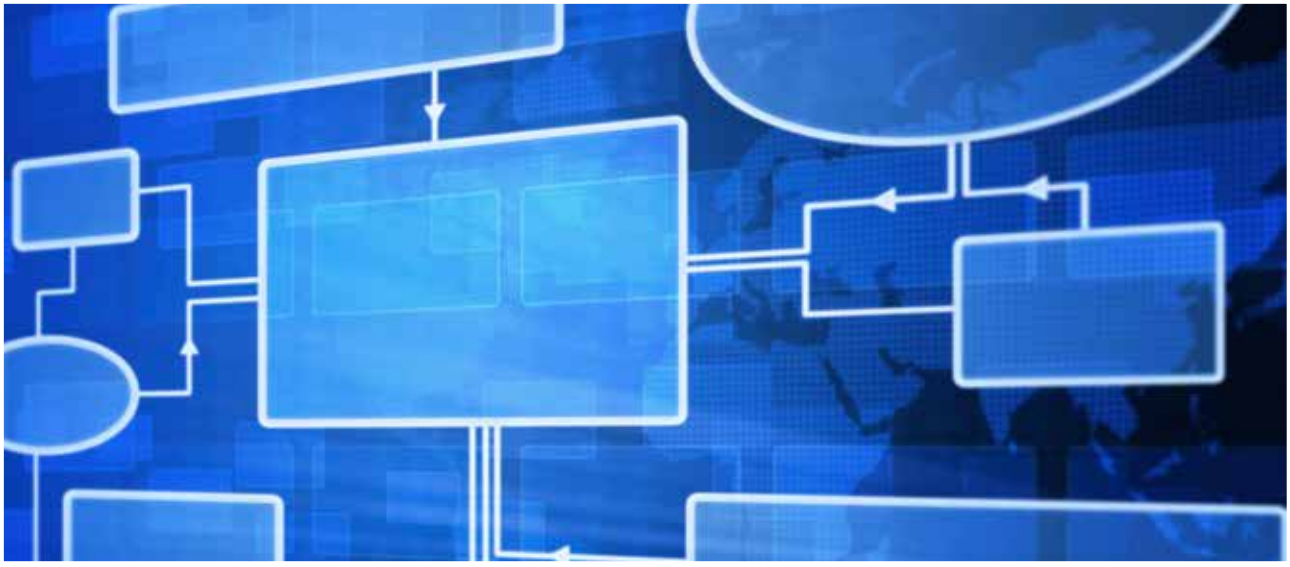
3 The IPDET is an executive training program whose goal is to equip students with the tools required to evaluate development policies, programs and projects, carried out in a local, national, regional or global scope.

4 Most information on the theory of change in this paper are referenced in the expositive classes and corresponding class notes given by professors Linda G. Morra Imas and Ray C. Rist.

REFERENCES

ACTKNOWLEDGE AND ASPEN INSTITUTE. Theory of Change. Roundtable on Community Change. S. loc., 2003. Available on: http://www.theoryofchange.org/. Accessed on: September 7, 2015.

CLARK, Heléne; ANDERSON, Andrea A. Theories of change and logic models : Telling them apart(introduction). Aspen Institute Roundtable on Community Change. Aspen, 2004.



DAYCHOUM, Merhi. 40 ferramentas e técnicas de gerenciamento (40 Management Tools and Techniques). Brasport. Rio de Janeiro, 2007

INTERNATIONAL PROGRAM FOR DEVELOPMENT EVALUATIONS TRAINING. Designing and Conduction Effective Evaluations : Core Curriculum Presentations. Ottawa, 2015.

INTERNATIONAL STANDARDS OF SUPREME AUDIT INSTITUTIONS.– Princípios Fundamentais de Auditoria do Setor Público – ISSAI 100inNormas Internacionais das Entidades Fiscalizadoras Superiores (ISSAI) : Princípios Fundamentais de Auditoria (nível 3). TCU. Brasília, 2015.

MORRA-IMAS, Linda G.; RIST, Ray C. The road to results : designing and conducting effective development evaluations. World Bank. Washington, 2009.

PALUMBO, Salvatore. Movendo-se dos insumos aos impactos (From Inputs to Impacts) (adapted from MORRA-IMAS; RIST, 2009, p. 152). Brasília, 2015. 1 illustration.

TRIBUNAL DE CONTAS DA UNIÃO (FEDERAL COURT OF ACCOUNTS). Manual de Auditoria Operacional(Performance Audit Manual), TCU. Brasília, 2010.Available on: <http://portal.tcu.gov.br/lumis/portal/file/fileDownload.jsp?inline=1&fileId=8A8182A14D78C1F1014D7957B04E155C>. Accessed on: October 4, 2015.

TRIBUNAL DE CONTAS DA UNIÃO (FEDERAL COURT OF ACCOUNTS). Técnicas de análise de problemas para auditorias (Techniques to Analyze Audit Problems). TCU. Brasília, 2013. Available on: <http://portal.tcu.gov.br/lumis/portal/file/fileDownload.jsp?inline=1&fileId=8A8182A14D78C1F1014D7957D4F85058>. Accessed on: October 4, 2015.

WEISS, Carol. Evaluation Research: Methods for Assessing Program Effectiveness. Englewood Cliffs, New Jersey: Prentice Hall, 1972 apud MORRA-IMAS, Linda G.; RIST, Ray C. The road to results : designing and conducting effective development evaluations. Worldbank. Washington, 2009.

Project management auditing: a study of the main practices adopted

Carlos Alexandre Nascimento Wanderley is a Superior Officer of the Navy of Brazil, and works as an auditor in the Internal Control Center of the Navy in the fields of Public Accounting and Budget. He is the author of the books *Auditoria – Teoria e Questões* and *Controle Externo e Auditoria Governamental.*

ABSTRACT

This paper aims to present the most important studies on project management auditing and to identify the differences and similarities between the approaches adopted in these studies. It is a bibliographical, exploratory qualitative research. We identified the similarities and differences between the approaches adopted. From the results, we concluded that project management audits do not count with a specific literature or defined procedural aspects. This paper corroborates this fact by pointing out the diversity of methods used to conduct project management audits.

Keywords: Project Management, Strategic Projects, Audit.

1. INTRODUCTION

During the past years, the three government spheres have spent a large amount of money in big events, such as the 2014 FIFA World Cup and the Rio 2016 Olympics and Paralympics, besides strategic projects on Defense.

The big strategic projects that the Federal Government has implemented and managed do not indicate any rule, legislation, or instruction

to guide the audits carried out by the External Control, Intern Control of the Executive power, or by the intern audit unit in the structure of the agency responsible for the main strategic plan. Thus, the audit of project management is still a new territory, since a definitive approach that combine project management and audittechniques does not exist.

In this context, we highlighted the considerable increase in the budgetary resources allocated for investments in the Defense sector: perspectives point out that subsidies will surpass R$140 billion in the next twenty years. The particularities found in this sector of the public policies of the Federal Government range from contractual forms, which may involve various governmental actors, to arrangements and obligations stated by specific legislation (BRASIL, 2014).

Therefore, based on a bibliographic and document review, this paper aims to present the most important studies on project management auditing and identify the differences and similarities between the approaches adopted in the studies. The secondary objective of this research is to provide a theoretical background to support the management of big strategic projects to improve the public administration performance and to effectively provide information to society as a whole through audits.

This type of study is important and necessary because it intends to contribute to the transparency process of the management acts performed by public actors, to the quality of public expenditures, to the continuous evaluation of results, and to goal achievement concerning a big project management.

2. IMPORTANT STUDIES ON PROJECT MANAGEMENT AUDITING

2.1 MCDONALD'S STUDY

Studying audits in project management software, McDonald (2002) highlighted that the goals of project audits are the following: to develop a sound project plan in a reasonable amount of time; to reasonably ensure that the team and the project manager have applied the proper technique to develop a successful project; to clearly identify the highest risks the project may face; to estimate the possible chances of success; and, finally, to identify what can be done to lead the project in the most efficient way concerning the schedule, the resources, the costs, and the quality.

McDonald verified that project management audits tend to concentrate on management processes and methods related to

people instead of concentrating on business processes or technical processes.

2.2 GERMAN INSTITUTE OF INTERNAL AUDITORS'S STUDY (DIIR)

The German Institute of Internal Auditors (DIIR) (2008) emphasizes that the rules related to the best practices in project management, such as PMBOK®, PRINCE2 , or ICB may be the criteria of an audit.

It presents three types of audit: project management, business case and business requirement. The project management audit includes the analysis of the organization, processes, project products, and portfolio management. It checks if the project management or the portfolio management is adequate to administrate project activities, to ensure that time, budget and quality goals can be reached. It examines the organization, the plans, the controls, the particularities and the operational measurement of the project management units concerning efficacy and efficiency. If the management presents weaknesses, the audit makes appropriate recommendations for improvement.

The business case audit includes the evaluation of the efficacy and efficiency of the processes that prepare the business case to a project. It checks if the project justification is properly based on sufficiently valid assumptions, such as analytic calculation, and commercial or economic criteria.

Table 1: Project Audit Universe

AUDIT AREAS and PROJECT STAGES	STAGE I INITIATION	STAGE II PLANNING	STAGE III EXECUTION	STAGE IV COMPLETION	STAGE V POST IMPLEMENTATION
I. AUDIT AREA PROJECT MANAGEMENT					
1. Project organization	Project sponsor/stakeholder	Plan, project, organization, project manager	Project organization, project roles	Project organization, project roles	Dissolution of project organization
2. Integration management	Project mandate, provisional project charter, Open-issue-list	Project plan, project structure plan, project management plan, management of open issues	Project management meetings, steering committee meetings, documented decision, management of open issues	Transfer of open issues to line	Ideas for follow-up projects
3. Content and scope management	-	Change management plan, change request form	Change requests, updating of project plan	Transfer of project results to line	-
4. Time management	-	Milestone plan, activity plan and sequencing, resources and work packages, critical path	Time management, compliance measures, updating of plans	-	-
5. Cost management	-	Cost plan	Cost-benefit equation (target--performance comparison, forecast)	Completion diagram	Historical cost-benefit analysis, margin/variance analyses
6. Quality and test management	-	- Quality plan	Quality review reports, approvals	Quality review reports, approvals	-
7. Human resources management	-	Human resources requirements plan, project team list	Recruitment, human resources management	Dissolution of project team	-
8. Communication management	-	Meeting list, communication plan, project documentation system, configuration plan	Project management meetings, minutes, workshops, project results documentation	Knowledge transfer (transfer to line)	Lessons learned
9. Project reporting	-	Templates for reports, KPIs for the project	Project progress report	End stage report	-
10. Risk management	-	Risk management plan, initial risk list	Risk management, updating of risk list	-	-
11. Procurement management	-	Procurement plan, quotations	Contracts, accounting, performance of the contract	Completion accounts	-
II. AUDIT AREA BUSINESS CASE					
Business case	Project objectives, analyses, assumptions	Business case, calculations, approvals, budget approvals	Additions to the business case, change to assumptions	-	-
III. AUDIT AREA: BUSINESS REQUIREMENTS					
Business requirements	-	Results provided by the project teams, e. g. analysis of the status quo, plan, drafts	Results provided by the project teams, prototypes, test plans, tests	Final results provided by the project teams	Post implementation results

Source: DIIR (2008)

The goal of the business requirement audit is to evaluate the business requirements of the project and their implementation as part of the project work. Concerning an approved business case, this type of audit checks if the definition of the business requirements and its subsequent implementation are appropriate and if they are in accordance with the legal, regulatory or specific guidelines of the company.

According to DIIR (2008), the universal structure of project audits is based on management processes presented in the PMBOK®. Within the important types of audit, there are auditable audit objects, which are specific for each stage of the project. The audit areas, project stages and audit objects together are the project audit universe, as set forth below in Table 1:

According to DIIR (2008), the matrix shows a minimum structure only.. Other audit objectives may be included depending on the project content, schedule, and special characteristics and circumstances, on specific factors of the organization, and on the audit work in progress.

Reusch (2011) corroborates this by mentioning that, in comparison with PMBOK's® project management standards and good practices, the project audit to be performed need to add some knowledge areas and process groups. The author highlights that, concerning PMBOK®, two knowledge are missing: project funding and social responsibility. He states that the development of project management standards and good practices must fill those gaps as fast as possible. He emphasizes that auditors can promote a higher development of rules on project management when they go beyond the already existing project management standards and good practices.

2.3 CLELAND AND IRELAND'S STUDY

According to Cleland and Ireland (2012), project audits vary according to the need of comparing the plan and the effective execution practices. Planning them ensures that the relevant areas are audited by comparing each of them with the plan, the standard, the process, the procedure or the practice of the project.

The authors mention that the constitution of the audit team depends on the purpose of the work. Besides, the success of the work is connected to the team's skills, knowledge and ability. Additionally, the authors emphasize that the auditors do not need a technical qualification in project management. Table 2 presents the types of project audits with their respective purposes and expected results: The authors emphasize that the ways to conduct audits are similar, because they are designed to identify the activities that complies with the project basic documentation and the differences between what is in the plan and what was actually done.

2.4 YAMEI'S STUDY

Yamei (2013) presents important critical control points concerning audit types that are

Table 2: Types of project management audits

TYPES OF PROJECT AUDIT	PURPOSES	RESULTS
Progress	Review of the project progress from three perspectives: schedule, budget disbursement and technical aspects.	Comparison between the planned progress and the effective completion from the three perspectives.
Process	Review of the project team's practices to ensure compliance with the process and its efficiency to achieve goals	To ensure that the process will produce the results expected.
System	Review of the technical or administrative system, e.g. the communication plan, which is a supporting operation or role of the project.	Information on the adequacy of the supporting system of work in the project. To ensure the system works in compliance with the documented orientation.
Product	Review of the technical completion of the project in the product construction, and if the latter complies with the plan.	To report the degree of convergence between the technical parameters and the work parameters.
Contract	To verify the compliance with contractual requirements and if the project team is carrying out the work established in the contract.	Report of the level of fulfilment of the contractual requirements.
General	Review of every aspect of a project and a comparison between the planned completion and the actual completion.	Report of the level of fulfillment of the requirements to complete the project.
Special	Review of the specific parameters of a project to determine the project status and progress. A special audit occurs due to a loss of confidence in the project completion.	Report focused on the project progress and status. It may present some recommendations to improve the actual status of the project.

Source: Cleland and Ireland (2012)

related to every project management process, as follows:

- The audit of the investment decision--making process must occur in the project planning stage, with a special focus on the project proposals, the feasibility study, and the project approval to avoid inconvenient decisions;

- The audit of project proposals verifies whether the project establishment is real and whether the procedures of report delivery are complete and relevant;

- The audit of the feasibility study of the project focus on the prevention or reduction of errors in policy decisions and determines the validity of the conclusions about the feasibility. At this stage, the main forms of audit are scrutiny and the comparative analysis;

- The management audit in project planning must check the technical conception of the project, and include the cost budget, the planning itself, and bidding and contract-related aspects;

- The audit of the project conception verifies the implementation of bidding procedures (legality of project contracts and specific regulation) and whether the companies involved have the necessary qualifications. At this stage, the most important task is to identify unjustified problems that result in waste or excessive changes in the project, which may increase the costs or difficulties to control it;

- The audit of the cost budget examines if the budget is reasonable, controlled, and adjustable, and if it meets the requirements of the standards applicable;

- Auditing in the project implementation stage helps verify the development, the quality and the cost management of the project. It must be based on the conception of documents, contracts, and annual plans; and

- The audit conducted in the project delivery stage evaluates the importance of the completion and the economic benefits of the project. It manages surplus materials and equipment, and the project data transfer and archiving. It also verifies if the accounting related to the project completion includes information on the project budget execution, the funding sources, if the construction cost was reasonable, and if the project delivery and schedule format was correct.

Finally, Yamei (2013) highlights that the project audit results need a deep analysis, since the audit work does not determine the origin of the existing problems.

2.5 BRAZILIAN NATIONAL STANDARDS ORGANIZATION – ABNT

Project auditing is focused on the dynamics of project decisions and governance controls to fulfill the organization's superior strategies, which are defined in a program, portfolio or in a project-focused corporate policy.

According to the NBR 12677(2014), the organization must conduct intern audits at previously planned periods to determine whether the project management system meets the planned dispositions and requirements, and if it was kept and put into practice.

According to NBR 12677 (2014), the project governance principles to audit project management systems are: continuous business justification, accountability, performance, conformity, emphasis on the project management, and experiential learning. Regarding these principles, the upper management should prove its commitment with the establishment, the implementation, the operation, monitoring, the critical analysis, the maintenance and the improvement of the project management system by means of a documented and periodically validated tool.

The business case is a tool used to judge whether the project must continue or not. The client's requirements must be in the business case. This tool must be documented and updated throughout the project life cycle.

According to NBR 16277(2014), the types of project audit presented in Table 3 help to better meet the various demands on a project audit, regarding the audit nature, its results and the report production.

The time to conduct each type of audit depends on the needs of the organizations; each of them choses the appropriate type to apply and its periodicity.

2.6 SHARBATOGHLIE AND SEPEHRI'S STUDY

According to Sharbatoghlie and Sepehri (2015), in a traditional approach to project management, the project activities are rarely monitored and audited and, still, in a period of time that may last weeks or months. The authors add that the project management audit carried out in a considerable lag can create inefficiencies, such as delays and budget bust.

Thus, Sharbatoghlie and Sepehri (2015) emphasize that a project management model under continuous auditing can significantly improve the ability of the project management team to monitor project activities.

The new continuous auditing approach is the introduction of a dynamic and advanced system of intern audit that aims to identify, capture and critically store data, information and knowledge generated during the project execution. Using data, information and the knowledge available, public and private companies and government agencies can monitor and report their control variables on a continuous basis.

Table 3: Types of project management audits

TIPO	OBJETO DA AUDITORIA	CRITÉRIOS DE VERIFICAÇÃO	
		ESTRATÉGIAS ORGANIZACIONAIS	REQUISITOS DOS CLIENTES
Auditoria da responsabilidade em projetos	Análise dos processos decisórios e suas consequências em termos de resultados	Grau de realização dos objetivos do projeto	Grau de satisfação do cliente
Auditoria de aplicação das estratégias em projetos	Alinhamento dos projetos às estratégias organizacionais	Grau de realização dos objetivos estratégicos da organização	Não se aplica
Auditoria de aquisições em projetos	Uso dos recursos nas aquisições necessárias aos projetos	Grau de eficácia no processo de aquisições do projeto	Não se aplica
Auditoria de desempenho em projetos	Avaliação de resultados financeiros em termos de competitividade e estratégias econômicas	Grau de desempenho do projeto em relação aos resultados financeiros esperados	Não se aplica
Auditoria de conformidade em projetos	Questões de qualidade em nível de excelência e regulação nas boas práticas do gerenciamento de projetos	Grau de efetividade dos acordos de nível de serviço do projeto	Atendimento às cláusulas contratuais

Source: NBR 16277 (2014)

3. ANALYSIS

In the studies by DIIR (2008), Cleland and Ireland (2012), and ABNT, by means of NBR 16277 (2014), we observed the adoption of a structure that gathers the audit types with objects, purposes, and criteria to conduct works and achieve the expected results. McDonald (2002), Yamei (2013), and Sharbatoghlie and Sepehri (2015) presented doctrinal aspects about the conduct of project management audits focused on the general goals of the audit, the critical control points at each stage of a project, and on the development of continuous audits.

McDonald (2002) focused on defining the main goals of the project management audit. DIIR's project audit universe (2008) consist of three main audit types that address the project management, the business case, and the business requirements, respectively. Their objects are the project stages and the areas to be audited according to the statements of the project plan. DIIR's research (2008) presented three audit types arranged in a matrix that includes the stages of a project.

Similarly to McDonald, Cleland and Ireland (2012) highlighted the objectives of a project management audit. They described the importance of an appropriate audit planning and the constitution of the audit team. Compared to DIIR's study (2008), Cleland and Ireland (2012) presented seven types of project management audit their respective purposes and expected results. They focused on the progress, the process itself, the system, the product to be delivered, the contracts, and the general and specific aspects of the project. However, the audit types proposed were not organized in accordance with the stages of a given project.

Yamei (2013) highlighted that the results of a project management audit need a deep, thorough analysis, since audit works do not determine the origin of the problems. The author clearly presented the main critical control points of each stage of the project.

Evidences Yamei's study (2013) suggested types of audit to work as control points in project management. Such audits are related to the following topics: decision-making process of the project, proposals, project feasibility, planning, design, cost, implementation, and product delivery.

NBR 12677 (ABNT, 2014) presented six governance principles that should be observed during audits. Similarly to Cleland and Ireland's and DIIR's studies, ABNT presented five types of project management audit, but they are not organized according to the stages of a project. It classified the audits in accountability, strategy, procurement, performance, and conformity audits. These audit types indicate their respective objects and criteria to help conduct the audit works.

Sharbatoghlie and Sepehri (2015) did not address the appropriate audit types for each

stage of a project. However, they warned about the need of a minimum period of time between project management audits to avoid inefficiencies in the project conduction. In this situation, the continuous audit would be an important tool to the project management. NBR 12677 (2014) goes in the same direction. It advises organizations to perform internal audits at previously planned periods to determine if the project management system complies with the planned arrangements.

4. FINAL REMARKS

This research gathered an important and appropriate large theoretical background that will help the implementation of good practices and management procedures in the project management scope. It also provided information to society as a whole through the audits performed.

We identified the similarities and differences between the approaches adopted. From the results obtained, we concluded that project management audits do not count with a specific literature or procedural aspects defined. This paper corroborated this fact by pointing out the diversity of methods used to conduct project management audits.

Project management audit is a complex task with many nuances, variations, objectives, and forms of conduct. This complexity arises from the project to be carried out and from the good practice of project management chosen.

We cannot guarantee that this research has covered all the important points required for an efficient project management audit. Thus, we suggest the extension of this study based on references of other good practices of project management not described in the PMBOK®.

REFERENCES

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. NBR 16277: Auditoria de projetos-Requisitos. Rio de Janeiro, 2014.

BRASIL. Tribunal de Contas da União. Relatório do Grupo de Trabalho para elaboração de Proposta de capacitação em auditoria de Projetos Estratégicos de Defesa. Brasília, DF, 2014.

CLELAND, David I; IRELAND, Lewis R. Gerenciamento de Projetos. Rio de Janeiro: LTC, 2012.

German Institute for Internal Auditing. DIIR Audit Standard nº 4: Standard for Auditing Project - Definitions and rules. German, 2008.

MCDONALD, James. Software project management audits–-update and experience report. The Journal of Systems and Software. v. 64, n. 3, p. 247–255, 2002.

REUSCH, Peter. New Standards for Project Audit and the Impact on Existing Standards for Project Management. In: The 6th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications, 2011, Prague, Czech Republic. Artigo apresentado... Prague, Czech Republic: IDAACS, 2011.

SHARBATOGHLIE, Ahmad; SEPEHRI, Mehran. An Integrated Continuous Auditing Project Management Model (CAPM). 4th International Project Management Conference, 2015.

YAMEI, Guan. Research of Innovation System about Project Management Audit. In: 2013 6th International Conference on Information Management, Innovation Management and Industrial Engineering, 2013, China. Artigo apresentado..., China: ICIII, 2013.

A

C

D

E

F

I

M

T

Distrito Federal
Telephone: (61) 3316-5338
Fax: (61) 3316-5339
E-mail: segepres@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria-Geral da Presidência
Setor de Administração Federal
Sul, Quadra 04, Lote 01
Edifício-Sede, Sala 153
CEP: 70042-900, Brasília – DF

Acre
Telephones: (68) 3321-2400/ 3321-2406
Fax: (68) 3321-2401
E-mail: secex-ac@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado do Acre
Rua Guiomard Santos, 353 – Bosque
CEP: 69900-724, Rio Branco – AC

Alagoas
Telephone: (82) 3221-5686
E-mail: secex-al@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado de Alagoas
Avenida Assis Chateaubriand, nº
4.118 – Trapiche da Barra
CEP: 57010-370, Maceió – AL

Amapá
Telephones: (96) 2101-6700
E-mail: secex-ap@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado do Amapá
Rodovia Juscelino Kubitschek,
Km 2, nº 501 – Universidade
CEP: 68903-419, Macapá – AP

Amazonas
Telephones: (92) 3303-9800
E-mail: secex-am@tcu.gov.br
Address: Tribunal de Contas
da União – TCU
Secretaria de Controle Externo no
Estado do Amazonas
Avenida Joaquim Nabuco, nº 1.193 – Centro
CEP: 69020-030, Manaus – AM

Bahia
Telephone: (71) 3341-1966
Fax: (71) 3341-1955
E-mail: secex-ba@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado da Bahia
Avenida Tancredo Neves, nº 2.242 – STIEP
CEP: 41820-020, Salvador – BA

Ceará
Telephone: (85) 4008-8388
Fax: (85) 4008-8385
E-mail: secex-ce@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado do Ceará
Av. Valmir Pontes, nº 900 – Edson Queiroz
CEP: 60812-020, Fortaleza – CE

Espírito Santo
Telephone: (27) 3025-4899
Fax: (27) 3025-4898
E-mail: secex-es@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo no
Estado do Espírito Santo
Rua Luiz Gonzalez Alvarado,
s/ nº – Enseada do Suá
CEP: 29050-380, Vitória – ES

Goiás
Telephone: (62) 4005-9233 /
4005-9250
Fax: (62) 4005-9299
E-mail: secex-go@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado de Goiás
Avenida Couto Magalhães, Qd. S-30 lt.03 nº 277
Setor Bela Vista
CEP: 74823-410, Goiânia – GO

Maranhão
Telephone: (98) 3232-9970/
3232-9500/ 3313-9070
Fax: (98) 3313-9068
E-mail: secex-ma@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado do Maranhão
Av. Senador Vitorino Freire, nº 48
Areinha – Trecho Itaqui/ Bacanga
CEP: 65010-650, São Luís – MA

Mato Grosso
Telephone: (65) 3644-2772/ /
3644-8931/ 36443164
Fax: (65) 3644-3164
E-mail: secex-mt@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado de Mato Grosso
Rua 2, Esquina com Rua C,
Setor A, Quadra 4, Lote 4
Centro Político Administrativo (CPA)
CEP: 78049-912, Cuiabá – MT

Mato Grosso do Sul
Telephones: (67) 3382-7552/
3382-3716/ 3383-2968
Fax: (67) 3321-2159
E-mail: secex-ms@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo no
Estado de Mato Grosso do Sul
Rua da Paz, nº 780 – Jardim dos Estados
CEP: 79020-250, Campo Grande – MS

Minas Gerais
Telephones: (31) 3374-7277/
3374-7239 / 3374-7233
Fax: (31) 3374-6893
E-mail: secex-mg@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado de Minas Gerais
Rua Campina Verde, nº 593
– Bairro Salgado Filho
CEP: 30550-340, Belo Horizonte – MG

Pará
Telephone: (91) 3366-7453/
3366-7454/ 3366-7493
Fax: (91) 3366-7451
E-mail: secex-pa@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado do Pará
Travessa Humaitá,

nº 1.574 – Bairro do Marco
CEP: 66085-220, Belém – PA

Paraíba
Telephones: (83) 3208-2000
Fax: (83) 3533-4055
E-mail: secex-pb@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado da Paraíba
Praça Barão do Rio Branco, nº 33 – Centro
CEP: 58010-760, João Pessoa – PB

Paraná
Telefax: (41) 3218-1350
Fax: (41) 3218-1350
E-mail: secex-pr@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado do Paraná
Rua Dr. Faivre, nº 105 – Centro
CEP: 80060-140, Curitiba – PR

Pernambuco
Telephone: (81) 3424-8100 /
3424-8109
Telefax: (81) 3424-8109 E-mail:
secex-pe@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado de Pernambuco
Rua Major Codeceira,
nº 121 – Santo Amaro
CEP: 50100-070, Recife – PE

Piauí
Telephones: (86) 3301-2700
Fax: (86) 3218-1918
E-mail: secex-pi@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado do Piauí
Avenida Pedro Freitas, nº 1.904
Centro Administrativo
CEP: 64018-000, Teresina – PI

Rio de Janeiro
Telephones: (21) 3805-4200 /
3805-4201 / 3805 4206
Fax: (21) 3805-4206
E-mail: secex-rj@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado do Rio de Janeiro
Avenida Presidente Antônio Carlos, nº 375
Ed. do Ministério da Fazenda, 12º
andar, Sala 1.202 – Centro
CEP: 20030-010, Rio de Janeiro – RJ

Rio Grande do Norte
Telephones: (84) 3092-2500 / 32118753
Fax: (84) 3201-6223
E-mail: secex-rn@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo no
Estado do Rio Grande do Norte
Avenida Rui Barbosa, 909 – Tirol
CEP: 59015-290, Natal – RN

Rio Grande do Sul
Telephone: (51) 3228 0788 /
3778-5600 / 3778-5601
Fax: (51) 3778-5646
E-mail: secex-rs@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo no
Estado do Rio Grande do Sul
Rua Caldas Júnior, nº 130
Ed. Banrisul, 20º andar – Centro
CEP: 90018-900, Porto Alegre – RS

Rondônia
Telephones: (69) 3223-1649 / 3223-8101 /
3224-5703 /
3224-5713 / 3301-3602 / 3301-3604
Fax: (69) 3224-5712
E-mail: secex-ro@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado de Rondônia
Rua Afonso Pena,
nº 345 – Centro
CEP: 76801-100, Porto Velho – RO

Roraima
Telephones: (95) 3623-9411/
3623-9412 / 3623 9414
Telefax: (95) 3623-9414
E-mail: secex-rr@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado de Roraima
Avenida Getúlio Vargas nº4570-B – São Pedro
CEP: 69306-700, Boa Vista – RR

Santa Catarina
Telephone: (48) 3952-4600
Fax: (48) 3952-4624/ 3952-4636
E-mail: secex-sc@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo no
Estado de Santa Catarina
Rua São Francisco, nº 234 – Centro
CEP: 88015-140, Florianópolis – SC

São Paulo
Telephone: (11) 3145-2600 /
3145-2601 / 3145-2626
Fax: (11) 3145-2602
E-mail: secex-sp@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado de São Paulo
Avenida Paulista, nº 1842
Ed. Cetenco Plaza Torre Norte
25º andar – Centro
CEP: 01310-923, São Paulo – SP

Sergipe
Telephones: (79) 3301-3600
Fax: (79) 3259-3079
E-mail: secex-se@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado de Sergipe
Avenida Dr. Carlos Rodrigues da Cruz, nº 1.340
Centro Administrativo Augusto
Franco – CENAF
CEP: 49080-903, Aracaju – SE

Tocantins
Telephone: (63) 3232-6700
Fax: (63) 3232-6725
E-mail: secex-to@tcu.gov.br
Address: Tribunal de Contas da União – TCU
Secretaria de Controle Externo
no Estado do Tocantins
302 Norte, Av. Teotônio Segurado
Lote 1A – Plano Diretor Norte
CEP: 77001-020, Palmas – TO

How to publish articles in the TCU Journal

THE JOURNAL

The TCU Journal is the institution's official publication and it carries technical articles with topics related to the Courts of Audits, Government Oversight, Public Administration, Public Law, Accounting, Finance, and public sector auditing.

THE EDITORIAL BOARD

The Journal Editorial Board, which is a permanent collegiate body of a technical nature, is responsible for final selection of published articles. The board is presided by the Court's Vice-President and it is comprised by the oldest Auditor in office, by the General Prosecutor of the TCU Public Prosecutor's Office, by the General Secretary of Government Auditing, the General Secretary of the Presidency, and the General Director of the Serzedello Correa Institute.

SELECTION OF ARTICLES

Analysis and selection of material to be published includes the following criteria:

1. compatibility with the theme of the Journal's ;
2. contribution to technical and professional improvement of TCU staff and to the study of work topics;
3. quality, objectiveness and impersonality of produced text.

NON-REMUNERATION

Approval and publication of works in the TCU Journal does not entitle authors to monetary compensation since distribution of the Journal is free. However, copyrights under the form of the Law are safeguarded.

Each author will receive five copies of the Journal issue in which his/her work has been published.

INTELLECTUAL RESPONSIBILITY

Approved texts are published without any change in content. Concepts and opinions expressed in signed doctrinal works are the sole responsibility of the authors.

Published works may be disseminated elsewhere as long as the TCU Journal is quoted, informing the year, issue number, and publishing date.

HOW TO SUBMIT CONTRIBUTIONS

Those interested in publishing works in the TCU journal should send their text to revista@tcu.gov.br, with the following specifications:

Regarding formatting

1. File format: .doc/.docx extensions
2. Font: Times New Roman – size 11.
3. Titles and subtitles in bold.
4. First line of paragraphs indented by 1 cm and justified alignment.
5. Simple spacing between lines.
6. Avoid blank lines between paragraphs.
7. Page format: A4 (21x29.7 cm)
8. All margins with 2 cm.
9. Maximum of 7 pages (references not considered).
10. Text abstract according to technical norms standards.
11. Every highlight in the text should be in bold. Use of italics is restricted to words foreign to the English language.

Regarding author's identification

Include a five lines maximum resume in the article of, in the following standard:

Mr. So and So is an employee of the Federal Court of Accounts - Brazil, with a BA in Business Administration from the University of Brasilia (UnB) and an MA in Public Administration from the Federal University of Rio de Janeiro (UFRJ).

Send a picture whose minimum size is 10x15cm and resolution is 300dpi.

Provide address for shipment of copies of the Journal issue in which the work is published.

Regarding the content

Texts should present wording suited to standard use of the English language.

Moderate use of footnotes and citations is recommended.

Regarding citations

Citations should be made in accordance with technical standards and should be carefully checked by authors. Sources should be mentioned in the text.

Regarding references

At the end, the text shall have a full list of references of documents used by author as theoretical fbasis.

Only published works or works available for public access should be used.

References should be prepared according to technical standards.