NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

BLOCKCHAIN TECHNOLOGY IN SUPPORT OF THE BRAZILIAN NAVY LOGISTICS AND BUDGET CONTROL SYSTEM

by

Philippe T. Siqueira and Carlos A. Correa Jr.

December 2020

Co-Advisors: Walter A. Kendall
Geraldo Ferrer

Second Reader: Arijit Das

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** December 2020	**3. REPORT TYPE AND DATES COVERED** Master's thesis

4. TITLE AND SUBTITLE
BLOCKCHAIN TECHNOLOGY IN SUPPORT OF THE BRAZILIAN NAVY LOGISTICS AND BUDGET CONTROL SYSTEM

5. FUNDING NUMBERS

6. AUTHOR(S) Philippe T. Siqueira and Carlos A. Correa Jr.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey, CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
N/A

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release. Distribution is unlimited.

12b. DISTRIBUTION CODE
A

13. ABSTRACT (maximum 200 words)

Blockchain technology is a contemporary phenomenon that brings new perspectives to a diversity of fields that can benefit from its characteristics of transparency and reliability. The purpose of this thesis is to explore some potential applications of this technology within the Brazilian Navy's (BN) supply chain management and budget control processes, contributing to a more efficient public administration. Through case studies, the thesis aims to unpack the complexity of blockchain applications, explore U.S. Department of Defense and industry application patterns, collect data related to successful implementations of this technology, and analyze the possibility of its implementation for the BN. There are certain limitations to its application, such as the relative immaturity of this technology and paucity of case studies in Brazil, and a lack of regulation regarding blockchain adoption in Brazil. Overall, this study suggests a pilot program to integrate the BN logistics and budget control systems on a blockchain platform to better manage multi-party transactions and support the decision-making process. The objective is to render the BN savings in time and dollars, permitting the optimization of warfighter support. On the side of the budgetary system, it would help automate cost estimates, track specific projects' expenses, identify the actual allocation of funds, and provide a trustable historical record.

14. SUBJECT TERMS supply chain, logistics, blockchain technology, logistics innovation, budget, Brazilian Navy, Marinha do Brasil	**15. NUMBER OF PAGES** 77
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
Unclassified	Unclassified	Unclassified	UU

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release. Distribution is unlimited.

BLOCKCHAIN TECHNOLOGY IN SUPPORT OF THE BRAZILIAN NAVY LOGISTICS AND BUDGET CONTROL SYSTEM

Philippe T. Siqueira
Lieutenant, Brazilian Navy
BNS, Brazilian Naval Academy, 2010

Carlos A. Correa Jr.
Lieutenant, Brazilian Navy
BNS, Brazilian Naval Academy, 2010

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL
December 2020

Approved by: Walter A. Kendall
Co-Advisor

Geraldo Ferrer
Co-Advisor

Arijit Das
Second Reader

Eddine Dahel
Academic Associate, Graduate School of Defense Management

Raymond F. Barnes
Academic Associate, Graduate School of Defense Management

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

Blockchain technology is a contemporary phenomenon that brings new perspectives to a diversity of fields that can benefit from its characteristics of transparency and reliability. The purpose of this thesis is to explore some potential applications of this technology within the Brazilian Navy's (BN) supply chain management and budget control processes, contributing to a more efficient public administration. Through case studies, the thesis aims to unpack the complexity of blockchain applications, explore U.S. Department of Defense and industry application patterns, collect data related to successful implementations of this technology, and analyze the possibility of its implementation for the BN. There are certain limitations to its application, such as the relative immaturity of this technology and paucity of case studies in Brazil, and a lack of regulation regarding blockchain adoption in Brazil. Overall, this study suggests a pilot program to integrate the BN logistics and budget control systems on a blockchain platform to better manage multi-party transactions and support the decision-making process. The objective is to render the BN savings in time and dollars, permitting the optimization of warfighter support. On the side of the budgetary system, it would help automate cost estimates, track specific projects' expenses, identify the actual allocation of funds, and provide a trustable historical record.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

AI	Ação Interna (Internal Action)
ALTCRED	Alteração de Créditos (Credit Change Process)
AO	Ação Orçamentária (Budgetary Action)
API	Application Programming Interfaces
BCB	Banco Central do Brasil (Brazilian Central Bank)
BN	Marinha do Brasil (Brazilian Navy)
CA	Crédito Adicional (Additional Credit)
CDAM	Centro de Distribuição e Operações Aduaneiras da Marinha (Navy Distribution and Customs Operations Center)
CMO	Comissão Mista de Planos, Orçamentos Públicos e Fiscalização (Joint Budget Commission)
COFAMAR	Conselho Financeiro e Administrativo da Marinha (Navy's Financial and Administrative Council)
COMRJ	Centro de Obtenção da Marinha no Rio de Janeiro (BN's Procurement Center in Rio de Janeiro)
COPLAN	Conselho do Plano Diretor (Director Plan Council)
COrM	Coordenadoria de Orçamento da Marinha (Executive-Secretary)
DAbM	Diretoria de Abastecimento da Marinha (Navy's Supply Systems Command)
DE	Specialized Directorate
DGOM	Diretoria de Gestão Orçamentária da Marinha (Navy Budget Management Directorate)
EMA	Estado-Maior da Armada (BN's General Staff)
ERP	Enterprise Resource Planning
LDO	Lei de Diretrizes Orçamentárias (Budget Guidelines Law)
LOA	Lei Orçamentária Anual (Annual Budget Law)
NAVAIR	Naval Air Systems Command
OObt	Órgão de Obtenção (Procurement Organization)
OC	Control Organization
OD	Distribution Organization
ODG	Órgão de Direção Geral (General Management Organization)

ODS	Sectorial Directorates
ODT	Órgão de Direção Técnica (Technical Management Organization)
OMC	Consumer Military Unit
PLOA	Projeto de Lei Orçamentária Anual (Bill of Annual Budget Law)
PO	Plano Orçamentário (Budgetary Plan)
PPA	Plano Plurianual (Multiyear Plan)
SAbM	Sistema de Abastecimento da Marinha (Brazilian Navy Supply System)
SCM	Supply Chain Management
SE	Foreign Request
SGM	Secretaria-Geral da Marinha (Secretary-General of the Brazilian Navy)
SINGRA	Sistema de Informações Gerenciais do Abastecimento (Supply Management Informations System)
SIOP	Sistema Integrado de Planejamento e Orçamento do Governo Federal (Planning and Budget Integrated System)
SIPLAD	Sistema do Plano Diretor (Director Plan System)
SOF	Secretaria de Orçamento Federal (Federal Budget Secretary)
STN	Secretaria do Tesouro Nacional (National Treasury of Brazil)

ACKNOWLEDGMENTS

We would like to thank God for the gift of life.

We would also like to express our highest appreciation to our families for their immense support throughout this challenge. Your unforgettable help made the difference and gave us the power and motivation to achieve the best in our lives and careers.

To our advisors, Lecturer Walter (Tony) Kendall and Professor Geraldo Ferrer, and second reader Arijit Das, thank you for pushing us to a higher level and trusting in our potential in developing a worthy thesis for our Navy and country.

We would like to extend our gratitude to the Brazilian Navy for the opportunity to study in such a renowned institution and have such a great life experience.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

New technologies have been developed, bringing benefits and challenges to companies that want to be in the state of the art. Blockchain technology, though it is still in its infancy, is one such technology that brings new opportunities to a variety of fields. The purpose of this thesis is to explore possibilities for blockchain technology within the Brazilian Navy (BN). Specifically, this thesis explores how the BN can realize the technology's primary benefits—transparency and reliability—within the navy's supply chain management (SCM) and budget control mechanisms, which will contribute to more efficient public administration.

The Brazilian public administration is governed by five principles established in its constitution: legality, impersonality, morality, publicity, and efficiency. In the search for efficiency, government institutions conduct studies on recent technologies for possible applications in daily government activities. In the BN, the Naval Systems Analysis Center (CASNAV) is the unit responsible for those studies. It develops research and projects to explore the application and employment of new procedures and tactics for naval systems and single units and works on the development of digital systems to support the decision-making process.

Those systems should provide reliable and accurate information to be useful for the managers. That makes technology a crucial tool for many business processes in all organizations. Supply chain management (SCM) and budget allocation are essential areas that can benefit from the development of new technological capabilities. One of the latest technologies contributing substantially to these activities is enterprise resource planning (ERP), which plays a crucial role in enhancing supply chain operations (Banerjee, 2018).

ERP combines an organization's various systems into a single and merged software program with a unique database, making it a powerful tool that improves the capabilities of management processes within organizations by maximizing resource utilization and improving planning (Banerjee, 2018). In particular, ERP brings together

transaction processing and data structure capabilities that contribute to better intra-organizational communication, providing real-time information sharing.

The traditional centralized management model requires the existence of big intermediaries, such as banks, government, and companies, to establish trust among them. They perform all the business transactions such as identification and authentication through record-keeping with adequate results. Another way to authenticate business transactions is blockchain technology. It runs on a decentralized database where all the platform participants have access to the information in the database. According to Underwood (2016), that technology's network allows a shared data environment where the register of transactions is digital and available to the network members, eliminating the central authority's role to control the data. This technology represents a potential upgrade in how organizations can optimize their decision-making processes.

Although blockchain technology is relatively immature, on April 28, 2020, the Brazilian president published Decree number 10,332, establishing the Digital Government strategy, in which one of the expressed goals is the use of blockchain solutions. Thus, Brazil's public administration now has this goal as a contributing factor to its technological evolution. In line with that goal, the BN suggested that blockchain technology associated with logistics and budget control be analyzed. This suggestion motivates the present study.

This study investigates blockchain technology and its characteristics as a contemporary phenomenon. Case studies as a research method will help BN decision makers understand the complexity of blockchain applications, explore the patterns of these applications by the U.S. Department of Defense and industry, collect data related to successful cases, and analyze the possibility of implementation in the BN. To accomplish that, we identify the BN's systems related to budget control and supply chain management, in an attempt to make an association with similar structures that already make use of the addressed technology. Thus, modern solutions can prepare the BN for the challenges to come in a world where information technology will be increasingly paramount for faster, more reliable, and transparent responses.

A. PURPOSE

Our project focuses on the feasibility of implementing an ERP system based on blockchain technology that would merge an updated logistics system for the BN and its current budget management system as a pilot program for introducing this technology in the BN.

ERP systems are powerful tools that improve the management processes capabilities within organizations by integrating their information to enhance data managing capabilities (Banerjee, 2018). ERP combines an organization's various systems into one shared application that smoothly gathers data and communicates with other areas within the organization (Koch et al., 1999). Therefore, transparency and accessibility across the business processes are crucial improvements that ERP software provides.

With an ERP system, it is possible for all organizational entities to use one platform to achieve more efficient financial reporting and employee benefits and supply chain management. In finance, a modern ERP can provide real-time information and offer dashboards that help the decision-making processes. Also, such systems can upgrade inventory management by reducing manual entries and automating these processes. For human resources, it is possible to manage employees' data and gather their performance information in the ERP's subsystems.

In the logistics field, the intention is to identify critical activities that are not well served by the current IT system, which is out-of-date, and suggest improvements and partnerships to develop a new platform. Regarding budget management, the current network does not need a replacement due to its recent updates, but it has vast room for improvement in terms of how the budget management system can work seamlessly with the logistics system on a blockchain platform. We expect to explore these current deficiencies and deliver a useful recommendation to the BN.

B. SCOPE

The study touches on the transport area of the BN's logistics management process and on the potential impact of the implementation of an ERP platform based on the blockchain technology in financial and budget management. The reason for this selected

area is the availability of information on actual cases that are well documented in academic resources.

Our goal is to use recent public and private cases involving blockchain applications and the best practices in these implementations to support the baseline for a new IT solution for the BN. Specifically, the project focuses on the benefits of this upgrade for BN's management processes. Thus, detailed steps related to the IT architecture implementation and operation are not fully presented in this research.

This study has some inherent limitations, including the following:

- The maturity level of most features of blockchain technology is low.
- There are few published case studies of blockchain implementation in Brazil.
- There is a lack of regulation regarding blockchain adoption in Brazil.

Despite the difficulties just presented, this study observes the practices already carried out in the business community and uses English language publications available for technical support. Regarding the lack of Brazilian regulation, this study hopes to make the topic more relevant to initiate discussions regarding the legal frameworks for the adoption of this technology within the relevant Brazilian agencies.

C. THESIS OVERVIEW

The present study answers the following primary research question:

- How can the Brazilian Navy (BN) apply blockchain technology to improve the transparency and reliability of its information systems?

We also explore the following secondary research questions:

- How can BN supply chain management benefit from this change?
- What are the benefits and implications of blockchain technology for BN information systems?

- How does this technology fit into the BN budget planning decision-making processes?

Chapter II provides a theoretical reference for understanding blockchain technology. It introduces the basic concepts of blockchain technology, presenting its characteristics, known applications, and positive and negative points. This chapter is of great value in demystifying the perception that this technology is used exclusively in the field of cryptocurrency.

Chapter III covers the current processes and policies used by BN for logistics and budgetary control. This chapter also identifies possible problems in these processes that can be solved with the use of blockchain technology.

Chapter IV presents a case study related to the use of blockchain technology in the logistics field, showing an example of relative success that could be implemented by the BN. When we talk about logistics, we must take into consideration market innovations that require internal and external technologies to go hand-in-hand. Thus, being prepared to integrate the BN system with that of businesses (suppliers) and other public administration units is vital for the BN's future.

Then, in Chapter V, a new case study involving budgetary control is presented. This case study is unique in that it covers only internal BN processes since other technologies guide the federal government budget and its systems. This update seems to be valuable, since due to its recognized technological pioneerism at the national level, BN was able to modernize its systems—allowing them to be ready for future scenarios, and thus, BN could influence other public administration agencies to carry out a similar migration.

Chapter VI concludes with the findings of the research and the opportunities for the broad implementation of blockchain technology in BN's management system. The final chapter also recommends future studies on the application of blockchain technology in other areas within the BN.

THIS PAGE INTENTIONALLY LEFT BLANK

II. OVERVIEW OF BLOCKCHAIN TECHNOLOGY

This chapter provides a brief explanation of the technology covered in this study—blockchain—and its applications to acquaint the reader with the possible transformations resulting from its use. The overview highlights the technology's utility, particularly in terms of an ERP solution, for business transactions and supply chain management.

The simple definition of the term blockchain is, indeed, a chain of blocks. "Each block is linked to the previous block with a cryptographic hash. A block is a data structure which allows to store a list of transactions. Transactions are created and exchanged by peers of the blockchain network and modify the state of the blockchain" (Wüst & Gervais, 2017, para. 4). Consequently, blockchain is a technology to store and access data (Verhoeven et al., 2018). That kind of connection between the blocks—which links information from the previous block to the current one—permits the storage of the complete transaction story.

Figure 1 describes the typical structure of a blockchain. The central block (Block n) connects with the previous block (Block n-1), adding that block's information to the structure. That connection occurs in a chain so that the next block (Block n+1) will contain the central block's data, and the one before that, in an iterative process. In this way, all the information remains logically associated.

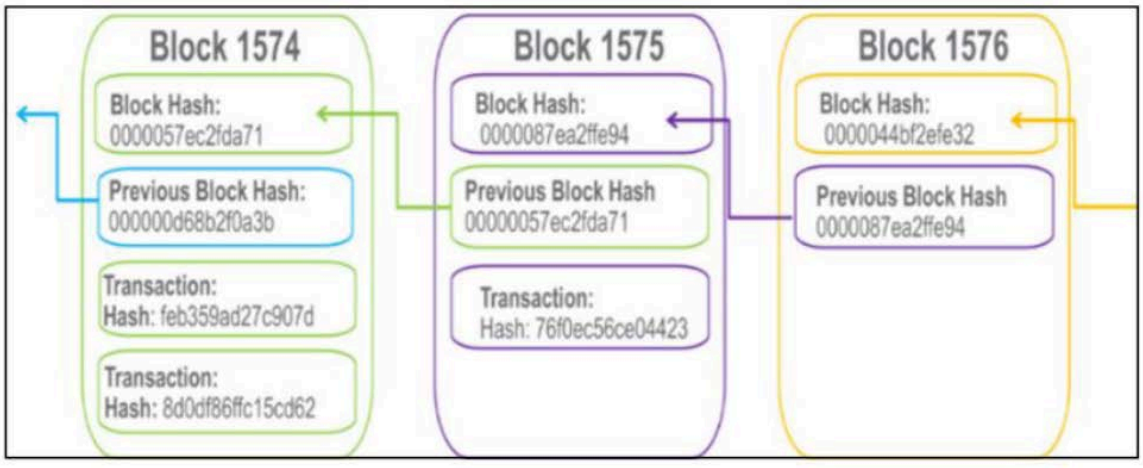

Figure 1. The typical structure of a blockchain. Source: TechBlog (2018).

The blockchain infrastructure and operation have two foundational components known as smart contracts and ledgers that provide reliability to the data and execute pre-defined rules between parties in a contract (Banda et al., 2020). Therefore, “a smart contract is a computer code running on top of a blockchain containing a set of rules under which the parties to that smart contract agree to interact with each other” (Kubáč, 2018, p. 40). According to The Founder’s Handbook (Banda et al., 2020), these codes form a powerful tool to enhance the quality of business transactions that parties previously agreed to and validated in the network. Smart contract codes are seen as facilitators since they verify and validate a transaction or performance without needing human intervention. Thus, one feature of this technology is the automation and decentralization of consensus, as transactions are executed without any intervention, without third-party services. “These transactions act upon the state of business objects or assets defined and managed in smart contracts and ultimately recorded in the ledger” (Banda et al., 2020, p. 27).

The main advantage and impact of the blockchain is the trustworthiness of transactions and the ability to share assets (Eljazzar et al., 2019). As the ledger is immutable, shared, and distributed among participants, its presence contributes greatly to make transactions reliable and secure. Further, private blockchains have a predefined group of platform participants who validate the transactions, guaranteeing the database integrity. On the other hand, in public blockchains, anyone can participate in the validation process if they have the computational power to do so. After the validation, the consensus mechanism appears. This mechanism is a protocol to ensure that all transactions emerge from a legitimate source by having every participant—or at least a majority—consent to the distributed ledger’s state (Sayeed & Marco-Gisbert, 2019). Indeed, according to Perboli et al. (2018), data reliability needs powerful cryptographic technologies to prevent changes in transactions or the manipulation of transactions for undesirable purposes. Any attempt to manipulate the data is promptly registered and available to all participants in the platform, allowing them to identify the action and deny it.

One benefit of a blockchain is that this technology does not require a central administrator, nor does it need centralized data storage, which is more vulnerable to cyberattacks and data breaches. Governments, banks, and other big companies are often

targets of attacks due to the power of their information and how valuable it is for competitors. This highlights two important features of a blockchain: security and immutability.

Additionally, transparency is another relevant advantage. As long as every member of the network accesses the same data, a single point of truth is created, establishing the transparency of blockchain technology (Hackius & Petersen, 2017). This feature is the one that motivates the use of this technology beyond cryptocurrency.

Regarding accessibility, a blockchain can be public, private, or even hybrid, although this last type is less common. As an analogy, according to Petrisin and Johnson (2019), a public blockchain is similar to the internet, while a private blockchain is similar to an intranet. This characteristic of accessibility is directly related to the applications that this study presents later. Public blockchains allow everyone to access and register information on the platform. Consequently, public networks should not be used to manage sensitive information, like military records and banking transactions. Such networks are not the best solution for environments that need privacy, since the data is accessible to everyone.

Private, or permissioned, blockchains require an invitation to access them and validation from the network. The allowance for new participants varies according to the network. The actual users can decide about granting permission to access a blockchain or can assign this role to specific nodes on the system (Jayachandran, 2017). These mechanisms provide a higher level of trust in who can register any record in the platform. Permissioned networks provide privacy of information and faster processing due to their database's size compared to that of public ones.

One of the disadvantages of blockchain technology, however, affects both aforementioned platforms: energy consumption. Public blockchains use a significant amount of power to keep each node's computational assets running to solve the cryptographical problem related to each new block. Every time a new node, or participant, is created, it has to communicate with all the other nodes to maintain transparency (Golosova & Romanovs, 2018). The computing power is responsible for

recognizing the digital signatures of all transactions in the blockchain, which uses a public-private cryptography scheme that all nodes have to read and process (Blockchain Technology, 2016). Thus, as the platform grows, it needs more resources to ensure its capabilities.

The biggest challenge for a blockchain platform implementation might be integrating the partners involved in the business processes of a project or product. By definition, all participants share the same information within the environment. They should register their operations and actions on the same platform to maximize the technology's benefits. This situation leads to a considerable trade-off in terms of the costs of implementation and the desire to engage in the development of a relatively immature system. This study presents some applications of blockchains, using real-life examples when applicable.

A. BLOCKCHAIN APPLICATIONS

Many public and private blockchain uses in industry serve as examples of how the technology helps improve decision processes and how it might change the way people think about managing data.

1. Digital Registries

Registering a smart asset becomes more secure, cheaper, and more trustworthy with blockchain technology. Digital registration is the key to check and transfer an asset on a blockchain platform (Swan, 2017). This feature allows the system to record the transfers of property like cars and land through the internet without duplication. In other words, once registered on the blockchain, the asset is unique and has all its documents, and further updates are safely kept on the system. Ownership transfers also benefit from the use of a blockchain, because they become cheaper, the associated paperwork decreases, and the risk of fraud is reduced.

Another application in this context is the digital registration of sensitive personally identifiable information such as birth and death certificates, and passports. The current physical identification methods seem old-fashioned in comparison to the virtually

connected, paperless, and contactless world. Blockchain technology provides reliability and integrity to these documents. It helps to speed up processes within government agencies, prevent fraud, and reduce costs. In the United States, the state of Illinois, for instance, took the initiative to explore the use of blockchains in government processes like birth registries (Illinois Blockchain Initiative, 2017) and it intends to expand the scope of this application.

Unlike the U.S. example, however, not all governments are likely adopters of this new technology. Developing countries are perhaps the least trusting countries in the world (Mattes & Moreno, 2018). Consequently, blockchain implementations would face particular challenges in those countries, particularly because of the technology's reliance on and contribution to building trust. These nations usually struggle with the development of new technologies and capabilities to improve their economy. One of the reasons for this resistance is the government's and big investors' desire to keep control over their own activities, which has led to unchecked corruption as collateral effect. All the transparency that this technology provides is a threat to their interests. For instance, if a government grants registered voters permission to vote via a blockchain platform, the votes would not be able to be manipulated by corrupt governments. The possibilities for fraud are almost nonexistent.

2. Finance

When people think of the term blockchain, what comes to mind first is cryptocurrencies due to the notoriety of bitcoin. Yet, bitcoin is just one example focused on a potentially valuable currency, which is not the core of this study. Cryptocurrencies, although they are beyond that the scope of this study, are "an inherently good fit for blockchain because [it] represents a solution to the 'double spend' problem and [because the] underlying blockchain solves multiple issues with our legacy banking system, including the need for a trusted third party, cross border remittance payments, susceptibility to hacking, fractional reserve banking, and a fluctuating interest rate" (Petrisin & Johnson, 2019, pp. 29–30). All of this helps to increase the relevance of cryptocurrency as an example for our study.

The Great Recession in 2008–09 crashed the banking industry. With the crisis, opportunities for banking improvements arose to address old mistakes and meet new requirements. Although blockchain eliminates the banks' power as an intermediary for transactions between two parties, the American financial services industry is working on this platform to extract other benefits. Moreover, distributed ledgers are powerful tools in reducing costs and inefficiencies, improving profits, assisting with compliance, and reducing fraud (McLean & Deane-Johns, 2016). Nevertheless, the implementation of this technology still faces resistance from some financial organizations.

Bank and financial regulators are still learning about the technology and how to deal with data transparency and integrity to provide consistent implementation and evaluation. Companies are also struggling to find a solution that assures the system's scalability and stability due to the size and sensitivity of the transactions.

B. HOW BLOCKCHAIN ENHANCES BUSINESS TRANSACTIONS

The way people do business may also change due to the opportunities that blockchain provides. As already mentioned, this technology eliminates the need for a third-party institution and might increase financial transactions and services (Chen & Bellavitis, 2019). Decentralized finance has a considerable potential to upgrade current payment services, especially cross-border ones, and how companies establish their contracts.

Further, blockchain represents a disruptive technology for facilitating the flow of money across borders like information does. As the globalization of transactions increases, it also helps to grow the demand to support international payments from customers. The current centralized bank networks have their own rules, systems of records, and technology that do not necessarily match when exchanging information. Moreover, there are issues like the lack of transparency about exchange rates, the lack of speed in settling transactions across many intermediaries, and difficulties in tracing money. In this context, blockchain is a robust solution for processing transaction and moving money between users, with no intermediaries involved (Castellanos et al., 2017). All these characteristics contribute to driving customers from the traditional banks to

companies that provide financial services through technology, the so-called fintech banking.

If banks adopt a blockchain network as their payment infrastructure, they will keep their role in this industry, even as their role as an intermediary institution becomes extinct (Schupmann, 2017). The decentralized networks using blockchain technology enable individuals to move values internationally more quickly, cheaply, and safely. Peer-to-peer connections allow blockchain to reduce costs and increase capabilities for transactions by eliminating centralized intermediaries (Chen & Bellavitis, 2019). This is because every participant in the process shares the same platform and rules, which inherently provide those benefits. Facilitating international payments might also impact the customers' behavior as they trust and feel may more comfortable using the service. One obstacle hindering this innovation from becoming more common, however, is the regulations that need to exist to make all of this legal in different countries.

C. BLOCKCHAIN IN SUPPORT OF SUPPLY CHAIN MANAGEMENT

Blockchain platforms are powerful tools to improve logistics and supply chain processes. The decentralized aspect and the transaction transparency blockchain platforms provide can help to increase the security and traceability of physical assets. In this context, a synchronized blockchain platform permits useful visibility during the various processes, from their origins to their destinations, with accurate information that helps to optimize the time-to-market of products and increase end-to-end transparency (Rodrigues et al., 2018). Organizations like Walmart and Maersk are some examples of large enterprises that have adopted blockchain platforms in their activities. Both use the IBM solution Hyperledger Fabric for enabling a permissioned blockchain platform and have checked to see if the benefits of this technology are worth the investment. This section provides more details of the applications and the benefits to operations in these two different supply chain examples.

To help respond to food contamination problems, Walmart started to use blockchain to track its supply chain operations for some products. Delays in identifying the origin of contaminated food threaten people's health, lead to a loss of consumer

confidence in the product or seller and in the industries or farmers' activities, and waste due to having to dispose of all the suspicious products. A blockchain network can provide fast and reliable information on the processes to reduce the risks in the supply chain. Also, this technology can help minimize the adverse impact on human health and enable public health officials to investigate the origins of contaminated food and suggest better solutions to avert an outbreak (Walmart, 2018). Blockchain technology offers an end-to-end solution that make it possible to register transactions of "audits, agricultural treatments, identification numbers, manufacturers, available device updates, known security issues, granted permissions, and safety-protocols, all logged in real-time and permanently stored as e-certificates" (Kamath, 2018, p. 48).

The blockchain pilot program that Walmart uses presents some especially exciting findings regarding traceability. First, in their mango chain process from the farm to the consumer, Walmart asked employees where a specific group of mangos came from. It took them about six days and 18 hours to find out (Nuce et al., 2017). Using the blockchain platform, they could immediately trace the whole route of the fruits from the farm to the shelves, and their answer to the same question took 2.2 seconds (Nuce et al., 2017). Having the ability to analyze all processes in the chain in real time also permits decision makers to identify improvement opportunities more quickly. For instance, another useful finding from the mango chain example was the identification of a bottleneck in the process, which was the four days spent in the cross-border proceedings (Doskey & Johnson, 2018). Thus, all registered information on the platform can play an essential role in SCM improvement, if that information is accurately measured and analyzed.

The other example of an enterprise that has implemented blockchain technology is Maersk. Sea transport is responsible for the most significant share of the global commercial trade. Thus, the shipping industry is a crucial player in most supply chains around the world. In this context, Maersk, as a leader in container shipping, started a pilot to seize the benefits from emerging blockchain platforms and has improved the shipping environment through its use of a new network leveraging Hyperledger technologies, which are modular in nature and allow for plug-and-play applications (IBM, 2018).

Maersk uses the TradeLens platform, a container-centric digital shipping solution that aims to make global trade more efficient by reducing errors and cutting out wasted time (ICT, 2019). The platform can improve efficiency and transparency, even in simple processes like locating assets by eliminating the need to ask multiple sources (del Castillo, 2018). Nonetheless, scalability poses a considerable challenge to achieve complete success with this platform. All companies within the supply chain must participate in the network to enhance its benefits. As more supply chain participants adopt the platform, the better it is. A robust and reliable platform, therefore, might incentivize competing firms to participate and collaborate as the platform improves, but it is first necessary to surmount potential technical and contractual barriers to avoid undesirable data sharing and spillage (del Castillo, 2018).

The two examples mentioned previously help to synthesize some applications that contribute to improving SCM efficiency, despite the challenges these organizations faced. The military can also benefit from the development of digital tools to enhance its readiness and planning. A blockchain platform can provide real-time information about troops' necessities at the base and on the battlefield to prevent shortages of crucial supplies such as food, medicine, or spare parts. To avoid critical errors that could compromise missions, however, there are three inherent values of blockchain technology that must be well defined and established from the start. The first is privacy. To create a useful platform, the top leaders should decide which information they want to disclose and share with the network's participants. Supplying the troops on missions is not something new; neither is the selection of the suppliers. Yet, the platform should be able to determine these needs without sharing the operation's details. Second, higher privacy leads to less transparency. Private blockchains decrease the level of decentralization, which means that data is less accessible to external entities, but this type of blockchain also has fewer nodes. In this context, the ledgers' distribution should be wide enough to avoid an attack in more than 51% of the nodes that provide consensus in the platform and ensure a safe level of decentralization. Preventing such an attack, which occurs when a malicious actor controls the majority of the network's computing power, means being able to verify blocks quicker and making their values "true." Trust is the third value that the platform should enhance. This is related to relying on a partner to share strategic information with an intermediary.

The use of blockchain platforms in SCM is still growing, but the current initiatives already show the potential to be powerful tools to increase efficiency and reduce costs and paperwork. Those platforms should be big enough to enhance their characteristics regarding the limits of each niche, and to establish accountability among all involved in the processes and help direct efforts effectively. Due to the technology's relative immaturity, it is hard to predict other applications and problem sets until there are more functioning blockchains (Angert, 2019). Nevertheless, the pilot projects described in this section are useful for evaluating their outcomes and incentivizing other organizations to join or launch such programs.

D. BLOCKCHAIN AS AN ERP ENHANCEMENT

ERP systems are powerful tools to optimize business processes because they provide "consistent, complete, relevant, timely, and reliable information for decision making" (Veit, 2005, p. 12). Blockchain technology can add value by making information immutable and more transparent. Moreover, with a private blockchain, it is possible to share the system with other stakeholders in the environment, like suppliers, government regulators, and consumers, by managing their data access. Thus, an ERP built on a blockchain platform has great potential to raise an organization's management and technological levels and improve all its partners' business processes.

Some reasons to implement an ERP platform in an organization are related to growth, technology, and higher expectations. First, systems that make use of outdated technologies usually limit a company's ability to expand globally and, hence, decreases the company's growth opportunities. Second, as new technologies emerge, organizational platforms should be updated together to continue to work well. This is especially true if a company has systems with different architectures that are not compatible, making the workers struggle to access, merge, and share information. Third, meeting customers' and employees' expectations is essential to improve their management. Thus, systems should be tools that motivate a company's staff to succeed and to deliver better services or products.

ERP implementation, however, can be costly and it takes time to realize the benefits of such a platform. Moreover, it can change the organizational culture, require

extensive training, decrease productivity temporarily, or lead to mishandled customer orders (Stein, 1999). To avoid these pitfalls, an organization should follow best practices as it implements an ERP system to decrease the chance of project failure. According to Ram et al. (2013), project management and training and education are crucial for ERP systems implementation, and training and education mostly and directly influence post-implementation performance outcomes. Therefore, it is crucial to manage training effectively due to its significant role in the success or failure of an implementation project, especially when adopting blockchain technology might require more extensive learning efforts.

ERP systems connected to a blockchain associated with a supply chain represent a powerful application not only for managing data, but also as a decision-making tool. All enterprise systems have three sets of master data: product information, customer names, and supplier names (Banerjee, 2018). In one actual product sale, the item sold may have different identifications in each of those sets that need cross-references in the enterprise's ERP system. So, in this context, the software needs to be especially robust to set up the data, which can translate to increased maintenance issues and costs and time-consuming operations. With a permissioned blockchain, those who participate in the process will share the same information, without the need to duplicate data, and any changes will be reflected almost in real time (Banerjee, 2018). Thus, the synchronization and standardization are enormous benefits of an ERP connected to a blockchain.

Although connecting ERP systems to a blockchain allows for tracking activities beyond the organization's boundaries, this implementation has some challenges. First, regarding the size of the network, the computational power requirement must be considered. High storage requirements related to the register size of multiple nodes might be an issue for the network (Zheng et al., 2018). Second, all the participants should use the same platform to register their activities, because each blockchain is a restricted environment by definition; that means one blockchain does not interact with another. Third, there is no legal framework for blockchains globally. There might be critical issues arising from some countries' regulations, as the information does not belong to one single data center (Fabiano, 2017).

There are still other potential barriers to integration. The costs of maintaining and on-boarding the nodes can be high (Banerjee, 2018). The latency for validating transactions should be short, maybe seconds, because the transactions in a blockchain are essential for the subsequent activities based on them and for making business decisions. For instance, the bitcoin network has a latency of ten minutes on average, which is not desirable for systems like those that operate supply chain management. Another restriction is the storage size restriction for both public and private blockchains. It means that some transactions will become invalid due to their information size, even if there is no standard for payload size as it depends on the network's nodes' capability (Banerjee, 2018). Fortunately, this problem may decrease over time with the further development of blockchain technology.

III. THE BRAZILIAN NAVY'S ADMINISTRATIVE PROCESSES

This chapter aims to discuss the current logistics system and explain the budgetary processes within the BN. Overall, the BN Supply Systems Command (Diretoria de Abastecimento da Marinha—DAbM) is responsible for coordinating and regulating BN's logistics activities. In this context, there is an organizational system called the Supply Managerial Information System (Sistema de Informações Gerenciais do Abastecimento—SINGRA)—similar to the U.S. Navy's Relational Supply system (RSupply)—which has been operating since 2001. SINGRA records the orders between the warehouses and military units and helps to manage stock, among other tasks. For the budgetary cycle of planning, execution, and control, the BN has an office called the Navy Budget Management Directorate (Diretoria de Gestão Orçamentária da Marinha—DGOM), which conducts the activities related to the Brazilian Navy's budget. Moreover, the Director Plan System (Sistema do Plano Diretor—SIPLAD) is the system used to manage the operational processes. These two systems have critical particularities that show how blockchain can fit the BN and provide better information for the Brazilian Armed Forces' decision-making processes. The following topics also detail the organizational structure, the SCM system evolution, and the current budgetary policy that guides how the BN conducts its activities.

A. LOGISTICS SYSTEM

The supply task is assigned to the BN Supply System (Sistema de Abastecimento da Marinha—SAbM), a subsystem of the Logistics Support of the BN. Supply activities are subject to guidance, coordination, and control specific to the Supervisory and the Superintendency parties, without compromising the responsibilities of the military units involved. Thus, SAbM is the set of organizations, processes, and resources of any nature, interconnected and interdependent, structured to promote, maintain, and control the material necessary to sustain the forces and other naval organizations in full efficiency condition (Secretaria-Geral da Marinha [SGM], 2009).

1. Structure

Structurally, the SAbM comprises the following organizations: General Supervision (Estado-Maior da Armada—EMA), Superintendence (SGM), Technical Supervision (Diretoria-Geral do Material da Marinha—DGMM), Management (DAbM), and Execution—responsible for inventory control, storage, and distribution—and procurement (Centro de Obtenção da Marinha no Rio de Janeiro—COMRJ; Comissão Naval Brasileira na Europa—CNBE; Comissão Naval Brasileira em Washington—CNBW, and Warehouses) organizations. Figure 2 shows how they are organized.

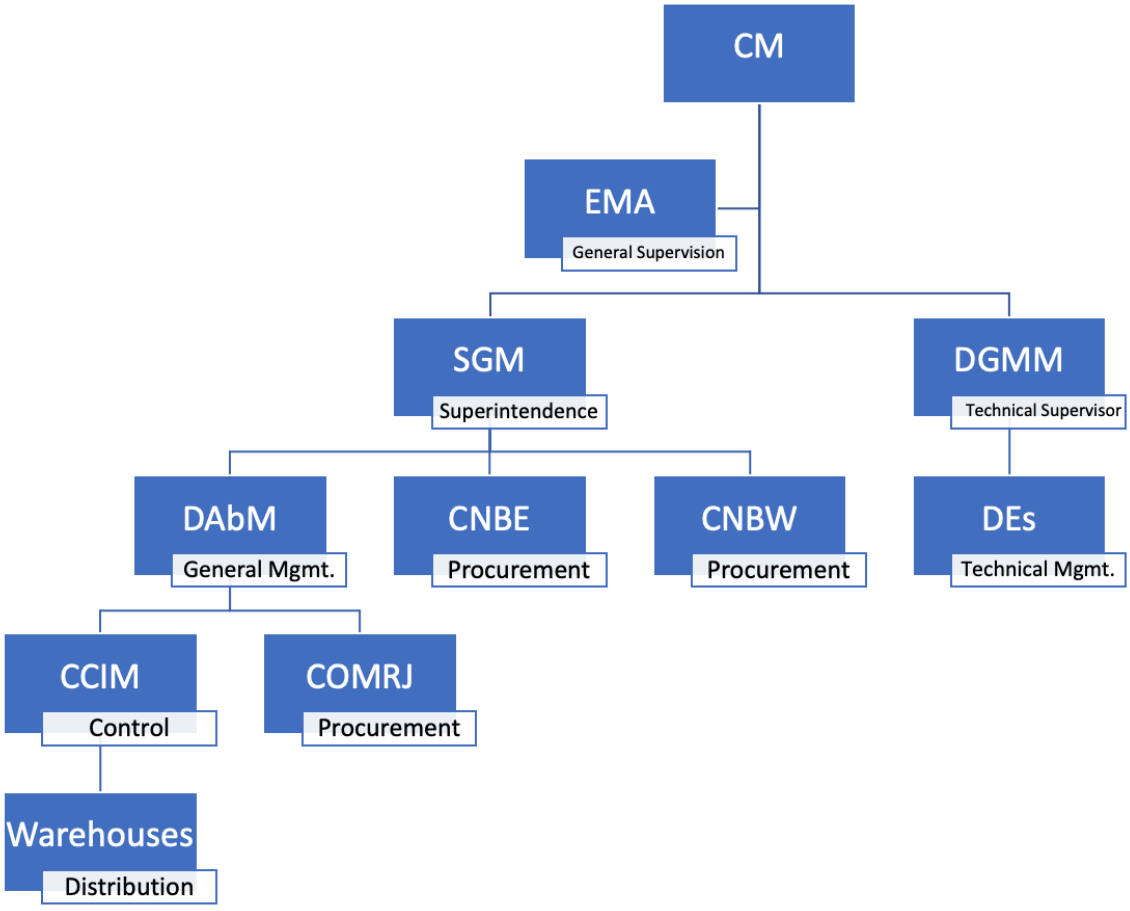

Figure 2. The structure of Brazil's Navy Supply System

The General Supervision organization is responsible for guiding, coordinating, and controlling the Superintendence bodies and Technical Supervision activities related to naval supply. It is responsible for the formulation and approval of plans and programs necessary for the efficient performance of the supply activities related to the material designed to maintain the naval forces and other military units in full efficiency condition. That task is performed by the BN's General Staff (EMA) in particular.

The SGM acts as the Superintendence organization and it is in charge of exercising managerial supervision and ensuring faithful compliance with the directives, norms, and orders, and enforcing proper instructions and the efficient and coordinated operation of SAbM.

The Technical Supervision organization is responsible for guiding, coordinating, and controlling the exercise of technical supply activities, by subordinate or non-subordinate military units. That role is played by the BN's DGMM.

The Management organizations plan and govern the supply activities—technical or general—in their respective areas of jurisdiction. There are two types: the Technical Management organizations that are usually in the Specialized Directorate (DE) and the General Management organization within the BN Supply Systems Command (DAbM).

The Execution organizations are responsible for the effective operation of the supply, technical, or management activities. They are split into four types:

The Technical organizations are responsible for the performance of technical activities concerning the material for their specific competence. The technical and managerial peculiarities of the material used in the BN identify homogeneous sets of items—characterized by management responsibilities—aggregated under the concept of material jurisdiction. The material jurisdiction is established by DGMM—in coordination with SGM—defining, for each material item, the set of military units responsible for an item's supply. That material jurisdiction is defined by an alphabetic code—called a jurisdiction symbol—associated with the NATO Stock Number (NSN). It allows materials to be grouped according to their specific nature or application. When an item is

entered in the SAbM, the Technical organization assigns the material item a jurisdiction symbol . Finally, DAbM discloses it through catalogs or specific documents.

The Control organizations are responsible for maintaining the balance between the military units' needs and the material available at the accumulation points through the control of stock levels. This control results in the replenishment of stock, as well as the redistribution and destination of surplus materials. The BN's Inventory Control Center (Centro de Controle de Inventário da Marinha—CCIM) is in charge of this role.

The Procurement organizations are responsible for procurement, within the country or abroad, of the material in which the BN is interested. These organizations are accountable for the stages of search, identification, and selection of suppliers of the order through the purchase of the material or contracted services and follow-up on deadlines and delivery conditions. That attribution is exercised based on the information resulting from the inventory control made by the Control organizations. The BN's Procurement Center in Rio de Janeiro (COMRJ) performs the procurement activity in Brazil. At the same time, two units are responsible for overseas purchases: the BN's Naval Commission in Washington (CNBW) and the BN's Naval Commission in London (CNBE).

The Distribution organizations are responsible for the accumulation and supply of the material related to their specific competence. There are three types of these organizations: primary warehouses, regional supply centers, and supplying organizations. The primary warehouses are nationwide facilities—within the DAbM chain of command—responsible for distributing material of a specific category, duly selected and specified. The regional supply centers are facilities under DAbM functional supervision, liable for distributing several material types within a particular region. Lastly, the supplying organizations are facilities of national, regional, or local scope, accountable for distributing material of any category, whose Management organization is not DAbM.

2. Supporting System

SINGRA was first developed in 1999 to replace the previous system in 2001. SINGRA, which has been improved since its adoption, uses several modules for intercommunication among several databases.

There is a module that encompasses the management of the material within the warehouses, with information on the location of specific items, their storage time, and stock replacement. Another module serves to control the quantities of the material at the accumulation points. Among other modules, one refers to the registration of bidding processes, and still another handles the material cataloging.

Over time, SAbM was structured, organizing activities in the form of a set of operations carried out from the guidance, coordination, and control of specific organizations intended for these purposes.

The BN has adopted an ERP to improve the performance and efficiency of its supply chains. At the time, the BN did not choose to use any existing systems on the market, and instead developed its own ERP—SINGRA—in partnership with the Federal University of Rio de Janeiro. Consequently, the system has excellent adherence to the processes of the force and has faced minimal resistance to its implementation, bringing the expected gains to logistical support and attracting support from users, factors that positively influence its evaluation (Bezerra, 2015).

3. Subsystems

Due to technological constraints, the SINGRA currently offers two interfaces: the Client-server and the Web interfaces. The first contains all the SINGRA transactions, primarily used by the organizations belonging to the SAbM. That environment has a centralized database and a distributed application. The second contains a subset of the client-server interface transactions, designed to ease access to the system by the military units. Its login is made through the intranet.

The subsystems available in the SINGRA-CS environment are the following:

- Cataloging—allows the execution of cataloging managerial activity, exercised by the military units components of the BN Cataloging System (Sistema de Catalogação da Marinha do Brasil—SCMB).

- Material Requisition—permits the execution of the supply management and surplus destination activities by SAbM's Distribution organizations.

- Financial—enables the distribution and control of resources and establishes financial limits related to the material categories supported by SAbM, beyond the management and updating of sales prices registered in the SINGRA.

- Procurement—allows the execution of the procurement management activities, exercised by the procurement units in the country.

- Project Management—permits the supply planning for a set of necessary items to execute a given project, providing features that facilitate the creation of material requests, material segregation, and orders. It is mainly used in the management of the supply of spares to the assets—ships, weapons systems, etc.—foreseen in the General Maintenance Program (Programa Geral de Manutenção—PROGEM) and of initial appropriations.

- Planning—supports the execution of inventory control management activities by SAbM's OC, providing an automated tool that allows demand analysis, verification of stock levels, and the issuance of an order. Within the country, this is performed through procurement estimates and acquisition requests, while it is accomplished abroad by utilizing foreign orders.

- Control—permits the performance evaluation of the SAbM's Control, Procurement, and Distribution organizations.

- Administration—enables the management of the support activities to SINGRA, such as access control and transactions executed by the users, control of the activities calendar, and the dissemination of information by notice boards and e-mail. This subsystem is exclusively for DAbM use.

The subsystems available in the SINGRA-Web environment are the following:

- Cataloging—allows the end-of-line military units (OMC) to carry out several queries related to the cataloging management activity.
- Deposit—permits the execution of inventory control managerial activities and storage exercised by the Distribution organizations.
- Movement—enables the OMC to make requests of material for consumption, transfer, and return to SAbM, including fuels and lubricants. Hence, it provides managerial control of stocks, quotas, contracts, and reservations in the BN and the carrying out of various queries at the SINGRA.
- Procurement—allows the insertion and tracking of a foreign order.
- Project Management—permits the OMC to manage its supply projects, notably those destined to spare parts supply for the ships and combat vehicles foreseen in the PROGEM or its initial appropriations.
- Uniform Distribution—helps the activities developed by the Uniform Distribution Centers (Centro de Distribuição de Uniformes—CDU), Uniform Distribution Stations (Posto de Distribuição de Uniformes—PDU), Mobile Uniform Distribution Unit (Posto-Móvel de Distribuição de Uniformes—PDU-Móvel), and Uniform Order Stations (Posto de Encomenda de Uniformes—PEU).
- Transport Logistics Management System (Sistema de Gerenciamento Logístico de Transporte—SISGLT)—enables the management and tracking of cargo transportation executed in the country and abroad.
- Onboard Material Control System (Sistema de Controle de Material de Bordo—SISBORDO)—allows the management of the movement of materials within the OMC's scope, supporting the management activities related to cataloging, procurement, stock control, and supply.

The biggest challenge for SINGRA is the integration of its subsystems to provide better supply chain management. This criticism is understood by senior naval leaders, and human and financial resources are being employed to seek a solution or at least to mitigate the problems presented.

B. BUDGETARY APPROACH

The Brazilian Constitution establishes three instruments that the executive branch has to elaborate: Multiyear Plan (PPA), Budget Guidelines Law (LDO), and the Annual Budget Law (LOA) (Constitution of the Federative Republic of Brazil, 1988). The National Treasury of Brazil (STN) describes them as follows:

> PPA is the legal instrument of planning for a longer term, establishing priorities and directions for the Government's actions. PPA establishes—for a 4-year-period and by region—The Government's guidelines, goals, and objectives that will guide the use of public and private resources (when resulting from partnerships) for capital expenditure and others associated with it as well as those related to continuous programs.
>
> LDO is the link between PPA and LOA, establishing which programs, among the ones included in PPA, will have priority in the next year's budget. LDO also is responsible for: setting fiscal goals for the Federal Government; disciplining annual budget preparation and execution; determining changes in the legislation along with its budget adequacy; regulating the federal debt and the Federal Government's personnel and social expenses; establishing official financial agencies' investment policies; regulating inspections made by [the] Legislative [branch] and on jobs or services with evidence of serious irregularities; and other general provisions.
>
> LOA estimates revenues and establishes the amount the federal government is authorized to expend during the year. LOA must be compatible with LDO and PPA, and can be amended by additional credits' bills. LOA consists of a Fiscal and Social Security budget, as well as an investment budget for companies in which the Government, directly or indirectly, holds the majority of shares with voting rights. (National Treasury of Brazil, 2020a)

Figure 3 is an example of the current PPA term. In the first year of a four-year presidential mandate, the Congress approves the PPA elaborated by the actual

administration. Therefore, in the last year of each PPA, another administration may conduct the previous one's priorities and goals while preparing its own PPA.

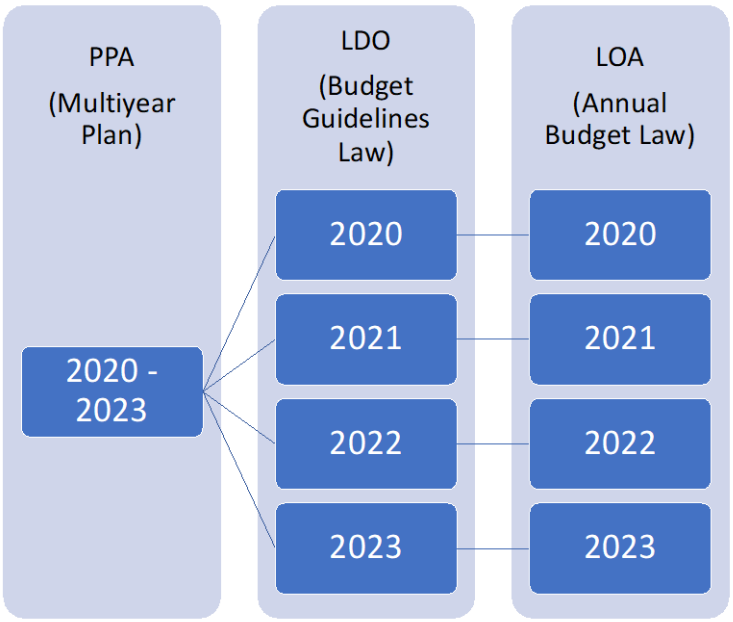

Figure 3. PPA-LDO-LOA relationship.

The defense sector is not a high priority subject in terms of budget allocation in Brazil. Defense expenditures are scarce, which leads to the necessity of effective decision-making processes in the distribution and execution of the available budget. In 2019, the total Brazilian defense budget corresponded to 1.5% of its GDP (SIPRI, 2020).

In comparison to the other nine South American countries in Figure 4, Brazil ranks sixth in defense expenditures based on percentage of GDP. Nevertheless, its GDP of $ 26.9 trillion is 2.7 times greater than that of Colombia, with a $ 10.0 trillion GDP, but ranked first in terms of defense expenditure. Among the five major emerging economies globally, Brazil, Russia, India, China, and South Africa (BRICS), Brazil's percentage of GDP destined for defense is only above South Africa's. For 2021, the estimate is about 1.4% of the GDP. Furthermore, in terms the discretionary expenses only, the Brazilian defense budget proposal corresponds to just about 0.2% of the GDP for 2021.

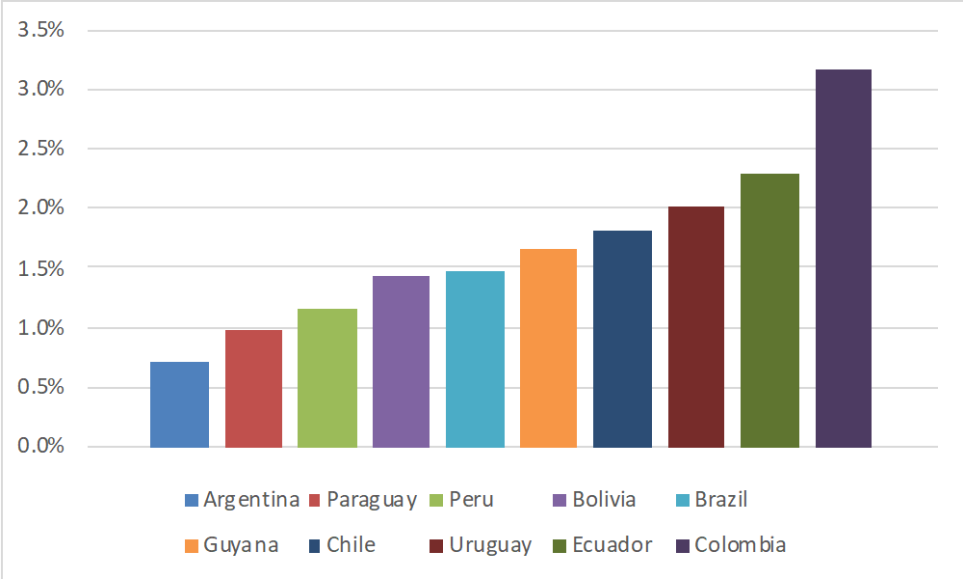

Figure 4. Military expenditures in South America. Adapted from SIPRI (2020).

Since 2014, Brazil has been dealing with a fiscal debt that is constraining its growth. In 2016, the Brazilian Congress approved an amendment to the Constitution, which states that the following year's federal budget is equal to the budget for the current year plus inflation. This 20-year budget cap helps to control public spending. On the other hand, the adjustment has not been sufficient to decrease the mandatory expenses, which is adding more pressure on the discretionary ones, especially federal public investments. For instance, discretionary spending represents 6% of LOA's total expenses for 2020 (IFI, 2020).

The negotiations between the ministries and the Federal Budget Secretary (SOF) for more resources are challenging due to the limited federal budget. Improving planning, execution, monitoring, and evaluation of resources under the BN's responsibility strengthens the arguments when requesting increased funds to optimize the achievement of the branch's interest. At a higher level, the budget formulation starts in May when the executive branch presents the first draft of the proposed budgetary distribution for each of its ministries and ends the first tranche on August 31 when the president sends the draft budget to Congress. After the legislature receives the Bill of Annual Budget Law (PLOA), there is another round of discussions until

December, when they amend and approve it, turning it into the LOA (SOF, 2020). During this period, intensive political negotiations play a critical role within the legislative body.

During budget formulation, the Joint Budget Commission (CMO), composed of members from the Federal Chamber and the Senate, conducts studies and interviews to support possible amendments. During this evaluation, organizations within each ministry use political and technical arguments to bargain more money regarding the available threshold and define their policies for the next fiscal year. Within the BN, technical support is part of DGOM's work, which is the central authority in planning, executing, and guiding the methodology applied to the branch's budgeting.

To help accomplish its mission, DGOM is responsible for developing and managing a system called SIPLAD, which operates all the budgeting transactions within the BN's organizations. SIPLAD has a tight connection with the Integrated System of Federal Government Financial Administration (SIAFI), which is the Brazilian government's central financial management system (STN, 2020b). SIPLAD encodes the federal funding according to an organic identification system of Internal Actions (AI) used within the BN to execute its operations. During budget planning, the AI codes assigned make concrete the BN goals, and the respective details associated with these AI codes correspond to an achievable result (SGM, 2014). The government uses a mechanism similar to AI called Budgetary Action (AO). The objective of AO is to identify the goals of each funding type from a federal perspective.

The BN carries out budgeting activities under the Director Plan System (SPD), for which the functional relations are depicted in Figure 5. Following is a brief description for each organizational element, according to SGM (2014).

- General Management Organization (ODG): conducted by EMA, after delegation by the BN Commander (CM).
- General Councils:

1. Director Plan Council (COPLAN): responsible for advising the CM about the SPD's planning cycle.
2. Navy's Financial and Administrative Council (COFAMAR): responsible for advising the CM about the BN's financial situation during the execution cycle.

- Sectorial Directors (ODS): responsible for coordinating the financial activities within their respective sectors.
- Executive-Secretary (COrM): an office inside SGM responsible for working in close relationship with entities and organizations outside the BN to regulate the federal budget planning and execution.
- Executive Directors (GM): responsible for planning, executing, and controlling the funding for the goals under their jurisdictions.
- Assistant Executive Directors (GM Assistant): responsible for coordinating and guiding the subordinate units in the SPD activities and synthesizing the information for the Executive Directors.
- Executive Managers, Military Organizations (OM): military units responsible for executing the budget.

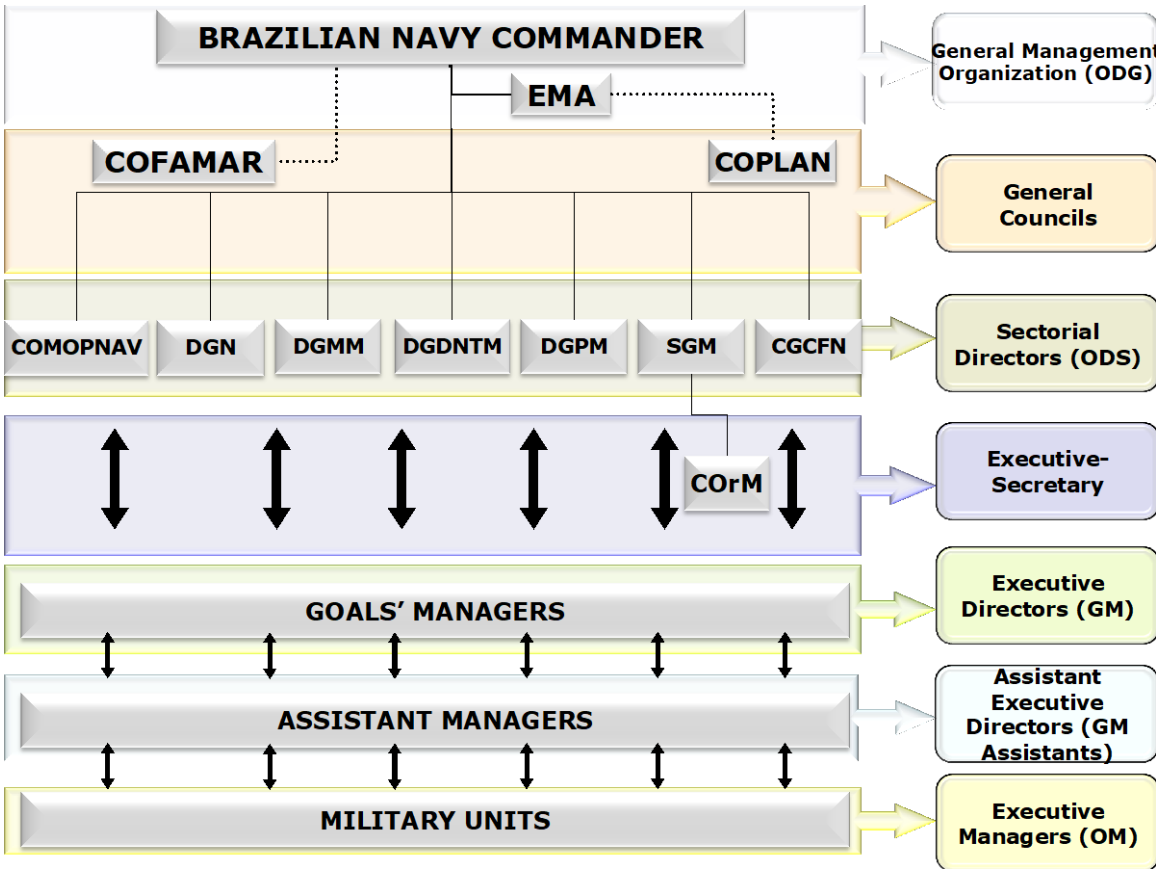

Figure 5. SPD functional hierarchy. Adapted from Secretaria-Geral da Marinha (2014).

Once a fiscal year starts, the SPD also does the short-term planning for the next one, and the AI plays an essential role in its initial steps. As soon as the BN's General Staff discloses its priorities and orientation for the budget formulation, the military units review their needs, such as administrative expenses, operations and maintenance costs, and investments, by submitting their requested subsidies in SIPLAD for each corresponding AI they intend to execute in the following year. The information provided has a financial and physical schedule for each AI and a short text supporting the request.

The Executive Directors gather the information from the AI and analyze it for any inconsistencies to report to the Sectorial Directors. The Assistant Executive Directors help the Executive Directors in this analysis, especially for the units geographically far from the Executive Directors' offices. The Sectorial Directors work as budget

coordinators for their respective fields in the BN, such as naval operations, human resources, and O&M. The Sectorial Directors receive the AI subsidy requests from their respective Executive Directors and Assistant Executive Directors, and prioritize these requests according to available thresholds and submit their proposals to the General Staff. However, at this level, it is possible to identify a significant problem regarding the subsidy evaluation. General activities like utility payments and necessary material expenses usually have the same identification code, respectively, and many military organizations may use that code to work on their planning. For instance, just one AI may have 50 different justifications for 50 unrelated bases. Furthermore, some coordinators have more than 200 distinct AIs to analyze.

This situation could lead to a discretionary prioritization between the AIs, where the Executive Directors focus on the higher values or more significant projects to consider, disregarding the daily activities or small tasks. Moreover, understanding that this could happen, the military units might produce a less detailed background for their requests. In such cases, the requests may be positioned as incremental to the current year's appropriation with minor adjustments for official rates, such as the government's estimated inflation rate for the following year. This is especially likely for those goals that are not linked directly to significant strategic planning. Thus, improving current practices through the clear connection of strategic objectives to the plans in execution may, initially, be interpreted as a reduction in the amount of discretion directors' have in decisions made about resource allocations.

After all the evaluation and prioritization of AIs by the Sectorial Directors, the BN's General Staff ratifies what will receive funding for the following year according to the Sectorial Directors' respective thresholds. Then, DGOM can conduct the next phase of the BN's budget proposal, which is to correlate the BN's budget to the federal budget coding and submit the proposal to the Ministry of Defense, which consolidates each branch's proposals and is responsible for sending them to the SOF, the Brazilian authority for national budget management, for preparation of the federal budget.

Related to the execution cycle, there are two essential concepts: Credit Change (ALTCRED) and Additional Credit (CA). The first one represents the primary step for

any operation with an AI in SIPLAD. ALTCRED is a BN document that registers any changes in the appropriated funding, such as a transfer of credit ownership and modification of the desired goal. SIPLAD daily executes many ALTCREDs to adjust the budget to the actual needs of the military units. The second concept, the CA, is a mechanism provided for in the Constitution to regulate the changes in an AO's amount established by the LOA. When a public organization needs to reallocate its funding, it submits a CA to SOF to make this change and ensure it is adequate to meet the new objective. For instance, if the BN wants to move 15% of its budget for the AO related to ship maintenance to the one assigned for logistics acquisitions, it has to submit a CA with the corresponding justification. According to the LOA, the SOF can modify up to 20% of each AO. Beyond that, the executive branch has to send a CA solicitation to Congress for approval (Tollini, 2009).

In conclusion, the concepts presented in this section are crucial to understanding how the BN handles its budget and how SIPLAD can adopt an ERP system based on blockchain technology that might help the BN to improve the allocation of resources by integrating budget planning and execution activities.

THIS PAGE INTENTIONALLY LEFT BLANK

IV. LOGISTICS APPLICATION ANALYSIS

This chapter explains the possibilities of using blockchain technology in the field of BN logistics. It discusses how the BN can add transparency and increase reliability to its logistics decision support system, SINGRA, using examples of the traceability of goods in blockchain platforms. At the end of this chapter, special attention is given to the impacts that the COVID-19 pandemic has had on the use of this technology and how blockchains can contribute to improving the supply chain response to humanitarian assistance or disaster relief efforts.

A. OVERVIEW

In the last chapter, the BN logistics system was presented, indicating that one key player in supply activity is the BN's Distribution organizations. These organizations encompass primary deposits, regional supply centers, and supplying organizations. Figure 6 shows how those organizations are distributed in the country, and their different colors identify their jurisdictional areas. The inventory is centralized in the Rio de Janeiro state. One reason for that is more than half of the BN personnel work there. Still, as a second motivation, those organizations take care of certain activities at the national level, such as the acquisition, storage, and distribution of ammunition exercised by the Navy Ammunition Center or even the national and international transportation and customs clearance duties carried out by the Navy Distribution and Customs Operations Center (CDAM).

Figure 6. Locations of BN's Distribution organizations in the Brazilian territory

The movement of items in the national territory is carried out with the support of the CDAM. In contrast, the primary warehouses carry out regional transport in the area of Rio de Janeiro. When a primary warehouse item is requested by some unit outside this jurisdiction area, the regional supply centers come on the scene. They carry out the consolidation of requests from their jurisdiction to optimize cargo traffic.

If an item is available at the primary warehouses, the item is promptly packed and delivered to the CDAM for cargo dispatch. Periodic transports are made to regional supply centers to optimize shipments. Exceptions exist, however, such as the urgent need for a part to repair a damaged ship. That item would use a single expedited service, mainly air shipping. If the item does not exist in stock, its acquisition is arranged with the procedures previously mentioned.

The management of information between BN's units occurs through the SINGRA system; however, there is a lack of online follow-up regarding its data. It is not a fully

integrated system, which needs improvement. The use of a blockchain could contribute to such integration, enabling the SINGRA to make a singular technological advance and provide more precise information, in cooperation with the naval force's logistics decision support.

Currently, much of the information in SINGRA is entered manually by an operator. Thus, regardless of the volume of changes, there is a lack of data synchronization. Therefore, this situation affects not only decision making but the level of readiness of the force. To correct potentially incorrect subsidies, a process redesign is necessary, which could impact the speed of SINGRA's response time.

B. TRACEABILITY IN SUPPORT OF MILITARY OPERATIONS

As of November 2020, the following joint operations are underway: AMAPA—fighting the problems created by the lack of electricity in one of the country's states; AGATA—fighting cross-border environmental crimes; GREEN BRAZIL 2—fighting and repressing ecological crimes in the Legal Amazon; COVID-19—mitigating the consequences of the outbreak of the novel Coronavirus; and ELECTIONS 2020—providing, in the electoral zones and polling stations, in partnership with public security agencies, peacekeeping so that citizens can exercise their right to vote. Those operations are being carried out practically throughout the entire country. It is important to have a reliable organizational system that contributes significantly to supporting logistical decisions when the Brazilian Armed Forces are employed in several operations.

Those operations involve a great movement of personnel and material. Some military material classes demand more rigorous control because they have a high added value and are coveted in the parallel market. The following can be mentioned as items that need special monitoring: petroleum, oil, lubricants (class III), ammunition (class V), medical items and pharmaceuticals (class VIII), and repair parts (class IX). As mentioned earlier, the SISGLT is the BN's subsystem responsible for cargo tracking in the national territory and overseas.

Thinking about the possibility of blockchain use, it is possible to envision the SISGLT as one of the subsystems that will see greatest improvement. Having a real-time

follow-up capability can help units to have the on-time status of their cargo. That way, if an operation starts suddenly in response to humanitarian assistance or disaster relief event, it would be easier to track and send new movement orders to those loads, contributing to greater speed, efficiency, and effectiveness in the use of resources.

Beyond the simple tracking of items, the platform would be able to analyze different scenarios and propose the use of resources in the most advantageous way possible. Thus, summarizing the current situation with five joint operations, an optimization of the means employed could be proposed considering distances and the mode available for transporting items, load preparation time, and other factors.

Many solutions have proved adequate for the purposes for which they are proposed. In the case of food traceability, U.S. giant Walmart innovated and anticipated its competitors by creating the Walmart Food Traceability Initiative. That initiative allowed the company to track the fresh farm goods from its suppliers, increasing the transparency in the system. Adaptations for employment in the military will not be long in coming.

C. AVIATION SUPPLY CHAIN—MAINTENANCE AND PROCUREMENT

The Naval Air Systems Command (NAVAIR) has been conducting several studies to implement a blockchain platform to support its aircrafts' maintenance. The desire in optimizing the aviation supply chain is to minimize the human factor, which is largely responsible for mishaps related to aviation safety.

The authors had the opportunity to participate in an IBM seminar where the company presented an overview of one NAVAIR project. NAVAIR's main goal on that project is to have all aircraft maintenance events on the blockchain platform so that it can automate the coordination, reconciliation, distribution, and validation of data components with stakeholders and systems.

It should be noted that a system capable of managing the ordering, tracking, and status of F-18 spares is already in use by NAVAIR. The SIMBA Chain blockchain platform allows making automatic payments to suppliers, optimizing the filling out of

forms, and avoiding the typing errors that occur when manually entering data in the system. That program is partnered with Indiana Technology and Manufacturing Companies.

In comparison, the subsystems of BN's SINGRA that could be improved with these proposed changes would be maintenance—called project management—and procurement. The first of these could include preventive, scheduled maintenance of naval ships, submarines, and vessels. Automation of this component would be of great value since it would reduce personnel workload in administrative activities—data entry and corrections, among others—bringing more efficiency to BN's supply chain management and maintenance processes, without compromising the safety of the personnel and equipment.

D. HEALTH SUPPLY CHAIN DURING COVID-19 PANDEMIC IN THE USA

At a time when there was the need for better coordination, blockchain technology—which was only in the testing phase—came to mind. The proposed use of this technology in the health supply chain is very similar to that proposed in this study support military operations mentioned earlier. In each case, the goal is to get a determined item to a particular location quickly. Improving the traceability of medical supplies could help improve management of the overall health supply chain.

"The virus has revealed the weaknesses in our supply chains, our inability to deploy resources where they are most needed to address the pandemic, and difficulties in capturing and sharing the data needed to make rapid decisions in managing it" (van Hoek & Lacity, 2020). That impacting statement is to explain how the pandemic pushed blockchain forward.

In 2020, during the early stage of the COVID-19 pandemic, there was a global race to acquire ventilators. To meet the demand in the United States, some companies proposed converting part of their production line to produce ventilators, while others created solutions to convert equipment. A startup called Rapid Medical Parts made use of blockchain technology to print parts so that it could convert a large stock of sleep apnea machines into ventilators.

The combination of additive manufacturing with blockchain technology allowed the parts' design and printing instructions to be assured, avoiding any adulteration, keeping the project safe and tamper-proof. The result was spectacular. Within 12 days, the idea had already generated a contract for ventilators with the Pentagon.

Making use of the immutability of the ledger, one of the features of the blockchain, opens a range of possibilities for blockchain technology in controlled environments, such as in the health supply and the military logistics fields.

E. POTENTIAL USES FOR BLOCKCHAIN TECHNOLOGY IN THE BRAZILIAN NAVY

When presenting the overview of the SINGRA system and its capabilities, the authors highlighted one of the most significant drawbacks it presents is lack of subsystems integration for real-time data monitoring. Most data is manually entered, and SINGRA does not have any artificial intelligence to deal with the magnitude of the data via various subsystems. Blockchain technology would help enable more efficient data collection and allow for real-time data analytics for efficient and accurate decision making from the data collected. These capabilities would improve the most common processes, such as acquisition, maintenance, transport, and cataloging, among others.

Automating the procurement process can be very advantageous since most of the burden is related to filling out forms, issuing certificates, verifying invoices, and making payments. With a system able to manage this process's main steps, there would be a reduction in workload, permitting the allocation of personnel to other relevant activities.

In terms of the maintenance of the BN's ships, vessels, and aircraft, it is essential to have a system capable of managing the assets' life cycles. That is directly related to the maintenance of equipment vital to the BN systems. Blockchains associated with data analytics can feed a system capable of managing the needs of predictive maintenance, generating the requirements of items to fulfill these routines, and—being connected to the acquisition process—initiating the acquisition of the necessary parts that may not be in stock.

Critical and high-value loads are always sensitive. Transporting such cargoes requires many precautions to avoid incidents. Controlling temperature, assuring the route's safety, enabling real-time tracking, all those capabilities should help BN's logistics and enhance the transport system.

Lastly, cataloging is always hard work. Splitting vital systems into single parts and entering those data into the system is time consuming. If SINGRA can incorporate 21st-century solutions, BN's suppliers should provide the associated data regarding their equipment and parts, helping to insert it in the updated system.

Updating those mentioned subsystems, as well as others not discussed in this study, will add value to the Brazilian Navy since most of the logistics process resides in those activities—procurement, maintenance, transport, and cataloging. Having a modern decision support system can also contribute significantly to the efficient use of public resources, elevating the force's reputation. Moreover, a technology capable of increasing transparency and reliability can make BN's supply chain a reference for other branches of service, hence contributing to the Brazilian Navy's reputation for technological innovation and serving as a point of pride for the federal government.

THIS PAGE INTENTIONALLY LEFT BLANK

V. BUDGETARY SYSTEM ANALYSIS

This chapter discusses how the Director Plan System (Sistema do Plano Diretor—SIPLAD) can benefit from a logistics blockchain platform and how the BN can improve its budget planning and allocation, by combining information from both systems. First, we present the current processes' weaknesses by examining a specific Budgetary Action (Ação Orçamentária—AO) from the BN's budget. Second, we analyze how SIPLAD might fit the new logistics system as a tool for better decision-making processes. Finally, our research presents the potential outcomes from the changes suggested. All data for this chapter is available from governmental websites for free public consultation.

A. CASE OVERVIEW

To illustrate the BN's main issues, we provide an example from the AO registered under the code 20XN—Navy Readiness. This AO sponsors the preparation and maintenance of the BN resources through actions that ensure their operational capabilities. These funds support activities such as planning, training, doctrine development, logistics, and mobilization to foresee and provide materials and necessary services to keep the ships, aircraft, and the Brazilian Marine Corps resources at efficient conditions. AO 20XN is crucial for the BN and, as such, represented more than one-third of the BN's discretionary budget in 2019.

To respect the Brazilian Constitutional principle of legality, the annual budget law (Lei Orçamentária Annual—LOA) establishes some rules for the exchange of funding between public organizations within the government. In this case study, we discuss one that regulates the increase or reduction of AO funds, which has been valid under the same conditions since 2016. Considering the amounts stated in the LOA, each AO can change up to 20% without Congress's approval. Below this limit, an ordinance from the Ministry of the Economy authorizes the change after an evaluation and validation by the Federal Budget Secretary (Secretaria de Orçamento Federal—SOF).

The time frame during which SOF allows organizations to include their needs in the Planning and Budget Integrated System (Sistema Integrado de Planejamento e

Orçamento—SIOP) is, on average, one week every other month. Thus, it is fair to consider that SOF authorizes the budget changes for the public administration every two months during controlled fiscal and economic situations. Yet, there is no official deadline for SOF to analyze and for the Ministry of the Economy to approve the solicitations.

For amendments that need congressional validation, the requests have the same requirements until the Ministry of the Economy sends the bill to the legislative branch. In this scenario, the approvals usually occur at the end of the second quarter and during the fourth quarter. In both situations, the funds involved stay blocked for use. Once their request is posted, the organizations have to wait a long time to execute their budget.

B. AO 20XN MODIFICATIONS

Every funding change starts with the previously described system procedure called ALTCRED in SIPLAD, regardless of the reason for the requested change. The military units insert their needs in the system, offering their current funds as a counterpart to what they actually need. Subsequently, DGOM tries to match everyone's needs to the available funds. When sufficient funds are not available to satisfy a requested change, DGOM holds the ALTCRED and the funds available, until the BN´s General Staff allows for the completion of the processes.

Additionally, BN's General Staff conducts a review of the BN priorities for budget execution resulting from changes in critical contracts, for instance, or new projects and opportunities. When finished, it determines which sectors will make the funding available for the exchange and order them to include the respective ALTCRED in SIPLAD. As the SOF window for solicitations on SIOP gets closer, DGOM compiles all the information in SIPLAD and submits it on SIOP as a CA, distinguishing it by the legal approval document.

Figure 7 presents the percentage of change in the LOA's amount for AO 20XN from 2016 to 2019, including each legal instrument's size within the individual difference. It is apparent that, in most years, the BN needed congressional approval to execute almost half of the AO 20XN modifications. Most of those were because the other

AOs offered as counterparts exceeded their limit of 20% in modifications. Thus, not only the plans for AO 20XN changed in those years, but many plans in other sectors also did.

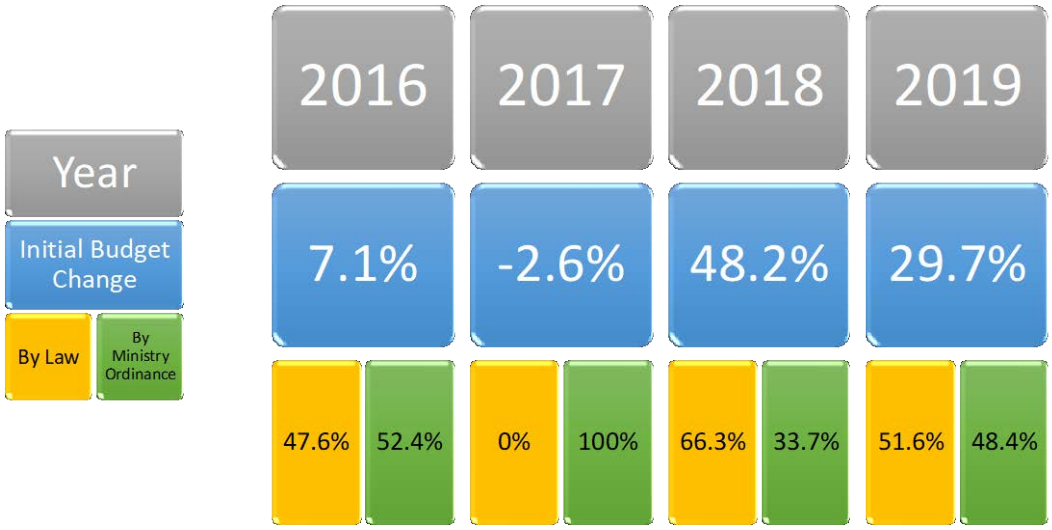

Figure 7. AO 20XN modification per year and legal instrument. Adapted from SIOP (2020).

Another issue related to the numerous laws needed to adjust the budget is the time it takes to make the money available. Congress's schedule is busy, and giving priority to budget bills depends on intensive negotiations between the executive and legislative branches. Having the funds blocked in the meantime could harm planning as it delays programs' schedules and creates pressure on the organizations' acquisition activities in the public administration. Also, it is reasonable to imagine that the BN priorities could change in the period.

The biggest weakness in the processes of adjusting the budget might be within the BN itself. Although the BN cannot influence how external agents deal with that situation, it can improve its one-year planning. The justifications provided by military units and refined by the Executive Directors usually consider only short-term expenditure series adjusted for inflation or the estimated currency exchange rate for the following year. Especially for AO 20XN, which has broad application in the BN, the justifications should have consistent arguments to demonstrate their importance for the BN's readiness.

We can also observe the impact of weak budget planning, looking at the Budgetary Plan (PO) variation from what the BN planned initially for AO 20XN. The PO is a budgetary identification method of a managerial nature (not included in the LOA), whose purpose is to allow greater detail for the AO. Every AO may have some PO that indicates specific areas that will receive funds to contribute to achieving the primary AO objectives. To request an exchange of funding between POs, the BN should also submit a solicitation on SIOP. Nevertheless, in this case, SOF can process the changes internally and quickly. To illustrate, Figure 8 presents how the PO of AO 20XN varied compared to the initial authorized amount from 2016 to 2019.

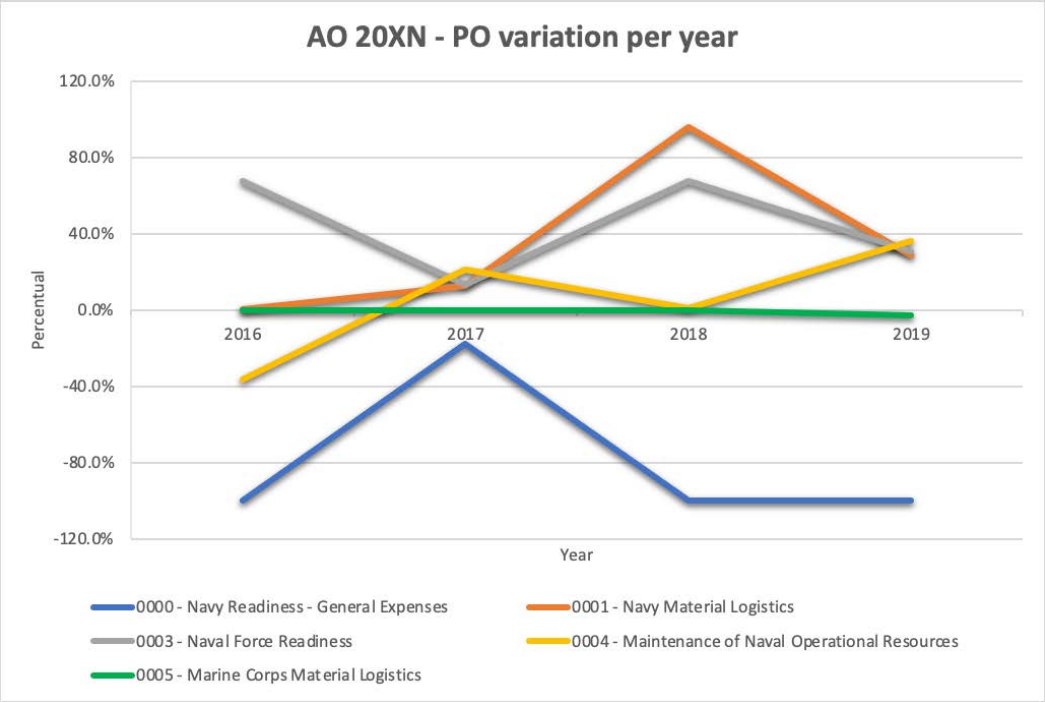

Figure 8. Changes within AO 20XN. Adapted from SIOP (2020).

We do not consider the PO 0000 and 0005 in this research because the relevance of their total amount is relatively low in comparison to the whole AO. Yet, we can observe considerable numbers of changes in the PO that may indicate some distortions in the planning. The reasons for this may vary and deserve a further in-depth study.

C. IMPROVING BUDGET PLANNING DECISION-MAKING PROCESSES IN THE BN

Transparent and reliable information is the basis of a robust system. In this context, the innovation suggested for SINGRA in this research intends to fill the transparency and reliability gaps in the BN's logistics field. SIPLAD is still undergoing improvements to its tools with new updates and features, trying to integrate its subsystems. Nonetheless, it is a stable and useful system for BN. Although it does not have the advantages of being built on a blockchain platform, merging the budget system with SINGRA might be a considerable upgrade for the BN. The idea, in this case, is to be a pilot of an ERP system for the BN in the future.

In the case of the AO 20XN, the PO 0001−Naval Material Logistics and PO 0004−Maintenance of Naval Operation Resources have a close relationship with supply chain operations. The first one characterizes expenses related to technical and managerial activities for inventory control, acquisitions, storage, and cargo traffic, for instance.

There are some benefits of and implications for the use of blockchain technology in BN information systems. First, if SINGRA operates on a blockchain platform, all the information from these operations will be available on time for the Executive Directors to work on the following year's planning. Therefore, with control of the whole supply chain, it will be much easier to know how many of a specific spare part the warehouse has in stock, evaluate the reorder point and lead time, or even know how well the shipping company is fulfilling the contract's expectations. In sum, it might be useful to work with this information when predicting the budget for the next year.

Second, integration of SIPLAD in this system would be decisive for both systems. In the budget execution phase, smart contracts might play an essential role as they automatically perform a predefined instruction. After finishing a delivery, SINGRA might submit an ALTCRED on SIPLAD asking for funds to pay the shipping company, or maybe it could track all the expenses of a specific AI and their status. During budget planning, the combined platform can be used to produce detailed reports on the exact usage of funds and resources and even to predict certain items' behavior to estimate their future necessity.

In the case of PO 0004, for example, it considers all expenses associated with preventive and corrective maintenance of the ships and aircraft, as well as the Marines' resources across the country. When dealing with ships and aircraft repairs, spare parts' replacement should be faster with a system that keeps the managers updated regarding the stock rotation.

The BN has nine Naval District Commands, which are responsible for specific regions of Brazil. They have missions like humanitarian help for the native people in the Amazon forest and protecting and patrolling the borders' rivers. Supporting these District Commands is challenging, especially for specialized maintenance, since the naval bases and private shipyards face logistics complexities related to the distance from principal commercial and industrial centers. Moreover, the BN has to provide material and personnel to conduct the ships' services whenever needed. The pilot ERP might decrease the lead time by recognizing these needs in advance and starting a new acquisition or transferring equipment on time. Furthermore, it would be easy to identify the expenses in detail and keep a reliable record of each repair for further analysis.

Therefore, the examples just mentioned illustrate how extreme changes in AO 20XN funding could be avoided during the year. When the correct data is available for research, it is easier to predict new operations, acquisitions, and repairs. The ERP pilot will help managers plan their budget and focus on the results. Reliable and transparent data is robust in supporting the Brazilian Navy's decision-making processes, especially when dealing with scarce funds.

One advanced application of the new platform relates to utility expenses. The PO 0004 has a specific AI that considers the costs for the essential operation of the military units subordinate to each District Command. These expenses include energy, water supply, and trash collecting. Using the funds appropriated as a model, the new platform could track all these expenses and combine them with external components that contribute to changing each region's behavior of consumption.

Temperature, air humidity, number of service members, and size of the units, for instance, might compose a module that helps to predict the consumption of these

services. Financial information like energy companies' rates, state fees, and taxes would also belong to this module. Therefore, the prediction of these expenses requires physical and economic registries from the military units and their location that, combined with historical data series, could belong to a machine learning algorithm that improves the planning processes. A smart contract within the new ERP system might calculate a pattern that could be useful for this situation.

If accurate, this estimate will reduce the Executive Directors' work on this particular AI when planning for the following year so that they just confirm the estimate given by the system. The military organizations would only have to enter with the information to ask for funds to pay the bills, as they already do. This procedure will save time for the Executive Directors and end-line bases. There will be no need for every unit to justify this AI funding or for further analysis by the Executive Directors.

D. SYSTEMS INTERACTION

Integrating SIPLAD and SINGRA as the first step for a future ERP system for the BN is challenging. Yet, it is also an opportunity because it represents a much-needed upgrade to the logistics platform in combination with stable budgetary data. Ideally, all systems should perform under the same infrastructure, in this case, the blockchain technology. The technology is not widely known in Brazil, however, except for a very few private and public sector initiatives.

Therefore, the communication between SIPLAD and SINGRA via Application Programming Interfaces (API) could present some weaknesses since the budgetary data may have intrinsic vulnerabilities related to its programming language. Also, SIPLAD must always communicate with the government's budgetary systems, which might be an issue since the federal fiscal systems are not able to integrate and validate the information from a blockchain platform yet.

If the BN's path to start an ERP pilot is challenging, it will also be challenging for the federal government. Yet, there are pioneer programs within the public sector that use blockchain technology, like the one undertaken by the Brazilian Central Bank (BCB). The BCB created a shared data platform for governmental agencies to facilitate

authorization and registration processes required by financial institutions (Brazilian Central Bank, 2020). There is vast room for improving public services using blockchains, but the political incentive to support research and development is lacking.

As blockchain technology matures in Brazil, it could lead to the integration of organizational systems within the public administration. In this context, the most significant barrier is that blockchain platforms do not interact with one another. Thus, it is crucial that the government implements new capabilities in its systems to allow the development and integration of other platforms using this technology. Without this step, the benefits of merging SINGRA and SIPLAD in an ERP system might decrease.

Blockchain platforms are useful for upgrading the decision-making processes by introducing transparency and reliability to the environment in which they operate. Nevertheless, we are not proposing a comprehensive and one-size-fits-all system for the whole government using this technology. Therefore, public administration should consider exploring and encouraging the use of other integrated and decentralized systems that reduce government expenses by facilitating transactions and reducing human resource allocation for programmable processes.

VI. CONCLUSION

Blockchain technology can be a useful development for the improvement of business transactions in many sectors of public and private environments. Moreover, it can improve the efficiency of management operations and provide accurate information for the top leaders of the BN. Consequently, the BN will be able to use its resources better, guaranteeing the readiness needed to accomplish its constitutional missions. Using the case of this research, developing a private network to replace the existing logistics system in the BN could benefit all of its supply chain management. Additionally, merging the new SINGRA with SIPLAD in a pilot program on an ERP platform would be an opportunity for a full upgrade of the decision-making processes related to the allocation of funds. These two applications of blockchain technology in the BN would contribute to the improved transparency and reliability of its information systems.

A. SUMMARY OF BENEFITS AND CHALLENGES

In the logistics field, the biggest challenge is integrating all the relevant subsystems and using data more efficiently. As we know, the blockchain will not solve a previous system problem. It will help to enhance capabilities but cannot fix inaccurate or defective systems. Thus, the first step in undertaking the pilot proposed in this thesis is to recreate a system architecture in which the subsystems could transact with each other and permit artificial intelligence to conduct operations, enabling comprehensive collaboration to construct a smarter application.

Among the benefits of such an upgrade would be greater transparency for BN's supply chain management as users would be able to view all records using the blockchain. It would be possible to monitor the data from its creation in the system. Also, there would be increased data reliability resulting from queries being processed instantly, reducing the need for human intervention in the process and optimizing data management. Consequently, a modern integrated system capable of managing multi-party transactions that can support the decision-making process should be strategically

beneficial as it will enable the BN not only to realize savings in time and dollars, but to optimize warfighter support.

Regarding the budgetary aspect, the gains from participating in an ERP system can translate to better use of BN resources to guarantee its readiness. Transparency is a core characteristic of blockchain technology. Thus, the proposed ERP solution that incorporates this technology will be decisive in tracking a specific project's expenses and identifying not only the actual allocation of funds but those needed for the future. That visibility will help decision makers and planners evaluate changes during the project's life cycle and provide a historical record of how it has been managed. Moreover, the reliability of the data is crucial for this analysis, and blockchain provides that as well. One concern related to ERP pilot development should be ensuring that only correct users are allowed to access the data in the system, especially for classified missions and programs. In sum, establishing the new platform will make the BN an expert point of reference in the public administration.

One of the main benefits BN could realize in its budget planning is the automation of cost estimates for recurring expenses such as utility costs. These costs include those for power and water supply. Every military unit has to work on these numbers and justify their needs. The lack of standardization in the organizations' calculations for such expenses, as well as and the number of military organizations for which the Executive Directors must analyze these expenses, leads to a general prediction for the whole sector. Therefore, the system's detailed and reliable information, combined with machine learning algorithms, will improve these predictions, which can translate to saving the relevant workforce time and the BN funds.

The quality of the data will allow the BN to improve its decision-making processes for the allocation of funds. As presented in this research, the BN's largest source of funds has significant problems in executing short-term planning. Changes in objectives, new program opportunities, and faulty estimates are some of the factors contributing to these problems. It is essential to mention here that most of the budget execution phase changes occur between AOs inside the BN. Thus, for each increase in a certain AO, there is another that decreases. Sometimes, the change can occur between

AOs managed by different sectors in the BN, which requires more negotiations among the Executive Directors. Thus, attending to one sector might harm the planning of others. The new ERP platform could be a powerful tool to help reduce problems with funding predictions.

Integrating information systems through a blockchain platform is beneficial for the BN as this solution can reduce costs, enhance the data quality, and increase managerial capabilities. Nevertheless, the BN will face challenges in the implementation because blockchain technology is still relatively immature within both private and public sectors in Brazil. In the private sector, companies have often struggled to join a partnership and invest their money in a feature that has not proven its cost-benefit worth. In the second case, governments might not prioritize the development of this kind of initiative due to scarce resources, even though blockchain solutions are valuable for society. The lack of a corresponding advance, especially in governmental systems, might harm the BN ERP pilot's advantages.

B. FUTURE RESEARCH

Blockchain technology has the potential for a wide range of applications within the BN. Based on our research and proposed pilot, we conclude it is first important to gain an understanding of the reasons for many changes within the Budgetary Actions (Ações Orçamentárias—AO) and Budgetary Plans (Planos Orçamentários—PO). The BN must also incentivize a pilot that develops a blockchain platform with useful machine learning algorithms to predict budget spending behaviors and suggest courses of action for the top-level leaders within the BN. This case study may also be expanded to integrate logistics and the performance of naval operations.

Considering the organic systems, we identified two crucial areas in the BN that deserve an in-depth study of how to use blockchain technology to better serve the sailors. We suggest that future researches focus on the architecture implementation phase. First, the military personnel system is the one in which the advantages would be significant. The security and reliability of blockchain platforms could provide a network where the users update their personal information. The personal data would be available for the

units according to each corresponding level of access. Thus, activities related to registration on the bases and military personnel transfers would be less arduous. Also, the integration of the military personnel system with the payment system offers another considerable opportunity, allowing for the update of paychecks automatically, for example, to reflect changes in the personal situation of an individual sailor.

Second, observing the practices developed during the recent pandemic period, the authors recommend exploring the subsequent benefits of blockchain functionalities related to the health supply chain. It is essential not to limit such a study to the movement of items and explore the adaptation of equipment to the example of the ventilators created. The possible benefits go beyond cost reductions in item transportation and efficient inventory management. We can cite the reduction of failures and fraud, the increased speed in identifying problems, and the rise in confidence among the entities involved.

LIST OF REFERENCES

Angert, S. (2019). *Blockchain technology implementation in the U.S. customs environment* [Master's thesis, Naval Postgraduate School]. NPS Archive: Calhoun. https://calhoun.nps.edu/handle/10945/63473

Banda, A., Hamilton, M., Lowry, E., & Widdifield J. (2020). *The Founder's Handbook*. https://www.ibm.com/downloads/cas/GZPPMWM5

Banerjee, A. (2018). Blockchain technology: Supply chain insights from ERP. In *Advances in Computers* (Vol. 111, pp. 69–98). Elsevier. https://doi.org/10.1016/bs.adcom.2018.03.007

Brazilian Central Bank (BCB). (2020). *Blockchain platform for authorizations in the financial system is released*. https://www.bcb.gov.br/detalhenoticia/431/noticia

Bezerra, M. (2015). *Análise da atual estrutura logística da Marinha do Brasil, relacionada aos sobressalentes, frente aos desafios decorrentes da incorporação dos novos submarinos [Current Brazilian Navy logistics structure analysis, related to spare parts, facing the challenges arising from the incorporation of new submarines]*. Pontifícia Universidade Católica do Rio de Janeiro Brazil. https://www.maxwell.vrac.puc-rio.br/25744/25744.PDF

Blockchain Technology. (2016, November 21). *Advantages & disadvantages of blockchain technology*. https://blockchaintechnologycom.wordpress.com/2016/11/21/advantages-disadvantages/

Castellanos, J. A. F., Coll-Mayor, D. & Notholt, J. A. (2017). Cryptocurrency as guarantees of origin: Simulating a green certificate market with the Ethereum Blockchain. *2017 IEEE International Conference on Smart Energy Grid Engineering (SEGE)*, pp. 367–372. https://doi.org/10.1109/SEGE.2017.8052827

Chen, Y. & Bellavitis, C. (2019). Blockchain disruption and decentralized finance: The rise of decentralized business models. *Journal of Business Venturing Insights, 13*, e00151. https://doi.org/10.1016/j.jbvi.2019.e00151

Constitution of the Federative Republic of Brazil. (1988). http://www.planalto.gov.br/ccivil_03/constituicao/constituicaocompilado.htm

del Castillo, M. (2018, August 9). IBM-Maersk blockchain platform adds 92 clients as part of global launch. *Forbes.* https://www.forbes.com/sites/michaeldelcastillo/2018/08/09/ibm-maersk-blockchain-platform-adds-92-clients-as-part-of-global-launch-1/#77ae9a6968a4

Doskey, T., & Johnson, S. (2018). *Blockchain technology in the Department of Defense*. [Master's thesis, Naval Postgraduate School]. NPS Archive: Calhoun. https://calhoun.nps.edu/handle/10945/61355

Eljazzar, M. M., Amr, M. A., Kassem, S. S., & Ezzat, M. (2019, January 23). *Merging supply chain and blockchain technologies*. ArXiv. http://arxiv.org/abs/1804.04149v2

Fabiano, N. (2017). Internet of Things and blockchain: Legal issues and privacy. The challenge for a privacy standard. *IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData)*, pp. 727–734. https://doi.org/10.1109/iThings-GreenCom-CPSCom-SmartData.2017.112

Federal Budget Secretary (SOF). (2020). *Technical budgetary manual (MTO)—2021*. https://www1.siop.planejamento.gov.br/mto/doku.php/mto2021

Golosova, J., & Romanovs, A. (2018). The advantages and disadvantages of the blockchain technology. *2018 IEEE 6th Workshop on Advances in Information, Electronic and Electrical Engineering (AIEEE)*, pp. 1–6. https://doi.org/10.1109/AIEEE.2018.8592253

Hackius, N., & Petersen, M. (2017). *Blockchain in logistics and supply chain: Trick or treat?* https://doi.org/10.15480/882.1444

IBM. (2018). *Introducing Hyperledger fabric*. https://www.ibm.com/blockchain/se-sv/hyperledger.html

ICT Monitor Worldwide. (2019). *Customs broker Livingston joins IBM/Maersk TradeLens blockchain*. http://search.proquest.com/docview/2204527824/

Illinois Blockchain Initiative. (2017). *Illinois partners with Evernym to launch birth registration pilot*. https://illinoisblockchain.tech/illinois-partners-with-evernym-to-launch-birth-registration-pilot-f2668664f67c

Independent Fiscal Institution (IFI). (2020). *Fiscal monitoring report*. https://www2.senado.leg.br/bdsf/bitstream/handle/id/567343/RAF36_JAN2020_Orcamento.pdf

Jayachandran, P. (2017). *The difference between public and private blockchain*. IBM. https://www.ibm.com/blogs/blockchain/2017/05/the-difference-between-public-and-private-blockchain/

Kamath, R. (2018). Food traceability on Blockchain: Walmart's pork and mango pilots with IBM. *The Journal of the British Blockchain Association*, *1*(1), 1–12. https://doi.org/10.31585/jbba-1-1-(10)2018

Koch, C., Slater, D., & Baatz, E. (1999). The ABCs of ERP. *CIO Magazine*, *22*. http://wikifab.dimf.etsii.upm.es/wikifab/images/d/da/The_ABCs_of_ERP.pdf

Kubáč, L. (2018). RFID technology and blockchain in supply chain. *Transactions of the VŠB - Technical University of Ostrava, Mechanical Series, 64*(1), 35–44. https://doi.org/10.22223/tr.2018-1/2042

Mattes, R., & Moreno, A. (2017). *Social and political trust in developing countries* (E. M. Uslaner, Ed.; vol. 1). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190274801.013.10

McLean, S., & Deane-Johns, S. (2016). Demystifying blockchain and distributed ledger technology - Hype or hero? *Computer Law Review International, 17*(4), 97–102. https://doi.org/10.9785/cri-2016-0402

National Treasury of Brazil (STN). (2020a). *About fiscal planning*. https://www.gov.br/tesouronacional/en/fiscal-policy/about-fiscal-planning

National Treasury of Brazil (STN). (2020b). *What is SIAFI?*. https://www.gov.br/tesouronacional/en/siafi/what-is-siafi

Nuce, M., Yiannas, F., Pradhan, M., & Zabrocki, D. (2017). *Blockchain technology* [Webinar]. PWS Webinar Series. https://www.pma.com/content/articles/2017/09/webinar-blockchain-technology

Perboli, G., Musso, S., & Rosano, M. (2018). Blockchain in logistics and supply chain: A lean approach for designing real-world use cases. *IEEE Access, 6*, 62018–62028. https://doi.org/10.1109/ACCESS.2018.2875782

Petrisin, B., & Johnson, G. (2019). *Application of blockchain technology on enlisted detailing process*. [Master's thesis, Naval Postgraduate School]. NPS Archive: Calhoun. https://calhoun.nps.edu/handle/10945/62756

Planning and Budget Integrated System - SIOP. (2020). *Federal Budget Dashboard - Free consultation*. https://www1.siop.planejamento.gov.br/QvAJAXZfc/opendoc.htm?document=IAS%2FExecucao_Orcamentaria.qvw&host=QVS%40pqlk04&anonymous=true&sheet=SH06

Ram, J., Corkindale, D., & Wu, M.-L. (2013). Implementation critical success factors (CSFs) for ERP: Do they contribute to implementation success and post-implementation performance? *International Journal of Production Economics, 144*(1), 157–174. https://doi.org/10.1016/j.ijpe.2013.01.032

Rodrigues, B., Bocek, T., & Stiller, B. (2018). The use of blockchains: Application-driven analysis of applicability. In *Advances in Computers* (Vol. 111, pp. 163–198). Elsevier. https://doi.org/10.1016/bs.adcom.2018.03.011

Sayeed, S., & Marco-Gisbert, H. (2019). Assessing blockchain consensus and security mechanisms against the 51% attack. *Applied Sciences, 9*(9), 1788. https://doi.org/10.3390/app9091788

Schupmann, C. (2017). Blockchain as an emerging cross-border payments infrastructure. *IILJ Emerging Scholars Paper. 28*.

Secretaria-Geral da Marinha. (2009). *Normas para a execução do Abastecimento [Supply execution rules]*. Marinha do Brasil.

Secretaria-Geral da Marinha. (2014). *Normas para o Plano Diretor* [*Director plan management rules]* (1st review). Marinha do Brasil.

Stein, T. (1999, May 24). ROI: Making ERP add up. *Information Week, 735*, 59–68.

Stockholm International Peace Research Institute (SIPRI). (2020). *Military expenditure by country as a percentage of Gross Domestic Product, 1988–2019*. SIPRI. https://www.sipri.org/sites/default/files/Data for all countries from 1988–2019 as a share of GDP.pdf

Swan, M. (2017). Anticipating the economic benefits of blockchain. *Technology Innovation Management Review, 7*(10), 6–13. https://doi.org/10.22215/timreview/1109

TechBlog. (2018). *Part 2: How blockchain works.* http://shyamtechno.blogspot.com/2018/05/part-2-how-blockchain-works.html

Tollini, H. (2009). Reforming the budget formulation process in the Brazilian congress. *OECD Journal on Budgeting, 9*(1), 1–29. https://doi.org/10.1787/budget-v9-art1-en

Underwood, S. (2016). Blockchain beyond bitcoin. *Communications of the ACM, 59*(11), 15–17. https://doi.org/10.1145/2994581

van Hoek, R. & Lacity, M. (2020) *How the pandemic is pushing blockchain forward.* https://hbr.org/2020/04/how-the-pandemic-is-pushing-blockchain-forward

Veit, B. (2005). Department of the Navy converged Enterprise Resource Planning program. *Armed Forces Comptroller, 50*(4), 11–15. https://www.secnav.navy.mil/fmc/Documents/Article_Veit.pdf

Verhoeven, P., Sinn, F., & Herden, T. (2018). Examples from blockchain implementations in logistics and supply chain management: Exploring the mindful use of a new technology. *Logistics 2018*, 2(3), 20. https://doi.org/10.3390/logistics2030020

Walmart (2018). *Walmart food traceability letter*. https://corporate.walmart.com/media-library/document/leafy-greens-food-safety-traceability-requirements-supplier-letter/_proxyDocument?id=00000166-0c8a-d96e-a3ff-8ffe51e30001

Wüst, K., & Gervais, A. (2018). Do you need a blockchain? *2018 Crypto Valley Conference on Blockchain Technology (CVCBT)*, 45–54. https://doi.org/10.1109/CVCBT.2018.00011

Zheng, Z., Xie, S., Dai, H. N., Chen, X., & Wang, H. (2018). Blockchain challenges and opportunities: A survey. *International Journal of Web and Grid Services*, *14*(4), 352−375. https://doi.org/10.1504/IJWGS.2018.095647

THIS PAGE INTENTIONALLY LEFT BLANK

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California