Audit App: an effective tool for government procurement assurance[1]

Qiao Li
is a PhD candidate at Rutgers University, in New Jersey, U.S.A. The research work developed by Li includes analytical audit, planning and risk management in audits, audit support systems, and machine learning.

Jun Dai
is an assistant professor at the Southwestern University of Finance and Economics, China, and a PhD candidate at Rutgers University, in New Jersey, U.S.A. The research work developed by Dai includes analytics audit, automation in audit, audit applications and blockchain.

ABSTRACT

Recently, governments in many countries have started open data initiatives to make their operations more transparent to citizens. With the open data, anyone who has an interest in monitoring government spending can apply technologies to perform analyses on open data. This study proposes 29 audit apps that could assist various parties in analyzing open government procurement data. These apps could help investigating procurement data from different perspectives such as validating contractor qualification, detecting defective pricing etc. This study uses Brazilian Federal Government procurement contract data to illustrate the functionality of these apps; however, the apps could be applied to open government data in a variety of other nations.

Keywords: Audit Apps; Data Analytics; Government Procurement.

1. INTRODUCTION

According to the World Trade Organization (WTO), government procurement accounts for an average of 10% to 15% of the Gross Domestic Product (GDP) of an economy[2]. Governments are large purchasers of goods and services, which makes them widely abused victims of procurement fraud[3]. Due

to complicated bidding and contracting processes, various contract types, confidentiality of related information and decentralization of data storage, it is very difficult for interested parties to organize, analyze, and monitor the procurement contracts of federal and local governments. In recent years, governments in many countries, such as the United States of America, Canada, and Brazil, have started open data initiatives, aiming at making information about government operations more readily available, useful, and transparent for their citizens[4].

Although open data sources make governments' information available to the public, few studies or methodologies have examined how interested parties can collect and analyze the data. Therefore, this study aims to develop and propose audit apps that could serve as efficient tools for monitoring government expenditures and detecting potential contract anomalies. Audit apps are formalized audit procedures performed through computer scripts, which have seen a recent increase in popularity. This analysis proposes a framework that provides guidance to design effective audit apps that examine government procurement contracts. To illustrate this we also designed 29 audit apps that identify potentially high-risk contracts. Eight of these apps are developed to demonstrate their utility and benefits using the contract data from the Brazilian federal government.

2. BACKGROUND

2.1 OPEN GOVERNMENT DATA AND RELATED ISSUES

In the term open data, "open" indicates that the data are freely available to everyone to use and redistribute (AUER et al., 2007). Such data are gathered and maintained by governments and can be accessed by citizens through online websites. Many countries have built open databases to make data available to the public. For example, Brazil has published a federal procurement information system called "SIASG". Brazil also provides Application Program Interfaces (APIs) for citizens to download data about federal procurement contracts, associated suppliers, goods etc. Although a large variety of government data have been disclosed, this study focuses only on open data that relate to government procurement. Examples of countries that have built websites and databases containing government procurement data include the U.S.A., China, Australia, Canada, Brazil, and the U.K. Open data have had some successes. For example, the British government published government contract data in 2010. Using this, a British official found duplicate purchase records in several government departments that cost over £4 million ($6 million). In another example, officials in San Francisco made transport data public in 2012. They estimate the re-

sulting fall in phone queries has already saved over $1 million (ECONOMIST, 2015). There are, however, some issues with open data that hamper further success. Firstly, data quality is not good enough. Although governments of many countries are required to disclose related data, the level of disclosure varies. Are all the useful data fields given? Are the data details adequate? Is there any missing information? These issues could alter the effectiveness of open data analysis. Secondly, some open data are not prepared in a machine-readable format such as scanned PDF format (which are actually pictures). This makes it harder to collect and analyze such data. Thirdly, the amount of data is huge. This means that searching open data portals and extracting relevant and useful information is often an arduous task. Another issue is that few individuals have the skills to mine data, interpret data, and then put those interpretations or conclusions to good use. Finally, unpublished data could be very valuable, but they are hardly accessible due to data privacy issue (ECONOMIST, 2015).

2.2 INTERESTED USERS OF OPEN DATA

Parties interested in exploring open data, identifying anomalies, discovering irregularities, and detecting frauds include, but are not limited to: citizens, the press, business competitors, and political competitors. There are at least two challenges to address before these groups start working with open data. First, in addition to government open data, they may also need to collect useful data from other sources. Such sources may include social media, the news, government reports, and analysts' reports. It is difficult for interested parties to collect this information and integrate it with government open data. An even bigger challenge exists in analyzing the large amount of data available. Few analytical tools have been specifically designed for the variety of users who want to investigate government data (O'LEARY, 2015). Although there are many general data analytics software programs on the market, the inherent complexity of these analytical tools may impede users from understanding and using the software. This problem is especially pronounced for users with limited auditing and data analytics background. Therefore, developing efficient and effective data analytical tools is a critical issue.

2.3 APPS IN THE AUDITING DOMAIN

Audit apps are formalized analytical routines performed by a computerized tool (DAI; KRAHEL; VASARHELYI, 2014). Each audit app often performs a single analytical audit test, usually requiring few user interactions. Users only need to load data into audit apps to obtain results without many complicated operations. Auditors can even create customized audit apps that accomplish special audit tasks. Audit apps have seen a recent increase in popularity. This is in part due to software developers and audit ser-

vice providers, who have devoted efforts to create audit apps[5]. Few apps on the market, however, are specially developed for citizens wishing to analyze open government data.

Audit apps could be among the favorite tools to analyze open data for several reasons. One reason is that apps in general can be operated easily and with only minimal training. This allows various interested parties from all education backgrounds to analyze data with ease. The low cost of apps is another reason why they are an attractive option. Most users are ordinary citizens or business competitors and not professional auditors. As a result, it is difficult for them to afford expensive professional audit software. Audit apps are cost-effective substitutes that allow users to perform a wide variety of analytics-based audit tests. Customization is another important advantage of apps, because it allows extending apps to fulfill user-specific tasks. Users could create customized apps using professional Software Development Kits.

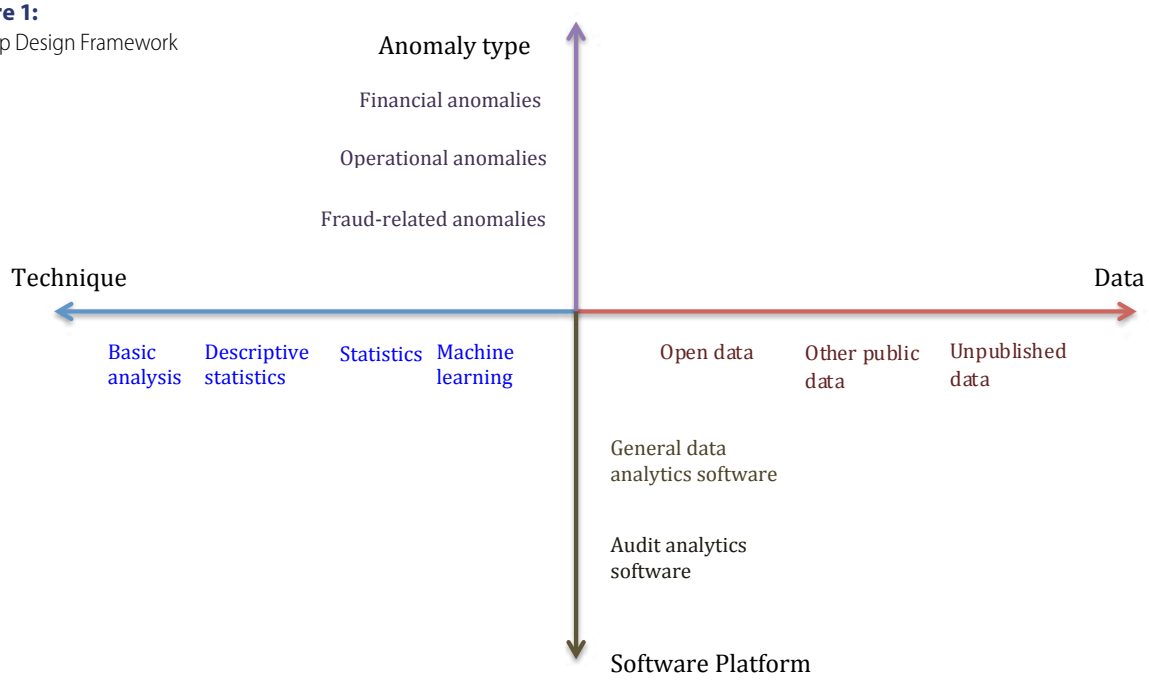
3. AN APP DESIGN FRAMEWORK

Guidance is needed for the design of efficient and effective apps. We propose a framework that provides app design guidance for government procurement audits. The framework (shown in Figure 1) contains four dimensions: anomaly type, data type, software platform, and technique.

The first dimension is anomaly type. Anomalies could be categorized into three types: financial, operational, and fraud-related. Financial anomalies refer to data anomalies that may affect government financial statements or reports. These may include missing data or incorrect/outdated values. Operational anomalies focus on the inefficiency of government operation and activities. These include the purchase of luxury office products (such as an extreme expensive massage chair), obviously unnecessary goods (such as jewelry), or necessary goods priced significantly higher than the market rate. Fraud-related anomalies are unusual data patterns that could result from frauds. For example, if all bidders offer a uniform price and refuse to negotiate during the government bidding process.

The second dimension is the software platform. This will be used to develop and operate audit apps. Generally there are two types of platforms: Audit Data Analytics Software (ADAS)[6] and Generalized Data Analytics Software (GDAS)[7]. ADAS contains pre-programed audit functions making it easy to build apps based on those functions. GDAS usually has the capability of handling high-volume data such as various open data. GDAS also contains a wide range of statistics and machine learning models making it useful

Figure 1:
An App Design Framework



for app development. The drawback of this type of software is that it requires technical background or training of users in order to understand those sophisticated models. Because each software platform has its special characteristics, developers may create several versions of apps that allow users to run them on different software.

The third dimension is data type. Recently, many studies have discussed the use of "big data" for assurance purposes (VASARHELYI; KOGAN; TUTTLE, 2015; CAO; CHYCHYLA; STEWART, 2015; YOON; HOOGDUIN; ZHANG, 2015; ALLES, 2015). Since more countries and organizations start to open their data, such open data will quickly move towards big data (O'LEARY, 2015). In addition, other public data, such as articles of the news, social media, and data collected from machines or various sensors can be collected. These data can all be combined and used to detect anomalies or support investigations (VASARHELYI et al., 2015). Furthermore, certain unpublished information, such as internal operation policies of governmental units, could also provide insight into identifying abnormal government activities. When combined with public data, unpublished information can be used to locate risky government operation processes, and identify potential fraudulent contracts or transactions. Apps need to be developed to facilitate the analyses of a wide variety of data.

The last dimension is technique. Basic analytic techniques could be used to detect unusual patterns. Such techniques include summarization, query, and data matching. Descriptive statistics could provide a wide view of data. Statistics (e.g., regression and time series) and machine learning (e.g., clustering and classification) are advanced techniques that can effectively uncover patterns hidden within complex data. Developers should take advantage of such techniques to create effective and efficient apps.

4. DESIGNING APPS FOR GOVERNMENT EXPENDITURE AUDIT

We proposed 29 apps that could assist with identifying potential anomalies in government expenditure. Such anomalies include suspicious contracts or the use of unqualified suppliers. Table 1 shows the proposed apps.

The first three apps provide a preliminary check on the reliability and completeness of government contract data. They also demonstrate any special data patterns. Abnormal data patterns, such as missing values and abnormal fluctuation, may indicate risks in the contracting process. These apps provide preliminary data-level assurance by identifying contracts with missing or abnormal values. Apps 4 to 10 assist in identifying suspicious suppliers. Since suppliers could be involved in many types of frauds, it is necessary to develop apps to monitor suppliers' behaviors during the bidding and contracting processes. These apps are therefore designed to detect frauds such as bribery,

Table 1:
A list of proposed apps

N°	Purpose of App	Anomaly Indicator	Data	Techniques
Apps for Data Incompleteness/Unreliability Check and Data Patterns Discovery				
1	**Check abnormal contract value**	Unusual number such as 0, 0.01,0.05	Contract data	Query
2	**Check data completeness and integrity**	Missing suppliers/bidding mode/dates/etc.	Contract data	Query
3	**Discover special data patterns (using dashboard)**	Abnormal data fluctuation, extreme large or small numbers etc.	Contract data	Descriptive statistics
Apps for Suspicious Suppliers				
4	**Check supplier information**	Suppliers do not exist in the supplier master file	Contract data, Supplier data	Data matching
5	**Check supplier qualification**	Suppliers, or their parent companies/subsidiaries, are on the list of suspended companies	Contract data, Suspended companies	Data matching
6	**Check relationships**	Family members of suppliers work for the government	Information of suppliers' family members	Query
7	**Check "waived bidding"**	Suppliers have a high proportion of contracts that did not go through normal bidding processes	Contract data	Query
8	**Check abnormal bidding winners**	Some companies always win, or all suppliers win equal number of bids	Contract data, Bidding data	Summarization
9	**Check regional distribution of suppliers**	Suppliers in specific geographical areas win most contracts	Suppliers' geo- information	Visualization
10	**Check abnormal bidder combination**	The same bidders always or never bid with each other	Bidding data	Summarization
Apps for Abnormal Prices and Initial Contract Value				
11	**Check abnormal contract values**	The initial values of contracts do not conform to Benford's Law	Contract values	Benford's Law
12	**Compare contract prices**	Suppliers submit much higher prices in government bids than market price	Price data	Data matching, query
13	**Detect split purchase**	Contracts with same suppliers, dates, and goods/services	Contract data	Duplicate detection
14	**Predict and detect abnormal winning prices**	Winning prices are much higher than the predicted prices	Contract data	Regression
15	**Detect abnormal price gaps**	A large gap between the winner's bid price and others' prices	Pricing information	Query
16	**Check the standard deviation of bidding prices**	All suppliers' prices appear uniform. Suppliers refuse to negotiate the prices	Bidding prices	Standard deviation
17	**Check contract changes**	The initial values of contracts are largely changed	Contract data	Data matching
Apps for Abnormal Bidding Procedure and Mode				
18	**Check valid bidders**	Only a very few valid suppliers	Bidding process	Query
19	**Detect withdrawal of bidders**	Qualified bidders inexplicably withdraw valid bids	Bidding process, supplier data	Query, data matching
20	**Detect duplicate bidding offers**	Companies submit bids with identical individual line items or lump sums	Bidding process	Duplicate detection
21	**Detect duplicate bidders**	Bidders with duplicate addresses, fax or phone numbers, or other demographic data	Demographic information of bidders	Duplicate detection
22	**Check abnormal fluctuation of bid price**	Competitors announce price increases at the same time, at the same amount	Bid prices during the bidding process	Duplicate detection
Abnormal Product/Service Implementation				
23	**Check luxury products**	Government purchase luxury goods	Contract data	Text mining
24	**Check obviously unnecessary items**	Government purchase many unnecessary items such as gift cards	Contract data	Text mining
25	**Check excessive costs**	Costs greatly exceed estimates	Contract data	Query
26	**Check working hours**	Employees are billed for more hours than typically working hours	Invoices	Query
27	**Check duplicate billings**	Duplicate billings for the same products or services	Billings	Duplicate detection
28	**Check abnormal delivery location**	The delivery location is not an office, plant, or job site	Delivery address	Visualization
29	**Check geographic information of invoices**	Employees are billed at multiple distant job sites on same day	Invoices	Visualization

kickback schemes, and bid rigging practices. Apps 11 to 17 are designed to identify unusual price patterns. Since risky contracts are usually associated with abnormal prices, those apps could draw attention to high-risk contracts. Apps 18 to 22 can be used to analyze and monitor the complex bidding procedure. These apps could quickly identify suspicious bidding behaviors. Suspicious bidding behavior may include when only a few valid bidders participate in a bid, or when there are any inexplicable bid withdrawal behaviors. Apps 23 to 29 help to identify purchases of abnormal or unnecessary products, as well as charges of services not rendered. This includes over-spending on office products or misusing public funds.

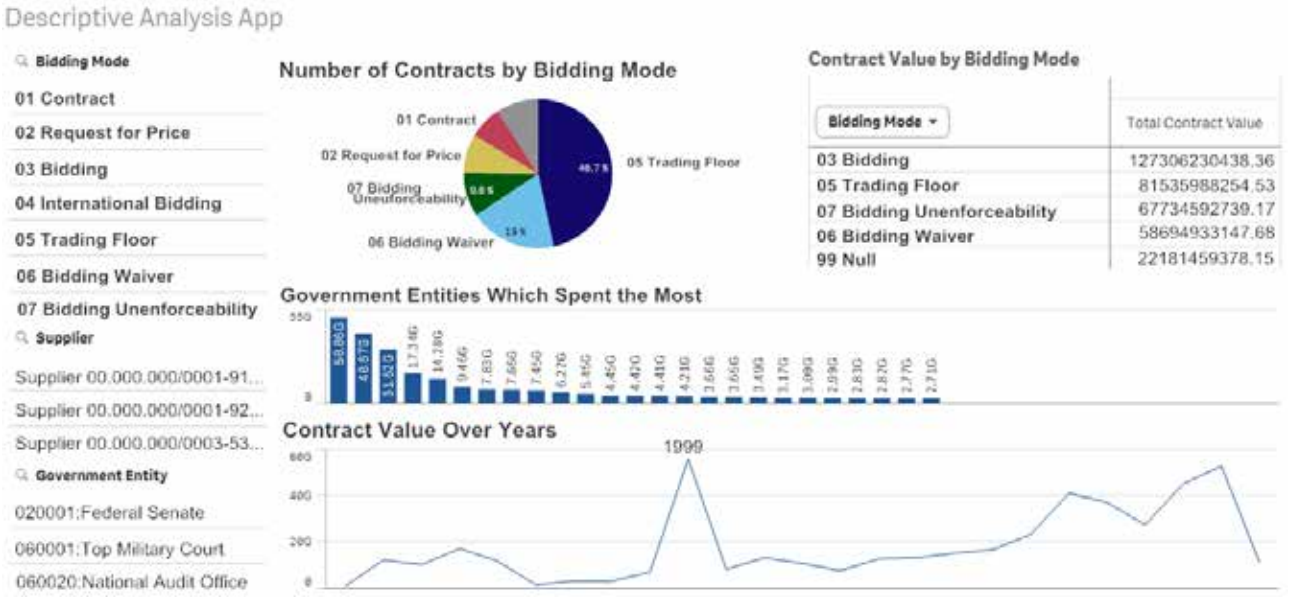
5. ILLUSTRATION OF APPS USING BRAZILIAN FEDERAL PROCUREMENT CONTRACTS

In order to demonstrate the usefulness of audit apps in government contract audit, we collect contract and supplier data from the Integrated System of General Services Administration (SIASG), and the National Registry of Suspended Companies (CEIS), from 1989 to 2014. The contract file mainly contains information about government entities, goods/service suppliers, bidding methods, starting/ending dates, and the initial values of the contracts. The supplier file records companies that preregistered to participate in the bidding processes. Data from this file includes companies' CNPJ and their demographic information. The CEIS system records the CNPJ of companies that are banned from selling products or services to the Brazilian federal government and includes the start and end date of their sanctions. Based on the data, we developed eight apps to perform descriptive analysis, data incompleteness/integrity checks, and anomaly detection.

5.1 DESCRIPTIVE ANALYSIS DASHBOARD

An audit app[8] is developed aiming to perform descriptive analysis on the government procurement contract data. Figure 2 uses a dashboard to show the results. The left panel lists the important fields in the dataset. The right panel uses several charts to show the descriptive analysis of contract values, bidding modes, and government entities. The pie chart shows that 9.6% and 19% of purchases were associated with a bidding mode of 06 (bidding unenforceability) or 07 (bidding waiver), respectively. The table summarizes the initial value of contracts in each bidding mode. According to the table, contracts with bidding mode 07 and 06 rank the third and fourth respectively

Figure 2:
Audit App for Descriptive Analysis (Adapted from Dai; Li, 2016)



in terms of initial contract values. The information from the pie chart and the table indicates that contracts with bidding mode 07 or 06 could be at a high risk of fraud. This is because kickback and bribery schemes are likely to occur when goods or services are purchased without regular bidding processes. The bar chart shows the spending of each government entity between 1989 and 2014. The top three government entities are outliers who spent much more than the rest. The line chart shows the changes in total contract values over time. A peak is found in 1999, the year when the first financial crisis hit Brazil[9]. This indicates a potential risk concern for government expenditures.

5.2 DATA INCOMPLETENESS AND INTEGRITY CHECK

The important fields in contract data are the suppliers, bidding mode, and the start and end dates of the contracts. Therefore, the integrity of those critical data should be checked before performing advanced analytics. Three apps[10] are created for checking the integrity of each of the three fields, and report contracts with missing values. The results show that 35,516 (out of 470,683) contracts do not have supplier information; 16,167 contracts are missing bidding mode, and the start or end dates are not shown in 1,000 contracts. Missing values in the critical fields could result from simple input errors, or fraudulent activities such as bribery or kickback schemes. Further audit tests should be performed to identify and verify the reasons for such missing values.

5.3 ANOMALY DETECTION

High-risk contracts are usually associated with special data patterns that rarely occur in normal situations. For instance, a supplier may win a bit by offering an extremely low price at first, only to raise that price later on. Another example would be a company continuing to sell goods and services, despite being penalized for a breach of obligation. Abnormal patterns in contracts usually indicate fraudulent behavior on the part of suppliers, government entities, or both. Such frauds can cause huge losses to governments. These contracts should be identified and flagged for further investigation. In this study, four apps are developed for detecting contracts having abnormal initial values or suppliers.

An audit app[11] is developed to detect contracts with extremely small initial values (less than 0.1 Brazilian real). The results show that a total of 9,334 contracts have initial values under 0.1 Brazilian real. Among those contracts, 8,678 contracts have 0.00 initial value, 625 contracts have initial values larger than 0.00, but smaller than 0.05, and the initial value of the remaining 31 contracts fall in the 0.05 to 0.10 range. All those contracts should be flagged. Further tests should also be performed on these to examine if the extremely small initial values are reasonable.

Another app[12] is developed to perform Benford's Law analysis on the initial values of the contract. Benford's Law has been widely used in accounting for fraud detection (NIGRINI, 1999; NIGRINI; MILLER, 2009). The frequencies of the first one or two digits of the contracts' initial values should not exceed those suggested by Benford's Law. If this is not the case, it may indicate a potential fraud involving the contracts. The results of the app suggest that there are more contracts that have initial values starting with "60", "79", and "80" than expected. This indicates potential risks in these contracts. The internal policy of the Brazilian government allows simplified bidding procedures if a contract value is lower than 80,000 Brazilian reals. Direct purchases without bidding are allowed if the value is no more than 8,000 Brazilian reals. Results of the Benford's Law analysis indicate that companies and government agencies may have colluded in reducing the initial contract value in order to conform to these limits which simplify purchasing processes.

Examining suppliers is an important aspect of government procurement audit: auditors should pay more attention to purchases made with companies on the CEIS registry. This is because the use of such high-risk suppliers is more likely to result in breach of contract, or the supply of low quality of products or services. Contracts signed with the subsidiaries or parent companies of the suspended companies also need careful examination. These companies may subcontract the work to those related firms under sanction. An audit app[13] is developed to identify the contracts whose suppliers or the subsidiaries/parent of the suppliers are on the CEIS registry. The results show that a total of 25,100 contracts have been signed with companies or their subsidiaries/parent that are, or were, on the CEIS list. For example, the supplier "33.000.118" and their subsidiaries have signed 1,717 contracts with Brazilian government entities from 1989 to 2014. This occurred despite the fact that this supplier was temporarily suspended by a specific government agency from December 15, 2014 to December 14, 2016. Maybe this supplier serves other government agencies; however, the contracts signed by company and its subsidiaries should be carefully examined.

The SIASG system contains an independent supplier file that records preregistered companies participating in the bidding processes. Although registration is not mandated, companies in the supplier file have a lower risk of fraud as compared to non-registered companies. This occurs because registered companies are checked during the centralized registration process. They are therefore guaranteed to meet the legal requirements for participating in government contract bidding. On the contrary, contracts signed with companies that did not register are exposed to a higher risk of fraud. There is still a possibility that the companies will win contracts even if they do not meet all the legal requirements. This may occur when there is collusion between the companies and the government agencies. An app[14] is developed to help detect contracts with suppliers that did not preregister in the system. The results show that a total of 40,942 contracts were signed with non-registered suppliers. Further audit tests need to be performed such as examining whether the companies charge more than the market price, whether there is a personal relationship between companies' management and the government agency etc.

6. CONCLUSION

Since government procurement averages approximately 10%-15% of a country's GDP (OECD, 2015), procurement audits and the detection of potential anomalies or frauds are important issues. This study dis-

cussed the use and benefits of apps for government procurement audits. Twenty-nine specific apps are proposed to facilitate audit government expenditure. Eight apps are developed to demonstrate their usefulness in contract audits. This article could provide insights on how to create effective apps, and how to use apps in government procurement auditing.

NOTES

1 This article is based on the study that is published in Journal of Emerging Technologies in Accounting (DAI; LI, 2016). All the figures and tables in this article came originally from that study and are modified to fit this article by the authors.

2 Available from: <https://www.wto.org/english/tratop_e/gproc_e/gproc_e.htm>. Access on: Nov 25. 2016.

3 Available from: <http://www.whistleblower-lawfirm.com/types-of-fraud-Government-Procurement-Fraud.html>. Access on: Nov. 25, 2016.

4 Available from: <https://www.data.gov/open-gov/>. Access on: Nov. 25, 2016.

5 For example, Caseware has over 50 audit apps on an online market (DAI et al., 2014). Qliksense allows users to develop audit apps by creating customized dashboard. Other companies, such as Forestpin and TeamMate Analytics, also developed some app-like products.

6 Examples of ADAS include ACL and CaseWare IDEA.

7 Examples of GDAS include R, Weka, SPSS, SAS.

8 This app is developed using Qlik Sense.

9 http://bibliotecadigital.fgv.br/dspace/bitstream/handle/10438/16274/Panel%202%20-%20Gabriel%20Palma%202_0.pdf?sequence=1.

10 These apps are developed using Caseware IDEA.

11 This app is developed using Caseware IDEA.

12 This app is developed using Caseware IDEA.

13 This app is built on the SAS Enterprise.

14 This app is built on the SAS Enterprise.

REFERENCES

ALLES, M. G. Drivers of the Use and Facilitators and Obstacles of the Evolution of Big Data by the Audit Profession. *Accounting Horizons,* v. 29, n. 2, p. 439-449, 2015.

AUER, S.; BIZER, C.; KOBILAROV, G.; LEHMANN, J.; CYGANIAK, R.; IVES, Z. DBpedia: a nucleus for a web of open data. *Lecture Notes in Computer Science*, v. 4825, p. 722-735, 2007.

CAO, M.; CHYCHYLA, R.; STEWART, T. Big Data analytics in financial statement audits. *Accounting Horizons*, v. 29, n. 2, p. 423-429, 2015.

DAI, J.; KRAHEL, J. P.; VASARHELYI, M. A. Which audit app(s) should auditors use? An exploratory study of using recommender systems for audit app selection. Working Paper. *Rutgers, The State University of New Jersey*, USA, 2014.

DAI, J.; LI, Q. Designing audit apps for armchair auditors to analyze government procurement contracts. *Journal of Emerging Technologies in Accounting*. Online early, 2016. Available from: <http://dx.doi.org/10.2308/jeta-51598>. Access on: Nov. 30, 2016

Economist. 2015. Open government data: Out of the box. Available from: http://www.economist.com/node/21678833/print. Access on: Nov. 25 2016.NIGRINI, M. J. I've got your number: how a mathematical phenomenon can help CPAs uncover fraud and other irregularities. *Journal of Accountancy* [Internet], May 1999. Available from: <http://www.journalofaccountancy.com/issues/1999/may/nigrini.html>. Access on: Nov. 25, 2016

NIGRINI, M.; MILLER, S. J. Data diagnostics using second order tests of Benford's Law. *Auditing: A Journal of Practice and Theory*, v. 28, n. 2, 305-324, 2009.

OECD."Size of public procurement"in Government at a Glance. Paris: OECD Publishing, 2015. Available from: <http://dx.doi.org/10.1787/gov_glance-2015-42-en>. Access on: Nov. 25 2016

O'LEARY, D. E. Armchair auditors: crowdsourcing analysis of government expenditures. *Journal of Emerging Technologies in Accounting*, v. 12, n. 1, p. 71-91, 2015.

VASARHELYI, M. A.; KOGAN, A.; TUTTLE, B. M. Big data in accounting: an overview. *Accounting Horizons*, v. 29, n. 2, p. 381-396, 2015.YOON, K.; HOOGDUIN, L.; ZHANG, L. Big Data as complementary audit evidence. Accounting Horizons, v. 29, n. 2, p.431-438, 2015.