An experimental investigation of the impact of using big data analytics on customers' performance measurement

Marwa Rabe Mohamed Elkmash
Department of Accounting, October University for Modern Sciences and Arts, Cairo, Egypt, and

Magdy Gamal Abdel-Kader and Bassant Badr El Din
Department of Accounting, Cairo University, Cairo, Egypt

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Abstract

Purpose – This study aims to investigate and explore the impact of big data analytics (BDA) as a mechanism that could develop the ability to measure customers' performance. To accomplish the research aim, the theoretical discussion was developed through the combination of the diffusion of innovation theory with the technology acceptance model (TAM) that is less developed for the research field of this study.

Design/methodology/approach – Empirical data was obtained using Web-based quasi-experiments with 104 Egyptian accounting professionals. Further, the Wilcoxon signed-rank test and the chi-square goodness-of-fit test were used to analyze data.

Findings – The empirical results indicate that measuring customers' performance based on BDA increase the organizations' ability to analyze the customers' unstructured data, decrease the cost of customers' unstructured data analysis, increase the ability to handle the customers' problems quickly, minimize the time spent to analyze the customers' data and obtaining the customers' performance reports and control managers' bias when they measure customer satisfaction. The study findings supported the accounting professionals' acceptance of BDA through the TAM elements: the intention to use (R), perceived usefulness (U) and the perceived ease of use (E).

Research limitations/implications – This study has several limitations that could be addressed in future research. First, this study focuses on customers' performance measurement (CPM) only and ignores other performance measurements such as employees' performance measurement and financial performance measurement. Future research can examine these areas. Second, this study conducts a Web-based experiment with Master of Business Administration students as a study's participants, researchers could conduct a laboratory experiment and report if there are differences. Third, owing to the novelty of the topic, there was a lack of theoretical evidence in developing the study's hypotheses.

Practical implications – This study succeeds to provide the much-needed empirical evidence for BDA positive impact in improving CPM efficiency through the proposed framework (i.e. CPM and BDA framework). Furthermore, this study contributes to the improvement of the performance measurement process, thus, the decision-making process with meaningful and proper insights through the capability of collecting and analyzing the customers' unstructured data. On a practical level, the company could eventually use this study's results and the new insights to make better decisions and develop its policies.

Originality/value – This study holds significance as it provides the much-needed empirical evidence for BDA positive impact in improving CPM efficiency. The study findings will contribute to the enhancement of

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the performance measurement process through the ability of gathering and analyzing the customers' unstructured data.

Keywords Technology acceptance model, Big data analytics, Diffusion of innovation theory, Customer performance measurement

Paper type Research paper

1. Introduction

The continuous increase of data, created by smart devices, radio-frequency identification [1] technologies, sensors, social media, available video surveillance and more, has led to the complexity of performance measurement systems. These data require innovative techniques (to store, process and analyze) to provide meaningful information to support the decision-making process.

Businesses and organizations used to store and analyze their data using relational databases and data warehouses designed to deal with structured data. Examples of data often stored in a structured form include customer resource management, enterprise resource planning, retail, financial and customer information. Nowadays organizations need to store increasingly detailed data for longer periods [2].

Big data analytics (BDA) has been around for years. BDA is the use of advanced analytic techniques against very large diverse data sets that include structured, semi-structured and unstructured data from different sources and in different sizes from terabytes to zettabytes. These amounts of data cannot be processed or analyzed using conventional data processing techniques. BDA could support performance measurement systems for organizations through the analysis of a huge volume of structured and unstructured data.

This study investigates the hypothetical implementation impact of using BDA (voice analytics, video analytics, text analytics, social media analytics, sentiment analysis and Web analytics) on customers' performance measurement (CPM). Moreover, this study aims to determine the accounting professionals' acceptable level of customers' analytics and their intention to use.

The main findings of this study were as follows. First, measuring the customers' performance with the help of the BDA increased the organization's ability to analyze the customers' unstructured data. Second, BDA decreased the costs incurred by the organization to analyze the customers' unstructured data. Third, BDA contributed to handling the customers' problems quickly. Fourth, BDA helped in minimizing the time spent to analyze the customers' data and obtaining their performance reports. Finally, any managers' attempt to hide critical information related to customers is prevented. These findings will contribute to the improvement of the performance measurement process, thus, the decision-making process with meaningful and proper insights through the capability of collecting and analyzing the customers' unstructured data.

The results of testing the differences in participants responses according to the years of work experience before the hypothetical implementation of BDA showed that there was not a statistically significant difference in all CPM efficiency factors except the cost factor, which showed a statistically significant difference among the participants' responses. The results of testing the differences in the CPM efficiency factors, according to the years of work experience after the hypothetical implementation of BDA, showed that there was not a statistically significant difference in all efficiency factors. The findings of the robustness tests supported the main analysis results. CPM elicited an improvement after using BDA compared to before using BDA. The results from calculating the effect size for all the CPM components showed the existence of a large effect of BDA on CPM.

The remainder of this study is structured as follows. Section 2 discusses the theoretical discussion and the hypotheses development. Section 3 addresses the research method. Following this the results will be introduced in Section 4. Section 5 addresses the discussion, and finally the conclusion of the research will be presented in Section 6.

2. Theoretical discussion and development of hypotheses

The following theoretical discussion is developed to address the research problem of this study. The theoretical discussion is the platform for the research model, thus, formulating the research hypotheses. The theoretical discussion of this study starts with the behavioral aspects of accepting the BDA. To achieve this objective, the researchers based their discussion on two theories in the literature: diffusion of innovation (DoI) theory and the technology acceptance model (TAM).

According to the DoI theory, diffusion is the process by which an innovation is communicated through a channel over time in a social system. The following are the four critical elements in the diffusion process:

(1) the innovation;

(2) its communication channels;

(3) the social system; and

(4) time to adopt the innovation (Rogers, 2010).

It permits academics to discover the elements that could impact the approval and successful implementation of technology. As a result, the theoretical discussion of this study was based on a prevalent theory – the DoI theory. It provided a broad analysis of the technology of a specific innovation within an organization. The theory worked as the base for discovering the technology adoption within the organization, whether to adopt or not to adopt the BDA.

Based on the DoI theory, if the new invention is beneficial, easy to use and affordable, the society will embrace it and begin to spread the news of the innovation among each other. Based on the DoI theory, the adoption of the BDA will go through the following processes:

- the awareness of BDA;
- the decision to adopt the BDA through the original free version;
- the decision to stay using the technology if it meets users' needs; or
- the decision to reject it at the end of the assessment period.

The main drawback of this theory is that the introduction of technology is not as plain as stated by the DoI theory (Chau, 1996); it is difficult to measure it, and adopters do not exert an identical amount of effect as proposed by Rogers. Moreover, the theory does not consider the social support required to adopt a new invention. For these reasons, the DoI theory could not be able to offer possible acceptance criteria that individuals or organizations would choose to follow an innovative invention as the BDA. The decision to adopt an innovation contains more than the consciousness by the innovation as stated by the DoI theory. For instance, organizations may be aware of the BDA through the process of diffusion; but, other critical elements such as the inability to afford it or unawareness of its usefulness may deprive some organizations of adopting the BDA innovation. These criticisms clarified why the DoI theory alone is inadequate to explain the acceptance of BDA. Searching the literature for other behavioral theories that may explain the acceptance of a new technology led the researchers to the theory of TAM.

Davis (1989) stated the theory of TAM as an information system theory that models how users come to accept and use technology. Davis mentioned that the degree of acceptance is based on the persons' believes that using a particular system would be free from effort. The model recommended certain factors that impact the user's decision to accept new technology. The first factor is the perceived usefulness, which is the degree to which a person considers that using a specific system would improve the job performance. The second factor is the perceived easiness of use, which is the degree that an individual considers that using a specific system would be free of effort. The third factor is the attitude toward use, which is the behavioral intention and the actual use of the system (Davis, 1989). Oliveira and Martins (2011) stated that the model is applicable to a wide variety of technologies, ranging from a basic application such as Microsoft Word to BDA.

For this study, the researchers used the DoI theory to develop the theoretical framework of this study, as it discovers the features that could affect the approval and successful utilization of technology into a particular ecosystem. The TAM is used to understand the users' intentions and perceptions about BDA (the proposed innovation to measure customers' performance) to explain how this new invention acquire push and spread within a social system.

Customers play a key role in the success of any organization. Customers represent the first line in the income statement of any organization; in other words, they represent the sales figure. Moreover, another key performance indicator concerned with the customers in the income statement of any organization is the sales returns and allowances. CPM was tackled in the accounting literature for years. Traditionally, CPM was based on surveys which did not prove its effectiveness in performance measurement and evaluation. Organizations tried to shift the CPM into numbers that could give better indicators, thus, better decision-making. The key performance indicators (KPIs) that were implemented to measure customer performance were through measuring customer satisfaction, customer retention, customer attraction, customer loyalty and so on. In the accounting literature, many ratios were developed to measure the customer perspective.

The BDA was able to play a key role in the customers' performance indicator. The BDA combined the traditional method with the KPIs through performing analysis for customer performance. For measuring customers' performance, six types of BDA were chosen: voice analytics, video analytics, text analytics, social media analysis, sentiment analysis and Web analytics to examine their effect on customers' performance. The rationale for choosing these analytics is its ability to measure human interactions (unstructured data) which is in line with CPM.

The theoretical model, outlined in Figure 1 (developed by the authors), represents the cornerstone for developing the research hypotheses. The theoretical model of this study addresses two statuses. First, the current CPM system used by the organizations is based mainly on structured KPIs that deal with structured data. Second, the proposed system is based on BDA, which contrasts in the data collection and analysis method as it can accumulate, extract and analyze non-structural data. The ability to analyze non-structural data improves measuring customers' performance.

The research questions that this study meant to answer are: will the usage of BDA improve CPM efficiency? In addition, will accounting professionals recommend using BDA to measure customers' performance? Have perceived usefulness? Believe in its easiness to use?

To get answers to these questions, CPM efficiency criteria should be set. First, the CPM efficiency level (customers' perspective) has been determined through five points: the ability to analyze available data to measure customers' performance, the cost afforded by the company to measure customer satisfaction, the ability to handle customers' problems, the

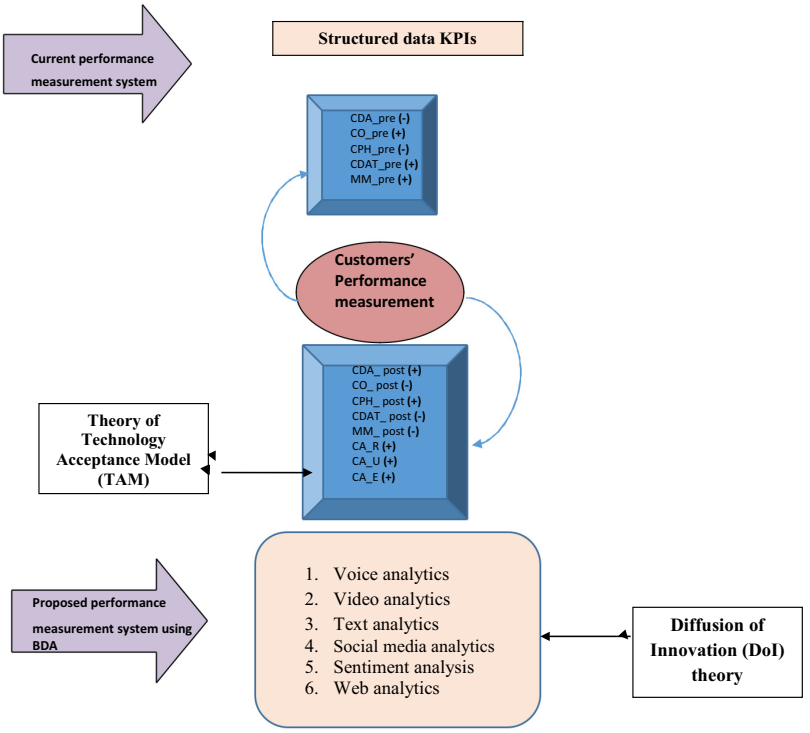

Figure 1. Theoretical framework

time spent to analyze customers' data and the possibility of department manager manipulation.

Owing to the novelty of the topic, there was a lack of theoretical evidence. Therefore, the following hypotheses were developed:

H1. Using big data analytics within the organization will increase the ability to analyze the customers' data to improve measuring their performance.

H2. Using big data analytics within the organization will reduce the customers' data analysis cost.

H3. Using big data analytics within the organization will increase the ability to handle the customers' problems quickly.

H4. Using big data analytics within the organization will minimize the time spent to analyze the customers' data and obtaining customer performance reports.

H5. Using big data analytics within the organization will facilitate controlling managers' bias when they measure customer satisfaction.

H6. Accounting professionals recommend using big data analytics to measure customers' performance.

H7. Accounting professionals have perceived usefulness for customers' analytics.

H8. Accounting professionals believe in customers' analytics easiness to use.

3. Research method

3.1 Design

This study adopts a within-subject Web-based quasi-experiment. Schoeffler *et al.* (2013) make a comparison between Web-based experiment and laboratory experiment findings arising from a specific experiment and did not catch any major differences among the findings. There has been a growing tendency of Web-based experiments (also known as the online laboratory) in social sciences and psychology (Bainbridge, 2007). The researchers could collect more various samples and attract a broad number of participants with the assistance of Web-based experiments (Kramer *et al.*, 2014).

The within-subject designed experiment is favorable over the independent groups or between-subjects design as the variations among the participants are similar in all the manipulations and thus, any variances within the dependent variable (s) is because of the fluctuations within the independent variable (Cozby and Bates, 2011). Additionally, the usage of repeated measures is acceptable if the goal is to reveal the participants to a wide range of situations and to inspect the variances in their replies (Cook and Campbell, 1979).

Cook and Campbell (1979) categorized quasi-experimental research designs into various classifications based on the circumstances surrounding data collection. This study uses the one-group pretest-posttest design. This is a frequently used study design where a single pretest observational measurement (O1) is made, an intervention (X) is implemented and a posttest measurement (O2) is made (Davis and Albright, 2004).

The quasi-experiment of this study presents a hypothetical scenario of a pastry producer operating 110 retail branches. The experimental case has been informed by the following:

- the interviews conducted with the sales manager (the performance measurement system of the selected company); and
- the practical examples for business analytics (The 60+ business analysis tools every manager needs to know) Bernard Marr 2016 (BDA system to measure the customers' performance).

3.1.1 Interviews conducted with the sales manager. The sales managers in four manufacturing companies have been interviewed. The interviewees were inquired to display the performance measurement process used for customers according to their personal experiences to be an inspiration for composing the experimental case (Phase 2). The interviews were unstructured with mostly open-ended questions.

Following is one of the responses of the interviewees, verbatim:

> Mainly we depend on five measures usually used to evaluate the customer satisfaction: returns by customers as % of sales, on-time delivery, customer satisfaction rating, new customer sales and, repeated sales (% sales from repeated customers) (Sales Manager 2).

3.1.2 Practical examples for business analytics (key business analytics: the 60+ business analysis tools every manager needs to know) Bernard Marr 2016. The relevance of these practical examples of business analytics mentioned in Bernard Marr 2016 book originated from the aspiration to form a proposed case, which represents the new proposed system for measuring customers' performance. This aim has been reached with the assistance of the ideas existing in these examples specifically, regarding voice analytics, video analytics, text analytics, sentiment analysis, social media analytics and Web analytics. Therefore, the

experimental case could answer this study's research questions better, with an emphasis on the influence of BDA on the CPM.

The composition of the experimental case depended on three phases. Phase 1 aims to collect demographic data about the participants. Phase 2 presents a simulation of the performance measurement system of the selected company. The simulation (informed by the interviews conducted with the company sales managers) was conducted to introduce the current system used by the company to measure customers' performance. It begins with general information about the company and the used performance measurement system followed by a summarized table containing the company's strategic objectives, customers' performance measures, the calculation method and the responsible manager. A screenshot of the software used by the company was offered as a part of the information.

The participant was asked to take the role of the corporate manager and have a task to determine the efficiency level of the used measures through a group of statements using five-point Likert scale after offering them specific situations encountered by the company.

Note that the CPM efficiency factors have been determined through five scales: the ability to analyze available data to measure customers' performance, the cost afforded by the company to measure customer satisfaction, the ability to handle customers' problems, the time spent to analyze customers data and the possibility of department manager manipulation.

Phase 3 of the experimental case proposes a novel system to measure the customers' performance. Customer analytics (proposed system) depends on BDA particularly six types: voice analytics [3], video analytics [4], text analytics [5], social media analytics, sentiment analysis and Web analytics [6]. A description of the company's status if the previous analytics has been applied was the beginning of this phase. Each of these analytics has been illustrated through text and images. Besides, an explanatory video about video analytics traits has been offered to the participants.

The same group of statements using a five-point Likert scale previously used in Phase 2 has been repeated as post-test measures to determine if there were differences in participants' perceptions regarding the proposed CPM system.

3.2 Experiment participants

To tackle this study's research problem, accounting professionals represent the population of this study. This study implemented the convenience sampling technique. Therefore, the sample involves all accounting professionals who were keen to join. In line with Mark *et al.* (2009), in the case of probability sampling, the exact sampling frame is a matter of concern. As this study relies on a convenience sample – a non-probability technique, the precise sampling frame was not mandatory.

To reach a large number of accounting professionals, Master of Business Administration (MBA) classes were visited, and the students were invited to participate in the experiment for the following reasons. First, Lipe and Salterio (2000) noted that they used MBA students to reduce the influence of participants depending on their own company's (rather than the firm's experimental case) strategy and interrelated performance measures when finalizing the case. Second, Ashton and Kramer (1980) did not catch variances between the information processing of students and non-students. Third, using a subject pool of MBA students is consistent with participants in prior experimental research on the performance measurement (Banker *et al.*, 2000; Lipe and Salterio, 2000; Banker *et al.*, 2004; Dilla and Steinbart, 2005).

After getting permission from the professors of MBA classes, six MBA classes were visited, and a session taking approximately 15 min had been given for each class before requesting their emails, and they were invited to volunteer to participate in the experiment

through the internet. The research instrument was sent by mail to a total of 234 MBA students. A total of 14 emails bounced (because of invalid email addresses) and 220 were sent, from which only 185 emails were opened. The final number of opened emails that had been completed was 104. This process involved sending reminder email to non-respondents three times until progressing to the above number of respondents. The response rate was 44.4%.

3.2.1 Pilot study. Pilot testing aimed at ensuring the possibility of collecting data via Web-based experiment, the content of the experimental case to evaluate the clearness of instructions and questions involved within the research instrument and the whole time occupied to finish the experiment.

The initial phase of the pilot test was piloted with 25 participants, including 9 PhD students, 11 professional accountants and 5 accounting professors.

The instrument was revised based on the feedback obtained at this phase. Some participants' notes verbatim are mentioned below:

> I think, it needs a very interested participant to complete it. It contains a lot of information
>
> (Participant 4).

On the other hand, there were positive comments informed that the manipulations were used in the projected approach and that the presentation and design of the research instrument were motivating for the participants. Moreover, they suggested that the case was realistic and easy to understand.

> I believe that it is a state of the art. I enjoyed participating in it
>
> (Participant 2).
>
> You have chosen very good examples
>
> (Participant 16).

The research instrument was ready to be subjected to data collection after it has been designed, pilot-tested and improved (Mark *et al.*, 2009; Dillman *et al.*, 2014).

3.3 Variables measurements

The research instrument used to collect data for this study has been established by SurveyMonkey, one of the foremost online data collection software. The experimental case covers the dependent variables: the CPM efficiency factors which had been measured before and after the intervention (or treatment) which was the implementation of the BDA (the independent variable) manipulated through the proposed system to measure customers' performance depending on six types of analytics – voice analytics, video analytics, text analytics, social media, sentiment analysis and Web analytics. In other words, comparisons of CPM efficiency factors were made between the current performance measurement system and the proposed performance measurement system to determine if there are differences.

Researchers were expected to offer the participant (s) with an outline of the research project in the first section of the participant information sheet. The content of the sheet is the title of the project, a brief of the research, the rationale for the invitation and the participant's right to decline participation. Descriptions of what the participants will be asked to do, secrecy and anonymity, the planned use of the data to be collected and the complaints process are the content of the second section of the sheet.

The study required the data gathering on four demographic variables related to education, work experience and gender. The demographic variables were measured as simple answers to the questions requesting data on these variables. Specifically, the predetermined answers against participant's undergraduate degree comprised of business administration, accounting, computer sciences, information systems and other options to choose from. The responses about full-time work experience are accounting or auditing – finance or investing – marketing or sales – human resources followed by the other option. The responses of the years of work experience were distributed into three ranges to choose from 1 – less than 5, 5 – less than 15, 15 or more, gender requested about the respondent's sign of male or female. The demographic variables have been measured following the existing research equivalent to this study.

CPM efficiency factors have been measured using five-point Likert items in terms of five scales: first, the ability to analyze available data to measure customers' performance measured by "5" representing "very high" and "1" as "very low." Second, the cost afforded by the company to measure customer satisfaction measured by "1" representing "very high" and "5" as "very low." Third, the ability to handle customers' problems measured by "5" representing "very high" and "1" as "very low." Fourth, the time spent to analyze customers' data measured using "1" representing "very long" and "5" as "very short." Fifth, the possibility of department manager manipulation measured using "1" representing "very high" and "5' as "very low."

For TAM elements, recommend using BDA analytics to measure customers' performance measured by "5" representing "not recommended" and "1" as "extremely recommended." The usefulness of customers' analytics in evaluating their performance measured by "5" representing "not useful" and "1" as "very useful." Perceived easiness of customers' analytics measured by "5" representing "strongly disagrees" and "1" as "strongly agree."

4. Results

This section will introduce the descriptive statistics (most of the study variables go along a non-normal distribution) followed by testing the first five hypotheses using the Wilcoxon signed-rank test and finally testing the last three hypotheses using the chi-square goodness-of-fit test:

- descriptive statistics (Table 1); and
- hypothesis tests.

4.1 Customers' performance measurement efficiency factors hypotheses

Testing and reporting the results of the five research hypotheses related to CPM will be at this section using Wilcoxon signed-rank test which is used in situations in which there are two sets of scores to compare, but these scores come from the same participants. As such, think of it as the non-parametric equivalent of the dependent *t*-test (or a Mann–Whitney test for repeated measures data) as it works similarly in that it is based on the differences between scores in the two conditions you are comparing. Once these differences have been calculated, they are ranked, but the sign of the difference (positive or negative) is assigned to the rank. Therefore, it is relevant to test the hypotheses, which contain pre and post-variables measuring.

The significance of the Wilcoxon signed-rank test has been reported using the test statistics (*z*-statistic) and the *P*-values. Table 2 includes negative ranks, positive ranks, the ties and mean ranks for the hypothesized relationships.

Variable	Mean	Median	SD
Customers' data analysis[a] (CDA)			
CDA_pre	2.33	2.00	0.841
CDA_post	4.50	5.00	0.813
*Customers' performance measurement cost*b (CO)			
CO_pre	2.22	2	0.696
CO_post	2.78	3	0.881
*Customers' problems handling*c (CPH)			
CPH_pre	2.20	2	0.918
CPH_post	4.40	5	0.898
*Customers' data analysis time*d (CDAT)			
CDAT_pre	2.05	1	0.896
CDAT_post	4.13	5	1.183
*Manager manipulatio*ne (MM)			
MM_pre	2.15	2	0.868
MM_post	3.76	4	0.919
Recommend BDA to measure customers' performance (CA_R)	1.75	2	0.537
Usefulness of customers' analytics (CA_U)	1.70	2	0.573
Customers' analytics easiness (CA_E)	2.00	2	0.639

Notes: [a]The company's ability to analyze available data to measure customers' satisfaction (CDA). [b]The cost afforded by the company to measure customer satisfaction (CO). [c]The company's ability to handle customers' problems that cause customers dissatisfaction immediately (CPH). [d]The time spent to analyze customers' data by tracking their behaviors in real time to measure their satisfaction (CDAT). [e]The possibility of department manager manipulation when assessing customer satisfaction (MM)

Table 1.
Descriptive statistics

To interpret and report the results, the contents of the above table should be illustrated. The column labeled *P*-value shows that in case the *P*-value is less than 0.05, then the two groups are significantly different. Positive and negative ranks (the footnotes clarifying what they mean) to tell you how the groups differ (the greater number of ranks in a specific direction

	Tested hypothesis			Mean rank	Ties	Test statistics (*z*-statistic[a])	*p*-value
H1	*CDA_pre and CDA_post*	Negative ranks[b]	9	10.50	5	−8.480	0.000
		Positive ranks[c]	95	47.80			
H2	*CO_pre and CO_post*	Negative ranks[d]	11	38.25	12	−8.480	0.000
		Positive ranks[e]	86	37.93			
H3	*CDH_pre and CDH_post*	Negative ranks[f]	7	10.50	4	−9.100	0.000
		Positive ranks[g]	98	49.52			
H4	*CDAT_pre and CDAT_post*	Negative ranks[h]	10	9.00	0	−8.980	0.000
		Positive ranks[i]	98	49.06			
H5	*MM_pre and MM_post*	Negative ranks[j]	15	30.79	7	−7.333	
		Positive ranks[k]	87	46.74			0.000

Notes: [a]*Z* based on negative ranks. The test statistic is the smaller of the positive and negative ranks. [b]CDA_post < CDA_pre; [c]CDA_post > CDA_pre; [d]CO_post < CO_pre; [e]CO_post > CO_pre; [f]CDH_post < CDH_pre; [g]CDH_post > CDH_pre; [h]CDAT_post < CDAT_pre; [i]CDAT_post > CDAT_pre; [j]MM_post < MM_pre; [k]MM_post > MM_pre

Table 2.
Hypotheses testing

tells you the direction of the result). Regarding Z statistics, in case these values are bigger than 1.96 (ignoring the minus sign), then the test is significant at $P < 0.05$. Therefore, there is a significant difference between depression scores.

Test of *H1*: Using BDA within the organization will increase the ability to analyze the customers' data to improve measuring their performance.

The results revealed that for all the 104 participants recruited to the study, the CDA after using BDA elicited an improvement compared to the pre using BDA. z-statistic equals −8.480 (P-value = 0.000), indicating a significant difference exists (in the expected direction) between the median of CDA_post and CDA_pre. *H1* has been confirmed.

Test of *H2*: Using BDA within the organization will reduce the customers' data analysis cost.

The results showed that for all the 104 participants recruited to the study, the CO after using BDA elicited slight improvement compared to the pre using BDA. z-statistic equals −8.480 (P-value = 0.000), indicating a significant difference exists between the median of CO_post and CO_pre. *H2* has been accepted.

Test of *H3*: Using BDA within the organization will increase the ability to handle the customers' problems quickly (CDH).

The results revealed that for all the 104 participants recruited to the study, the CDH after using BDA provoked an improvement compared to the pre using BDA. z-statistic equals −9.100 (P-value = 0.000), indicating a significant difference exists (in the expected direction) between the median of CDH_post and CDH_pre. *H3* has been confirmed.

Test of *H4*: Using BDA within the organization will minimize the time spent to analyze the customers' data and to obtain the customers' performance reports (CDAT).

The results revealed that for all the 104 participants recruited to the study, the CDAT after using BDA elicited an improvement compared to the pre using BDA. z-statistic equals −8.980 (P-value = 0.000), indicating a significant difference exists (in the expected direction) between the median of CDAT_post and CDAT_pre. *H4* has been confirmed.

Test of *H5*: Using BDA within the organization will facilitate controlling the managers' bias when they measure customer satisfaction.

The results showed that for all the 104 participants recruited to the study, the possibility of manager manipulation after using BDA showed an improvement compared to the pre using BDA. z-statistic equals −7.333 (P-value = 0.000), indicating a significant difference exists (in the expected direction) between the median of MM_post and MM_pre. *H5* has been confirmed.

4.2 Elements of the technology acceptance model for customers' analytics hypotheses

Examining and reporting the results of the three research hypotheses related to the components of TAM regarding the customers' analytics will be at this section using the chi-square goodness-of-fit test which is used to determine whether the distribution of cases (e.g. participants) in a single categorical variable follows a known or hypothesized distribution. The proportion of cases expected in each group of the categorical variable can be equal or unequal. Hence, it is the most appropriate test for a single variable like TAM elements.

Test of *H6*: Accounting professionals recommend using BDA to measure customers' performance (CA_R).

The mode is the score that occurs most frequently in the data set (Field, 2009). In the case of CA_R, it is 2 (very recommended). According to Table 3, the CA_R frequencies were more toward very recommended (Point 2) where 67.3% from the study sample choose it, followed by 28.8% choosing the extremely recommended option. Therefore, 96.1% (67.3% + 28.8%) from the study sample recommend using BDA to measure customers' performance.

To compute the chi-square goodness-of-fit test, two new variables should be constructed. The first variable is "CA_R_responses" with assigned codes of "1" for "extremely recommended," "2" for "very recommended," "3" for "somewhat recommended" and "4" for "not recommended." If the frequency data has already been summated for the various categories, the second variable "CA_R_frequency" has to be created containing the respective frequency counts. This procedure will only work if the cases already "weighted" from the data menu (Table 4).

In Table 4, the chi-square goodness-of-fit test results for responses (CA_R) show the observed frequencies (Observed *N*) for each category and the expected frequencies (Expected *N*), which are the frequencies expected in case the null hypothesis is true. The difference between the observed and expected frequencies is presented in the Residual column.

Test statistics provide the actual result of the chi-square goodness-of-fit test. In case of (CA_R), the test statistic is statistically significant: χ^2 (2) = 120.196, $P < 0.0005$. Thus, the null hypothesis has been rejected and conclude that there are statistically significant differences in the participants' responses, with more participants "very recommended" BDA ($N = 69$) and "extremely recommended" ($N = 30$) compared to very few "somewhat recommended" ($N = 2$) and the "not recommended" ($N = 1$). Therefore, *H6* has been confirmed.

Test of *H7*: Accounting professionals have perceived usefulness for customers' analytics (CA_U).

The mode in case of CA_U is 2 (very useful). According to the table, the CA_U frequencies were more toward useful (Point 2) where 61.5% from the study sample choose it, followed by 34.6% choosing the extremely useful option. Therefore, 96.1% (61.5% + 34.6%) from the study sample reported the usefulness of BDA to measure customers' performance (Tables 5 and 6).

In case of CA_U, the test statistic is statistically significant: χ^2 (2) = 103.769, $P < 0.0005$. Therefore, the null hypothesis has been rejected and conclude that there are statistically significant differences in the participants' responses, with more participants "very useful" BDA

Table 3. (CA_R) frequencies

Recommend using BDA to measure customers' performance (CA_R)	Frequency	(%)
Extremely recommended	30	28.8
Very recommended	69	67.3
Somewhat recommended	2	1.9
Not recommended	1	1.0
Total	102	99.0%

Table 4. Chi-square goodness-of-fit test results for CA_R

Responses	Observed *N*	Expected *N*	Residual	Chi-square (test statistics) χ^2	*P*-value asymp. sig
Extremely recommended	30	25.5	4.5	120.196	0.000
Very recommended	69	25.5	43.5		
Somewhat recommended	2	25.5	−23.5		
Not recommended	1	25.5	−24.5		
Total	102				

($N = 64$) and "extremely useful" ($N = 36$) compared to very few "somewhat useful" ($N = 3$) and the "not so useful" ($N = 1$). *H7* has been confirmed.

Test of *H8*: Accounting professionals believe in customers' analytics easiness to use (CA_E).

The mode in case of CA_E is 2 (agree). According to the table, the CA_E frequencies were more toward agree (Point 2) where 67.3% of the study sample chooses it, followed by 17.3% choosing "strongly agree" option. Therefore, 84.6% (67.3% + 17.3%) from the study sample agree that customers' analytics is easy to use (Tables 7 and 8).

Table 5. (CA_U) frequencies

Perceived usefulness for customers' analytics (CA_U)	Frequency	(%)
Extremely useful	36	34.6
Very useful	64	61.5
Somewhat useful	3	2.9
Not so useful	1	1.0
Total	104	100

Table 6. Chi-square goodness-of-fit test results for CA_U

Responses	Observed *N*	Expected *N*	Residual	Chi-square (test statistics) χ^2	*P*-value asymp. sig
Extremely useful	36	26.0	10.0	103.769	0.000
Very useful	64	26.0	38.0		
Somewhat useful	3	26.0	−23.0		
Not so useful	1	26.0	−25.0		
Total					

Table 7. (CA_E) frequencies

Customers' analytics easiness to use (CA_E)	Frequency	(%)
Strongly agree	18	17.3
Agree	70	67.3
Neither agree nor disagree	15	14.4
Disagree	1	1.0
Total	104	100.0

Table 8. Chi-square goodness-of-fit test results for CA_U

Responses	Observed *N*	Expected *N*	Residual	Chi-square (test statistics) χ^2	*P*-value asymp. sig
Extremely useful	36	26.0	10.0	103.769	0.000
Very useful	64	26.0	38.0		
Somewhat useful	3	26.0	−23.0		
Not so useful	1	26.0	−25.0		
Total	104				

In case of CA_E, the test statistic is statistically significant: χ^2 (2) = 105.615, $P < 0.0005$. Therefore, the null hypothesis has been rejected and conclude that there are statistically significant differences in the participants' responses, with more participants "agree" BDA (N = 70) and "strongly agree" (N = 18) compared to few "neither agree nor disagree" (N = 15) and very few for the "disagree" (N = 1). *H8* has been confirmed.

4.2.1 Additional analysis of experience. Previous literature has found that experience may impact people's judgment and decision-making. To exclude the possibility that the difference in subjects' evaluations may be because of their different experience levels, an additional analysis of experience has been performed using the Kruskal–Wallis test and Mann–Whitney tests [7].

The Kruskal–Wallis H test (sometimes also called the "one-way ANOVA on ranks") is a rank-based nonparametric test that can be used to determine if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable (Field, 2009).

A Kruskal–Wallis H test presented that there was not a statistically significant difference in all CPM efficiency factors except the cost factor pre-BDA hypothetical implementation. The P-value for CDA_pre, CPH_pre, CDAT_pre and MM_pre were 0.312, 0.493, 0.546 and 0.444, respectively. Hence, the null hypothesis has been accepted for CDA_pre, CPH_pre, CDAT_pre and MM_pre.

A Kruskal–Wallis H test showed that there was a statistically significant difference for CO_pre $H = 8.666$, $p = 0.013$. It can be seen that, based upon the mean ranks, the highest mean rank = 57.52 for the participants with years of work experience "5 – less than 15." Followed by the mean rank = 51.58 for the participants with years of work experience "15 or more," then the participants with years of work experience "1 – less than 5" with a mean rank = 41.36. Therefore, the null hypothesis has been rejected, and the alternative hypothesis has been accepted for CO_pre.

A Kruskal–Wallis H test disclosed that there was not a statistically significant difference in all CPM efficiency factors post-BDA hypothetical implementation. The P-value for CDA_post, CO_ post, CPH_ post, CDAT_ post and MM_ post are 0.853, 397, 0.551, 0.609 and 916, respectively.

4.2.2 Post hoc tests for the Kruskal–Wallis test.

4.2.2.1 Mann–Whitney test for CO_pre. Doing non-parametric *post hoc* procedures by using Mann–Whitney tests for CO_pre showed that there was a statistically significant difference $H = 8.666$, $p = 0.013$.

The participants' responses regarding the CO_pre differ significantly between the two groups of years of work experience where $Z = -2.966$, $P = 0.003$. Based upon the mean ranks, the highest mean rank was assigned to the participants' group with "5 – less than 15" years of work experience where their responses were more toward high (Point 2). The participants' responses regarding the CO_pre did not differ significantly between the two groups of years of work experience where $Z = -0.509$, $P = 0.611$.

A robustness test has been done to enhance the research results. It is suggested to measure, in a standardized way, the size of the effect. The results showed that for all CPM components, there was a large effect (the effect size is well above the 0.5 threshold for a large effect) [8].

5. Discussion

This section is intended to interpret and analyze the empirical results acquired against the hypotheses tested in the prior section on data analysis. The main drive is to connect the

proven results to the objectives, research questions and the research problem motivating this study. The findings will be argued in relative to the theoretical discussion that is based on the integration of DoI theory (Rogers, 2010) with the TAM (Davis, 1989).

The first aim of this study is examining the impact of the hypothetical implementation of six types of BDA (voice analytics, video analytics, text analytics, social media analytics, sentiment analysis and Web analytics) on CPM and the accounting professionals' acceptance level of these analytics and their intention to use.

The results showed that for all the categories of the CPM efficiency factors (i.e. CDA: customers' data analysis, CO: CPM cost, CPH: customers' problems handling, CDAT: customers' data analysis time, MM: manager manipulation) were hypothesized (*H1*, *H2*, *H3*, *H4* and *H5*) to improve CPM in case of using BDA. The results indicated that BDA significantly improves CPM factors. Therefore, *H1*, *H2*, *H3*, *H4* and *H5* are supported.

Data turns to BD when its volume, velocity or variety surpasses the abilities of the information technology operational systems to collect, store, analyze and process it. Most of the organizations may be capable of handling the vast amount of unstructured data using varied tools and equipment, but with the rapidly growing volume and a fast stream of data, they cannot mine it and derive crucial insights in a well-timed way (Khade, 2016). The significant improvement of CDA because of the implementation of BDA provides empirical evidence to the benefits gained from it. Moreover, it offers a solution to the problems of data collection insufficiency and inability to deal with some types of customers' data (i.e. customers' data analysis).

Applying BDA to measure customers' performance contributes to achieving high-performance results as it increases the ability to track customers' behaviors in real time and to discover any bottlenecks, thus taking the appropriate actions. The whole process takes a very short time, which leads to high customers' satisfaction and accordingly increases the sales rate. Arguably, using BDA can be considered as an assistant factor in improving the company's financial results as an indirect effect.

According to Ittner and Larcker (1998), designing and applying customers' indicators as a part of the balanced scorecard, the system needs high costs. The results of testing *H2* revealed that the "BDA" decreased the cost afforded by the company to analyze the customers' unstructured data. However, this result could not be considered as a strong finding enhancing the accounting professionals' perceptions of the cost afforded by the company to analyze customers' data. This is because the participants in the study added many comments asked about the BDA cost and the investment required from the company to apply it. Moreover, they were wondering how they can decide precisely if applying BDA will reduce the customers' data analysis cost. There was not any information related to the investments required to apply BDA mentioned in the research instrument. Therefore, to overcome this shortcoming and as a guide to the average costs for applying the specific analytics for this study, we will illustrate a sample of the analytics pricing. Overall, the pricing is convergent among analytics vendors, and each vendor provides many tiers of packages relevant to various organizations' sizes.

For example, Brand24 [9] offers social media monitoring software for $399 per month including (1 million mentions/mo, 10 users, 12 months archive, data analysis, sentiment analysis, PDF reports, live help, Excel file export, consultant). Another example is Microsoft Azure analytics offering three types of analytics. First, text analytics [10]: the maximum transactions included in tier: for 25,000 the price is $74.71, for 100,000 the price is $249.86, for 2,500,000 the price is $2,499.84 and for 10,000,000 the price is $4,999.99. Second, speech analytics price 0.5 per hour. Third, video analytics: standard encoder $0.015 per output minute and premium encoder $0.035 per output minute.

The problem of the insufficiency measurement originated from the existence of an enormous amount of data, particularly the unstructured, which require time, effort, cost and accuracy to extract beneficial insights from it. However, the current performance measurement system cannot perform this process efficiently.

The results of testing *H3* verified that the "BDA" increase the ability to handle the customers' problems quickly. Handling customers' problems professionally and at the right time enables the organizations to avoid the majority of customers' churn reasons and raise their satisfaction level.

The results of testing *H4* confirmed that the "BDA" minimize the time spent to analyze the customers' data and obtaining the customer's performance reports. The software specialized in each type of BDA (voice analytics, video analytics, text analytics, social media analytics, sentiment analysis and Web analytics) produces its reports in real time.

The results of testing *H5* proved that BDA could control managers' bias when they measure customer satisfaction. Arguably, BDA can be used as a de-biasing technique through its monitoring capabilities where every customer transaction or behavior is captured. This mechanism prevents the managers from any attempt to tamper or collusion with others to hide critical information related to the customers.

The second part of the first aim of this study is evaluating the accounting professionals' acceptance level of customers' analytics and their intention to use it. Technology adoption offers an informative cost-saving vision to govern the relevance of technology investment in any organization. It permits determining the elements that impact the approval and successful implementation of technology (Chau, 1996).

The theory of TAM attempts to explain in what way users desire to admit and use technology. The model recommended many elements affect the user's choice when approving new technology: the intention to use (R), perceived usefulness (U) and the perceived ease of use (E). The study findings regarding *H6*, *H7* and *H8* support the accounting professionals' acceptance for BDA through the TAM elements (i.e. the intention to use (R), perceived usefulness (U) and the perceived ease of use (E)). The results help understanding better the people's intentions and perceptions about BDA to clarify how this new invention gains push and spread. The results therefore are consistent with the DoI theory and TAM.

6. Conclusion

This study examines the influence of the experimental usage of BDA on measuring customers' performance. Our findings were derived from the theoretical discussion which was developed through the combination of the DoI theory with the TAM. Empirical data was obtained using Web-based quasi-experiments with 104 Egyptian accounting professionals. Further, the Wilcoxon signed-rank test and the chi-square goodness-of-fit test were used to analyze data. Our empirical results indicate that measuring customers' performance based on BDA increase the organizations' ability to analyze the customers' unstructured data, decrease the cost of customers' unstructured data analysis, increase the ability to handle the customers' problems quickly, minimize the time spent to analyze the customers' data and obtaining the customers' performance reports and control managers' bias when they measure customer satisfaction. The study findings supported the accounting professionals' acceptance of BDA through the TAM elements: the intention to use (R), perceived usefulness (U) and the perceived ease of use (E).

Our study succeeds to provide the much-needed empirical evidence for BDA positive impact in improving CPM efficiency through the proposed framework (i.e. CPM and BDA framework). Furthermore, our study contributes to the improvement of the performance measurement process, thus, the decision-making process with meaningful and proper insights through the capability of collecting and analyzing the customers' unstructured

data. On a practical level, the company could eventually use this study's results and the new insights to make better decisions and develop its policies.

This study has several limitations that could be addressed in future research. First, we focus on CPM only and ignore other performance measurements such as employees' performance measurement and financial performance measurement. Future research can examine these areas. Second, we conduct a Web-based experiment with MBA students as a study's participants, researchers could conduct a laboratory experiment and report if there are differences. Third, owing to the novelty of the topic, there was a lack of theoretical evidence in developing the study's hypotheses.

Notes

1. Radio-frequency identification.
2. Available at: www.pearsonitcertification.com/articles/article.aspx?p=2427073&seqNum=2
3. Illustrated by an image shows a voice analysis report.
4. Illustrated by a video represents the video analytics traits (After choosing the explanatory video, the researcher removed any sign indicating the name of the company that offers BDA solutions using Snagit program).
5. Illustrated by an image of text analytics report about users tweets, which show how the positive tweets about any company, brand, product or service separated from the negative and neutral tweets.
6. Illustrated by an image of Web analytics.
7. Data available upon request.
8. Data available upon request.
9. https://brand24.com
10. https://azure.microsoft.com/en-us/services/cognitive-services/text-analytics/?v=18.05

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Further reading

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Corresponding author

Marwa Rabe Mohamed Elkmash can be contacted at: mrabe@msa.eun.eg