Exploring Big Data Analytics Adoption using Affordance Theory

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Abstract: This research explores big data analytics adoption in organisations using affordance theory. Big data analytics are a set of tools and techniques that help companies to get useful business insights from the data. Adoption of big data analytics is a challenging task. Affordance theory has been used to study usage and effect of information technology. In this work, we have modified the affordance theory framework to study adoption of big data analytics. The framework takes into account characteristics of the technology, the goal and characteristics of the organisation. Organisation achieve different outcomes based on their goals and characteristics. We have used case study method to verify efficacy of the adopted framework. The results clearly show that the framework is effective in studying the adoption of big data analytics.

1 INTRODUCTION

Today, a large number of organisations produce, obtain and store data about their business. These organisation want to extract valuable knowledge from this data using big data analytics (Dhar, 2013). Many organisations are in the process of adopting big data analytics (BDA) in order to make data driven decisions. Data analytics is the key differentiator in the competitive position of organizations. In 2012, 2.5 exabytes $\approx 10^9 GB$) of data was generated every day and this rate doubles every 40 months (McAfee et al., 2012). This data is generated in real time, has varied form and is voluminous. Such kind of data is called Big Data and big data cannot be handled using traditional techniques. Analytics is becoming an integral part of organisations and business processes (Davenport, 2013). However, only 15 percent of the organisation who intended to adopt BDA actually adopted analytics (Strauss and Hoppen, 2019). Data and technology are important for big data analytics. Some other important factors are- understanding of the management of the potential of analytics, skills of the employees, data policy (LaValle et al., 2011).

An organisation may have a business case and an associated objective. In order to achieve the objective, the organisation may require to adopt big data analytics. The organisation needs to check its readiness for big data analytics. An adoption framework may help the organisation to proceed in a systematic manner. Theory of affordance provides a potential big data analytics adoption framework. Section 2 provides a review of the relevant literature including theoretical framework. We have identified factors for each phase and discussed them in section 3. We have verified our framework using two case studies that are presented in Section 4. We close the paper with a discussion and conclusion presented in Section 5.

2 LITERATURE REVIEW

Big data analytics or simple big data has been defined as a holistic approach to manage, process and analyse 5 Vs (i.e., volume, variety, velocity, veracity and value) in order to create actionable insights for sustained value delivery, measuring performance and establishing competitive advantages (Wamba et al., 2015). Big data analytics may involve sophisticated computational methods that are applied to massive data. BDA can help firms in decision making. Also, BDA helps in customer segmentation, fraud detection, quantifying the risks and forecasting sales, etc. (Russom, 2011). Companies can enhance their efficiency, improve the profitability and their competitiveness (Alharthi et al., 2017). Top-performing companies are known to use data analytics twice than lower-performing companies (Grimaldi et al, 2019). However, big data analytics (BDA) adoption is a project whose outcome is anything but deterministic. According to Adaptive Structuration Theory, outcome of an IT project depends on many factors (DeSanctis and Gallupe, 1987). IT artefacts are visualised

in terms of their technical specifications and affordances they offer to goal oriented and experienced users (Markus, 2015). There is another dimension that deals with intent and values of the IT artefact that is referred to as symbolic expression or spirit of the system. In this article we will not concern ourselves with this dimension. Affordances (Gibson, 1977) are what a group of users may be able to do with IT artefacts given their goal and experience. Some organisations have adopted and integrated BDA across a wide array of functions. Such organisations have been termed as transformed organisation (LaValle et al., 2011). On the other end of the spectrum are the aspirational organisations that barely use data analytics to guide their decisions. Experienced organisations are the ones that fall in the middle and have started using data analytics for decision making but it is not integrated into their business processes. Each of these types of organisations have different level of experience with data analytics. Their goals may also be different for a data analytics project.

Affordances emerge from the interaction between the actor and objects (Bernhard et al., 2013) (Pozzi et al., 2014). The information about affordances becomes available when interaction between actors and objects take place. In addition, information may also be available from external sources. Affordance is a pre-condition for an action, but existence of an affordance does not mean that an action will happen. Information about affordances must be available to the actors for them to perceive affordances (Bernhard et al., 2013). The actor will perceive only a limited set of affordances from the entire set of affordances available. The perception may be correct, false or a combination of the two. The perceived affordances may be actualised by actualisation effort. The actualisation effort is dependent on the perceived difficulty of the affordances. The actualised affordances will create an effect. However, the actualised affordances may or may not have desired effect. There are three different use cases for IT artefacts – adoption, use and effect (result). The studies available in literature mostly focus on use or effect (Strauss and Hoppen, 2019). In this article, we have focused on adoption.

2.1 Affordance Theory Framework

The theory of affordance is the base for our framework that is adopted from (Bernhard et al, 2013). In this framework, constituents of an organisation who have potential to interact with technology are actors. The big data analytics technology is the artefact. Big data analytics technology consists of BDA tools, hardware and software (Strauss and Hoppen, 2019).

The framework consists of four phases (shown in Figure 1 that are explained below.

2.1.1 Affordance Emergence

Organisation and technology need to interact in order for technology affordances to emerge (Hutchby, 2001) (Majchrzak and Markus, 2012). The affordances emerge in the form of information about affordances. In case of adoption, the technology doesn't yet exist in the organisation. Therefore, affordances cannot emerge through this channel. As an alternative, the organisation may gather information from external sources. Another possibility is that the organisation asks one or more vendors to make their technology available. The actors interact with the vendor technology with a goal in sight. The information thus generated and gathered results in emergence of affordances- a possibility for available action. Prior experience with technology plays an important role. Affordances have dual-functional nature- enabling and constraining nature. The actor will perceive affordances as enabling or constraining based on his capabilities and goals (Pozzi et al, 2014). Affordance emergence is the first construct of the affordance theory framework. Affordances that emerge may be different for aspirational, experienced, and transformed organisations. Transformed organisations may be able to see different or more affordances than an aspirational organisation. It is the responsibility of the organisation to be aware of the goal and discover relevant affordance available (Bernhard et al, 2013).

2.1.2 Affordance Perception

In IS literature, it is argued that affordances exist irrespective of actors, their goals and experience (Pozzi et al, 2014). Therefore, affordance perception is the first process instead of affordance emergence. Affordance perception is the process of recognition of affordances. The affordances related information affects the affordance perception and gives clues to the user that affordances exist. Factors such as actor's goals and capability, and features and information about object are important factors for affordance perception. We take a position that affordance emergence and perception are two different processes in the context of IS adoption. The emerged affordances from the technology that is being considered for adoption may be more than what the organisation is interested in. Perceived affordance can be different from affordances that emerged. Actor may recognise only a subset of all affordances that emerge.
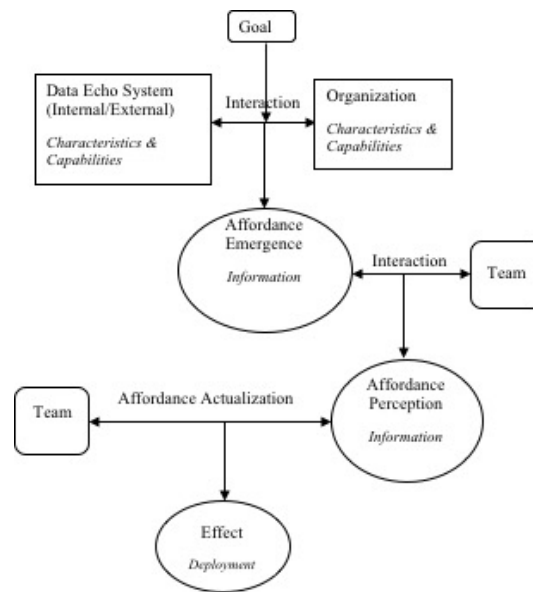
Figure 1: Affordance Theory Framework; a rectangle represents what must exist at the beginning, rounded corder rectangle represents what is made available; an oval indicates outcome of a phase; the indicators are in italics text.

2.1.3 Affordance Actualisation

In case of technology adoption, actualisation involves actions to make technology affordances ready to use. Actualisation is a goal-oriented and iterative process (Leonardi, 2011). The actualisation effort is a collective activity done at the level of the organisation. The degree of effort may vary a lot in actualisation—the amount of action required by an actor to realise the possible results. The actualisation effort and its outcome depend on many factors (Pozzi et al., 2014). For technology adoption, among all the factors, the actualisation of previous affordances is particularly interesting. This particular factor captures experience of the actor. If an organisation has prior experience with a predecessor of the present technology, the organisation may have required ability and understanding of the technology under consideration (Bernhard et al, 2013). The organisation may have environmental structures to support adoption. A transformed organisation is likely to have less difficulty in adopting a new big data analytics technology compared to an aspirational organisation. The technology configuration and technology features are also important factors in actualisation. Skills and knowledge of the employees of the organisation also play a critical role in actualisation. The willingness to change behaviour is considered important in affordance actualisation (Pozzi et al, 2014). The effort may also depend on the affordances selected to be actualised. An organisation may perceive false or wrong affordances (Bernhard et al., 2013). During the actualisation phase, wrong or false affordances will become apparent. Most of the factors that are considered important during actualisation phase are consistent with factors that are considered critical from a project management perspective (LaValle et al., 2011) (Gao et al., 2015).

2.1.4 Affordance Actualisation Effects

Effect of affordance actualisation are of two types based on time perception of the actor: short term effect and long-term effect. Short term effects are called immediate concrete outcomes. Immediate concrete outcomes guide the actualisation and help in predicting the long-term effect (Strauss and Hoppen, 2019). Actualisation effect of big data analytics adoption is different from the effect of using big data analytics. Immediate concrete outcome may be that adopted big data analytics tool performs as expected on the test data. Long-term effect may include improvement in the business.

3 FACTORS FOR AFFORDANCES EMERGENCE, PERCEPTION AND ACTUALISATION PHASES

In the emergence phase, interaction between IT artefacts and actors take place. Affordances appear when there is an interaction between actors and IT artefacts. This interaction happens more specifically between capabilities and characteristics of actors and IT

artefacts. In the perception phase, information that emerges from emergence phase is utilised to perceive affordances. Finally, in the actualisation phase, the chosen affordances are realised. There are indicative factors for each phase. The health of these factors are indicative of preparedness of the organisation for adopting big data analytics.

3.1 Relevant Factors for Affordances Emergence

3.1.1 Data and Its Properties

Data and its properties are important for affordance emergence (Russom, 2011) (Alharthi et al., 2017) (McAfee et al., 2012). 4Vs (volume, velocity, variety, veracity) of the data is the starting point for big data analytics (Grimaldi et al., 2019). An organisation that has big data and is desirous of drawing value (fifth V) from the data is a candidate for adopting big data analytics. The organisation should also have a data management policy in place. Without a policy data that is collected may be poorly understood and may not be good enough for generating knowledge. Data policy deals with data access, security and privacy issues.

3.1.2 Data Analytics Tool

Experience in data analytics tool may be helpful in selecting big data analytics tools and technology (Grover and Kar, 2017). A wide range of tools are available; some are proprietary and others are open source (Srinivasan and Kumari, 2018). There are many ways of selecting the right BDA tool, and what tools are selected depends on the need of the organisation, budget, and available skill set. An organisation may have a selection process in place.

3.1.3 IT Infrastructure

IT infrastructure is an essential factor in adopting big data analytics (Behl et al., 2019) (Nam et al., 2019) (Gupta and George, 2016). If an organisation has big data, it must have infrastructure and processes to collect and store data. Big data analytics may require specialised hardware and software to be able to process big data. An organisation may not have IT infrastructure for big data analytics (Wamba et al., 2017). Procurement of required IT infrastructure is part of affordances actualisation phase. Some organisations use third party IT infrastructure or shared IT services and may need to expand it (Behl et al., 2019).

3.1.4 Organisational Characteristics

The attitude of top management towards Big Data Analytics plays an important role in adoption (Behl et al., 2019) (Russom, 2011) (Nam et al., 2019) (McAfee et al., 2012) (Gupta and George, 2016). Chief data/technology/information officer must be interested and committed to adopting data analytics. Lack of management bandwidth is a major issue that stops organisations from taking up data analytics project (LaValle et al., 2011). The management may have a goal (Ji-fan Ren et al., 2017) (Gupta and George, 2016) to be achieved by adopting big data analytics. If the top management takes a strategic decision to adopt BDA, the project is more likely to succeed (Behl et al., 2019).

Data analytic experience and skills of employees is another important factor (Hoffman and Podgurski, 2013) (Behl et al., 2019) (Gupta and George, 2016) (Alharthi et al., 2017). An organisation that has been using data analytics will be better prepared to adopt big data analytics. If the organisation has actualised affordances in the past, employees will have the skill set to carry on the BDA project (Behl et al., 2019). Skills such as data preparation, data visualisation, domain knowledge, problem-solving ability, and quantitative aptitude for solving a new problem are relevant. Another possibility is that the organisation has been using data analytics but the project was outsourced. In such a situation, an in-house team would have been involved. This team will be able to lead the big data adoption project whether done in-house or out-sourced.

3.2 Relevant Factors for Emergence Perception

The information that is gathered during affordance emergence serves as the basis for this phase. The information may reveal affordances or may shield affordances. For instance, if the organisation has a data policy in place, data access emerges. If the organisation has no data policy, data access is shielded. A selection and purchase process, vendor and product selection emerge. An absence of such a process reveals a need for creating a purchase process. The organisation will need to identify criteria (Kangelani and Iyamu, 2020) for selecting the most suitable BDA tool. Prior to affordance actualisation, the organisation may want to experiment with select few products (Strauss and Hoppen, 2019). The vendors may provide demonstration version to the organisation.

3.3 Relevant Factors for Affordance Actualisation

Affordances actualisation is a team effort. Actualisation has to be managed as a project. Composition and abilities of the team are important for affordances actualisation. There are two possibilities- an in-house team may be capable of executing the project, or an implementation partner may be required. The in-house team will identify and engage an implementation partner. The in-house team will plan affordance actualisation. Planning (Steven Ji-fan et al, 2017) is a systematic process to use resources to accomplish the goal. Planning provides a structure to activities, their sequencing, their time and resource requirements. Planning reduces risks (Rackoff et al., 1985). The factors that were important during emergence phase are important for actualisation. Commitment of the management, skills of the employees, data policy etc. all come together in affordance actualisation phase. In addition, budgeting (Trelles et al., 2011), affordance actualisation team composition (Goldsmith et al, 2000) and characteristics of the selected technology (Behl et al., 2019) (Gupta and George, 2016) play important role. Change management and employee training (Behl et al., 2019) (Gupta and George, 2016) are also required for adoption to succeed (Bernhard et al., 2013).

3.4 Relevant Factors for Actulisation Effect

The effect of affordances actualisation is deployment of big data analytics technology in the organisation to achieve the decided goal (Ji-fan Ren et al., 2017). Effect of actualisation can be judged with respect to goal using historical data. The long term effect of deployment depends on many other factors. Success of long term usage of the technology may be judged using corresponding framework (Pozzi et al., 2014) (Bernhard et al., 2013) (Strauss and Hoppen, 2019).

4 CASE STUDY

We have validated our framework using case study methodology. We have analysed two organisations. Both organisations are very different.

4.1 Case Study 1

About the Organisation Artificial Limbs Manufacturing Corporation of India (ALIMCO) is a 100% Gov-

ernment of India owned central public sector enterprises. This is a Mini Ratna organisation. ALIMCO was established in 1972 and started manufacturing of hearing, mobility, vision and other rehabilitation aids in 1976. It's headquarter is situated in Kanpur, Uttar Pradesh, India. ALIMCO is governed by the Ministry of Social Justice & Empowerment, Department of Empowerment of Persons with Disabilities, India. It manages sales, promotion, distribution of its products. ALIMCO has four auxiliary production centres located in four different cities across India. The enterprise also has four marketing centres in across India. Findings: We visited ALIMCO Kanpur Centre and interviewed their IT head. Our findings are as follows. Data- The total data of all ALIMCO centres put together is less than 15 GB. The data primarily consists of employee data, payroll data, production data, inventory data and sale transaction data. IT Infrastructure- All IT functions of ALIMCO headquarter located at Kanpur are conducted from a small room with outdated systems. Systems are connected through Wi-Fi technology and can share information within a centre. All ALIMCO centres are not integrated. Information of one centre is not readily accessible to the other centres. The current IT infrastructure is not flexible and cannot be upgraded easily. Processing of a request takes time from couple of hours to a day. The attitude of top management towards BDA-Top management is focused on production and related activities. They have not concerned themselves with data analytic yet and have not figured out potential of data analytics. There are only two employees in the IT section.

4.1.1 Comments and Findings

ALIMCO is using a transactional processing system (TPS) and is in the process of graduating to using management information system (MIS). ALIMCO is also considering implementing an ERP system in near future. They have a relational database management system. With some effort, they can use the existing data for forecasting and production planning. ALIMCO is less than an aspirational organisation as far as big data analytics adoption is concerned.

4.2 Case Study 2

4.2.1 About the Organisation

XYZ is a multinational investment bank and financial services company. It is the sixth-largest bank in the world and largest bank in Europe, with 2.715 trillion US dollars assets. XYZ formally started operation more than 150 years ago. XYZ provides services in

retail banking, corporate banking, investment banking, mortgage loans, private banking, wealth management, credit cards, finance, and insurance. It has around 4000 offices in more than 65 countries and has around 38 million customers. The company has around 2,50,000 employees, more than half are female. The revenue of the company is 56 billion US dollars.

4.2.2 Information Gathered

XYZ started business intelligence (BI) implementation more than 20 years ago.. The bank has a core business end and an IT/operation end. Analytics needs are raised by the business end. The IT department implements and deploys solutions to analytics requirements. We contacted a senior analyst who is a part of the data analyst team for four years. We interviewed him that took around 40 minutes. XYZ currently applied data analytics in fraud analysis, risk calculation, money laundering and data security. The organisation wants to excel in these fields through data analytics. Data security is still a challenge for the bank. Apart from that, bank also aspires to automate all its operations. The bank also wants to encourage use of cryptocurrency and digital money. The bank already have data, data policy and IT infrastructure in place. The management is well aware of the potential of data analytics. Employees have experience with business intelligence. and skills makes it a possible, achievable business goal for XYZ. The bank has more than 100 TB for analytics purposes. Data is in a well-defined structured form. The data is collected from may sources. New data is generated and become part of the data store every second. The bank owns latest IT infrastructure. The IT infrastructure can be easily expanded to increase storage and computing capacity. A request is processed mostly in real time. Specialised requests are processed in less than one hour. Data analytics tools and platforms include python, SAS, R, R Shiny and Tableau. Previous data analytics affordances actualisations have been completed on time. Employees have domain knowledge and statistical knowledge. IT team is equipped with coding skills. Managers understand the business and the role of the technology well. They are well versed with IT services of the organisation. They understand the future needs. Regular meetings of the functional team, analytics team and business team are help every week. Discussions during these meetings help in identifying new opportunities. Every affordances implementation is planned meticulously. The team is built according to the skills and experience required for a project. Skill building training is organised for emerging technology. Training is either delivered by

an in-house team or a specialised third party. The bank already has loan prediction model, risk analysis model and data security model in place. According to the interviewee, for a bank, data security is of utmost importance. A bank may compromise and not deploy latest technology. But the bank can not compromise with data security. A single data breach may bring the credibility of the bank down. Data analytics has reduces incidences of data breach and has made transactions secure. The bank has been able to reduce the manpower by 30% due to technology. The bank wants to become a self-serviced bank and do away with direct service employees.

4.2.3 Analysis

We now map our findings from the interview to our proposed framework.

- Data and Its Properties. The bank has volume, velocity and variety of good quality data. The bank has been using business intelligence for drawing value out of the data.

- IT Infrastructure. The bank has reliable, flexible and integrated IT infrastructure. IT infrastructure is accessible to employees. IT is used for running applications, accessing data and for data analytics.

- Organisation Characteristics. The present top management has been part of the data analytics team in the past. They know various data analytics applications that have been deployed in the organisation. They are familiar with the data analytics strategy and its objective. The management may not have technical know how, but they certainly know its capabilities. Consequently, management takes data analytics initiatives and sets goals for the initiative. Due consideration is given to the budget and benefits while deciding a goal.

- The Management Motivates Employees to Adopt Data Analytics. The management is aware of the potential challenges and plans accordingly. The bank has been using business intelligence and data analytics for last 30 years. Employees and the IT team have been working together on data analytics projects. The IT team understands the business and is equipped to manage and execute data analytics projects. Employees of the organisation are also well aware of potential of data analytics. They have skills to work with IT team on data analytics projects. Employees have no hesitation in adopting data analytics.

  The organisation has all required characteristics to generate and gather information for affordance emergence and perception.

- Affordance Perception. The bank has data policy in place. They also have processes for selecting technology and vendors. Their prior experience helps them to make right choices.

- Affordance Actualisation. We learnt that the team plans actualisation and sticks to the plan during actualisation effort to the extent possible. Management regularly provides advice and provide training to employees. The previous affordance existence, perception and actualisation inspire the bank to explore advanced affordances.

- Affordance Effect. The bank has successfully actualised and deployed data analytics.

4.2.4 Comments

The bank is a transformed organisation. Data analytics has become integral part of the organisation. The company has been drawing value from big data analytics.

5 CONCLUSIONS

Big data analytics has potential to help organisations to gain useful business insights. An organisation must have a clear goal leading to a business case while adopting data analytics. Adoption of big data analytics require preparedness of the organisation. Affordance theory provides a framework to check preparedness of an organisation for adoption of big data analytics. The framework also guides actualisation of identified affordances. The framework has three phases, namely affordance emergence, perception and actualisation phases. We have adopted affordance theory framework for big data analytics adoption. We have included organisational and technological factors that play important role in the framework. We have not included factors that are part of external environment such as government policies, market etc. TOE (Technology Organisation Environment) theory (H.O. Awa and Igwe, 2017) considers environment in addition to technological and organisational factors.

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