The Assimilation of Big Data Analytics (BDA) by Indian Firms: a Technology Diffusion Perspective

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Abstract

Big Data Analytics (BDA) is an emerging technology that is being used in many echelons of business and management. Recent IS research about this technology lack focus on the factors that impact its organizational adoption. However, adoption is just one part of assimilation and companies cannot gain the greatest benefits without assimilating it in a full-scale and deep level (Zhu et al. 2006). Accordingly, assimilation of BDA into the organizational decision-making and operations is very important to fully realize its benefits and worthy of study, especially in emerging economies such as India.

Drawing upon diffusion of innovation (DoI) theory (Rogers E.M., 1995), institutional theory (Paul J.D. and Powell W.W., 1983), and Technology-Organization-Environment (TOE) framework (Tornatzky L.G., Fleischer M., and Chakrabarti A.K., 1990) present paper proposes the antecedents that influence BDA assimilation in context of Indian firms.

Keywords: Big data analytics, Innovation diffusion, Absorptive capacity

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1. Introduction

Big data refers to large datasets that are challenging to store, search, share, visualize, and analyze. Here usually the orders of magnitude outstrip conventional data processing and the largest of data warehouses. For example, as per a white paper released by Oracle in Enterprise Architecture (Aug 2012), an airline jet collects 10 terabytes of sensor data for every 30 minutes of flying time, New York Stock Exchange collects 1 terabyte of structured trading data per day, or a conventional structured corporate data warehouse is sized in terabytes and peta- bytes. Big Data is sized in peta-, exa-, and even in zetta-bytes. And, it is not just about volume, the approach to analysis contends with data content and structure that cannot be anticipated or predicted. Proper analytics and the science behind them filter low value or low-density data to reveal high value or high-density data. Big Data has a broad array of interesting architecture challenges. As a result, new analytical techniques are required to adopt.

It is often said that data volume, velocity, and variety define Big Data, but the unique characteristic of Big Data is the manner in which the value is discovered. Big Data is unlike conventional business intelligence, where the simple summing of a known value reveals a result, such as order sales becoming year-to-date sales. With Big Data, the value is discovered through a refining modelling process: make a hypothesis, create statistical, visual, or semantic models, validate, and then make a new hypothesis. It either takes a person interpreting visualizations or making interactive knowledge-based queries, or by developing ‘machine learning’ adaptive algorithms that can discover meaning.

The growth of big data is a result of the increasing channels and variety of data in today's world. Some of the new data sources are user-generated content through social media, web and software logs, cameras, information-sensing mobile devices, aerial sensory technologies, genomics, and medical records.

Companies are now investing in solutions that interpret consumer behavior, detect fraud, and even predict the future. As per a McKinsey report (May 2011), leading companies are using big data analytics (BDA) to gain competitive advantage. They predict a 60% margin increase for retail companies who are able to harvest the power of big data.

There is no question that the rise of big data in prominence has led to a huge focus on exploring how organisations can harness information to gain a competitive advantage. However, despite big data's well documented benefits, how many organisations across the globe are putting it to use and in which way? In recent years, BDA (Big Data Analytics) has emerged as a new technology to increase overall efficiency of management and better decision-making. Compared to traditional analytics system, BDA can enhance the productivity and performance of organizations in real-time.

However, IS research lack focus on BDA adoption which is just one part of an assimilation process, and it cannot ensure BDA's wide-scale exploitation and usage. The benefits of BDA can only be fully realized through wide-scale assimilation. According to Fichman (1999) and Zhu et al. (2006a), the adoption stages of assimilation are especially worthy of a focused study, especially in emerging economies such as India. The economical status and regulatory environment of such countries are different from developed countries where BDA technology already has started spreading its wings for high level of usage. Thus, it is worthy to investigate how innovation assimilation is influenced by contextual factors in these environments.

Motivated by above theoretical gaps, present paper proposes an integrative model integrating antecedents that impact BDA assimilation in the Indian context. The model is based on diffusion of innovation (DoI) theory, institutional theory and technology, organization and environment (TOE) framework.

1.1 Review of Theories on Innovation Assimilation

Innovation assimilation, being a dynamic and complex process, can be better understood by the use of multi-stage models. There are literatures on stage-based innovation models to justify the use of aggregation measure of assimilation.

A three-staged change model including *unfreezing*, *moving*, and *refreezing* describes the phenomenon of a system implementing organizational innovation (Lewin, 1952). Another study categorized assimilation into three primary stages: *knowledge-awareness stage*, *evaluation-choice stage*, and *adoption-implementation stage* (Meyer and Goes, 1988). Further studies propose the stages like adoption, internal diffusion, and external diffusion (Prem Kumar et.al., 1994) and adoption, implementation, and assimilation (Zhu et.al., 2006b).

Literature also identifies that assimilation can be viewed as a six-stage process from *initiation* followed by *adoption, adaptation, acceptance, routinization* to a complete *infusion* stage (Cooper and Zmud, 1990).

Studies also investigate diffusion from a multi-stage perspective: *adoption*, *implementation*, and *assimilation* classifying each diffusion stage into three categories: (1) *adoption* consists of initiation, comprehension, earliness of adoption, and adoption; (2) *implementation* consists of adaptation, acceptance, and implementation; (3) *assimilation* consists of routinization, infusion and assimilation (Wu and Chuang, 2010). Antecedents,

which can influence each assimilation stage, are investigated as well as financial and non-financial firm performance.

The study conducted on the assimilation process of e-business (Zhu et. al., 2006b) investigates the assimilation from three stages perspective: *initiation*, *adoption*, and *routinization* based on the TOE framework. A comparative study between developed countries and developing countries suggests that technology readiness strongly influences assimilation in developing countries while technology integration has a significant effect on the assimilation in developed countries.

1.2 Aggregated Assimilation

Extant stage-based models capture the dynamic nature of innovation assimilation and provide a clear picture of the complete assimilation process. They also describe antecedents of each stage and provide a theoretical foundation for innovation assimilation research. This paper proposes to use an aggregated measure of assimilation and justifies the reason for this. Despite the scientific nature of stage-based models to describe innovation assimilation, this research proposes the use of an aggregate measure to operationalize BDA assimilation. Earlier study investigated the role of aggregation in the measurement of IT-related organizational innovation and identified some circumstances when aggregated measures are favourable (Fichman, 2001). Among these circumstances, antecedents that have the same direction in all assimilation stages are suitable for aggregation. Aggregation across assimilation stages can be more robust and generalizable and promote stronger predictive validity (Fichman, 2001). The proposed research model has all of the predictors in the same direction across all assimilation stages. Therefore, to increase the generalizability and predictive validity, present paper has aggregated behaviour across the assimilation lifecycle within an organization.

2. Antecedents of Innovation Assimilation

In this section the literature of TOE framework is introduced to identify the antecedents of innovation assimilation. The TOE framework identifies the influencing factors under the technology, organization, and environment categories that can impact IS-related decisions (Mishra et al. 2007). For example, a study investigates the intention of discontinuing information systems (Furneaux et.al, 2011). Another study employs the TOE framework to investigate EDI adoption in small businesses (Kuan and Chau, 2001). One of the research studies investigates six variables drawing upon the TOE framework to successfully differentiate non-adopters from adopters of e-commerce (Hong and Zhu, 2001). A recent study explores how factors within the TOE framework influence the e-business assimilation at the organizational level (Zhu et al., 2006b).

The TOE framework has substantial consistent empirical support in the literature. Thus, it provides a foundation for the analysis and consideration of suitable factors for understanding an innovation-adoption decision. Therefore, present research draws upon this framework to understand the influence of antecedents within each sub-category.

Regarding the technological context, classic DoI (diffusion of innovation) theory (Rogers, 1995) identifies five innovation characteristics including: (1) *relative advantage,* which means "the degree to which an innovation is perceived as being better than the idea it supersedes."(Rogers and Shoemaker 1971, p.213) (2) *compatibility*, which is defined as "the degree to which an innovation is consistent with existing business processes, practices and value systems"; (Rogers and Shoemaker 1971, p.223) (3) *complexity*, the degree to which an innovation is difficult to use; (Rogers and Shoemaker 1971, p.230) (4) *observability*, the degree to which the results of an innovation are visible to others; (Rogers and Shoemaker 1971, p.232) (5) *trialability*, the degree to which an innovation can be experimented with (Rogers and Shoemaker 1971, p.231). Among these factors the first three are most frequently

used to explain and predict innovation diffusions and therefore this study proposes to include them as technological factors in the research framework.

According to Iacovou et al. (1995), *organizational context* describes the characteristics of an organization, which mainly include firm size, degree of centralization, formalization, complexity of its managerial structure, the quality of human resources, and amount of slack resources available. These factors could help explain why some organizations are more innovative but others are less prone to innovate. One of the studies capture that the diversified performance differences of innovation diffusion are due to the significant differences in the resources the firm possess, which include managerial knowledge, technology infrastructure, and prior experiences with IT (Mishra et al., 2007). Other studies also suggest that the value firms obtain from IT is dependent on their skills to leverage it (Bhardwaj 2000; Mata et al. 1995). Firms that possess strong managerial capability and prior IT experiences can utilize agile technology like BDA technology more efficiently than their competitors. Therefore, present research includes managerial capability, IT infrastructure and absorptive capacity which is regarded as organizational resources as antecedents.

Environmental context is the arena in which a firm conducts its business -the industry, competitors, and dealing with government (Tornatzky and Fleischer, 1990). DiMaggio and Powell's institutional theory proposes that institutional environment provides rule-like social expectations and norms for appropriate organizational structures, operations as well as behaviors and practices. The firm's perceptions of these pressures affect its interpretation of the environment in general and innovation intentions in particular. Thus, this study investigates factors within the institutional pressure that will impact BDA assimilation processes. Institutional pressures are classified into three categories: coercive pressure, normative pressure, and mimetic pressure.

Coercive pressure is defined as the pressure originating from political influences exerted by the powerful firms on which the focal firm depends (Paul and Powell, 1983). This pressure is mainly from dominant suppliers and customers because these dominant partners hold resources organizations need such as new business contracts or funding.

Normative pressure refers to the perceived extent to which members of the dyadic relational channels have adopted the innovation and the extent to which the government and industry agencies promote the use of information technology (Paul and Powell, 1983). In the proposed model, we use regulatory support as the normative pressure that will influence BDA's assimilation processes.

Mimetic pressures are those that make an organization imitate others when the organizational technologies are poorly understood, goals are ambiguous, or the environment is uncertain (Paul and Powell, 1983). Because BDA standard is still uncertain and investment is irreversible which means the market of BDA is still uncertain. Companies will follow others that have successfully implemented this technology. Meanwhile, fierce competition makes companies imitate those enterprises that have already successfully adopted this technology. Therefore present research includes environmental uncertainty and competition intensity as the source of mimetic pressure.

3. Research model and Propositions

In this section, a research model to explain and predict BDA assimilation for Indian firms is proposed. As introduced in the previous section, the TOE framework is used to identify antecedents that impact BDA assimilation. In Figure-1, the theoretical model is described.

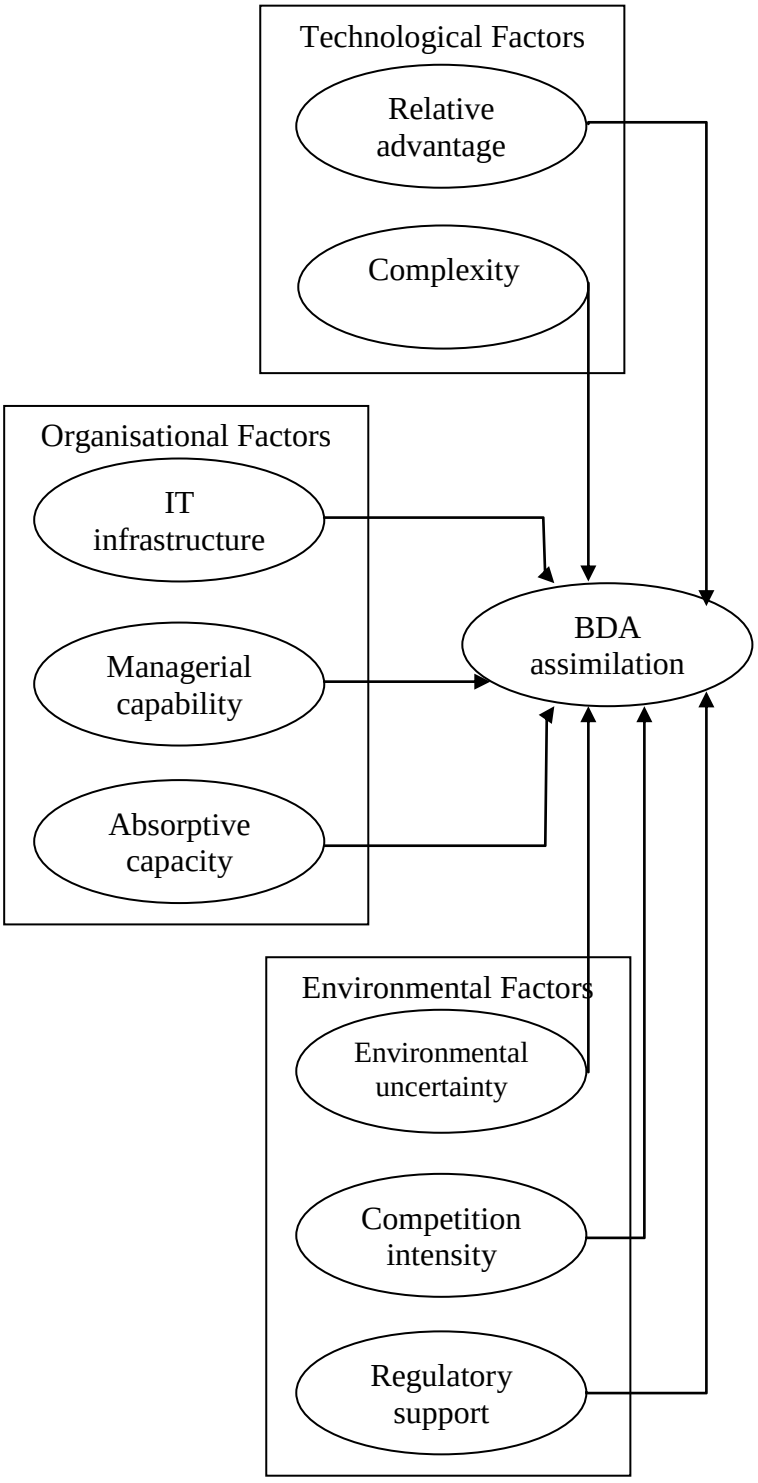

Figure-1 Proposed research model

3.1 Predictions Related to Technological Factors

In this section, influencing factors related to the technological context are introduced. Factors within this context include relative advantage and complexity.

3.1.1 Relative advantage.

Several studies have used relative advantage to predict innovation adoption and diffusion. For example, considering RFID (Radio Frequency Identification) technology as one of the agile technologies of last decade, there are some studies on RFID adoption, one by Tsai et al. (2010) who investigated RFID adoption in the Taiwanese retail industry and found that relative advantage had a positive impact on RFID adoption. Besides this study, Wang et al. (2010) investigated determinants of RFID adoption in the manufacturing industry and they also found relative advantage has a positive effect on RFID adoption. Zhu et al. (2006a) investigated determinants of post-adoption stages of innovation diffusion, using enterprise digital transformation as an example of innovation. Their results indicate relative advantage positively influence e-business usage. Ramdani and Kawalek (2009) predict SME's adoption of enterprise systems and suggest that the greater the perceived relative advantage of enterprise systems, the more likely they will be adopted by SMEs (small and medium enterprises). Kwan and Chau (2001) investigate adoption of EDI technology and suggest that relative advantage is a key factor within the technological context that can influence EDI adoption.

Following these studies, relative advantage may be an important factor that motivates organizations to adopt BDA technology. Decision makers will evaluate whether this technology has relative advantage over traditional systems. Compared to traditional systems, BDA can help companies in several aspects, for example, in tracking, controlling, decision-making and innovating in real-time. If integrated with

other backend systems, BDA can reduce the lead time, improve efficiency, and reduce labor costs. The preceding observations suggest the following proposition.

P1. Organizations that perceive the relative advantage of BDA will have a high degree of assimilation.

3.1.2 Complexity.

Complexity is defined as "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers and Shoemaker 1971, p.230). In the BDA context, *complexity* may be the immaturity of BDA technology, lack of common standards, the difficulty of integrating BDA with the existing enterprises' information systems and business processes.

Thus, complexity of innovation should also be analyzed to make sure that an organization has enough financial and human capital to overcome the difficulties during implementation process.

Complexity includes two components: the challenges of customization and high costs (Tsai et al., 2010). BDA systems should be customized for a specific working environment. There is a great need to adjust the BDA backend system and existing IT systems for better co-ordination like as data transmission. The second complexity involves the high investment or maintenance costs. Costs related to BDA operations including skilled manpower and IT infrastructures are high and irreversible.

Costs are further exacerbated by the absence of uniform BDA standards. Companies that perceive high technology complexity will act more cautiously in adopting BDA and assimilate it into their enterprises. Accordingly, following proposition may come out.

P2: Organizations that perceive high complexity of BDA will have a low degree of assimilation.

3.2 Predictions Related to Organizational Factors

Besides technological context, factors in the organizational context can also influence BDA assimilation processes. We include IT infrastructure, managerial capability as well as absorptive capacity into the organizational context and investigate their influence.

3.2.1 IT infrastructure.

Regarding IT infrastructure, Grant (1991) classified IT-based resources into three categories: (1) the tangible resource comprising the physical IT infrastructure components; (2) the human IT resources comprising the technical and managerial IT skills; (3) the intangible IT-enabled resources such as knowledge assets, customer orientation, and synergy.

According to resource-based theory, tangible resources enable firms to assimilate innovations more quickly and improve products (Bharadwaj 2000). Compared to a less developed and non-integrated IT infrastructure, a highly integrated IT infrastructure provides a platform to launch innovative IT applications faster than its competitors (Bharadwaj 2000). Therefore, tangible resources are relevant factors that might influence BDA assimilation processes.

Human resources include two components: technical IT skills and managerial skills. Since BDA assimilation process would entail significant changes of the business processes and IT infrastructure, managerial capability would play an important role in coordinating activities related with process redesign (Zhu et al. 2006b). Technical IT skills become important in the analysis, design, and implementation of changed business processes.

Intangible resource includes customer orientation, knowledge assets and synergy (Bharadwaj 2000). Previous research suggests that customer orientation has a significant role on innovation assimilation.

Since BDA can shorten, for example, the lead time from requirement generation to manufacturing to customers, it can radically improve the customer services. If a company is more customer-oriented, it will consider improving customers' satisfaction through introducing innovations such as BDA technology. Thus, customer orientation might be a significant sub-factor that has significant impact on BDA assimilation.

Knowledge asset refers how the knowledge, skills and experiences of the employees in an organization are embedded in its processes, policies, and information repositories (Bharadwaj 2000). Knowledge assets are also critical for the BDA assimilation, because if a firm has strong repositories of knowledge and skills in their employees, it will be easier for them to assimilate new innovations.

Synergy is defined as sharing of resources and capabilities across organizational divisions (Bharadwaj 2000). The firm that can share knowledge and information across its functional units is more flexible and can react faster to address needs. Because BDA technology has the power to share information across all key divisions like as marketing, warehouse, purchasing, production or R&D divisions across a company, it provides an excellent way to share resources and information. Thus, synergy of intangible resources should also relate positively with BDA assimilation, and we include it into our research model.

Based on the above review, physical IT infrastructure, human IT resources, and intangible resources should all have significant positive influences on BDA assimilation. A firm's IT infrastructure is a major business resource and a key source

for maintaining long-term competitive advantage (Bharadwaj, 2000). Therefore, we include IT infrastructure as an antecedent of BDA assimilation process and postulate sophisticated IT infrastructure enable organisations to assimilate BDA successfully.

P3. Increased sophistication of IT infrastructure will lead to increased BDA assimilation.

3.2.2 Managerial capability.

In a way BDA is a sweeping innovation that can radically change the strategic planning to operational processes of any organization, but doing so requires substantial managerial capability. Technologies that enable more radical improvement require substantial complementary changes to organizational structures, routines, and policies (Fichman, 2004). Consequently, BDA assimilation requires changes regarding organizational and process adaptations (Chatterjee et al. 2002). However, not all firms can manage adaptation effectively because they lack managerial skills and know-how for change management (Robert et al., 2003). Thus, the effect of *managerial capability*, which refers to the capability of managing organizational adaptation to accommodate BDA assimilation (Zhu et al., 2006b) is important to investigate.

Organizational adaptations regarding BDA assimilation include making organization changes on structures and coordination mechanisms (Chatterjee et al., 2002), and acquiring new expertise necessary to use the innovation (Fichman, 1999). Several studies explain IT failure as a frequent result of management issues such as lack of synergy between business and IT skills, knowledge on how to integrate the technology with the business strategy, how to acquire skilled technical people and train them to use the BDA systems. Such broad management failures suggest that

managerial obstacles can impede BDA assimilation when organizations cannot make organizational changes, redesign business processes, and acquire new expertise. Therefore, we posit that organizations that have advanced managerial capability can assimilate BDA smoothly than those that do not have enough such capabilities.

P4: Organisations with mature managerial capability have a high level of BDA assimilation.

3.2.3 Absorptive Capacity.

An organization's *absorptive capacity* is represented by its ability to recognize the value of new, external information, absorb it, and apply it for commercial ends (Cohen and Levinthal, 2006). Also effective absorptive capacity can be determined by prior relevant knowledge and intensity of effort (Cohen and Levinthal, 2006). Existing literature regard absorptive capacity as a knowledge base, especially the extent of prior knowledge the firm possess (Lane et al. 2001b). This is similar to *path dependency*, which is a firm's ability and incentive to adopt an innovation. It can be largely determined by its level of related experience with prior relevant technologies (Hassan and Chatterjee 2006). Such skills and knowledge are critical for successful adoption of new technology standards (Cohen and Levinthal, 2006). Thus, firms which have prior experiences *and knowledge* with related technology may have developed technical and managerial skills for deploying BDA technology compared with those firms without such experiences. Accordingly, following proposition may be suggested.

P5: Organisations with strong absorptive capacity have a high level of BDA assimilation.

3.3 Predictions Related to Environmental Factors

In this section, environmental factors are introduced that can impact BDA assimilation processes. In the proposed research model, environmental factors include competition intensity, regulatory support as well as environmental uncertainty. The reasons to include these factors are illustrated in the following part, and based on these factors three propositions are taken into consideration.

3.3.1 Environmental uncertainty.

As indicated in an earlier research, firms facing environmental uncertainty have greater incentives to adopt IOS (inter-organizational innovation) to improve information exchange and to reduce uncertainty between trading partners. Firms facing higher environmental uncertainty will sense more opportunities, are proactive and innovate more than other firms (Sharma, 2000).

Furthermore, market uncertainty forces organizations to adopt and implement new technological innovations to stay competitive (Bolloju and Turban, 2007). However, this situation might be different in India. Market uncertainty may have a negative influence on an Indian firm's proactive and innovative strategies and behaviors. The reason is that Indian firms are more risk averse than say, Western firms. Consequently, without external support from their business partners in the industry, they are less likely to take initiative to adopt BDA and associated technologies.

Moreover, adopting BDA technology requires considerable irreversible investment costs which mean risk to Indian enterprises. Compared to traditional analytics system, the cost of implementing BDA technology would be much higher especially for low-profit making organizations. This problem is even more serious for

the low-end product industry such as toys and clothes but not so serious in higher-end consumer products, such as smart phones and computers. Thus they are less likely to run the risk and be pioneer to adopt BDA technology.

Regarding standards uncertainty, the Indian government is yet to develop its own BDA standard, which adds unique uncertainty to the Indian market.

Additionally, there is still challenge about who is responsible for drafting the BDA standards. Currently this unclear responsibility inhibits the standards confirmation and thus inhibits the assimilation process. Taking these factors into consideration, we posit that BDA assimilation in India would be negatively influenced by environmental uncertainty.

P6. Environmental uncertainty negatively influences BDA assimilation in India

3.3.2 Competition intensity.

Competition intensity is "the degree that the company is affected by competitors in the market" (Zhu et al. 2004, p.24). The classic five-force competitive model (Porter, 1980) indicates that competitive pressure is an important external driver to initiate the deployment of IOS (inter-organizational innovation) among trading partners. Hence, competition intensity is likely to play a role in BDA assimilation.

This may be understood with an example of economic reform practices followed by another Asian economy –China. China's economic reforms towards a market economy promote more trade and encourage more foreign direct investment (FDI) since its economic reforms in 1979. These incremental trade and FDI contribute to China's economic growth. China has become the second largest FDI recipient in the world—after the United States—and is the largest host country among developing

countries (Fu, 2008). These FDIs bring capital, knowledge, and new managerial skills to the country. Their participation increases competition in the domestic markets which raises challenges to Chinese enterprises' technology and managerial capabilities. Recent opening of FDI in India too would likely to have more or less similar challenges in the long run. To meet these challenges, adoption of new technology such as BDA is necessary to increase their competitive advantage. Thus, we have following proposition.

P7: Competition intensity will positively influence BDA assimilation.

3.3.3 Regulatory support.

Regulatory support is a critical factor influencing innovation diffusion (Zhu and Kraemer 2005; Zhu et al. 2006b). There are two ways which could affect innovation diffusion. "One way is to take tax and other measures to increase or decrease payoff, the other way is to alter the climate in which they are received" (Williamson 1983). Another study investigates the assimilation of e-business and finds that governments can encourage e-business legislation by supportive regulations and policies (Zhu et al., 2006b).

These issues are particularly important in Asian countries. Another study investigates, for example, the assimilation process of Internet technologies in China and finds that Chinese companies have the highest concern for the regulatory environment in which they and their business reside (Chau et.al., 2008). In our research, since currently Indian government is executing the twelfth five-year plan and has plans to invest in R&D of the Internet and allied sectors like cloud computing, and develop digital and virtual technologies, BDA technology would be the key enabler of the Internet and digital world. Regulatory support from the government can

form an encouraging environment that will make decision makers aware of this technology and consider adopting it in their enterprises. Therefore, following proposition is suggested.

P8: Government regulatory support will influence assimilation of BDA technology in India positively.

Conclusion

Big Data Analytics (BDA) is an emerging technology that is being used in many echelons of business and management. Since recent IS research about this technology lack focus on the factors that impact its organizational adoption, present paper has proposed the antecedents that influence BDA assimilation in the context of Indian firms drawing upon diffusion of innovation (DoI) theory (Rogers E.M., 1995), institutional theory (Paul J.D. and Powell W.W., 1983), and Technology-Organization-Environment (TOE) framework (Tornatzky L.G., Fleischer M., and Chakrabarti A.K., 1990).

Organizations that perceive the relative advantage of BDA, increased sophistication of IT infrastructure, mature managerial capability, strong absorptive capacity, Competition intensity, and Government regulatory support will positively influence assimilation of BDA technology in India. On the other hand, organizations that perceive high complexity of BDA and environmental uncertainty will have a low degree of assimilation.

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