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E-GOVERNMENT SERVICES ADOPTION AND INTERDEPENDENCE: GRANGER CAUSALITY ANALYSIS

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ABSTRACT

Adoption of e-government services varies across different categories of services: government to citizen services, utility services, commercial services, informational services, social benefit services and mobile based services. Faced with the constraint of limited resources, policy makers face the challenge of resource allocation among these categories of services. Prioritizing among the different categories of services can help policy makers in resource allocation. This paper attempts to address this challenge by showing the applicability of Granger causality analysis in studying the causation analysis between the categories of e-government services. We show the applicability of Granger causality analysis in understanding the interdependence between e-government service categories by analyzing real transactions data of six categories of e-government services in India. Our analysis shows that the growth of inquiry services is positively impacting the growth of government to citizen transactions is statistically significant. Besides this, both utility services and mobile based services show significant bi-directional Granger causality with government to citizen services. We also discuss policy implications of our analysis.

KEYWORDS: E-society; E-government; E-transaction; Adoption; Granger causality; India

INTRODUCTION

E-government is considered a new phenomenon (Heeks & Bailur, 2007). The phenomenon of e-government is hardly two decades old (Bélanger & Carter, 2012).

Being new, the implications of e-government should not be underrated (Njuru, 2011). The impact of e-government is enormous, e-government has capability to change and revolutionize the world (Lau, Aboulhosen, Lin, & Atkin, 2008). It has the ability to induce the virtues of governance within society (West, 2001) and reduce the ills present within society (Chhabra & Jaiswal, 2009). Being such an important social phenomenon this field needs more and more attention from researcher (Zhang, Xu, & Xiao, 2014). This study attempts to contribute to the field of e-government by studying one of the critical aspect of e-government i.e. prioritization among e-government service categories so that it can help in better adoption of e-government services within the society.

Multiple e-government projects are initiated by the government to achieve their objective of delivering government services electronically to the citizens as well as of making government processes more efficient and transparent. Each of these projects deliver different categories of services. Few projects deliver essential government to citizen services like driving licenses, birth certificates etc., and some projects delivery utility services like payment of utility bills online. Similarly, there are projects that deliver commercial services, informational services, social benefit services and mobile based services. Adoption of services among this project is not uniform, some projects may be successfully adopted by the citizens while other projects may lag behind.

Policy makers have the challenge of devising strategies that can lead to better adoption of the projects. Government always have the constraints of time and resources as a result there is an urgent need to prioritize among the projects providing e-government services. Should all projects be equally treated or adoption of some categories of services be given higher priority as they can led to faster adoption of some other categories of services because of interdependence between them? Our study attempts to answer this question. This paper proposes and validates an approach that can help reveal the interdependence among the categories of e-governance services that can provide insight to policy makers for better prioritization of the e-governance services.

In this paper, we use time series econometrics to establish causation among various services of e-government. The analysis is done on the e-government transactions data collected by Government of India (GOI). GOI divides these transactions data into six categories. The e-government transactions data we use in this research occur in real time. Therefore, they reflect the true characteristics of e-government services adoption among the citizens.

Most of the studies on e-government adoption are project specific, a particular e-government project initiative is considered as the unit of analysis and data specific to that project are used to study adoption related issues. To the best of our knowledge, we are not aware of any study that combines two or more projects delivering e-government services to understand adoption challenges. Therefore, our

study is unique in two aspects. One, it combines six types of e-government services in one study. Two, it uses time series techniques to establish the causation in e-governance domain.

We organize the remaining parts of the study into six sections. The first section reviews the literature of e-government since its inception. The second section elaborates the methodology and theoretical foundation of the study. The third section explains the measurement and data collection process. The fourth section conducts the causality analysis of the data available from the previous section. The fifth section discusses the results of the analysis of section four. The final and sixth section concludes with policy implications that are inferred from the findings of this research.

LITERATURE REVIEW

The result of literature review suggests that there are five main themes of e-government research. First, regional context is given a lot of importance in e-government research (e.g. Lau, Aboulhosen, Lin, & Atkin, 2008; Thamer, 2010; Voutinioti, 2014). For example study of Lau et al. (2008) is a qualitative research. Authors conduct this study in the particular context of developing South American nations. Second, antecedent factors of the e-government adoption (e.g. Carter, 2008; Shareef, Kumar, Kumar, & Dwivedi, 2014; Susanto & Goodwin, 2010). These studies consider e-government as a global concept. Shareef et al. (2014) study revealed that the two antecedent factors, one, ability to use and second, assurance to use are the critical factors for adoption of e-government services in Canada. Third, moderating factors for e-government adoption (e.g. Moreno, Rufin, Molina, Figueroa, & Moreno, 2013; Warkentin et al., 2002; Weerakkody, El-Haddadeh, Al-Sobhi, Shareef, & Dwivedi, 2013). The newness of these studies is that they focus on the moderating variable of e-government adoption and environment concept. For example in a study of Moreno, Rufin et al., (2013) gender has been found a significant moderator of e-government adoption. Fourth, on barriers to e-government adoption (e.g. Abu-shanab, Al-rub, & Nor, 2010; Gilbert, Balestrini, & Littleboy, 2004; Savoldelli, Codagnone, & Misuraca, 2014). Fifth, unique services of e-government, for example, government servant and public sectors (e.g. Lawson-Body, Willoughby, Illia, & Lee, 2014; Salleh, Rohde, & Green, 2006; Zafiroopoulos, Karavasilis, & Vrana, 2012). Other subjects of studies focuses on formation of models for e-government adoption (e.g. Lim, Kim, & Lee, 2013), outcome of e-government adoption (e.g. Alhamidah, 2007), role of satisfaction in e-government adoption (e.g. Chan et al., 2010), connection of e-business to e-government (e.g. Tung & Rieck, 2005), influence of culture (e.g. Carter & Weerakkody, 2008) and demographic parameter (e.g. Kumar, Kumar, &

Mahmud, 2011) on e-government adoption. All the popular five themes of studies including other not so frequent themes are conducted on the basis of analyzing an e-government project as a single unit of analysis.

The majority of the studies referred in the previous section was conducted considering e-government as an integrated concept and explored the relationship of e-government to its environment. Although there are some studies that focus on e-government phenomena at the service level or disintegrated level (e.g. Azad & Faraj, 2009; Liang & Lu, 2013; Sang, Lee, & Lee, 2009) but these studies are very few. Azad & Faraj (2009) conducts a qualitative research aimed to find the practice of institutionalization of automated land mapping registration services and their delivery to the public. Furthermore, Liang & Lu, (2013) studied social norms and other antecedents to predict a particular e-government service i.e. tax filing services. The few papers cited above have analysed e-governance adoption at service level and they study only one service at a time. No literature focuses on the interrelationship of two or more E-government services in a single study.

Various disintegrated services of e-government are delivered by a portfolio of e-governance projects, there is a need to study adoption issues by exploring the interdependence among these projects. Based on the literature review conducted, we conclude that multi-dimensional (multi-services) study of e-government is one of the gaps in the existing literature on e-government adoption.

In the context of multi-dimensional analysis, the word dimension can be elaborated as, the distinct factor of e-government service (Duncan, 1972). On this argument, we define the dimension of e-government adoption as adoption of a service. A dimensional analysis provides a new perspective of understanding how a concept is socially constructed and also explores the concept's contextual meaning across these perspectives (Szajna & Ward, 2014). Therefore, a disintegrated level of e-government services may provide a new perspective on e-government's adoption within society. Conceptually aggregate or unified phenomenon is "*whole which occurs in nature as an important type of, individual (which may be physical, biological, psychological, or social)*" (Nagel 1952, p.17). Literature cautions against considering these *aggregates simply as a combination of independent members, but should be regarded as interdependent organic unities* (Nagel 1952, p.17). In the context of our study, whole in the previous line is referred to, total e-government transactions. The independent members that form this whole are individual types of e-government transactions occurring. Nagel (1952, p. 27) says that in relation to sum, the constituent parts are "internally" related, in the sense that these constituents stand to each other in relations of mutual causal interdependence. We substantiate this argument with other studies that have argued that the whole

process of social development is of close relationship. It has been found that growth of one factor reacted back upon the growth of other factors (Bernard 1926, p. 192). Based on these arguments this study attempts to explore the causation relationship among the portfolio of e-government services available in India. Furthermore, it is already explained that we do not find any research at actual transactions of e-government services. Combined with argument of need and gap in the literature our study specific research question can be defines as: *Is there interdependence among various categories of e-government services in India?*

The appropriate measure and methodology used to address the research question is elaborated in the next section

METHODOLOGY AND THEORETICAL FOUNDATION

In earlier sections, we have discussed our study of digital government of India by subdividing the e-government concept at different services level and its uniqueness. This section has three parts. First, we give an overview of the studies conducted on the similar rationale and methodological foundation. The analysis of the methodological literature suggests that Granger causality is one of the commonly accepted ways by which we address causal relationship (Aregbeshola, 2014; Seth, 2010; Zafiroopoulos et al., 2012). Second part elaborates the methodology of Granger causality and its suitability for present study. In the last part, we explain the appropriateness of this method for our study and the potential implication.

Although this study is an exploratory study, we base our research on the causality arguments available in the literature between various related constructs. Causality analyses of different economic constructs are very frequent, and conclusions of these investigations have huge policy impact as in giving hierarchical importance in resource allocation (Chong & Calderon, 2000; Elbahnasawy, 2014; Lio, Liu, & Ou, 2011). These studies conclude the causality relationship between governance, e-government, internet and corruption. The unit of analysis of these studies is at national level. National level time series data are analyzed to establish the causality. Based on the conclusion for various nations, the relative importance of any one construct in policy making may be used for addressing other constructs. Causality analysis studies that use the economics constructs of electricity consumption and national economy (i.e. Javid & Qayyum, 2014; Pao & Tsai, 2010; Yoo, 2005) have been studied many times. Time series yearly data on electricity consumption and per capita national income are the information on which these papers base their causality analysis. In both the examples, the econometrics methodology adopted is Granger causality, which based on the dependency of growth trend among the constructs established causality relationship between them. One such recent study of Pradhan, Maradana, Zaki, Dash, & Jayakumar (2016) investigates the causal relationship between economic growth and various indicators of venture capital

using Granger causality for 19 European countries for the period 1989-2014. Dutta (2001) investigated the Granger causality relationship of level of economic activity within a nation to its telecommunication infrastructure. These studies establish the fact that on the availability of time series data, the method of Granger causality can determine causal relationship between constructs. The earlier mentioned studies use the Granger causality approach in time series form of data. Granger causality approach can also be applied to panel data. Dewan & Ramaprasad (2014) uses Granger causality approach in panel data context. They investigate the causality relationship between music sales to the social media and traditional media. Lio, Liu, & Ou (2011) investigated the effects of Internet adoption on reducing corruption using a panel Granger causality approach. Similar to the most of the previously explained study, this study is also a national level study consisting of 70 countries and for data ranging from 1998-2005. The above examples demonstrate the applicability of Granger causality approach to establishing the causal relationship between various variables.

In India since first January 2013, on a daily basis, the government of India is collecting e-government transaction data under project e-taal. E-taal is a government web portal that provides e-government services transactions details at national and state level (Department of Electronic & Information Technology, 2015). More than 2 years of e-government project transactions data for all the states of India can be found in the portal. E-taal portal details are elaborated in the next section. This enormous data is still unutilized (Pandey & Bhatnagar, 2014). No research has discovered any insights from these transactions records. We conduct this study with an objective of bridging this gap. We have already mentioned that no prior research has been carried out at disintegrated level causality analysis of e-government transactions. Furthermore, there are no conceptual studies that try to understand e-government phenomena at disintegrated level. Therefore, this study does not stand on any theoretical foundation, instead tries to derive inferences from transactional data. Though we do not base our study on a strong conceptual and theoretical foundation, it finds its justification from the methodological framework as already explained. Time series econometric analysis and Granger causality are the methodological foundations on which we have built this study. Next part of this section describes the contribution of Granger's work in establishing causality that was absent prior to his efforts.

In most of the research studies, causality is inherited from literature. Statistically defining causality even today is complex, and it was entirely unknown, till Granger (1969).

Historically Wiener(1956) first time provided the concept of a causal relationship between one variable to another (Bressler & Seth, 2011). However, he could not explain it in complete. In 1969, econometrician Clive Granger (1969) mathematically resolved this issue. The basic idea of Granger Causality is simple. Let us assume that there are two variables X and Y. In which we are interested in predicting causality of Y based on X. Next we attempt to predict $Y(t + 1)$ (next Y) using only past Y. We also try to predict $Y(t + 1)$ using previous terms of both X and Y. If the second prediction has better significance, we conclude that past of X is capable of predicting $Y(t + 1)$ (Bressler & Seth, 2011). Therefore, establishing causation of X on Y. The contribution of Granger causality is so much that in the year 2003 Clive Granger received Nobel Prize for economic science. The potential of establishing causality by Granger method is widely accepted in many other fields that apparently seems far from economics. Field of medicine uses Granger causality to successfully established the causal relationship, that too neurophysiological characteristics of the brain (Kamiński, Ding, Truccolo, & Bressler, 2001). Although there is an enormous application of Granger causality, Granger (1988- p.199) has cautioned the use of this causality stating “these tests are useful, but we should evaluate this with care.” There are certain limitations with Granger causality, as the name itself suggest that it is Granger causality and not the real causality (Olusanya & Matthew, 2012). Even though, this fact does not reduce the contribution and applicability of Granger causality in social science research. Granger causality might not be a sufficient condition of causality but there are innumerable studies that established it as a necessary condition for causality establishment (Bonamini, D’Apice, & Forte, 2015; Evans & Wells, 1982; Phylaktis & Ravazzolo, 2005).

Considering the applicability of Granger causality analysis and availability of relevant time series data this article attempts to study the causation analysis of one category of e-government service on another. There is a fair chance of causality analysis of transaction data establishing causation but being a new phenomenon, various services of e-government may not be interdependent. In both scenarios this study can provide valuable insight because if interdependence is established then policymakers can get information on the hierarchal importance of various e-government services, that will guide them to utilize their valuable resources at high hierarchical services for better adoption of e-government. And if no interdependence exists, it will establish the fact that e-government services as of now are independent in nature. Therefore, individual services may be started and adopted by society irrespective of the success of each other.

MEASUREMENTS AND DATA COLLECTION

Yildiz (2007) define e-government as “utilizing the Internet and the World-Wide-Web for delivering government information and services to citizens”. Schillewaert, Ahearne, Frambach, & Moenaert (2005) define adoption as “the extent to which a particular technology is used”. These two definitions together we represent e-government adoption as the degree to which citizens are using government information and services through

Internet and World-Wide-Web. Since the data of e-government transactions are available on the national website, we base our analysis on this data.

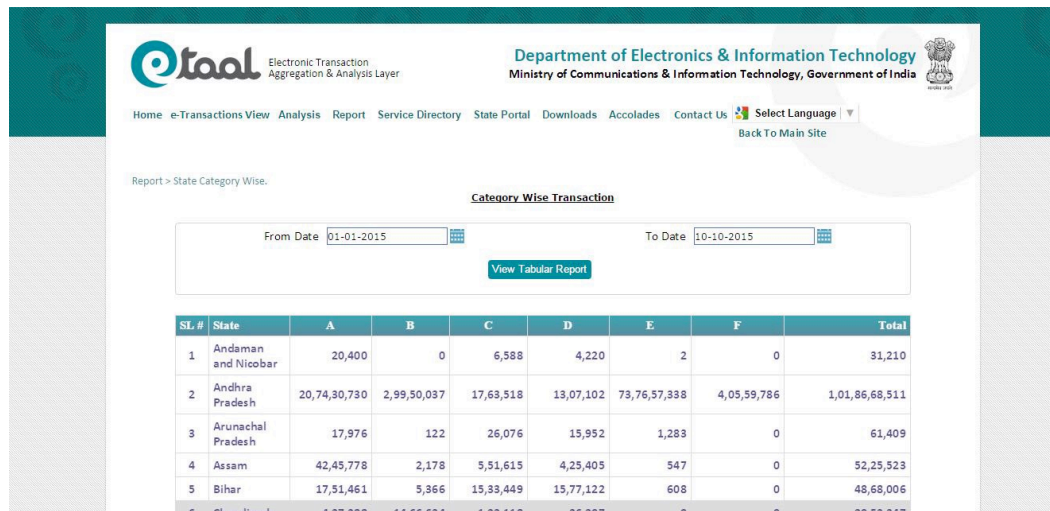


Figure 1-E-taal Website of E-government Transaction Data

E-taal (Figure 1) stands for electronic transaction aggregation and analysis layer. It is a web portal of Ministry of Information and Technology, Government of India. This web portal disseminates the electronic transactions statistics at national and state level, which belongs to their e-government projects (Department of Electronic & Information Technology, 2015). This data is the actual e-government transactions happening in India. Therefore, by the definition of e-government adoption mentioned above in the first part of this section, we categorized this as an amount of e-government adoption at the aggregate level. We can disintegrate this data on a daily basis at the state level and various category of services level. The database receives information from electronic transaction statistics from web-based applications from time to time on near real-time basis (Department of Electronic & Information Technology, 2015). Portal classifies e-government services of India under six category (DEIT, 2015). A type

of services belongs to statutory and non-statutory services. B is for utility bill payments. C is a business to citizen transactions. D is informational services. E is transactions related to social benefits. F is the sixth category of e-transactions is of mobile government. The individual services included under these broad categories are as shown in table 1.

These six types of e-government services are quite different to each other. A category is more of mandatory e-government services, B is utility services, C is commercial, D is informational, E is of social benefit, and F is mobile-government. Based on the mutually distinct type of services and reasoning of previous literature, different adoption pattern is argued. Date wise all the types of e-government transaction are downloaded from 1st Jan 2013 till 30th April 2013 from the website. Analysis is done on the data from these days.

Table-1 E-government services of Government of India

S.N.	Types	Broad classification of services	Detail of services
1	A	Statutory and non-statutory services	Certificates Tax Public distribution system
2	B	Utility bill payments	Electricity bill Water bill
3	C	Business to citizen transactions	Banking transactions Mobile recharge DTH recharge Addition deletion of telephone numbers

			Do not call registry of mobile phones
4	D	Inquiry services	Downloading the tender and other forms PNR railway inquiry Examination results
5	E	Social benefits transactions	Pensions MGNREGA Direct benefits transfer (DBT) Various scholarships payments
6	F	Mobile transactions	End to end mobile transactions

ANALYSIS

Data for the further study was downloaded from the website www.etaal.gov.in as explained in previous section. The numbers of transactions recorded on this site in a single day are in order of millions. For some services, for example, A type of government services, this number is more than half of the total transactions. For some other services like F, mobile transactions some days are only in thousands. The disparity in the volume of data across services is visible. Literature in the case of such variation and nature, suggest logarithmic conversion of data for further analysis. Therefore, daily transactions obtained from the above mention source were converted to log values. Table 2 shows the descriptive statistics of the data.

Furthermore, the differences of log values of the transaction will give us the relationship between the growth rate of various services that is most advantageous for policy and business implication. Policymakers are interested in the causality that governs the growth pattern of these services. Furthermore, business houses especially e-commerce organization are interested to know services growth pattern correlation to e-commerce growth, so that they may prioritize their e-commerce operation.

Table-2 Descriptive statistics.				
	Minimum	Mean	Median	Maximum
log(Transactions of Category A	13.28	14.86	14.81	15.6
log(Transactions of Category B	12.56	13.64	13.69	15.9
log(Transactions of Category C	7.169	8.615	8.542	9.423
log(Transactions of Category D	10.41	11.8	12.05	13.6
log(Transactions of Category E	8.113	11.13	11.79	17.34
log(Transactions of Category F	8.515	10.58	10.69	12.8
Number of states/ Union	36			
Number of observations =	120			

We use differences in the log value of the transaction for further causal analysis. We use R statistical software 3.01 version for further analysis of this data. We do the complete analysis of establishing Granger causality in five steps. First, stationarity of the data is assured. Data that is constant in mean and variance across the time is the essential condition for further analysis in time series. Therefore, stationarity of the log of transactions was checked. For the purpose of this augmented Dickey-Fuller test was conducted. Second, since the raw transaction data obtained from the website was not stationary, the difference of these operations was calculated. Third, stationary of the difference was checked. Fourth, after establishing the data as stationary, the appropriate lag number is next requirement for time series analysis. From the nature of data of government services it was assumed that it will be reflecting a weekly trend. Furthermore, this assumption was statistically established by VARselect feature of R software. Fifth, differenced log data was found to be stationary hence we use this for Granger causality analysis for a lag period of seven days. Table 3 shows the results of the augmented Dickey-Fuller test.

We examine all the types of e-government services for the alternate Hypothesis of Stationarity. They are found to be stationary at 99 percent significance. After the establishment of the stationarity of the data number of lag to be used in the

analysis is critical. The earlier researchers have found that lag length has significance relation with Granger causality, and inappropriate lag length may influence the causality (Elbahnasawy, 2014). Table 4 elaborates the program suggested lag period for Granger analysis.

S.N.	Difference in log of Variable	Dickey-Fuller Value	Significance Level
1	A	-9.9293	.01
2	B	-11.0044	.01
3	C	-7.6495	.01
4	D	-6.5685	.01
5	E	-6.0476	.01
6	F	-7.6323	.01

S.N.	Variable	AIC*	HQ**	SC***	FPE****	Length used
1	A	7	7	6	7	7
2	B	9	7	7	9	7
3	C	7	7	7	7	7
4	D	7	7	6	7	7
5	E	2	2	2	2	7
6	F	6	6	6	6	7

*Akaike's information criterion (AIC),

**Hannan-Quinn information criterion (HQ)

***Schwarz's Bayesian information criterion (SC)

****Final prediction error (FPF)

Lag length analysis is providing approximately as initially argued seven-day dependability of data. For the purpose of simplification, in final Granger analysis, seven-period lag length was used for all the variable A to F. Granger causality analysis was conducted for all the possible pairs of services. Out of the 15 possible pairs only five pairs were found to have significant causal. Two out of these five are bi-directional and one uni-directional as shown in Table 5.

1	B → A	0.0001593 ***
2	A → B	0.002378 **

3	D \longrightarrow A	0.04068 *
4	F \longrightarrow A	0.001785 **
5	A \longrightarrow F	0.01732 *
Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1		

DISCUSSION

The significance level presented in table four of the previous section suggests that there are reasonable evidence to conclude that some e-government services of India are dependent on other e-government services in terms of their growth pattern. Out of the six types of e-government services, we found A category of services i.e. government to citizen statutory and non-statutory services e-transactions as the most critical service. A variety of services is part of all the five significant causality directions. Services A, B, and A, F are mutually dependent on each other, therefore, shows bi-directional causality. Bi-directional causality implies there is mutual growth dependability relation between electronic utility services and government to citizen statutory and non-statutory services. The growth rate of one directly impacts the growth of another. The same conclusion is correct for the end to end mobile services and government to citizen statutory and non-statutory services. They both are found to cause each other significantly. Service category D i.e. inquiry services has been discovered as a significant antecedent to service A i.e. government to citizen statutory and non-statutory services e-transactions performed. This conclusion is in confirmation of the conceptual model of e-government adoption proposed by Layne & Lee (2001) and Andersen & Henriksen (2006). Service category C and category E are not found to play any causality significance as per the analysis conducted.

The insight that category E services i.e. social benefits services are independent is a valuable insight for government as they can formulate policy and spend more resources on adoption of E category services in a region even if citizen statutory and non-statutory services in category A or other category services are not adopted in that region. Similarly, C category i.e. business to citizen category services adoption can be driven by business organizations in regions even though basic e-government services are not available or adopted in that region.

CONCLUSION AND IMPLICATION

This research offers insight to government for policy decisions on e-government services adoption. No prior research analyzed the relationship among various e-government services. Our research statistically finds the Granger causal relation

among various e-government services. In the absence of causality understanding policy makers either give equal importance to all services or in the case of inadequate resources they may opt to give lesser importance to certain services. This research provides decision makers the insight to prioritize among different e-government services. The services that are found to be bi-directional causal relation are to be kept up in the hierarchical order of importance and functions independent a causal relationship may be held lower in order. This research further establishes the causal implication of e-government information services for the adoption of other e-government services. Therefore, awareness about e-government services will lead to better adoption in society.

Out of the six types of e-government services category provided by government of India, type C is most relevant to a business organization. The C type of transaction does not have any causal relationship with any other services. The relationship between D and A type of e-government services proves the decade old Layne and Lee model. The presence of information and inquiry services leads to the adoption of services by customers. Furthermore, independence of C types of services from the rest of services indicates that e-commerce services can be adopted by citizens even though e-government services are not adopted by the citizens.

LIMITATION OF THE STUDY

We conduct the present study only on the data of Indian Government for four months, from January 2013 till April 2013. Therefore, the results obtained from this study cannot be generalized either in other geographies or to other periods. The trend of technology adoption is dynamic in nature that reflects variation at various stages of adoption (Germain & Dröge, 1995). We conduct this study at an aggregate level of India, which is a much diversified country. A study at the further disintegrated level of Indian states may reflect better insights and will be more useful for policy and practical implications.

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