Accepted Manuscript

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PII: S0378-7206(16)30188-4
DOI: http://dx.doi.org/doi:10.1016/j.im.2016.09.006
Reference: INFMAN 2940

To appear in: *INFMAN*

Received date: 15-9-2015
Revised date: 28-6-2016
Accepted date: 29-9-2016

Please cite this article as: Amit Das, Harminder Singh, Damien Joseph, A LONGITUDINAL STUDY OF E-GOVERNMENT MATURITY, Information and Management http://dx.doi.org/10.1016/j.im.2016.09.006

A LONGITUDINAL STUDY OF E-GOVERNMENT MATURITY

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Abstract

We assembled a panel data set for the period 2002–2008 and fitted a mixed-effects regression model to study how the maturity of e-Government around the globe was influenced by changing levels of affluence, information communication technology (ICT) infrastructure, human capital, and governance. We found that e-Government matured faster with rising affluence (in terms of gross domestic product (GDP) per capita) and improvements in ICT infrastructure. Human capital and the quality of governance had no significant effect on e-Government maturity. The results suggest that a high level of e-Government maturity can be attained purely through investment in ICT infrastructure, without substantial changes to human capital or governance.

Keywords: e-Government maturity, ICT infrastructure, human capital index, governance, panel data analysis, mixed-effects models.

JUNE 27, 2016

1 INTRODUCTION

Though information technology applications in government are decades old, e-Government is a comparatively new phenomenon (Norris, 2010b). Traditional IT in government is inward looking and addresses mainly applications internal to government agencies. Conversely, e-government is outward looking and connects government agencies to external stakeholders such as citizens, businesses, and other government agencies. If the World Wide Web (web servers and browser clients communicating over the HTTP protocol) is viewed as a general purpose technology with the characteristics of pervasiveness, progressive improvement in cost performance, and support for innovation (Bresnahan & Trajtenberg, 1995); e-Government can be conceptualized as the application of this general purpose technology to the specific domain of government. At its core, e-Government uses mostly the same building blocks as retail and business-to-business e-commerce, and faces many of the same technical challenges (e.g., availability, scalability, and security).

While the technology itself might be familiar, e-Government has proven hard to theorize (Norris, 2010b). Sitting at the cusp of public administration and information systems – two multidisciplinary fields in search of their own dominant paradigms – e-Government presents a challenge to native as well as imported theories (Banister & Connolly, 2015). Pre-2000 viewpoints of informatization and infocracy (transformation of government processes and structures through information technology) have been largely supplanted by more critical accounts of the reinforcement of existing power structures, over-government, and surveillance. Expectations of technology-led transformation persist, but are now tempered by organizational inertia and the recognition of diverging interests.

Against this backdrop, many past studies of e-Government can be categorized by their focus on the supply of and/or the demand for e-Government. Studies on the demand side investigate the uptake of e-Government services and the satisfaction of users – how e-Government affects citizens and firms (Badri & Alshare, 2008; Scott et al., 2016). Demand-side research on e-Government also examines the *impacts* of e-Government projects, such as the financial and nonfinancial outcomes. The results from these studies find e-Government to be positively associated with business competitiveness, national economic performance, and environmental protection (Das & DiRienzo, 2010; Srivastava & Teo, 2007; 2008; 2010), and negatively with corruption (Krishnan et al., 2013).

Studies on the supply side examine obstacles e-Government projects face in achieving their goals (Tate et al., 2007; Goldkuhl, 2009) and the demands they place on the back-office functions of government agencies (Almutairi, 2010). They also include measures of "e-readiness" as an enabler of e-Government development, such measures often including technological infrastructure, citizens' skills, and political support. Large-scale empirical studies in this stream of research have explored how a variety of factors influences the adoption of e-Government around the globe. Factors found to have a significant effect include a country's income (gross domestic product (GDP)), the munificence of its macroeconomic environment, the quality of its information communication technology (ICT) infrastructure, the level of trust in the society, and the quality of its public institutions and civic life (Azad et al., 2010; Das et al., 2009; Singh et al., 2007; Srivastava & Teo, 2007; 2010).

With the exception of Ifinedo (2011), almost all the studies that have examined e-Government maturity so far use cross-sectional data (Singh et al. 2007; Srivastava & Teo, 2007) or within-country analyses (Karokola & Yngstrom, 2009; Rakhmanov, 2009). These studies provide useful information comparing e-Government activity in different countries at particular points in time. However, e-Government evolves *over time*, and the factors influencing this evolution cannot be identified from cross-sectional studies. In particular, how does e-Government mature in a country as its affluence, ICT infrastructure, human capital, and governance evolve over time? Cross-sectional studies, which compare countries at one point in time, cannot answer this question.

Furthermore, the apparent relationship between the predictor and outcome variables estimated through cross-sectional analysis may not hold up in longitudinal analysis. A classic case, where the conclusion from cross-sectional analysis, is *reversed* by longitudinal examination, is described in Rosenthal and Rosnow (2013) who cite Hagenaars and Cobben's (1978) study on the rate of religious nonaffiliation among Dutch women over time. Cross-sectional analysis of this data set erroneously suggests that Dutch women became more religious as they got older, when longitudinal analysis uncovers just the opposite, the confusion being caused by differences in religiosity across successive cohorts (later cohorts starting out more religious than earlier cohorts).

An additional concern with cross-sectional studies is the bias in coefficient estimates introduced by the misspecification of models, particularly the omission of potentially relevant predictors. Data permitting, one way to guard against omitted-variable bias is panel data analysis, where we regress period-to-period *changes* in the dependent variable on the *changes* in the independent variables. If the omitted variable (e.g., geography or culture) is time *invariant* for each country, its effect is captured in the intercepts of the regression model. The effect of omitted variables that change at the *same* rate for all countries is picked up by the slope on the time variable. Panel data analysis can thus be restricted to variables that change at different rates for different countries

(GDP, ICT infrastructure, human capital, governance, etc.). Limiting the proliferation of independent variables addresses the width (number of countries) versus depth (number of variables) trade-off (Cruz-Jesus et al., 2016) faced by most longitudinal studies; here we are able to retain 191 countries in our models, reducing the chances of sampling bias.

Driven by these twin concerns, stronger causal inference (Cohen et al., 2003) and robustness to errors arising from model misspecification, we develop and use panel data to examine the drivers of e-Government maturity. Our research question is: how does the maturity of a country's e-Government services change *over time* as it improves its income level, its ICT infrastructure, its human capital, and its governance institutions and processes? Our focus is not so much on comparing the *state* of e-Government maturity in different countries at a point time as on understanding why e-Government matures at different *rates* over time in different countries. Our mixed-effects statistical models allow countries to start at different levels of e-Government maturity at the start of the study window, and then experience different rates of growth over time (random components in intercept as well as slope estimates).

The next section presents in brief the conceptual arguments supporting our choice of variables that bear on e-Government maturity. Next, we describe our methodology and data, before presenting our results. We conclude with a short discussion of our findings, possible limitations, and avenues for future research.

2 **2 CONCEPTUAL MODEL AND HYPOTHESES DEVELOPMENT**

2.1 **2.1 e-Government Maturity**

e-Government maturity may be defined as the extent to which a government has established an online presence (West, 2005). The online presence of governments is realized through the features implemented in e-Government web sites such as free access to online publications, access to databases, and a variety of online services (free and paid). Well-developed e-Government sites use multimedia to supplement text in multiple languages, and allow access from a wide range of computing devices (such as tablets and smartphones). e-Government web sites must make it easy for users to voice their concerns and provide feedback, with special attention to disability access (Jaeger, 2006). Finally, e-Government web sites must safeguard privacy and security even more closely than their commercial counterparts, and present their policies in these matters clearly for all users.

The demanding requirements laid out above for e-Government web sites cannot be met overnight, and e-Government maturity usually represents a continuum of developmental stages, from publishing information to supporting online transactions, with some having progressed further than others (West 2007). Previous research on e-Government has thus conceptualized maturity using an evolutionary approach (Layne and Lee, 2001; Andersen and Henriksen, 2006). In this view, e-government is seen to progress through a series of *stages* as a function of integration and complexity, or as a function of increasing levels of online activity and customer centricity. Such maturity models are useful because they guide practitioners, help the citizenry understand the trajectory of e-Government, and can be used as a communication tool to explain e-Government to third parties (Kim & Grant, 2010).

In this study, we seek to measure and explain e-Government maturity as *demonstrated behavior*, in contrast to other measures that assess the *potential* of a country to enact e-Government. A well-known example of the latter is the United Nation's (UN's) e-Government Readiness Index, which includes, among other components, the state of a nation's telecommunication infrastructure and its level of human capital (United Nations Public Administration Network

(UNPAN), 2003; 2004; 2005; 2008; 2010). Other measures of e-Government potential include the World Economic Forum's Networked Readiness Index (World Economic Forum: 2004; 2005; 2007; 2008; 2009; 2010; 2011), which covers about half to two-thirds of all countries in the world.

The UN and World Economic Forum indices indicate the capacity of a country to engage in e-Government programs, but do not explicitly address its current success in implementing them. Hence, we rely on the evaluation of e-Government web sites by West and his associates at the Inside Politics research center at Brown University. West and his associates examined >1500 government web sites from >190 nations in the summer of each year from 2002 to 2008 (West 2002; 2003; 2004; 2005; 2006; 2007; 2008). Details of the data collected by West are provided in a later section. With respect to stage theories of e-Government evolution, some of West's criteria – databases, security features, and support for digital signatures and credit card payments – bear directly on the capability to deliver service transactions. As a result, our conceptualization of e-Government maturity is focused more on the provision of services than on political activity (Kim & Grant, 2010). Given the wide variation among countries, transaction capability appears to be, in the time frame of the study, a common denominator on which e-Government can be compared across countries.

2.2 **2.2 Determinants of e-Government Maturity**

The determinants of e-Government maturity examined in this study are national affluence (in terms of a country's GDP per capita, adjusted for purchasing power parity), ICT infrastructure, human capital, and governance. These factors have been used extensively in previous studies (Azad et al. 2010; Das et al. 2009; Singh et al. 2007; Srivastava & Teo, 2007; 2010) and shown to correlate positively with the development of e-Government internationally.

GDP: National affluence refers to a country's overall level of wealth, as measured by its per capita GDP. Well-off countries might have spare resources ("slack" in organization theory terms) to invest in ICT systems to support government functions. By contrast, less developed countries must focus on maintaining and improving the traditional modes and channels of government. A positive relationship between affluence and e-Government has been found in previous research (Das et al., 2009; Srivastava & Teo, 2010). However, Azad et al. (2010) did not find a significant relationship between e-Government and GDP. They conjectured that many countries adopt e-Government only symbolically and do not progress beyond the creation of "Potemkin e-villages" (Katchanovski & La Porte, 2005). Another reason for the lack of a relationship could be their use of a five-stage measure of e-Government adoption, which was much coarser than the indices used in other studies.

We can argue that as countries become richer, they undertake more and more ambitious e-Government services, going beyond just the "essential" information systems such as broadcasts of government policies and directories of government services. Of course, the success of such services sets up a virtuous cycle of positive feedback justifying further investment in e-Government. Hence, our first hypothesis is:

Hypothesis 1: Increase in a country's GDP per capita is positively associated with an increase in e-Government maturity over time.

ICT Infrastructure: Given slack resources in the form of GDP per capita, ICT infrastructure – the diffusion and use of information and communication technology in a country – is expected to promote the maturity of e-Government. With the prices of computing equipment falling steadily, the limiting factor for ICT development in recent times appears to be the availability and affordability of telecommunication bandwidth. The extent of ICT development directly facilitates (or limits) the delivery of e-Government services to its citizenry (Shareef et al. 2011; Srivastava & Teo, 2010) in terms of both reach and richness. Citizens in countries with higher levels of ICT penetration are also more likely to conduct their government-related affairs online (Singh et al. 2007). In related research, Fernández-i-Marín (2011) used a Bayesian linear model to estimate the "critical" level of internet penetration in European countries above which e-Government applications become viable.

In addition to reach, development of national ICT infrastructures enables more complex services, such as those requiring more bandwidth (e.g., streaming video), or those supporting mobile devices (e.g., location-based services). Hence, we postulate:

Hypothesis 2: Improvements in a country's ICT infrastructure are positively associated with an increase in e-Government maturity over time.

Human Capital: The human capital of a country reflects the extent to which the population is literate and has attained an adequate level of education. We operationalize literacy as the percentage of adult citizens who can read and write with understanding, and the overall level of education as the proportion of the school-going age population enrolled in primary, secondary, or tertiary educational institutions (Singh et al., 2007). Other potential operationalizations of literacy (e.g., average expected years of schooling) and education (e.g., proportion of skilled professionals in the workforce) are not pursued here due to the lack of cross-country data over time.

We suggest a twofold mechanism through which human capital can facilitate e-Government maturity. The primary impact of human capital arises from the demand it creates for e-Government services; such services are mostly useful to those who can to read, understand, and navigate software interfaces. A review by Jaeger (2006) confirms the role of education in internet use. Similarly, Zhao et al. (2007) conclude that the educated are better able to overcome ICT complexity to utilize e-Government services.

A more educated citizenry, aware of developments in neighboring countries and around the world, is more likely to *demand* e-Government. Berry & Berry (2014) postulate "citizen pressure" as one of four forces behind policy change, and Lee et al. (2011) found empirical support for citizen pressure (using the human capital index as one of its indicators) as a correlate of e-Government adoption in countries covered by the 2008 UN e-Government report.

A secondary effect of human capital on e-Government maturity may arise through the *supply* of skills in a nation's workforce capable of rolling out sophisticated ICT applications. As we limit our measure of human capital to basic literacy (as opposed to high-end ICT skills), we are not in a position to explore this effect of human capital on e-Government.

On the basis of the above reasoning, we cast our hypothesis about the role of human capital as follows:

Hypothesis 3: Increase in a country's human capital is positively associated with an increase in e-Government maturity over time.

Governance: Governance refers to "the traditions and institutions by which authority is exercised in a country" (Kaufmann, Kraay, and Mastruzzi, 2010). As e-Government involves the embedding of digital technology in the social process of governing a country, we might expect that a nation's e-Government maturity reflects how it is governed (Huang, 2007). Ciborra (2005) and Ciborra & Navarra (2003) examine how weak governance (in terms of the accountability and transparency of incumbent governments) constrains the delivery of e-Government, with specific reference to an aid-funded initiative in the Kingdom of Jordan.

At the technical level, e-Government does provide interested governments a way to engage citizens (for consultation, feedback, or dialogue) who might have earlier kept away from participation due to concerns about public visibility (Shareef et al., 2011). The implementation of e-Government also demands a certain level of government transparency because it requires the codification of business rules. In this way, responsibility for policy execution shifts from the discretion of street-level bureaucrats toward impartial “processors,” reducing the potential for arbitrary interpretation (Reddick, 2004). However, from an institutional perspective (North, 1990), only governments that seek to promote these values – engagement and transparency – are likely to pursue higher levels of maturity in e-Government. Governments that are unstable, corrupt, or do not enjoy the widespread mandate of their citizens, are unlikely to embrace e-Government beyond basic information publishing (mainly propaganda; Tolbert and Mossberger, 2006).

Good governance, as manifested in the six dimensions of Kaufmann, Kraay, and Mastruzzi (2010) – voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption – is also often associated with the increasing professionalization of the civil service and closer links with the citizenry. The role of institutions on e-Government diffusion has been studied extensively, and their progress or regress has been clearly demonstrated (e.g. Kamarck & Nye, 2002; Wilson, 2004; Katchanovski & La Porte, 2005; Dunleavy, 2007; Krishnan & Teo, 2012). The expectation that e-Government deployment in a country will respond to the overarching structures and processes of governance in the country guides our final hypothesis:

Hypothesis 4: Improvements in a country’s quality of governance are positively associated with an increase in e-Government maturity over time.

Figure 1 below depicts the conceptual model we test in this paper using mixed-effect regression analysis of panel data.

3 METHOD

3.1 Data and Measures

Countries form the natural unit of analysis in this study. Accordingly, we assembled data for 191 countries using established sources of secondary data. The nature of our data sources for this study offers two important advantages. First, it enables replication, critique, and extension of our results using publicly (and freely) available data. Second, the broad coverage (including almost all countries in the world) assures that our findings are truly generalizable and free from selection-related biases. The process of assembling the data set has been described below.

Our measure of *e-Government Maturity* is obtained from West (2002; 2003; 2004; 2005; 2006; 2007; 2008). Given our interpretation of e-Government maturity as demonstrated *behaviors* rather than just potential, we find West's measure the most thorough quantitative report available. West and his associates at the Inside Politics research center at Brown University examined >1500 government web sites from >190 countries in the summer of each year. Included among them were the web sites of the executive, legislative, and judicial branches of government, and the sites of cabinet offices and key agencies serving important functions such as health, taxation, education, interior, economic development, administration, tourism, transportation, military, and business regulation. Websites for subnational units and local/regional/municipal government units were not included in their study.

On the basis of a comprehensive examination of the characteristics of government web sites, West and his colleagues scored each country on a maximum of 100 points. These characteristics include:

1. online publications,
2. online databases,
3. the use of audio and video,
4. support for nonnative languages or foreign language translation,
5. free access (as opposed to paid access, a *negative* feature),
6. commercial advertising (another *negative* feature),
7. access for the disabled,
8. a privacy policy,
9. security features,
10. the presence and breadth of online services,
11. support for digital signatures and credit card payments,
12. an e-mail address for questions/concerns, comment forms,
13. provision of automatic e-mail updates,
14. website personalization, and
15. access from non-PC devices such as handheld computers (West 2006).

Non-English web sites were translated by foreign language readers.

West's measures of e-Government maturity are available for all years from 2002 to 2008. However, West (2003) introduced some changes to the methodology of measurement from 2002 to 2003, rendering the 2002 series difficult to compare with the data for the remaining years. We model e-Government maturity as a 1-year lagged function of the independent variables: time, GDP per capita, infrastructure index, human capital index, and governance index, to capture the delay between changes in the independent variables and changes in e-Government maturity, improving the ability to evaluate causality. The 1-year lag also means that the discordant values of e-Government reported by West for the year 2002, though reported in the summary statistics, do not actually enter the estimation of our models, as we do not include the values of the independent variables from the previous year (2001) in our data set.

The time-series of per-capita PPP-adjusted GDP of different countries each year from 2002 to 2008 (in 2010 international dollars) were drawn from the archive of the World Economic Outlook databases stored at the web site http://www.imf.org/external/ns/cs.aspx?id=28. We used the 2010 World Economic Outlook data series (International Monetary Fund, 2010) to reduce the effect of changes in the definition of the international dollar (also called the Geary-Khamis dollar) over the years.

Our measure for *ICT Infrastructure* is an index composed of three equally weighted components: Internet subscribers per 1000 people, broadband connections per 1000 people, and mobile subscriptions per 1000 people. This index reflects the range of technologies used to deliver most e-Government applications, and the relative scarcity of connectivity vis-à-vis standalone computing. The raw data are taken from the 2011 Yearbook of Statistics of the International Telecommunication Union (ITU), which contains the telecommunication/ICT indicators for the preceding 10-year period from 2001 to 2010 (ITU, 2011). Because of the 1-year lag in our models, the last year from which infrastructure index is actually used for estimation is 2007; hence, we did not complete the manual computation of these indices for 2008. Our index corresponds reasonably well with the digital development (DigiDev) factor extracted by Cruz-Jesus et al. (2016) from a variety of ICT-related measures, except for the exclusion of computer penetration from our index (we think that increasing use of mobile phones and tablets provide a viable alternative to traditional PCs and laptops for accessing e-Government applications).

Once again, we did not use the technology infrastructure index computed by UNPAN (2003; 2004; 2005; 2008; 2010) because

- it included (in the earlier years) components such as TV ownership and the density of fixed-line telephones (both being somewhat distant from e-Government), and
- the components of the UNPAN index and their relative weightages underwent material changes over the period of our study, compromising comparability across the years.

Our measure for *Human Capital* is similar to the "education index" described in the abovementioned UNPAN reports from 2003 to 2008, which in turn draw their data from the UNESCO. The human capital index is a combination of the adult literacy rate (defined as the percentage of people aged >15 years who can read and write with understanding a short statement on their everyday life) and the combined gross enrolment ratio of primary, secondary, and tertiary schools in a country. The latter refers to the percentage of school-age population enrolled in any educational institution, and contributes one-third of the final HCI measure, with the remaining two-thirds coming from the adult literacy rate. The human capital index ranges from zero to one.

According to our study, UNPAN shifted the basis of its education index from enrolment ratio to mean (and expected) years of schooling. Because of this change, our measure of human capital (two-thirds literacy and one-third gross enrolment ratio) had to be computed manually from the statistics provided in the annual Human Development Reports (United Nations Development Program, 2002–2009).

The time-series measures for *Governance* were developed by Kaufmann, Kraay, and Mastruzzi (2010). These indicators are aggregated from >200 variables, collected from 25 separate data sources created by 18 different organizations, such as Freedom House, the Economist

Intelligence Unit, and the U.S. State Department. Kaufmann et al. (2010) define governance broadly as the traditions and institutions by which authority is exercised in a country; based on this definition, they cluster its indicators into six dimensions using an unobserved component model. The dimensions of governance Kaufmann et al. (2010) arrive at are: voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption. Each year, across all countries, each of the six dimensions of governance is standardized, that is, normally distributed with a mean of zero and a standard deviation of one. Higher scores correspond to better governance, and virtually all scores fall between −2.5 and +2.5.

To improve the stability of estimation, we expressed GDP per capita in thousands of dollars, and rescaled (multiplied) the human capital and governance indices by a factor of 100 for inclusion in our regression model.

Table 1 below shows the descriptive statistics for independent and dependent variables over the years.

Subsequently, we present the pairwise correlations among the independent variables (lagged by 1 year) and the dependent variable:The pairwise correlations in Table 2, among the independent variables, and between them and the dependent variable, are all positive and statistically significant.

3.2 Data Analysis

Panel data aim to overcome one of the main weaknesses of cross-sectional studies: endogeneity originating from the omission of potentially relevant predictor variables, which can bias the estimates of both intercepts and slopes (Wooldridge, 2002). Panel data also reveal dynamic relationships between predictor and dependent variables as they unfold over time, which is not possible with cross-sectional data.

To make the most of the opportunity that panel data afford, we need to adopt an appropriate method of data analysis. Ordinary least square (OLS) regression is clearly inappropriate for the analysis of panel data. Each unit of observation (a country, in our case) contributes multiple observations to our data, but these observations are more likely to be correlated rather than independent (as assumed in OLS regression). Less obvious, but equally significant, is the fact that observations from a particular point in time (a year, in our case) might also be correlated, leading to further violation of OLS assumptions.

In our mixed linear model, we recognize the correlations among the e-Government maturity scores of the same country at different points in time. Individual-specific, time-invariant, unobserved heterogeneity (e.g., geography or culture) is captured using these multiple data from each country (and likewise for each point in time, for which there are data from multiple countries). The fixed-effects part of our model effectively incorporates proxies for individual country (Cohen et al. 2003), giving up *(n-1)* degrees of freedom corresponding to the *n* units under observation. Computationally, we use an estimation procedure (restricted maximum-likelihood (REML) estimation) that explicitly accounts for the loss of these degrees of freedom while estimating the random effects without bias.

Mixed-effect models have a fixed-effect component analogous to traditional regression (Singer and Willett, 2003). The random-effects component gives structure to the error term remaining after fitting the fixed effects by admitting different intercepts (and slopes for regressor variables) for different units (countries, in our case). In this respect, mixed-effects models allow more flexible modeling of panel data than repeated measure ANOVA; unlike ANOVA, they also allow the inclusion of time-varying covariates. Mixed-effect models are mathematically equivalent to hierarchical linear models (HLMs) and growth curve models (GCMs). All of these models stand in contrast to OLS regression by recognizing the within-unit correlations in panel data.

In a mixed-effect model, each country is allowed to have its own intercept and slope (over time) to reflect the reality that different countries start the period of study (2003–2007) at different initial *levels* of e-Government maturity, and also grow at different *rates* from these initial levels. Barr et al. (2013) advise researchers to keep linear mixed models “maximal” in the sense of including all theoretically justified random effects. Accordingly, we also set the variance–covariance structure of the random effects − intercept and slope − to be the most general (unstructured).

In our *random-intercept* models, the level of the dependent variable $egov_{it}$ for country *i* in year *t* is made up of the following components:

- the fixed intercept β_1 for all units,
- the country-specific random intercept U_{1i} for country *i*,
- the fixed slope β_j (along the independent variable x_j for each country *i*), and
- the random error ε_{it} for country *i* in year *t*

where $U_{1i} \sim N(0, \tau^2)$ and $\varepsilon_{it} \sim N(0, \sigma^2)$.

Allowing random variation in *slopes* (over time) across countries adds another component to $egov_{it}$

- the random slope on time U_{2i} for each country *i* with U_{1i} and U_{2i} distributed (multivariate) normally as $\binom{U_{1i}}{U_{2i}} \sim MVN\left(\binom{0}{0}, \begin{pmatrix} \tau_{11} & \tau_{12} \\ \tau_{21} & \tau_{22} \end{pmatrix}\right)$.

We start by examining the growth of e-Government maturity over time *without* regard to the effect of GDP per capita, infrastructure, human capital, or governance. We build a model of the fixed effect of time and the random effect (intercept) of country.

1. **Unconditional random-intercept model**: For country *i* in year *t*,

$$egov_{it}|time, U_{1i} = \beta_1 + \beta_2 time_t + U_{1i} + \varepsilon_{it}$$

where $U_{1i} \sim N(0, \tau^2)$ and $\varepsilon_{it} \sim N(0, \sigma^2)$ ... (1)

Grouping the fixed and random components of the intercept (1), may be rewritten as

$$egov_{it}|time, U_{1i} = (\beta_1 + U_{1i}) + \beta_2 time_t + \varepsilon_{it}$$

The following coefficients were estimated by the REML method, which explicitly accounts for the degrees of freedom consumed in estimating the fixed effects, thus providing unbiased estimates of the random effects. For this model, and for all other models, estimation was repeated with full (i.e., unrestricted) maximum likelihood estimation (MLE), which produces slightly biased estimates with tighter confidence intervals. All results remained the same, and the difference in coefficient estimates between the two procedures never exceeded 2% for significant coefficients. Such stability is expected for large sample sizes, and gives us greater confidence in our results.

Model 1 shows that the typical country's e-Government maturity rises by 1.054 units each year. However, different countries begin the observation period at different levels of e-Government maturity, and this variation in starting points is reflected in the significant random-effect parameter which has a 95% confidence interval of (4.339, 5.471). We conclude that the majority of countries started the observation period with an e-Government maturity level of 23 ± 5 points, thereafter increasing approximately 1% every year.

The inclusion of the theorized predictor variables – GDP per capita, infrastructure, human capital, and governance, each lagged by a year – leads to the formulation of our second model. Model 2 retains the varying intercepts and the constant slope over time, adding coefficients for the predictors (covariates), all of which also vary over time.

2. **Random-intercept model with time-varying covariates**: For country *i* in year *t*,

$$egov_{it}|gdpk, infra, humcap, govce, time, U_{1i}$$
$$= \beta_1 + \beta_2 gdpk_{i(t-1)} + \beta_3 infra_{i(t-1)} + \beta_4 humcap_{i(t-1)} + \beta_5 govce_{i(t-1)}$$
$$+ \beta_6 time_t + U_{1i} + \varepsilon_{it}$$

where $U_{1i} \sim N(0, \tau^2)$ and $\varepsilon_{it} \sim N(0, \sigma^2)$ ... (2)

Grouping the intercept terms together,

$$egov_{it}|gdpk, infra, humcap, govce, time, U_{1i}$$
$$= (\beta_1 + U_{1i}) + \beta_2 gdpk_{i(t-1)} + \beta_3 infra_{i(t-1)} + \beta_4 humcap_{i(t-1)} + \beta_5 govce_{i(t-1)} + \beta_6 time_t$$
$$+ \varepsilon_{it}$$

The following coefficients were estimated by the REML procedure.

Inclusion of the time-varying covariates reduces the slope of e-Government over time to 0.862, with additional positive contributions from GDP per capita (β_2=0.129) and infrastructure (β_3=0.093). In Model 2, the intercept of e-Government maturity (in 2003) varies in the 19 ± 3 range for the majority of countries. Later, it increases by approximately 0.862 units every year. An extra unit of GDP per capita (measured in thousands of dollars) adds 0.129 units to e-Government maturity. A one point improvement in the (rescaled) infrastructure index yields an additional 0.093 units of e-Government maturity.

Not only can countries enter the observation period at different levels of e-Government maturity but they can also develop at different rates over time due to geographical and cultural factors (among others). Subsequently, we develop a pair of models where the slope of e-Government maturity over time is also allowed to vary across countries (in addition to varying intercepts). Model 3 below estimates the level and variability of intercepts and slopes over time *without* regard to the covariates – GDP per capita, infrastructure, human capital, and governance.

3. **Unconditional random-slope model** (includes random intercepts): For country *i* in year *t*,

$$egov_{it}|time, U_{1i}, U_{2i} = \beta_1 + \beta_2 time_t + U_{1i} + U_{2i} time_t + \varepsilon_{it}$$

where $\begin{pmatrix} U_{1i} \\ U_{2i} \end{pmatrix} \sim MVN\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \tau_{11} & \tau_{12} \\ \tau_{21} & \tau_{22} \end{pmatrix}\right)$ and $\varepsilon_{it} \sim N(0, \sigma^2)$ …(3)

Alternatively,

$$egov_{it}|time, U_{1i}, U_{2i} = (\beta_1 + U_{1i}) + \beta_2 time_t + U_{2i} time_t + \varepsilon_{it}$$

or,

$$egov_{it}|time, U_{1i}, U_{2i} = (\beta_1 + U_{1i}) + (\beta_2 + U_{2i}) time_t + \varepsilon_{it}$$

The following coefficients were estimated by REML:

Letting the slope vary over countries leads to the same average value of slope on time as earlier (1.05), with a standard deviation of 1.011 across countries. The average value of the intercept is 22.914, with a standard deviation of 4.812 points. The negative correlation of slope and intercept shows that the slope (on time) is lower for countries with higher intercepts. Countries that start at lower levels of e-Government maturity (with more headroom) improve faster.

Our final model retains random intercepts and slopes (over time) while accounting for the contributions of the time-varying covariates – GDP per capita, infrastructure, human capital, and governance.

4. **Random-slope model with time-varying covariates**: For country *i* in year *t*,

$$egov_{it}|gdpk, infra, humcap, govce, time, U_{1i}, U_{2i}$$

$$= \beta_1 + \beta_2 gdpk_{i(t-1)} + \beta_3 infra_{i(t-1)} + \beta_4 humcap_{i(t-1)} + \beta_5 govce_{i(t-1)}$$

$$+ \beta_6 time_t + U_{1i} + U_{2i} time_t + \varepsilon_{it}$$

where $\binom{U_{1i}}{U_{2i}} \sim MVN\left(\binom{0}{0}, \begin{pmatrix} \tau_{11} & \tau_{12} \\ \tau_{21} & \tau_{22} \end{pmatrix}\right)$ and $\varepsilon_{it} \sim N(0, \sigma^2)$ …(4)

Grouping similar terms,

$$egov_{it}|gdpk, infra, humcap, govce, time, U_{1i}, U_{2i}$$

$$= (\beta_1 + U_{1i}) + \beta_2 gdpk_{i(t-1)} + \beta_3 infra_{i(t-1)} + \beta_4 humcap_{i(t-1)}$$

$$+ \beta_5 govce_{i(t-1)} + (\beta_6 + U_{2i}) time_t + \varepsilon_{it}$$

The following coefficients were estimated by REML:

Introduction of the time-varying covariates reduces the average slope to 0.865, with a standard deviation of 1.002 across countries. The average value of the intercept is 19.332, with a standard deviation of 4.629 points. The strong negative correlation of −0.745 between slope and intercept shows that e-Government maturity grows faster for countries with lower starting levels (of e-Government maturity).

4 RESULTS

Table 7 presents the coefficient estimates from our four models side-by-side.

For both pairs of models, random intercept and random slopes, the addition of the time-varying covariates – GDP per capita, infrastructure, human capital, and governance – improves model fit as indicated by the log likelihood and the size of the residuals. The regression coefficients of the first two covariates, GDP and infrastructure, are statistically significant.

The Hausman test, $\chi^2(5) = 4.73, p = 0.449$, shows that the random-slope model with time-varying covariates is consistent with the random-intercept model (with time-varying covariates) while being more efficient, with smaller residuals and tighter confidence intervals. The likelihood ratio (LR) test, $\chi^2(2) = 50.49, p = 0.000$, also shows that the random-slope model with time-varying covariates fits the data significantly better than the random-intercept model (with time-varying covariates) after accounting for the additional degrees of freedom consumed. REML allows LR tests to compare models with identical fixed-effect components and nested random effects (true in our case).

We thus choose Model 4 with random slopes (and random intercepts) as the best-fitting model for our data. Our preference for the random-slope model follows the advice of Barr et al. (2013) to keep linear mixed models maximal in order to correctly capture the random-effect structure of the data. Maximal models have more "expressive power" to represent the random-effect structure present in the data. The column of coefficient estimates from this model is shaded in Table 7 above.

Table 8 below summarizes our main results (based on Model 4).

Most, but not all, countries improved in e-Government maturity over the period of our study, 2002–2008. There is significant heterogeneity among countries in both intercept (starting points) and slope (rate of change over time) in their achievement of e-Government maturity.

In the aggregate, the rate of growth is slower for countries already at high levels of e-Gov maturity (negative correlation between slope and intercept). This suggests that it is easier to establish a minimal level of e-Gov maturity, but harder to make progressive improvements.

Our results support Hypotheses 1 (Affluence) and 2 (ICT Infrastructure), but *not* Hypotheses 3 (Human Capital) and 4 (Governance). In other words, only GDP per capita and ICT infrastructure are significantly associated with rising e-Government maturity over time. This pattern of results suggests that GDP and ICT infrastructure may be sufficient conditions for e-Government maturity, as measured by West and associates. In other words, it might be possible for a country, willing and able to make investment in technological capabilities, to advance its e-Government maturity without necessarily rebuilding public sector processes as described by Andersen and Henrikson (2006).

In agreement with other research on the topic, GDP per capita and the infrastructure index make significant positive contributions to e-Government maturity, but the contributions of the human capital and governance indices fail to reach statistical significance. Theory, as well as prior research based on cross-sectional analysis, raised expectations that e-Government maturity would be influenced significantly by human capital (an educated citizenry) and good governance (transparency, accountability, and effectiveness). That e-Government can develop, indeed flourish, without significant dependence on these two factors – human capital and governance – alerts us that the type of e-Government we are developing (and measuring) –viewing the citizen predominantly as a consumer of government services – is primarily an “infrastructure play.” In addition, the maturity of e-Government in a country does not signal higher levels of human capital or good governance. Proponents of e-Government as a vehicle for administrative reform are likely to be disappointed, but other research, notably Kraemer & King (1986; 2006), has often argued that the ruling elites are likely to appropriate technology in their own interests to maintain the status quo. Of course, we must also acknowledge that our overall understanding of e-Government adoption (including the challenges and barriers) lags behind the research on supply-side issues (deployment of e-Government). Rana, Dwivedi, & Williams (2013) note that this imbalance of understanding is reflected in the number of studies: supply-side 53 vs. demand-side 18.

3 **5 DISCUSSION**

We undertook this study to identify factors that are associated with e-Government maturity over time. To do so, we assembled a panel data set using established secondary data sources, and analyzed it with random-effect models. Table 9 below shows a comparison of our study with a few others that examine the antecedents of e-Government maturity.

Table 9 shows that only Ifinedo (2011) and this paper have used panel data to investigate the antecedents of e-Government maturity. However, use of OLS regression to estimate the effect of predictor variables is problematic for reasons mentioned in the earlier section. Across all these studies, GDP and ICT infrastructure are the only consistent predictors of e-Government maturity. Human capital and governance are the two predictors that are often significant in cross-sectional analysis, and do not hold up under our more stringent longitudinal analysis. To reiterate, our results do *not* indicate that the e-Government maturity of a country goes up (or down) as its human capital and governance go up (or down).

We must note that our results are robust to increase the lag between GDP and e-Government maturity to 2 years (leaving other independent variables with 1-year lags). The rationale for trying a longer lag for GDP was that the delay between changes in GDP and its effect on e-Government maturity might be longer, thus the effect being potentially mediated by the other independent variables. On finding consistent results, we retained the results of our original model (all independent variables lagged by 1 year) as it fares better in terms of missing data; it is able to utilize one additional wave of panel data than the variant with a 2-year lag for GDP. More data (larger sample size) promise higher statistical power and more precise estimates.

The role of GDP has been acknowledged by almost all other researchers, except for Azad et al. (2010) as noted earlier. Cruz-Jesus et al. (2016), in fact, report a nonlinear effect of GDP, suggesting that its effect is greatest for poorer countries. Only after a certain level of affluence is reached do other variables start to have an effect on the maturity of e-Government. The strong link between affluence and e-Government maturity reflects the fact that developing e-Government services continues to be an expensive affair (despite the falling cost of computer hardware), allowing wealthier nations to still dominate most e-Government rankings (Singh et al. 2007). The key role of GDP also raises some significant questions for the future of e-Government. As countries, such as some in Europe, embrace austerity in their fiscal policies, what will happen to their e-Government initiatives? As government expenditure decreases, will their e-Government maturity scores plateau and even decline?

Future research may be able to evaluate the particular elements of the ICT infrastructure (potentially involving mobile/wireless technology) that have greater impact on e-Government maturity. This could support the choice of ICT investments on a limited budget, potentially enabling poorer countries to spend their money wisely as they attempt to catch up with their more affluent counterparts.

With a large amount of data and careful statistical analysis, the lack of significance of either governance or human capital comes as a disappointment. The public administration literature is cautious about the potential of e-Government to transform the practice of government (Baldwin et al., 2012; Danziger & Andersen, 2002; Kraemer & King, 2006; Norris, 2010a; 2010b). It now appears that, at least in the short term, we may be stuck with a "limited" form of e-Government (primarily transactional, focused on the citizen as a consumer of services) rather than all-out e-participation/e-democracy viewed as likely a few years ago (Norris, 2010a; Norris, 2010b). The current form of e-Government is investment-intensive, but requires relatively little by way of citizen engagement or administrative reform.

If technology is viewed as a means of structuring relationships between governments and citizens, in terms of setting boundaries and accountability, then e-Government can be used as a badge to signal "good governance" to important parties (Ciborra, 2005). One example is the use of e-Government by developing countries to showcase themselves as attractive destinations for foreign direct investment, in effect using e-Government maturity as a signal of governance. Although our results actually cast doubt on this line of reasoning – inferring good governance from a relatively high level of e-Government maturity currently lacks a sound basis – we still encourage governments to promote the adoption of e-Government by educating their citizens to better utilize available services, while the next generation of e-Government applications are developed (Ayanso, Chatterjee, & Cho, 2011). If not anything else, familiarity with today's e-Government applications (mostly focused on service delivery) might flatten the learning curve for future applications potentially targeted at e-participation and electronic democracy.

3.1 **5.1 Limitations**

Technological advances have enabled new functionality on e-Government sites since the timeframe of the study, particularly in the area of mobile apps. Citizen awareness and utilization of e-Government services is also higher now than in the period studied. That said, there is no reason to believe that the structural relation between e-Government maturity and the predictors tested here – GDP, ICT infrastructure, human capital, and governance – have changed systematically since the 2002–2008 timeframe. Norris (2010b) points out that a decade may seem like a long time in the evolution of technology, but is a relatively short time within which to expect changes in administrative practice. Speaking of the technology itself, the world wide web continues to be the general purpose technology (Bresnahan & Trajtenberg, 1995) from which the tool set of e-Government is derived.

Some researchers have argued that e-Government rankings, such as the e-Government maturity measure used in this paper from West (2003; 2004; 2005; 2006; 2007; 2008) may not accurately depict the performance of public administrators in terms of e-Government. Such rankings focus on the visible elements of e-Government (such as number of services delivered online), without exploring the extent to which governments have used technology to transform their internal operations or radically improve business processes (Bannister, 2007; 2010). These rankings also ignore equally important aspects of e-Government, such as organizational collaboration, adaptation, and a shift from bureaucracy to service orientation (Andersen and Henriksen, 2006; Brown, 2007; Dawes, 2010). For example, if some administrations prioritize community links over service delivery, or emphasize local over national government interaction, their efforts may not be picked up by our maturity measure (Shackleton, 2004).

In the face of such criticism, new maturity models are being developed to incorporate additional dimensions beyond technology deployment, such as organizational integration and citizenship orientation (Lee, 2010; Calista & Melitski, 2007; Obi, 2015). As this study has relied on West's e-Government measure as the dependent variable, it is perhaps most relevant for governments who expect to achieve substantive change in public service delivery by innovating with technology. We see value in extending our research with the newer measures being developed to encompass more aspects of e-Government.

3.2 **5.2 Future research**

Although all of our models are linear (in terms of the relation between independent and dependent variables), recent research has identified a nonlinear effect of GDP on e-Government (Cruz-Jesus et al., 2016). Poorer countries experienced a bigger marginal contribution from GDP than the more affluent. Similar nonlinear effects may be postulated and tested for other independent variables as well.

Second, the current level of e-Government in a country might affect its future development in later years. The negative correlation between intercept and slope in the mixed-effect regression model means that countries entering the period of study with highly developed e-Government initiatives had less “headroom” to improve during the study period than countries that were at more rudimentary levels of e-Government at the start of the period. In other words, it is easier to achieve a minimal level of e-Government presence than it is to make progressive improvements. To examine this issue, we plan to include autoregressive parameters (lagged values of y) as predictors in our model to measure this effect.

Third, the lack of significance of governance in our model, alongside its theorized importance, indicates that it may be useful to examine broader measures of societal values, such as culture (Lee et al., 2011) or social capital, to capture aspects of society that fall outside our narrow definition of governance. A similar point can be made about human capital. Its lack of significance suggests the need for a more direct measure of citizens’ education than basic literacy and school enrolment (e.g., computer literacy and ICT skills of citizens). Future studies could examine how e-Government is used by citizens from different educational backgrounds, and how the spread of tertiary (college) education influences the supply of and demand for e-Government services.

Finally, this study, like most others on e-Government, has adopted a somewhat insular view in excluding external influences on e-Government development. Recent studies such as Lakka, Stamati, Michalakelis, & Martakos (2013) and Kromidha (2012) argue that focusing solely on endogenous factors is limiting, and recommend examining the role of concepts such as external ICT trade and international e-Government development assistance (for an example, see Ciborra, 2005). In particular, if development assistance can help poorer nations to implement e-Government, donor and recipient nations can work out arrangements (potentially spanning the private and public sectors) that benefit both sides.

4 **6 CONCLUSION**

Existing large-scale empirical research on e-Government is dominated by cross-sectional analyses. This limits the applicability of the findings of these studies and our confidence in them because of concerns over omitted variables, and the neglect of developmental processes. This paper attempts to overcome these methodological challenges by estimating a mixed-effects model on an international panel data set. Although the analysis can be enhanced further (as described in the Further Research section), our current findings are generally supportive of the infrastructure-focused point of view: substantial differences in e-Government maturity exist among countries, and the countries that do better at e-Government are the ones that are richer and have built better ICT infrastructure. Human capital and governance, as operationalized here, does not have a significant effect on e-Government maturity. The lack of significant effects for these variables should be probed further with alternative measures of human capital (such as computer literacy and ICT skills of citizens) and governance (such as social capital). Future research might also uncover specific technologies that support e-Government most effectively and investigate whether less well-off countries can leverage these technologies (or cheaper alternatives thereof) to leapfrog their more affluent peers. Finally, it is important to qualify our conclusions with the caveat that alternative measures of e-Government maturity might lead to different results and conclusions.

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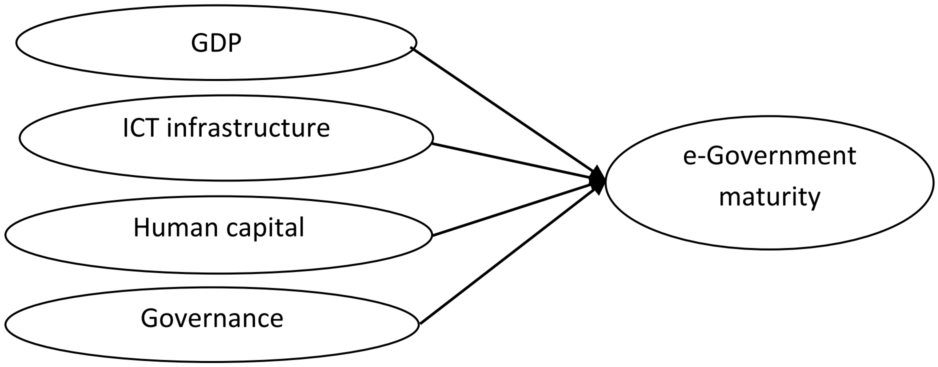

Figure 1. *Proposed Conceptual Model.*

Table 1: Means and standard deviations (SD) of independent and dependent variables

Year	**e-Gov index**		**GDP per capita**		**Infrastructure index**		**Human capital index**		**Governance index**	
	Mean	Std. Error	Mean	Std. Error	Mean	Std. Error	Mean	Std. Error	Mean	Std. Error
2002	40.67	0.59	9.64	0.87	16.23	1.31	77.28	1.46	−2.91	6.91
2003	27.24	0.44	10.08	0.90	17.25	1.38	77.88	1.45	−2.54	6.90
2004	25.34	0.40	10.75	0.96	17.39	1.40	78.12	1.42	−3.20	6.91
2005	25.75	0.46	11.89	1.07	14.85	1.23	78.79	1.46	−2.83	7.20
2006	27.54	0.49	12.10	1.06	20.95	1.57	76.91	1.47	−4.62	6.82
2007	30.45	0.55	12.73	1.10	21.26	1.62	78.10	1.40	−6.19	6.78
2008	30.89	0.55	13.50	1.08	Not available		Not available		−7.05	6.59

Table 2: Pairwise correlations

	e-Gov index	GDP per capita (lag 1)	Infrastructure index (lag 1)	Human capital index (lag 1)	Governance index (lag 1)
e-Gov index	1.000				
GDP per capita (lag 1)	0.510**	1.000			
Infrastructure index (lag 1)	0.540**	0.829**	1.000		
Human capital index (lag 1)	0.382**	0.539**	0.625**	1.000	
Governance index (lag 1)	0.412**	0.753**	0.824**	0.559**	1.000

Table 3: Unconditional random-intercept model

Model 1	Number of observations: 1142		Group variable: nation		Number of groups: 191	
	Observations per group: minimum: 3, maximum: 6, average: 6					
Log-restricted likelihood = −3562.236		**Wald chi²(5)**	173.75	**Prob > chi²**	0.000	
	Coef.	**Std. Err.**	**z**	**P>|z|**	**95% Confidence Interval**	
time	1.054	0.080	13.18	0.000**	0.897	1.211
intercept	22.902	0.522	43.89	0.000**	21.879	23.924
Random-effect parameters	**Estimate**	**Std. Err.**	**95% Confidence Interval**			
nation: Identity						
Sd (intercept)	4.872	0.288	4.339	5.471		
Sd (residual)	4.616	0.106	4.413	4.829		

** Significant at 0.01 level

Table 4: Random-intercept model with time-varying covariates

Model 2	Number of observations: 1025		Group variable: nation		Number of groups: 177	
	Observations per group: minimum: 1, maximum: 6, average: 5.8					
Log-restricted likelihood = −3108.165		**Wald chi^2 (5)**	353.11	**Prob > chi^2**	0.0000	
	Coef.	**Std. Err.**	**z**	**P>|z|**	**95% Confidence Interval**	
L1.gdpk	0.129	0.035	3.66	0.000**	0.060	0.198
L1.infra	0.093	0.025	3.73	0.000**	0.044	0.142
L1.humcap	0.022	0.018	1.22	0.224	−0.014	0.058
L1.govce	0.001	0.005	0.29	0.775	−0.009	0.012
time	0.862	0.084	10.21	0.000**	0.696	1.027
intercept	19.197	1.434	13.38	0.000**	16.386	22.009
Random-effect parameters	**Estimate**	**Std. Err.**	**95% Confidence Interval**			
Nation: Identity						
Sd (intercept)	3.174	0.233	2.749	3.666		
Sd (residual)	4.403	0.107	4.198	4.618		

** Significant at 0.01 level

Table 5: Unconditional random-slope model

Model 3	Number of observations: 1142		Group variable: nation		Number of groups: 191	
	Observations per group: minimum: 3, maximum: 6, average: 6					
Log-restricted likelihood = −3530.948		**Wald chi^2 (5)**	103.29	**Prob > chi^2**	0.0000	
	Coef.	**Std. Err.**	**z**	**P>|z|**	**95% Confidence Interval**	
time	1.050	0.103	10.16	0.000**	0.848	1.253
intercept	22.914	0.494	46.34	0.000**	21.945	23.883
Random-effects parameters	**Estimate**	**Std. Err.**	**95% Confidence Interval**			
nation: Unstructured						
Sd (time)	1.011	0.107	0.822	1.244		
Sd (intercept)	4.812	0.513	3.905	5.930		
Corr (time, intercept)	−0.444	0.110	−0.633	−0.206		
Sd (residual)	4.213	0.108	4.006	4.430		

** Significant at 0.01 level

Table 6: Random-slope model with time-varying covariates

Model 4	Number of observations: 1025			Group variable: nation	Number of groups: 177	
	Observations per group: minimum: 1, maximum: 6, average: 5.8					
Log-restricted likelihood = −3082.919		**Wald chi^2 (5)**	271.89	**Prob > chi^2**	0.000	
	Coef.	**Std. Err.**	**z**	**P>|z|**	**95% Confidence Interval**	
L1.gdpk	0.124	0.036	3.45	0.001**	0.054	0.195
L1.infra	0.097	0.024	4.05	0.000**	0.050	0.144
L1.humcap	0.020	0.018	1.12	0.262	−0.015	0.055
L1.govce	0.000	0.005	0.06	0.949	−0.010	0.010
time	0.865	0.108	7.99	0.000**	0.653	1.077
intercept	19.332	1.415	13.66	0.000**	16.558	22.106
Random-effect parameters	**Estimate**	**Std. Err.**	**95% Confidence Interval**			
nation: Unstructured						
Sd (time)	1.002	0.106	0.815	1.233		
Sd (intercept)	4.629	0.512	3.727	5.750		
Corr (time, intercept)	−0.745	0.059	−0.840	−0.606		

Sd (residual)	3.979	0.108	3.772	4.198

** Significant at 0.01 level

Table 7: Model comparison

Variable	**Random intercept (no covariates)**		**Random intercept (time-varying covariates)**		**Random slope (no covariates)**		**Random slope (time-varying covariates)**	
	coeff	*p-value*	*coeff*	*p-value*	*coeff*	*p-value*	*coeff*	*p-value*
GDP per capita			0.129	0.000**			0.124	0.000**
infrastructure index			0.093	0.000**			0.097	0.000**
human capital index			0.022	0.224			0.020	0.262
governance index			0.001	0.775			0.000	0.949

time	1.054	0.000**	0.862	0.000**	1.050	0.000**	0.865	0.000**
intercept	22.902	0.000**	19.197	0.000**	22.914	0.000**	19.332	0.000**
Sd (slope on time)					1.011		1.002	
Sd (intercept)	4.872		3.174		4.812		4.629	
Corr (time, intercept)					−0.444		−0.745	
Sd (residual)	4.616		4.403		4.213		3.977	
Wald chi-square (5 df)	173.75		353.11		103.29		271.89	
Log likelihood	−3562		−3108		−3531		−3083	

** Significant at 0.01 level

Table 8. Summary of Results

Variable	Coefficient	What it signifies
Intercept: fixed effect	19.332	Average level of West's e-Government maturity measure for all countries in 2003 at zero levels of GDP per capita, infrastructure, human capital, and governance in the previous year
Intercept: random effect	4.629	Average variation in the intercept among countries
Time: fixed effect	0.865	On average, West's e-Government maturity score for a country increases by 0.865 units every year
Time: random effect	1.002	Average variation in the slope among countries (some countries show negative slope)
GDP per capita	0.124	A $1000 increase in a country's GDP per capita is associated with an increase of 0.124 in its e-Government maturity score
ICT Infrastructure	0.097	A 1-point increase in a country's infrastructure score (scaled to 100) is associated with an increase of 0.097 in its e-Government maturity score

Table 9: Comparison of Related Research

Paper	Singh, Das, & Joseph (2007)	Ifinedo (2011)	Krishnan & Teo (2012)	This paper (final model)
Design	Cross-sectional	Longitudinal	Cross-sectional	Longitudinal
Data	178 countries, year 2006	64 countries, years 2003, 2004, 2005, 2008, 2010	178 countries, year 2008	191 countries, years 2002 through 2008
Analysis technique	Path analysis	OLS regression	Moderated multiple regression, 2-year lag between DV and IVs	Random-slope model with time-varying covariates, 1-year lag between DV and IVs
Dependent variable	e-Gov maturity (West, 2006)	Web measure + online service index (UNPAN, 2010)	Online service index (UNPAN, 2010)	e-Gov maturity (West, 2002 through 2008)
Predictors				

GDP	Positive, p<0.01[a]	Positive, p=0.05	Positive, p<0.01	Positive, p<0.01
ICT infrastructure	Positive, p<0.01	Positive, p=0.05	Positive, p<0.01	Positive, p<0.01
Human capital	Positive, p<0.05	Positive, p<0.01	Positive, p<0.05	Not significant
Governance	Negative, p<0.01[b]	Positive, p<0.05[c]	Positive, p<0.05[d]	Not significant[b]
Innovative capacity		Positive, p<0.01		

[a] Effects on ICT infra, human capital, and governance

[b] Composed of Voice and Accountability, Political Stability, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption (Kaufmann, Kraay, and Mastruzzi: 2005)

[c] Significant variables: Rule of Law and Corruption Perceptions (Transparency International, 2010)

[d] Significant variables: Political Stability, Government Effectiveness, and Rule of Law – main effects and interactions with ICT infrastructure