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Panel Data Analysis of E-Government and Growth Performance in the Presence of Trade

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Abstract

For sustainable development, countries are taking measures that support sustainable growth. Among these measures, trade is a major factor affecting growth. With increasing trade liberalization, it has been a challenge for many economies to sustain growth through increasing trade and sustaining its benefit over the long run. Therefore, the present study examines how e-government enhances growth through the mediation of international trade. Panel analysis of 154 economies has been conducted and results of Pooled OLS, Fixed Effect, Random Effects, and System Generalized Method of Moments are reported. The results obtained from the "System Generalized Method of Moments" support higher growth resulting from trade enhanced through e-government. Trade supports economic growth around the globe based on the quality of e-government provided. The provision of online services also enhances economic growth.

Keywords: Economic Growth, Endogeneity, E-Government, Trade, 2SLS.
JEL Codes: F10, O47, O38

1. Introduction

With the expansion of economies and the importance of trade to support and increase the prosperity of the nations realized, researchers have focused on the links between growth and trade

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(Freund & Weinhold, 2004; Meijers, 2013). However, the studies provide non-conclusive results about the effect of trade on growth. Some studies suggest positive (Fankel & Romer 1999; Sachs et al., 1995) while others suggest a negative effect of trade on growth (Majeed, 2016). Trade support growth is based on certain conditions (Mendoza, 2010) including infrastructure (Stone & Strutt, 2010), higher human capital, and well-developed markets (Chang et al., 2009). Thus, effects of trade on growth are non-conclusive therefore researchers are exploring ways that can sustain growth and all economies can benefit from the trade through the removal of barriers, therefore technological advancements can play a crucial role in that.

Macroeconomic models consider technological progress as a key input of the production process that boosts growth (Majeed & Ayub, 2018). The importance of ICT in boosting growth is also emphasized and empirical evidence suggesting a favorable impact of ICT on growth has been provided by several studies (Ishida et al., 2015; Cardona et al., 2013; Ahmad & Ridzuan, 2013; Seo et al., 2009). Digital technologies have the potential to overcome "information barriers, augment factors through automation and coordination, and transform products through scale economies and platforms". Thus, digitalization promotes innovations, inclusiveness, and efficiency, in a knowledge economy and leads to scale economies (World Bank, 2016).

Only a few studies have focused on the beneficial impacts of information communication technology and trade on growth (Majeed, 2016; Sassi & Goaied, 2013; Andrianaivo & Kpodar, 2011) however the implementation of ICT technologies in government sector also known as e-government has not been given due attention in the literature. The difference between ICT and e-government is that ICT presents "technologies that facilitate access to knowledge through telecommunications", while e-government incorporates not only ICT tools but also provide services through the utilization of such technological advancements.

There is consensus in the literature that e-government can play a substantial role in the enhancement of the economy's performance. E-government refers to "practicing tools and

infrastructures of ICT in public administration, authorizing citizens, ameliorating the provision of public sector services, boosting transparency, and upgrading the efficiency of public policy". According to UNDP (2006), e-government is the application of ICT tools to share information and provision of services to the public. Similarly, Von Haldenwang (2004), considers e-government as the application of ICT in public planning and administration, respectively. It could be said that e-government ensures the availability of convenient, efficient, and transparent information through the implementation of modern technologies by the public sector (Tandon, 2005; Chen et al. 2009).

Certain studies provide empirical evidence on the positive influence of e-government on growth (Gul et al., 2020; Majeed & Malik, 2017; Majeed & Malik, 2016a; Majeed & Malik, 2016b). The study of Majeed and Malik (2016a) using the simultaneous equation approach for 147 countries suggested a bilateral relationship between growth and e-government. The findings suggest that e-government support trade and growth. The causality results suggest a bidirectional relationship between growth and e-government, e-government and trade, and unidirectional causality from trade to growth. However, this study does not incorporate the influence of trade through better e-government on growth.

The results of Majeed and Malik (2016b) support that both the direct and indirect effects of e-government on growth are positive however indirect effects estimated through the channel of the financial sector are significant while the direct effect is insignificant, respectively. Majeed and Malik (2017) also supported the role of the financial sector and e-government for economic growth. Their study suggests higher growth from e-government through financial development which suggests the indirect effect is significant while e-government does not contribute to growth directly.

The findings of Gul et al. (2020), also support higher growth through e-government in middle-income economies. These studies highlighted the role of e-government in supporting growth however lack the evidence suggesting the mediating role of e-government in enhancing growth through international trade.

E-government supports trade through the removal of market imperfection, decreasing costs associated with the transaction, information, and market entry. Internet facilitates trade through the removal of restrictions and barriers associated with market imperfection and through decreases in costs associated with the market entry (Gnangnon & Iyer, 2018; Meijers, 2013; Freund & Weinhold, 2004). The findings of Gnangnon and Iyer (2018) for 175 economies for the span 2000-2003 support the positive impact of internet availability and use on increasing trade in services. Thus, the internet plays a mediating role in enhancing trade to support growth. However, e-government is not just about the internet, but it encompasses more factors.

There is a huge body of literature that explored trade-growth nexus (Majeed, 2016; Meijers, 2013; Stone & Strutt, 2010; Mendoza, 2010; Chang et al., 2009; Freund & Weinhold, 2004; Fankel & Romer 1999; Sachs et al., 1995) however the literature lack studies that examine how information communication technology can support trade and increases growth. Particularly the mediating role of e-government on growth through trade is ignored in the literature. Therefore, it is the need of the current study to examine how e-government enhances growth through increased trade. Economies that are efficiently employing e-government, has advantages of benefiting from the global world. Furthermore, the ICT and growth nexus has been explored in the literature however trade has received a little attention in this nexus. As empirical literature lacks evidence on the indirect influence of e-government on growth, therefore their findings cannot be generalized for other economies. Furthermore, the bidirectional relationship between e-government and growth which causes endogeneity has not been given due attention. Only one dimension of technological advancement has gained the attention of researchers (that is ICT) while leaving the most important one (e-government) unexplored. Not even a single study analyzed the potential influence of e-government in trade-growth nexus.

We have tried to examine the exclusive and interactive influence of trade on growth by addressing the following research questions. Does e-government support economic growth? Does e-

government enhance trade and support growth? Do online services boost growth through trade?

The contribution of the study in the literature can be justified as follows: First, it extends trade-growth and ICT-growth nexus by providing empirical evidence. Second, it is the first study that examined the impact of trade on growth through the higher quality of e-government. Third, as the study is based on a large panel therefore it can help in policy formulation in several countries facing challenges in sustaining growth. Fourth, the study provides robust results as it took necessary measures to tackle endogeneity by employing both internal and external instruments. Fifth, the study disaggregated e-government into its major components to have a better understanding and provide detailed analysis. Sixth, the study also proved the robustness of results through sensitivity analysis.

The study is organized in the following manner: the 2nd section incorporates e-government, trade, and growth nexus literature. The 3rd section provides methodology and data while the 4th section is based on discussion and findings. The 5th section concludes the work.

2. Literature Review

2.1 E-government-Growth Nexus

With technological advancements, the role of software development to support economic prosperity has increased. Software development has flourished the ICT industry. The study of Summer (1999) highlighted the beneficial influence of information technology on the economic development of economies. However, this study measured the economic performance of an economy through software development (as technological development is not just focused on software development it has much more to offer).

Although the literature supports the beneficial influence of e-government on development through the diffusion of knowledge and information facilities, only a few studies provide empirical evidence. Some studies attempted to explain the difference in growth rates through the availability and use of internet facilities across economies. The study of Choi and Yi (2009) by employing dynamic panel techniques for 217 countries

over the span 1991-2000 support higher growth from an increase in internet subscription. Internet availability being a component of e-government ensures access to knowledge dissemination and reduction in information costs thus leads to sustainable growth. Similarly, the findings of Czernich et al. (2011) by employing 2SLS for OECD economies for 1996-2007 supported an increase in growth from broadband. For broadband, they have used a dummy variable approach. The results cannot be generalized to other countries due to its limited scope and leaving the issue of endogeneity unaddressed.

The study of Mahyideen et al. (2012) for ASEAN economies for the time 1976-2010 using heterogenous cointegration techniques supports that ICT enhances the productivity of labor thereby increasing growth. The findings support the long-run relationship between ICT and economic growth. As the study does not address endogeneity and is only based on ASEAN economies therefore results cannot be generalized to other economies.

Only one dimension of e-government, ICT is analyzed. Recent studies provided empirical evidence on the beneficial consequence of e-government on growth (Majeed & Malik, 2017; Gul et al., 2020). Majeed and Malik (2017) by conducting cross-sectional analysis also supported the beneficial effect of e-government in strengthening growth. Although the findings of Gul et al. (2020), reported beneficial contribution of e-government on the enhancement of economic growth in middle-income economies however did not provide evidence on the possible indirect power of e-government which is also of great importance.

Some studies have explored the ways through which e-government support growth (Krishnan & Teo, 2013; Majeed & Malik, 2016a, b). Krishnan and Teo (2013) have explored the links between degraded environmental quality, corruption, and e-government for 105 economies over the span 2004-2008 using "structural equation modeling (SEM)". The study splits the effect of e-government into direct and indirect channels. The direct influence of e-government on growth is reported insignificant while indirect effect through corruption and environmental degradation is significant.

The findings of Majeed and Malik (2016a) support higher trade and growth through improved quality of e-government. However, the limitation of their study is that it ignores the indirect influence of e-government on growth. Another study by Majeed and Malik (2016b) supported the positive indirect impact of e-government through the financial sector on growth however direct impact was positive but insignificant. Recently a study for Asian economies by Majeed and Shah (2018) highlighted the favorable influence of e-government on growth.

The discussion suggests that although research on the favorable influence of ICT on growth has flourished during the past two decades however literature lacks the channels through which e-government supports growth. Moreover, as most of the studies are based on regional analysis therefore, they cannot be generalized at the global level. As the application of e-government is not based on geographical conditions that are country-specific therefore there is a need to examine its both direct and indirect links in the enhancement of economic growth which can help in the formulation of policies that support development across the globe. Furthermore, the problem of endogeneity that leads to biased results is also not focused in the e-government-growth nexus.

2.2 E-government and Economic Growth: Impact through Trade

This section is based on studies related to trade-e-government-growth nexus. As trade supports sustainable development, barriers to trade both tariff and non-tariff hamper its smooth flow. For higher growth through trade, removing trade barrier is not enough more measures like communication infrastructure is also important (Majeed & Ahmad, 2006) for integration into the global world which reduces entry, transaction and communication costs.

Internet support trade. Empirical literature supports the use of the internet in cost reduction and removal of barriers to market entry (Meijers, 2013; Freund & Weinhold, 2004). The data of 56 developing economies for the span 1995-1999 was analyzed by Freund and Weinhold (2004) and results suggest that higher use of the internet by government support both export and import.

Their findings supported an increase of 1% in export using the internet.

The study of Majeed and Ahmad (2006) examined the major determining factor of exports for 75 developing economies from 1970 to 2004 using the fixed-effects model. Their findings suggest that telephone (technological advancement) also facilitate exports. As in the present era with technological advancements, better communication technologies facilitate the expansion of trade, thus a major contributor to export. Communication tools support export.

The study of Clarke and Wallsten (2006) investigated the influence of the internet on trade analyzing the data of developed and developing economies using the instrumental variable approach. Monopoly over the data line and internet service producer were instruments used in the study. The empirical results support enhanced trade through the internet in the developing economies however in developed economies the results are insignificant.

The study of Meijers (2013) analyzed the data of 162 economies for 1990-2008 using dynamic panel data methods and causality to explore the growth-internet-trade nexus. The results support higher growth from the internet through trade. Unidirectional causality is reported from the internet to trade, growth to the internet, and trade to growth. The results confirm the significant indirect influence of the internet on growth through trade while the direct effect is not significant. The findings of Meijers (2013) contrasts with the results of Clarke and Wallsten (2006) who reported the significant indirect influence of the internet through trade on the growth of developing economies only while Meijers (2013) reported significant results in case of both developed and developing economies respectively.

Kurihara and Fukushima (2013) examined trade and internet association in 58 economies, developed and Asian developing economies for the span of 2005-2010. By using the Gravity model which suggests that bilateral trade between countries increases GDP however the distance between the countries decreases trade (due to more distance, costs increases). They provided evidence in favor of the beneficial effect of the internet on trade for all countries. The results suggest internet

effect trade positively however the effect is more prominent in the developing economies than the developed economies. The limitation of the study was the exclusion of some of the trading partners because of data unavailability.

The study of Yadav (2013) examined the importance of the internet in 52 developing countries of Asia and SSA (Sub Saharan African) economies between 2006 and 2010 analyzing the data of 23,789 manufacturing and service firms. The results obtained from the Logit and Probit model support that the internet led to higher exports and imports of firms however the increase in export was greater than the imports. The internet has an insignificant effect on the service market. The findings suggest that export-oriented firms earn higher profits, have higher productivity, pays higher wages, and contribute to development.

The above discussion provides an insight into how e-government can contribute to trade through removing trade barriers, increased availability of information, and higher interaction through web portals (Email, Skype, Zoom, Whats-App), thus minimizing the costs associated with entry and distance barriers. Thus, the empirical literature suggests the installation and usage of ICT by the government to promote and take advantage of trade to support development.

The literature has extensively examined the influence of ICT on trade however lacking evidence on the beneficial influence of e-government in enhancing trade and supporting growth. With the advancement in technologies and economies expansion, it is the need of the time to examine how e-government can contribute to higher trade which translates into higher economic growth and prosperity. Therefore, this study is of great importance as it analyzed the influence of trade on growth through e-government. Figure 1 explains the indirect influence of e-government on growth through increased trade.

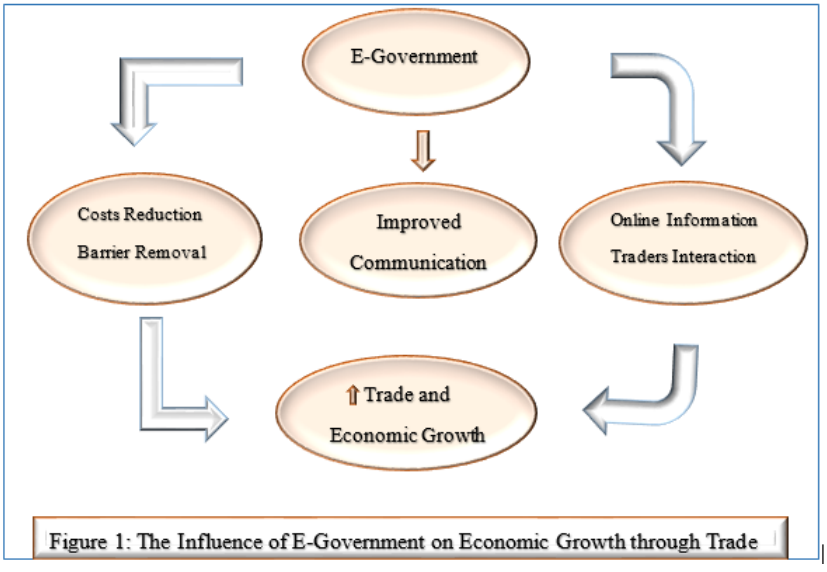

Figure 1: The Influence of E-Government on Economic Growth through Trade

3. Methodology and Data

The main contribution of the study is exploring the empirical links between e-government, trade, and growth. The links are explored by using the model developed by Mankiw *et al.* (1992).

$$y = f(A, k, n, h)$$

$$y_{it} = \beta_0 + \beta_2 A_{it} + \beta_3 k_{it} + \beta_4 n_{it} + \beta_5 h_{it} + u_i + v_t + \varepsilon_{it} \quad (1)$$

y present "per capita income", A is used for "the state of technology", k is "physical capital", n represents "the workforce", $\boldsymbol{u_i}$ represent "country-specific characteristics", and $\boldsymbol{v_t}$ represent "time fixed effects".

We have constructed our model following Mankiw *et al.* (1992) incorporating labor, human, and physical capital as inputs in production functions. The labor, human, and physical capital are not the only factors explaining divergence in income among countries (Majeed, 2019a; Majeed, 2019b), technological advancements also play a crucial role in sustaining economic growth. To capture the convergence, effect the lag value of income represented as $Y_{initial}$ is incorporated as a regressor in the model following Barro (1998).

$$y_{it} = \beta_0 + \beta_1 A_{it} + \beta_2 y_{initial} + \beta_3 k_{it} + \beta_4 n_{it} + \beta_5 h_{it} + u_i + v_t + \varepsilon_{it} \quad (2)$$

The state of technology is the factor responsible for the divergence of income among countries. As technological progress contributes to growth, therefore the proxies used in the literature for technological advancements are information technology (Meijers, 2013; Noh & Yoo, 2008; Clarke & Wallsten, 2006), information and communication technology (Majeed, 2018; Majeed & Ayub, 2018; Sassi & Goaid, 2013). The present study use e-government as a proxy for technological progress, unlike previous studies that use ICT (Mahyideen *et al*., 2012). E-government not only includes ICT but also incorporates the impact of human capital which is required for operations of e-government. E-government not only explains technological advancement, but it also sheds light on the implementation of advanced technologies as well. Therefore, equation 2 can be rewritten as:

$$y_{it} = \beta_0 + \beta_1 Egovernment_{it} + \beta_2 y_{initial} + \beta_3 k_{it} + \beta_4 n_{it} + \beta_5 h_{it} + \boldsymbol{u_i} + \boldsymbol{v_t} + \varepsilon_{\boldsymbol{it}} \quad (3)$$

The literature supports higher growth through e-government, but the quality of e-government may explain the difference in trade among countries. The impact of e-government on growth is indirect as it facilitates interaction and contact among trading partners therefore this impact may vary across countries. Liberalization also influences this relationship, as liberalized countries have a positive impact on the relationship while less liberalized countries will not be able to take advantage of this mechanism. Therefore, to fulfill our purpose interactive terms of $(Egovernment_{it} \times Trade_{it})$ is introduced as the main regressor.

The influence of e-government on growth is determined by the level of trade.

$$y_{it} = \beta_1 y_{it-1} + \beta_2 Egovernment_{it} + \beta_3 k_{it} + \beta_4 n_{it} + \beta_5 h_{it} + \beta_{26} Egovernment_{it} \times \text{Tarde}_{it} + \beta_7 Z_{it} + u_i + v_t + \varepsilon_{\boldsymbol{it}} \quad (4)$$

Trade is measured as a "share of export plus import in total GDP", e is "an error term" and Z is "the vector of control variables" which includes "*government consumption, population, and inflation*". The influence of trade on growth varies based on the quality of e-government. The influence of e-government on growth is captured by β_2 while the indirect effect is captured by the coefficient β_{26}.

$$\frac{\partial y_{it}}{\partial Trade_{it}} = \beta_6 + \beta_{26} Egovernment_{it} \quad (5)$$

The inclusion of interactive term of e-government and trade help us in exploring the influence of international trade on growth in the presence of e-government. The direct effect of e-government on economic growth is captured by β_2 and the indirect impact through β_{26} respectively.

$$\frac{\partial y_{it}}{\partial Egovernment_{it}} = \beta_2 + \beta_{26} Trade_{it} \quad (6)$$

The indirect effect of e-government on growth depends on trade integration. That is e-government influences economic growth through increased international trade. The data has been obtained from the World Bank and UN "E-government Development Index".

This study exploits a panel data of all countries across the world. However, e-government data for some countries was not available and, therefore, the final data set includes 154 countries from 2003 to 2018. E-government data has been taken from "EGDI (e-government development index) and it incorporates the online government availability and web connections for service delivery". E-government index is *"the weighted average of three indexes including web connectivity, telecom infrastructure, and skilled labor".* Equal weights of 0.33 are assigned to all the components. In the data, zero represents the worst while 1 indicates the best quality of e-government. Table A1 in the appendix describes the variables used.

Panel data techniques are used to explore the linkages among the variable of interest. The results of "Pooled OLS, Fixed Effect, Random Effects and System GMM" are reported. As

pooled estimation does not consider time and countries heterogeneity, therefore, Random and Fixed Effects are incorporated, however, these models do not consider heterogeneity, autocorrelation, and simultaneity for that purpose SGMM is incorporated respectively. The equation used for SGMM is given below:

$$y_{it} = \beta_1 y_{it-1} + \beta_2 Egovernment_{it} + \beta_3 k_{it} + \beta_4 n_{it} + \beta_5 h_{it} + \beta_{26} Egovernment_{it} \times \text{Tarde}_{it} + \beta_7 Z_{it} + u_i + \varepsilon_{it} \quad (7)$$

4. Discussions and Findings

4.1 Pooled OLS Results

Equation 4 is estimated to empirically find the association between e-government and economic growth due to trade. According to literature e-government facilitates interaction among traders to tap the full potential of the trade. It is not only tariffs that hamper trade but lack of interaction among traders and improper information about goods also retard trade in an economy.

The result of the 1st column of the table (1) illustrates that the coefficient of e-government is not significant. The estimate of the interactive term of trade and e-government is also insignificant that can be interpreted as e-government has no significant indirect effect on economic growth. The coefficient of physical capital is positive and significant which infers that the increase in the capital stock of a country by 1% will improve growth by 0.023%. The coefficient of labor force participation is also insignificant. The sign of the labor force is consistent with the empirical estimation of (Mankiw *et al*., 1992). The coefficient of the initial per capita income is highly significant and positive.

In the 2nd, 3rd, and 4th column of the table (1) we have incorporated control variables to examine the sensitivity of empirical findings of OLS. The coefficients of e-government and combined effect of e-government and trade remain insignificant in 2nd and 3rd column whereas the estimate of the combined effect of e-government and trade become significant in the 4th column. In our model, the coefficient of inflation is positive and significant. In the 4th column of the table (1) the coefficient of financial development implies that an increase in financial

development by 1% will lead to a 0.0190% decrease in economic growth.

Table 1
Empirical Findings of OLS

Growth Dependent	**(1) All Countries**	**(2) All Countries**	**(3) All Countries**	**(4) All countries**	**(5) Developing countries**	**(6) All Countries**
Y_{t-1}	0.990*** (0.00293)	0.994*** (0.00294)	0.994*** (0.00295)	0.995*** (0.00379)	0.994*** (0.00764)	1.001*** (0.00313)
Kapital	0.0236*** (0.00597)	0.0170*** (0.00597)	0.0170*** (0.00598)	0.0345*** (0.00799)	0.0206* (0.0118)	0.0227*** (0.00583)
Labor	-0.00883 (0.0117)	-0.0124 (0.0116)	-0.0124 (0.0116)	-0.00448 (0.0143)	-0.00341 (0.0196)	-0.00167 (0.0114)
Human Capital	0.0149** (0.00601)	0.00888 (0.00605)	0.00884 (0.00606)	0.0134* (0.00773)	0.0126 (0.0121)	0.00867 (0.00575)
E-government	-0.0132 (0.0194)	-0.00283 (0.0196)	-0.00334 (0.0202)	0.0402 (0.0266)	0.106** (0.0515)	
EG*Trade	5.16e-05 (7.64e-05)	8.78e-05 (7.60e-05)	8.76e-05 (7.61e-05)	0.000213* (0.000109)	0.000173 (0.000184)	
Inflation		0.00996*** (0.00187)	0.00994*** (0.00188)	0.0112*** (0.00254)	0.00940** (0.00420)	
Govt. Consumption			-0.000408 (0.00379)	-0.00360 (0.00493)	0.00559 (0.00684)	
Financial Dev.				-0.0190*** (0.00332)	-0.0235*** (0.00501)	
Online Service						0.0636*** (0.0195)
Telecom Infras.						-0.135*** (0.0251)
OS*Trade						-0.000176 (0.000185)
Tele*Trade						0.000346 (0.000213)
Constant	0.0170 (0.0599)	0.0212 (0.0599)	0.0225 (0.0612)	-0.109 (0.0785)	-0.0985 (0.106)	-0.0731 (0.0580)
Observations	755	696	696	462	240	755
R-squared	0.999	0.999	0.999	0.999	0.996	0.999

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Empirical results of the 5th column of the table (1) denote that e-government has a positive and significant impact on the economic growth of developing countries. The influence of e-government on economic growth through trade is insignificant but

positive. The net marginal influence of e-government is equal to the coefficient of e-government because its influence on economic growth through trade is insignificant. Trade caused by e-government is not significantly strengthening the positive contribution of e-government in growth. The coefficients of inflation are also positive and significant whereas government consumption has an insignificant effect.

Results of the 6th column of the table (1) indicate that online service has a beneficial influence on economic growth whereas telecommunication infrastructure has a negative significant impact on growth. The coefficient of online service implies that an increase in the availability of online services by 1% improves growth by 0.0636%.

The telecommunication sector of e-government has a negative influence on economic growth. Interactive terms of online service and telecommunication infrastructure with the trade are insignificant. So, we can conclude that e-government components are not affecting economic growth through trade. The R-square of all the regressions is 0.99 which indicates that 99% variation in the model is explained by regressors. Considering OLS estimation, we can conclude that in developing countries e-government contributes to economic growth. Online service is bolstering the potential of the economy.

4.2 Fixed Effect Results

To capture hidden heterogeneity in data results of FEM are reported. In the 1st column of the table (2) results demonstrate that the coefficient of e-government appears with a positive sign however it's not significant. The estimate of the interactive term of trade and e-government is significant, and it infers that a 1% increase in e-government in the presence of trade causes 0.0014% increases in growth. The contribution of e-government in economic growth is strengthened by trade. The net marginal effect of e-government on growth is expressed as:

$$\frac{\partial\, logY}{\partial\, EG} = 0.0560 + 0.00142Trade \qquad (8)$$

Net influence of e-government on economic growth is 0.05742% (0.0560 + 0.00142). The net influence of e-government is stronger than the exclusive influence of e-government on economic growth. Empirical findings estimated with FEM indicate that influence of e-government on growth depends on the extent of trade.

The coefficient of physical capital is significant and depicts that a 1% increase in the capital stock of a country enhances growth by 0.0637%. The coefficient of labor force participation is negative but insignificant. The increase in initial per capita by 1% improves economic growth by 0.74%.

In the 2nd, 3rd and 4th columns of table (2) additional regressors are introduced to check the robustness of findings. The coefficient of e-government remains insignificant even after controlling the results which indicate that e-government has an insignificant influence on growth. The estimate of the interactive term of e-government and trade remains significant in all the regressions. The estimate of financial development is insignificant.

The 5th column presents the findings for developing countries. Results exhibit that e-government's impact on growth is strengthened by trade. The net marginal influence of e-government on economic growth is 0.0514% in relationship with the trade.

$$\frac{\partial y}{\partial EG} = 0.0497 + 0.00175\text{Trade} \tag{9}$$

The estimate of initial per capita income is positive and significant whereas the coefficient of government consumption and inflation are insignificant. The coefficient of the cross term of e-government and trade implies that an increase in e-government in relationship with trade by 1% bolsters economic growth about 0.00175% in developing countries.

Empirical results in the 6th column of the table (2) indicate that online services do not contribute to economic growth whereas the coefficient of telecom infrastructure infers that a 1% increase in trade due to telecom infrastructure decreases economic growth about 0.154%. The Product-term of online service and trade is insignificant, but the cross-term of trade and telecom

infrastructure is positive. The result infers that a 1% increase in telecom infrastructure in relationship with trade increases economic growth by about 0.0016%.

Table 2

Empirical Findings of the Fixed Effect Model

Growth Dependent	**(1) All countries**	**(2) All countries**	**(3) All countries**	**(4) All countries**	**(5) Developing countries**	**(6) All countries**
Y_{t-1}	0.736*** (0.0169)	0.759*** (0.0173)	0.759*** (0.0173)	0.717*** (0.0284)	0.733*** (0.0393)	0.756*** (0.0190)
Capital	0.0637*** (0.0101)	0.0558*** (0.0107)	0.0550*** (0.0107)	0.0783*** (0.0162)	0.0762*** (0.0231)	0.0741*** (0.0104)
Labor	-0.0537 (0.0701)	-0.0871 (0.0735)	-0.0927 (0.0735)	-0.105 (0.0990)	-0.246* (0.126)	-0.0583 (0.0717
Human Capital	0.0242 (0.0170)	0.0122 (0.0173)	0.0175 (0.0176)	0.00771 (0.0258)	0.100** (0.0493)	0.0274 (0.0174)
E-government	0.0560 (0.0522)	0.0739 (0.0522)	0.0742 (0.0522)	0.0446 (0.0700)	0.0497 (0.102)	
EG*Trade	0.00142*** (0.000340)	0.00127*** (0.000342)	0.00125*** (0.000342)	0.00185*** (0.000482)	0.00175*** (0.000649)	
Inflation		0.00493** (0.00219)	0.00475** (0.00219)	0.00543* (0.00297)	-0.000671 (0.00537)	
Govt. Consumption			-0.0264 (0.0177)	-0.0477* (0.0249)	0.00451 (0.0346)	
Financial _dev				-0.00913 (0.00746)	-0.0216** (0.0107)	
Online Service						0.0486 (0.0369)
Telecom Infras.						-0.154** (0.0721)
OS*Trade						1.67e-05 (0.000370)
Tel*trade						0.00155*** (0.000601)
Constant	2.189*** (0.298)	2.179*** (0.310)	2.245*** (0.313)	2.663*** (0.459)	2.553*** (0.625)	2.058*** (0.315)
Observations	755	696	696	462	240	755
R-squared	0.831	0.850	0.851	0.840	0.850	0.826
Number of countries	154	152	152	125	67	154
Rho	0.985	0.984	0.983	0.988	0.954	0.985

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

$$\frac{\partial y}{\partial \text{Tele}} = -0.154 + 0.0015\text{Trade} \quad (10)$$

Trade strengthens the influence of telecom services on economic growth. The indirect influence of telecom infrastructure on economic growth depends on trade. The exclusive effect of telecom infrastructure is negative but in interaction with trade, it becomes positive. The indirect influence of e-government on economic growth through trade is increased from -0.154% to -0.156%. Telecom infrastructure is mainly contributing to economic growth through trade. We can conclude that the interactive influence of e-government and trade on economic growth across the world and developing countries is significant.

4.3 Random Effect Results

Empirical findings presented in the 1st column of the table (3) demonstrate that a 1% increase in e-government in the absence of trade integration causes economic growth to increase by 0.0515%. The coefficient of the interactive term of trade and e-government is insignificant that is contrary to the theoretical literature. In 1st column of table (3) coefficient of physical capital is significant which indicates that an increase in the capital stock of the country by 1% will cause a 0.0265% increase in growth. The estimate of labor force participation is negative and significant. While the coefficient of initial per capita income signifies that a 1% increase in the initial income of the country will enhance economic growth by 0.98%.

In the 2nd, 3rd, and 4th columns of the table (3) we have controlled results using other factors influencing economic growth. The coefficient of e-government remains significant even after controlling the results. Results support the beneficial influence of e-government on economic growth even in the absence of trade. In the 4th column of the table (3) the coefficient of the cross term of e-government and trade becomes significant which indicates that an improvement in e-government in relationship with trade by 1% enhances economic growth by 0.00039%. The net marginal effect of e-government in column 4 can be shown by taking derivative concerning e-government.

$$\frac{\partial \log Y}{\partial EG} = 0.11 + 0.00039Trade \quad (11)$$

The net influence of e-government on economic growth is 0.11039% (0.11+ 0.00039). E-government improves economic growth through trade liberalization.

Table 3

Empirical Findings of Random Effect Model

Growth Dependent	**(1) All countries**	**(2) All countries**	**(3) All countries**	**(4) All countries**	**(5) Developing countries**	**(6) All countries**
Y_{t-1}	0.979*** (0.00468)	0.984*** (0.00457)	0.984*** (0.00457)	0.989*** (0.00545)	0.982*** (0.0113)	0.997*** (0.00484)
Kapital	0.0265*** (0.00787)	0.0172** (0.00787)	0.0172** (0.00786)	0.0335*** (0.0101)	0.0242* (0.0146)	0.0245*** (0.00769)
Labor	-0.0401** (0.0200)	-0.0403** (0.0193)	-0.0400** (0.0193)	-0.0192 (0.0222)	-0.0144 (0.0307)	-0.0230 (0.0190)
Human Capital	0.00679 (0.00949)	0.000168 (0.00935)	0.000252 (0.00935)	0.00878 (0.0113)	0.0180 (0.0177)	0.00801 (0.00889)
E-government	0.0515* (0.0299)	0.0616** (0.0294)	0.0614** (0.0299)	0.110*** (0.0370)	0.150** (0.0668)	
EG*Trade	0.000193 (0.000134)	0.000187 (0.000132)	0.000187 (0.000132)	0.000391** (0.000174)	0.000502* (0.000286)	
Inflation		0.00940*** (0.00211)	0.00942*** (0.00211)	0.0112*** (0.00275)	0.00825* (0.00471)	
Govt. Consumption			0.000327 (0.00621)	-0.00399 (0.00750)	0.00306 (0.0101)	
Financial. Dev.				-0.0286*** (0.00425)	-0.0373*** (0.00633)	
Online Service						0.0754*** (0.0276)
Telecom Infras.						-0.149*** (0.0379)
OS*Trade						-5.06e-05 (0.000269)
Tele*Trade						0.000314 (0.000319)
Constant	0.233** (0.0990)	0.230** (0.0961)	0.227** (0.0991)	-0.00257 (0.120)	-0.00961 (0.163)	0.0396 (0.0953)
Observations	755	696	696	462	240	755
Number of countries	154	152	152	125	67	154
Over-all R^2	0.99	0.99	0.99	0.99	0.99	0.99
Rho	0.39	0.39	0.39	0.4	0.42	0.36

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The findings in the 4th column of the table (3) indicate the positive influence of e-government on economic growth through trade, however, the influence is not robust in REM. The coefficient of inflation is positive and significant whereas financial development hurts economic growth. Results in the 5th column of the table (3) indicate that e-government and its indirect influence through trade contribute to economic growth in developing countries. The coefficient of the cross term of e-government and trade implies that an improvement in e-government by 1% in relationship with trade will boost up economic growth about 0.0005%.

Empirical findings in the 6th column of the table (3) indicate that online service supports economic growth in the absence of trade. Telecommunication infrastructure adversely affects economic growth in the absence of trade. The coefficient of online service implies that a 1% increase in online service without trade will cause a 0.0754% increase in economic growth. Interactive terms of e-government components and trade are insignificant. Trade is facilitating the contribution of e-government in the economic development of a country.

The R-square of all models is 0.99 which implies that 99% variation in the model is explained by independent variables. Rho indicates that variation in error term is coming from time-series and cross-section.

4.4 Arellano Bond Model

Reverse causality exists between e-government and economic growth. Technological diffusion is determined by the economic performance of an economy (Czernich *et al.* 2009; Comin & Hobjin, 2004). To tackle reverse causality, we have employed the Arellano Bond method. Arellano bond tells us about AR (1) and AR (2), and the instrument's validity. Instruments used for e-government are "the percentage of people using the internet, fixed telephone lines per 100 inhabitants, and urban population".

Empirical results of the 1st column of the table (4) indicate that improvement in the quality of e-government by 1% support increment in economic growth by 0.001%. Initial per capita GDP,

physical and human capital contributes to economic growth whereas labor supply has an insignificant impact, respectively.

Table 4
Empirical Findings of SGMM

Growth Dependent	(1) All Countries	(2) All Countries	(3) All Countries	(4) All Countries	(5) Developing Countries	(6) All Countries
Y_{t-1}	0.937*** (0.0266)	1.026*** (0.0345)	1.028*** (0.0353)	1.058*** (0.0400)	0.855*** (0.0568)	0.887*** (0.0330)
Capital	0.457*** (0.159)	0.930*** (0.181)	0.909*** (0.202)	1.133*** (0.240)	0.0436 (0.198)	0.0888 (0.250)
Labor	-0.0643 (0.0784)	-0.360*** (0.100)	-0.346*** (0.117)	-0.555*** (0.164)	0.246* (0.141)	0.322*** (0.0977)
Human Capital	0.291*** (0.0705)	0.275*** (0.0869)	0.265*** (0.0959)	0.796*** (0.296)	-0.160 (0.351)	
E-government	0.0011*** (0.00028)	0.00132*** (0.000314)	0.00127*** (0.000384)	0.00379 (0.00269)	0.00204 (0.00383)	
EG*Trade		0.0239*** (0.00886)	0.0254** (0.0108)	0.0167** (0.0121)	0.0440*** (0.00922)	
Inflation			0.0122 (0.0511)	-0.0347 (0.0584)	-0.0310 (0.0566)	
Govt. Consumption				0.228* (0.120)	-0.0349 (0.154)	
Financial Dev.				0.2284** (0.1202)	0.1636 (0.1297)	
Online Service						-0.238 (0.240)
Telecom Infras.						0.353 (0.408)
OS*Trade						0.00604** (0.00253)
Tele*Trade						-0.00654 (0.00432)
Constant	2.557*** (0.759)	4.942*** (0.918)	4.758*** (1.200)	5.381*** (1.287)	0.183 (1.620)	-0.0297 (1.166)
Observations	757	692	692	692	353	758
Number of countries	152	150	150	150	78	153
Instrument[4]	20	20	19	19	19	19
P-value of AR(2)	0.594	0.647	0.037	0.121	0.19	0.08
P-value of Sargan test	0.872	0.807	0.336	0.808	0.35	0.17

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

[4] Exogenous instrument is percentage of people using internet, fixed telephone lines, and urban population. We have not taken the regional dummies as the instrument in panel data because they were not working well.

Estimation results in the 2nd and 3rd columns of the table (4) support improved growth through e-government in the absence of financial development.

The interactive influence of e-government and trade is positive. It indicates that trade liberalization strengthens the contribution of e-government to economic growth. The coefficient of the cross term of e-government and trade implies the improvement of 0.0239% in economic growth. The coefficient of inflation is insignificant. The indirect of e-government is expressed as:

$$\frac{\partial \log Y}{\partial \text{EG}} = 4.94 + 0.0239\text{Trade} \qquad (12)$$

The direct influence of e-government on economic growth in the 2nd column of the table (4) is 0.0013%. In the 2nd column, the net marginal impact of e-government through trade is 0.0239%. The net influence of e-government remains positive in all the panel data techniques. The contribution of initial per capita income to growth is validated in all the regressions of the Arrellano Bond model. The coefficient of labor supply is negative and significant while positive and significant in the case of developing economies. The physical capital contributes to growth in all regressions. The P-value of AR (2) is not significant it means there is no second stage autocorrelation in the model. The P-value of the Sargan test validates the instruments thus instruments are exogenous.

5. Conclusion

The study provides empirical evidence on the influence of e-government on economic growth through trade. To fulfill our purpose interactive term of e-government with trade is incorporated in the estimations. The relationship among the variables is explored through "Pooled OLS, Fixed Effects, Random Effects". Results of System GMM also provided due to its power in tackling heterogeneity, autocorrelation, and simultaneity, respectively.

The results of panel analysis suggest e-government increase growth through the enhancement of trade. The findings reveal with an increase in e-government quality by 1%, growth will be enhanced by 0.257% respectively. The significant and positive coefficient of e-government supports higher growth resulting from e-government. An increase in the availability of online services boosts growth by 0.075%. The product (interaction term) of trade and e-government is significant and suggests that through trade, e-government leads to higher economic growth. Alternatively, it could be said that trade leads to higher growth through reinforcement of e-government

The contribution of our study in the literature is manifolds: First, this is the only study that has examined the mediating role of e-government in supporting growth through improving trade. Second, as the study is based on a panel of 154 countries therefore its findings can be used for enhancing trade across the countries through improving e-government. Third, the study used an instrumental approach to provide robust results in the presence of simultaneity.

Due to data limitations, the long-run relationship between e-government and growth is not explored. Furthermore, as developing countries are struggling to sustain growth rates so development can be achieved and the standard of living could be raised, this is possible through employing e-government. As this study only examined the effect of e-government on growth through trade future studies can focus on how e-government can support higher output, reduce inequalities, support employment, increase transparency, and decrease corruption to support higher income.

Based on our results it can be suggested that governments should focus on the provision of online services as it decreases inefficiencies and leads to higher growth. Furthermore, as the world is a global village therefore, efforts should be made to enhance human capital which can provide online service and leads to higher productivity, respectively.

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Appendix

Table A1: Variable Description

Variables	Definition	Source
Per capita GDP	"GDP per capita at constant (2005) U.S dollars."	[1]
E-government	"The online presence and web connection of government to deliver are responsibilities."	[2]
Online service	"Degree of the web connectivity and online accessibility of government."	[2]
Telecom service	"Degree of telecommunication substructure of the government."	[2]
Human capital	"Gross secondary school enrollment of the total population."	[1]
Physical capital	"Fixed capital formation (Gross) percentage of GDP."	[1]
Labor supply	"Share of labor force participation total % of the population"	[1]
Financial development	Self-generated index by taking the principal component analysis of the ratio of credit provided to the private sector by bank and GDP and ratio of credit provided to the private sector by financial sector and GDP."	[1]
Trade	"Export plus import percentage of GDP."	[1]
Inflation	GDP deflator	[1]
Urban population	"Percentage of the urban population in the total population."	[1]
Fix_Telephone	"Fixed telephone lines per 100 inhabitants."	[3]

[1] World Bank (2018); [2] Global e-government reports; [3] ITU statistics