Mitigate Damages and Support Growth through E-government - A preliminary examination of Economies in the Global Pandemic

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Abstract (300 words max):

In this study, we approach the question in the context of severe global pandemic that yet to be brought under control both globally and regionally. Meanwhile, another global trend is the growing prevalence of internet and internet-based contactless activities, especially during the pandemic. Combining the two trends, we examine whether, and how adequately constructed e-governments have helped to contain the spread of the deadly virus and facilitated economic recovery. By examining closer the components of e-government index and the types of policy responses to the pandemic, as well as their impacts on the economic growth, we find that countries with better E-Government development, government tend to be more responsive, with stronger stringency, health and economic supporting policies. But the higher public participation makes the government response to the pandemic less effective. Our results indicate that the stringency policy helped to protect the economic growth while the investment in E-Government, the health and economic policies dragged the economic growth slower in the pandemic. However, our estimations also show that in the long-run, the expansion of online service provision and public participation in E-Government can promote the economic growth.

Keywords: E-Government, Global Pandemic, Economic Growth

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1. Background

As the COVID-19 pandemic continues to tarnished the world economy, nearly two years after the outbreak, it has become increasingly apparent that governments around the world have an crucial role to play, both to contain the spread the virus and protect lives, and to revitalize the economy. Indeed, with new variants continue to emerge, uncertainties remain as to when the pandemic will be brought under effective control. Meanwhile, internet-based contactless activities have flourished, on one hand, driven by sustained restriction to people's movement and interaction to contain the spread of the virus, and, on the other, supported by the development of internet-related technologies. Many foresee significant changed taking place and gradually taking roots in how societies will be organized and function in the future.

As societies change and adapt, an important question is how governments have and should respond to enhance and improve its performance, by taking advantage of the possibilities arisen from the emergence and the spread of many internet-based contactless governance tools. In this paper, we approach this question by examining whether and how e-government plays a role in the two important aspects, namely protecting lives and enhancing growth.

At the same time, as significant development gaps remain among countries, the degree of digitalization and the adoption of internet-based technologies varies considerably, including that by the government. In addition, some countries are heavily dependent on intra-regional and interregional economic exchanges, making the cost of a lasting pandemic extreme high. Therefore, it is thus finding effective ways to mitigate the damages through the use of new technologies is critical to find effective ways government can utilize new technologies and help mitigate the damages.

Our empirical analysis is carried in three steps. First, we estimate the growth equation with the before pandemic data to obtain a preliminary assessment on the effect of e-government on economic performance. Second, we investigate how the pandemic and the E-Government impact each other during the pandemic period. And third, based on the findings of the first two, we estimated the interactive impacts of the pandemic and the E-Government on the economic growth.

The rest of the paper is organized as follows. Section 2 reviews existing studies relevant to our research, Section 3 first introduce the theoretical model on which we derive our base-line empirical

equation. Data and variables are also explained. In Section 4, basic statistics and estimation results are presented and discussed. Section 5 concludes.

2. Literature Review

2.1 The impacts of pandemic on economic performance

As infectious cases began rising sharply in various countries in early 2020, governments took unprecedented steps to lock down social activities to contain the spread of the virus, which inadvertently disrupted the global economy. Government responses to the pandemic were extraordinary in terms of the speed with which they took place, the broad scope of the fiscal and monetary policies they adopted, and the number of countries that were involved. The negative impacts of the pandemic on the global economy has been a widespread agreement among economists (M. Szmigiera, 2021). A forecast by the World Bank published in 2020 indicated that the economic recession in 2020 would affect 90% of the world's economies and may become the deepest since World War II. According to the International Monetary Fund (IMF, 2021), global economic growth fell to an annualized rate of around -3.2% in 2020. In addition, the impacts can be long last. According to OECD (2021) calculations, Output may remain around 5% below pre-crisis expectations in many countries in 2022. OECD (2021) also warned that the pandemic is fragmenting the global economy through a growing number of trade and investment restrictions and diverging policy approaches that are being implemented on a country-by-country basis, which can have very long impacts on the global economy.

2.2 The impacts of E-Government on economic performance (or relationship)

Based on annual data for 24 OECD countries from 1998 to 2006, Corsi and D'Ippoliti (2013) show that the investment in e-government can significantly improve the productivity of public administrations, which can further contribute the economic growth.

Bélanger and Carter (2012) also argue that by using ICT, e-government allows government to provide more effective and efficient public services for businesses, employees, residents, and other government entities with better quality, which can lubricant the growth of the economy. The adoption of e-government can also boost public services and communication (Krishnan et al., 2013) as well as the information economy and other business opportunities which are also growth drivers of the economy.

Ali (2021) shows that better E-Government can help economies to enhance Foreign Direct Investment (FDI) inflows through three channels: the efficiency gains through cost and time reductions, reduced corruption with more inclusive, effective, accountable, and transparent public services, and access to information and knowledge about investment opportunities.

Based on annual data for 15 countries in the Middle East and North Africa (MENA) region between 2003-2018, Dhaoui (2021) shows that better e-government development significantly improves governance in terms of the control of corruption, government effectiveness, and regulatory quality. They also find that good governance has a positive contribution to sustainable development including GDP per capita. However, there is no significant evidence of e-government's positive impacts on any aspects of sustainable development they investigated.

On the other hand, there are also evidences show that the economic performance can also affect the development of e-government. For example, based on annual data of 534 largest cities in the world for the year 2003, 2009 and 2016, Ingrams, et al (2020) show that Population size, GDP, and regional competition have a positive impact on the development of e-government.

2.3 The impact (relationship?) of E-Government on pandemic (put 2.3 and 2.4 together?)

Based on survey of individuals, officials and government agents in Latin America and the Caribbean countries, Roseth (2021) find that the pandemic has led many countries to digitize a significant range of services. At the same time, the proportion of citizens using the internet to access government transactions rose from 21 percent before the pandemic to 39 percent during it. However, around 50 percent of citizens completed their last such transaction in person. With regard to teleworking in the public sector, almost half of all employees stated that they had been unable to perform critical tasks since the onset of the pandemic, many of which could have been resolved using digital governance tools. These findings point to the need to improve the availability and quality of digital services, as well as the feasibility of telework in government.

A UN/DESA Policy Brief shows that the percentage of government portal with COVID-19 information increased from 57 on 25 March 2020 to 86 on 8 April 2020. It argues that the digitalization can help government and society to respond to the crisis in the short-term, resolve socio-economic repercussions in the mid-term and reinvent existing policies and tools in the long-term.

Freeguard et al (2020) argue that the pandemic has accelerated the digital transformation of public service delivery and the government use of data in UK. They show that the digitalization has made the public service more efficient in terms of Coronavirus Job Retention, Self-Employment Income Support, the Vulnerable People Service, Verify and Notify citizens, etc. However, they also noticed some high-profile failures, such as the failures in the roll-out of the contact tracing app, which actually caused more problems than it solved for the government.

2.4 The impact of E-Government on the relationship between pandemic and economic performance

According to Knutt (2020), the Romanian Ministry of Labor used robotic process automation (RPA) to distribute direct payments to self-employed workers impacted by COVID-19. Of the 285,000 claims processed, 96% were automated, with each claim taking 36 seconds as opposed to 20 minutes when processed manually.

According to a Gartner report (2020), government organizations increased their IT spending on digital public services, public health, social services, education, and workforce reskilling in support of individuals, families and businesses that are heavily impacted by the COVID-19 pandemic in 2020.

Sullivan et al (2021) argue that digital was no longer a "nice to have" for government, but an imperative. They find that, to meet the needs of the pandemic, governments all over the world have accelerated their digital transformation through investment and human capital training, and 79% of government officials in their survey indicated that automation is making a significant positive impact on their business, adoption of automation is likely to continue.

Dawi et al (2021) conducted a web survey among 404 residents during the Recovery Movement Control Order (RMCO) period of Malaysia in 2020. Their analysis shows that e-government can significantly improve public engagement on protective behavior.

So far, no quantitative analysis on this topic found.

3. Methodology

We follow Bassanini and Scarpetta (2001)'s policy oriented study and use their policy-augmented growth equation derived from a growth model based on constant-returns-to-scale technology (Mankiw et al., 1992 and Barro and Sala-i-Martin, 1995) as our benchmark equation:

$$g_{i,t} = \beta_0 + \beta_1 lny_{i,t-1} + \beta_2 lnI_{i,t} + \beta_3 h_{i,t} + \beta_4 \Delta lnpop_{i,t} + \sum_{i=5}^{m} \beta_j lnV_{i,t}^{j} + \varepsilon \qquad (1)$$

where g is the annualized growth rate of GDP per capita; y is GDP per capita; I is the investment; h is human capital; $\Delta lnpop$ is population growth; the Vj is a vector of policy related variables affecting economic efficiency; and ε is the usual error term. The policy related variables include inflation, government size, financial development, openness, etc.

To investigate the impact of E-Government on economic performance, we add E-Government related variables into equation (1). As suggested by the UN E-Government survey, E-Government can affect the economy from two aspects: the development status of E-Government and the public participation of E-Governance. Our analysis also includes variables measuring these two aspects of countries' E-Government.

According to the existing literature mentioned earlier, the covid pandemic impact the economies mainly from three channels: First, the severe epidemic has made people unable to carry out normal economic activities due to the fear of being infected. Second, the preventative measures implemented by government to slow the spread of virus have also slowed down most economic activities. Third, governments' economic supporting policies may help reduce the economic damage caused by the epidemic and promote economic recovery. The first impact definitely has negative impact on economic performance in almost all aspects. Therefore, we add the pandemic related variables in to our estimated equations to investigate the impacts of pandemic severity, preventative measures and economic supporting policies on economic performance.

The pandemic effects may also change the effectiveness of E-Government. As many studies mentioned above have shown, during the pandemic, the development of E-Government has been speeded up in many countries, including both the infrastructure development and the utilization. At the same time, due to its contactless feature, E-Government may also improve the effectiveness of governments' preventative measures and the economic supporting policies. Therefore, the impacts of E-Government on economic performance may be strengthened during the pandemic.

We add the interactive variables of E-Government and pandemic related variables into our estimated equations to test these possible impacts.

The data we used to measure the variables mentioned above are from three sources: the economic related data are from CEIC Data's World Trend Plus Database; the E-Government related data are from UN's E-Government Survey for the year 2014, 2016, 2018 and 2020; the pandemic related data are from the Oxford Covid-19 Government Response Tracker (OxCGRT).

CEIC Data's World Trend Plus Database provides annual and seasonally adjusted quarterly time series data of key economic indicators such as nominal and real GDP and GDP growth, CPI, Government consumption, Exports, Imports, Capital formation, Population, etc. CEIC calculates seasonally adjusted series by X-12 ARIMA.

UN's E-Government Survey is a biennial Survey published by the Division for Public Administration and Development Management (DPADM) of UN since 2003. It assesses the E-Government development status (E-Government Development Index, EGDI) and the effectiveness of E-Government (E-Participation Index, EPI) of all 193 United Nations Member States. Both EGDI and EPI do not capture e-government development or inclusion in an absolute sense; rather, they only give performance rating of national governments relative to one another. The E-Government Development Index tries to incorporate countries' website development patterns and the access characteristics, such as the infrastructure and educational levels, to reflect how a country is using information technologies to promote access and inclusion of its people. Therefore, the EGDI is a weighted average of three normalized scores on three most important dimensions of e-government, (1) scope and quality of online services (Online Service Index, OSI), (2) development status of telecommunication infrastructure (Telecommunication Infrastructure Index, TII), and (3) inherent human capital (Human Capital Index, HCI).

The survey questions and the national scores of EPI focus on how well a government relays information to its constituents ("e-information sharing"), how engaged citizens are in the designing of policies("e-consultation"), and how empowered citizens feel in the decision-making process ("e-decision making"). The EPI is normalized by taking the total score value for a given country, subtracting the lowest total score for any country in the same year Survey and dividing by the range of total score values for all countries.

The OxCGRT tracks the development of the COVID-19 pandemic and the policy measures that governments have taken to deal with COVID-19 since 1 January 2020. It provides systematic information covering more than 180 countries and codes the information into 23 indicators. In our study, we use the number of confirmed cases, the government response index, stringency index, economic support index and the Containment and health index.

Detailed description of variables and data used in our empirical analysis are summarized as below:

Variables	Description	Availability
Economic variables		
$growth_{i,t}$	Seasonally adjusted year on year growth of quarterly real GDP	2015Q1-2021Q3
Export	Seasonally adjusted year on year growth of quarterly export in million US dollar	2014Q1-2021Q3
Import	Seasonally adjusted year on year growth of quarterly export in million US dollar	2014Q1-2021Q3
lnCF	Logarithm of seasonally adjusted quarterly Gross Fixed Capital Formation in million US dollar	2014Q1-2021Q3
CPIYOY	Seasonally adjusted year on year change of quarterly consumer price index	2014Q1-2021Q3
GDPPC	Real GDP per capita, annual data	2014-2020
lnH	Logarithm of the stock of human capital measured with the Human Capital Index from the CEIC, which is calculated by the Groningen Growth and Development Centre (GGDC) and based on years of schooling and returns to education, annual data	2014-2020
lnPop	Logarithm of population in million persons, annual data	2014-2020
lnDeposit	Financial development measured by the logarithm of total Deposits as a percentage of GDP, annual data	2014-2020
Open	Exposure of countries to foreign trade measured by the sum export and import as share of GDP, annual data	2014-2020
E-Government Variables		
EGOV	UN E-Government Index, bi-annual data	2016, 2018, 2020
EPart	UN E-Participation Index, bi-annual data	2016, 2018, 2020
EServ	Online service index, bi-annual data	2016, 2018, 2020
Tel	Telecommunication infrastructure index, bi-annual data	2016, 2018, 2020
Pandemic related Variables		
Pandemic	a dummy variable valued at 1 for the periods of 2020Q1-2021Q3, and 0 for the periods of 2015Q1-2019Q4	2015Q1-2021Q3
lnConfirmed	Logarithm of the Total number of confirmed cases. Equals 0 for periods before 2020Q1.	2015Q1-2021Q3
RConfirmed	Share of confirmed cases in population. Equals 0 for periods before 2020Q1.	2015Q1-2021Q3

GovResp	The OxCGRT Government response index measure the overall strength of government responses based on all indicators in the database. Higher value indicates stronger government responses. Equals 0 for periods before 2020Q1.	2015Q1-2021Q3
Stringency	The OxCGRT Stringency index measures the strictness of 'lockdown style' policies that restrict people's behavior and public information campaigns. Higher value indicates stricter policies. Equals 0 for periods before 2020Q1.	2015Q1-2021Q3
EconSupport	The OxCGRT Economic support index measures the strength of economic policies such as income support and debt relief. Higher value indicates stronger economic support. Equals 0 for periods before 2020Q1.	2015Q1-2021Q3
Health	The OxCGRT Containment and health index combines 'lockdown' restrictions and closures with health-related measures such as testing policy and contact tracing, short term investment in healthcare, as well investments in vaccines	2015Q1-2021Q3

All policy-related variables have been introduced with a one-year lag to reflect the lag of policy effectiveness. After combining data from all three data sources, we have 62 countries left in our estimations.

4. Descriptive Statistics and Estimation Results

4.1 Descriptive Statistics

Table 4.1 reports the statistics of variables we used in estimations. We can see from the values of standard deviation and the differences between minimum and the maximum values that, both the growth of economies (*Growth*) and the development of E-Government (*EGOV*) vary a lot across countries. The severity of pandemic as measured by the population share of confirmed cases (*RConfirmed*) and the strength of government responses (*GovResp*) are also quite different for different countries.

Table 4.2 shows the correlation coefficients of variables based on all of our data for the period of 2015Q1-2021Q3. We can see that the *Growth* is negatively correlated with all pandemic and E-Government related variables. Only trade related variables (*Open*, *Export* and *Import*) are positively related with *Growth*. These are somehow different from our expectations that the E-Government and some of the government responses to the pandemic should be good to the economic performance.

Table 4.1 Statistics of Variables

Variable	Obs	Mean	Std. Dev	Min	Max
GDPPC1	2,724	9.49	1.26	5.90	11.74
Growth	2,423	1.80	5.96	-62.18	43.75
lnCF	2,129	9.18	1.80	5.25	14.03
lnH1	3,456	0.94	0.29	0.17	1.47
lnPop	3,152	2.65	1.67	-1.11	7.25
Open	3,100	0.68	0.43	0.09	3.49
CPIYOY	2,788	258	7000	-4.46	304990
Export	3,413	4.64	25.86	-98.78	553
Import	3,427	3.82	18.12	-83.59	239
lnDeposit	2,988	11.50	2.27	3.56	17.30
Pandemic	4,987	0.23	0.42	0	1
Confirmed	4,987	133869	1323086	0	43500000
RConfirmed	3,152	0.54	1.93	0	18.711
GovResp	4,987	11.66	23.62	0	87.92
Stringency	4,890	12.55	25.79	0	100
Health	4,987	11.99	24.26	0	89.64
EconSupport	4,987	9.48	23.50	0	100
EGOV	2,384	0.57	0.21	0.06	0.98
Epart	2,384	0.57	0.26	0	1
Eserv	2,384	0.57	0.26	0	1
Tel	2,384	0.46	0.25	0.01	1

Table 4.2 Correlation Coefficients of Variables

	growth	*GDPPC1*	*lnCF*	*lnH1*	*lnPop*	*Open*	*CPIYOY*	*Export*	*Import*	*lnDeposit*	*Pandemic*
growth	1										
GDPPC1	-0.01	1									
lnCF	-0.03	0.25	1								
lnH1	-0.06	0.67	0.17	1							
lnPop	-0.07	-0.32	0.81	-0.22	1						
Open	0.06	0.14	-0.24	0.33	-0.35	1					
CPIYOY	-0.07	-0.31	0.01	-0.28	0.23	-0.22	1				
Export	0.52	-0.03	-0.03	-0.07	-0.03	0.08	-0.01	1			
Import	0.61	-0.01	0.00	-0.09	-0.02	0.07	0.01	0.56	1		
lnDeposit	-0.11	0.47	0.90	0.32	0.63	-0.18	-0.14	-0.09	-0.08	1	
Pandemic	-0.68	0.02	0.02	0.11	0.01	0.00	-0.04	-0.38	-0.49	0.09	1
Confirmed	-0.12	-0.02	0.20	0.00	0.20	-0.12	0.03	-0.07	-0.06	0.17	0.21
RConfirmed	-0.25	0.09	0.06	0.11	0.01	0.01	-0.02	-0.08	-0.11	0.11	0.45
GovResp	-0.66	0.01	0.05	0.10	0.04	-0.02	0.00	-0.36	-0.47	0.11	0.98
Stringency	-0.61	-0.02	0.05	0.07	0.07	-0.04	0.02	-0.34	-0.45	0.10	0.94
Health	-0.65	0.00	0.05	0.09	0.05	-0.02	0.00	-0.35	-0.47	0.11	0.97
EconSupport	-0.65	0.10	0.03	0.14	-0.03	0.01	-0.04	-0.35	-0.47	0.11	0.89
EGOV	-0.22	0.80	0.35	0.71	-0.10	0.08	-0.21	-0.12	-0.17	0.53	0.32
Epart	-0.07	0.46	0.50	0.45	0.24	-0.09	-0.13	-0.01	-0.05	0.58	0.13
Eserv	-0.08	0.53	0.48	0.42	0.19	-0.09	-0.10	-0.02	-0.05	0.59	0.10
Tel	-0.31	0.81	0.21	0.71	-0.25	0.15	-0.25	-0.19	-0.22	0.43	0.46

	Confirmed	*RConfirmed*	*GovResp*	*Stringency*	*Contain*	*EconSupport*	*EGOV*	*Epart*	*Eserv*	*Tel*
growth										
GDPPC1										
lnCF										
lnH1										
lnPop										
Open										
CPIYOY										
Export										
Import										
lnDeposit										
Pandemic										
Confirmed	1									
RConfirmed	0.42	1								
GovResp	0.24	0.51	1							
Stringency	0.23	0.47	0.98	1						
Health	0.24	0.51	1.00	0.99	1					
EconSupport	0.16	0.45	0.90	0.82	0.87	1				
EGOV	0.07	0.19	0.30	0.27	0.29	0.34	1			
Epart	0.10	0.08	0.14	0.13	0.13	0.15	0.78	1		
Eserv	0.08	0.08	0.11	0.10	0.10	0.13	0.82	0.93	1	
Tel	0.06	0.26	0.43	0.39	0.42	0.47	0.92	0.55	0.58	1

4.2. Estimation Results

Table 4.3 shows our estimations of the benchmark equation (the first column) and the overall impacts of the pandemic (Column 2-3) and the E-Government (Column 4-6) on the economic growth respectively. The dependent variables for all equations in this table are the year-on-year growth of seasonally adjusted quarterly GDP in real terms and the results are based on random effect panel data regressions. Our benchmark equation is the estimation of equation (1) based on before pandemic data (2015Q1-2019Q4). For the benchmark equation, the estimated convergent coefficients (the coefficient of GDPPC1, the GDP per capita lagged one period), the population and inflation (CPIYOY) are significantly negative while the estimated coefficients for capital formation, the growth of exports and imports, as well as the financial development (lnDeposit) are significantly positive. These are consistent with most existing literature. The estimated coefficients for human capital and open are not significant but with expected signs. Column (2) also estimates the equation (1), but are based on the data in pandemic (2020Q1-2021Q3). We can see that the estimated coefficients for *GDPPC1*, *lnPop* and *CPIYOY* are no longer significant. The sign of the estimated coefficient for *lnDeposit* even changes from significantly positive to significantly negative. This indicates that the pandemic does have significant economic impacts. In column (3), we add a dummy variable *pandemic* in to equation (1) and include data both before and in the pandemic. The significance and signs of estimated coefficients in clumn (3) are similar to those in column (1), except that *lnDeposit* becomes insignificant. The estimated coefficient for *Pandemic* is significantly negative which is consistent with our expectation of pandemic's negative shock on economies.

To test the impacts of E-Government development on economic growth, we add the E-Government related variables into equation (1) and estimate the equation with before pandemic data. As the E-Government data only available in two of the five before pandemic years (2016, 2018) covered by our study, our number of observations decreases from 1298 in column to 520 in column (4)-(6). We can see that the estimated coefficients for EGOV is significantly positive in column (4). This indicates that the development of E-Government does promote the economic

growth. When we decompose the E-Government into online service provision and the telecommunication infrastructure. We can see that in column (5), the estimated coefficient is significantly positive for online service provision while insignificant for telecommunication infrastructure. This indicates that the expansion of available online service can significantly help the economic growth, but the huge investment in telecommunication infrastructure has no clear impacts in short run. When we add the E-Participation index into the equation in column (6), its estimated coefficient is positive but not significant. But the estimated coefficient for E-Government index become insignificant with much smaller value. This means that better public participation in E-Government may play an important role in E-Government's economic impacts. In unreported results, we also estimated Eq4 with data in pandemic. The estimated coefficient for E-Government is still insignificant, but its sign becomes negative. This indicates that the impacts of E-Government might be very different in pandemic comparing to those before pandemic.

To investigate the impacts of pandemic on the development of E-Government, we use the four E-Government related variables mentioned above as independent variables and regress them on the dummy variable *pandemic* respectively based on the annual data of the years 2016, 2018 and 2020. To control the various trending factors of the E-Government development, we add the variable *year* into the estimations. As shown in Table 4.4, based on our random effect panel data regressions, the estimated coefficients for *pandemic* are all statistically significant, which indicates that the development of E-Government before and in the pandemic are significantly different. The signs of the estimated coefficients suggest that in the pandemic, the overall development of E-Government and the telecommunication connectivity are faster than before, while the improvement of the public participation and the provision of online services are slower. This indicates that, although the overall online and digital transformation of public governance is speedup in the pandemic, the involvement expansions of both citizens and public servants are slower. This may because of the reduce of the general public governance activities during the pandemic.

Table 4.3 The Over All Impacts of E-Government and Pandemic

Variable	(1) Benchmark		(2) In Pandemic		(3) Eq1		(4) Eq2		(5) Eq3		(6) Eq4	
GDPPC1	-2.636	***	0.644		-2.094	***	-3.411	***	-3.179	***	-3.171	***
lnCF	1.005	***	2.656	**	2.408	***	1.429	***	1.448	***	1.415	***
lnH1	-1.497		-1.182		-2.729		-1.264		-0.161		-0.900	
lnPop	-1.972	***	-0.931		-2.382	***	-2.323	***	-2.361	***	-2.310	***
Open	0.078		-1.565		0.234		0.274		0.272		0.279	
Export	0.024	***	0.169	***	0.041	***	0.019	***	0.020	***	0.019	***
Import	0.027	***	0.184	***	0.063	***	0.022	***	0.022	***	0.021	***
CPIYOY	-0.153	***	0.009		-0.095	***	-0.128	***	-0.124	***	-0.123	***
lnDeposit	0.793	**	-1.615	*	-0.174		0.694	**	0.705	**	0.669	**
Pandemic					-6.136	***						
EGOV							4.170	**			0.643	
Eserv									1.782	*		
Tel									-0.488			
Epart											1.836	
_cons	16.891	***	-8.124		12.051	***	19.210	***	17.358	***	17.940	***
N	1298		228		1526		520		520		520	
r2_o	0.206		0.551		0.508		0.293		0.287		0.295	
r2_w	0.169		0.652		0.558		0.166		0.166		0.169	
r2_b	0.304		0.388		0.371		0.422		0.413		0.425	

Notes: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level.

Table 4.4 The impacts of Pandemic on the Development of E-Government Development (Based on 2016, 2018 and 2020 annual data)

Variable	EGOV		Epart		Eserv		Tel	
year	0.020	***	0.046	***	0.045	***	0.013	***
pandemic	0.019	***	-0.093	***	-0.096	***	0.125	***
_cons	-40.078	***	-92.223	***	-90.692	***	-25.658	***
N	596		596		596		596	
r2_o	0.059		0.085		0.084		0.098	

Notes: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level.

Table 4.5 The impacts of Increasing Confirmed Cases on the Development of E-Government Development

	EGOV		Epart		Eserv		Tel		EGOV		Epart		Eserv		Tel	
								2020Q2								
RConfirm	7.87E-06	*	7.58E-06		7.98E-06		1.18E-05	**								
lnConfirm									0.036	***	0.050	***	0.048	***	0.035	***
_cons	0.711	***	0.711	***	0.700	***	0.657	***	0.325	***	0.195	***	0.206	***	0.285	***
N	105		105		105		105		145		145		145		145	
r2	0.054		0.029		0.040		0.075		0.180		0.252		0.266		0.115	
								2020Q3								
RConfirm	3.97E-06	***	4.42E-06	**	4.53E-06	**	5.03E-06	***								
lnConfirm									0.032	***	0.045	***	0.043	***	0.029	***
_cons	0.706	***	0.702	***	0.691	***	0.655	***	0.321	***	0.188	***	0.201	***	0.296	***
N	105		105		105		105		145		145		145		145	
r2	0.051		0.037		0.048		0.051		0.128		0.179		0.187		0.074	

Notes: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level.

Table 4.6 The impacts of Pandemic Related Policies on the Development of E-Government Development

	2020Q2								2020Q3							
Variable	EGOV		Epart		Eserv		Tel		EGOV		Epart		Eserv		Tel	
Stringency	-0.014	***	-0.015	***	-0.013	***	-0.017	***	-0.009	***	-0.010	***	-0.008	***	-0.013	***
Health	0.016	***	0.019	***	0.016	***	0.020	***	0.012	***	0.013	***	0.011	***	0.016	***
EconSupport	0.003	***	0.003	***	0.003	***	0.003	***	0.003	***	0.003	***	0.003	***	0.003	***
_cons	0.410	***	0.365	***	0.368	***	0.341	***	0.347	***	0.345	***	0.347	***	0.242	***
N	145		145		145		145		145		145		145		145	
r2	0.430		0.342		0.341		0.431		0.340		0.271		0.271		0.355	

Notes: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level.

To study whether the impacts of pandemic are different by severity of the pandemic, we regress the E-Government variables on the number of confirmed cases and the share of confirmed cases over total population respectively. As we have only one year (the 2020 UN E-Government Survey) in pandemic data for the E-Government, which reflect the E-Government development status at the end of 2020, we use robust OLS regressions based on the data for the second and third quarter of the year 2020. Our estimation results in Table 4.5 show that, for the second quarter of 2020, the greater share of confirmed cases significantly speed up the overall development of E-Government and the telecommunication connectivity while the increase of the number of confirmed cases significantly increase the development of all aspects of the E-Government. For the third quarter, the more severe pandemic in terms of both the number and share of confirmed cases speedup all aspects of the E-Government development.

We further investigate the impact of pandemic related policies on the development of E-Government with robust OLS regressions based on the data for the second and third quarter of the year 2020. As shown in Table 4.6, the stringency of virus containment measures significantly slowing down the development of E-Government in all aspects while the economic supporting policies and the health policies such as the tracing and vaccination, significantly promote the development of E-Government.

As we mentioned earlier, the development and availability of E-Government may also help the world's battle with virus and the economic performance. We investigate the impact of E-Government on government's response to the pandemic with random effect panel data regressions. To control the impacts of pandemic severity on governments' response, we add the number or the share of confirmed cases in the regressions respectively. To solve the endogeneity problem, we use the 2018 E-Government data, the latest before pandemic. Our estimation results in Table 4.7 show that when we use the share of confirmed cases to reflect the severity of the pandemic, E-Government significantly promote governments' overall response to the pandemic and the economic support policies. When we use the number of confirmed cases to reflect the impacts of pandemic severity, E-Government significantly promotes all aspects of the government responses.

Table 4.7 The impacts of the Development of E-Government Development on Government Responses in Pandemic

Variable	Stringency		Health		EconSupport		GovResp		Stringency		Health		EconSupport		GovResp	
RConfirm	0.000	***	4.49E-06		-6.3E-05	**	-5.53E-06									
EGOV1	-1.849		8.37848		73.918	***	16.693	**	23.737	***	20.944	***	67.758	***	27.105	***
lnConfirm									-2.059	***	-0.029		0.572	**	0.016	
_cons	65.332	***	51.682	***	0.471		45.178	***	65.023	***	44.401	***	-3.094		38.509	***
N	681		702		702		702		1010		1011		1011		1011	
r2_o	0.033		0.007		0.123		0.021		0.019		0.078		0.249		0.151	
r2_w	0.085		0.000		0.005		0.002		0.171		0.002		0.000		0.000	
r2_b	0.001		0.012		0.211		0.034		0.045		0.149		0.417		0.264	

Notes: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level.

Table 4.8 The impacts of the Public Participation on Government Responses in Pandemic (2020Q1-2021Q3)

Variable	Stringency		Health		EconSupport		GovResp		Stringency		Health		EconSupport		GovResp	
RConfirm	0.000	***	7.32E-06		-6E-05	**	-2.45E-06									
EGOV1	-22.214	*	1.762		64.603	***	9.221		6.588		22.100	***	48.910	***	25.799	***
EPart1	17.690	*	5.780		8.139		6.560		16.031	*	-1.121		17.509		1.210	
lnConfirm									-2.018	***	-0.027		0.616	**	0.022	
_cons	66.687	***	52.110	***	1.080		45.639	***	65.125	***	44.369	***	-2.896		38.488	***
N	681		702		702		702		1010		1011		1011		1011	
r2_o	0.041		0.012		0.120		0.025		0.020		0.078		0.242		0.151	
r2_w	0.088		0.000		0.007		0.001		0.174		0.002		0.002		0.000	
r2_b	0.003		0.020		0.206		0.039		0.051		0.149		0.402		0.263	

Notes: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level.

Table 4.9 The impacts of the E-Government Investment on Government Responses in Pandemic (2020Q1-2021Q3)

Variable	Stringency		Health		EconSupport		GovResp		Stringency		Health		EconSupport		GovResp	
RConfirm	0.000	***	1E-05		-5E-05		1.22E-06									
EServ1	19.272	***	10.668		42.604	***	15.025	**	28.261	***	10.138	**	45.510	***	14.731	***
Tel1	-20.132	***	-1.444		19.016		0.851		-6.643		8.778	*	13.823		9.516	**
lnConfirm									-1.956	***	-0.033		0.689	**	0.027	
_cons	62.378	***	50.738	***	9.937		45.520	***	64.581	***	46.347	***	1.811		40.856	***
N	681		702		702		702		1010		1011		1011		1011	
r2_o	0.055		0.024		0.105		0.037		0.026		0.074		0.221		0.143	
r2_w	0.089		0.001		0.009		0.000		0.172		0.002		0.004		0.000	
r2_b	0.029		0.043		0.178		0.059		0.035		0.142		0.365		0.250	

Notes: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level.

Table 4.10 The Impacts of the Pandemic on Economic Growth

Variable	Eq1		Eq2		Eq3	
GDPPC1	1.871	***	1.274	*	-2.387	***
lnCF	2.235	***	2.333	***	2.601	***
lnH1	-10.562	***	-9.245	***	-2.608	
lnP	-0.044		-0.424		-2.682	***
Open	1.455	**	1.187	**	0.225	
CPIYOY	-0.077	***	-0.078	***	-0.095	***
Export	0.052	***	0.052	***	0.041	***
Import	0.114	***	0.111	***	0.060	***
lnDeposit	-2.398	***	-2.118	***	-0.081	
Confirmed	-0.000	**				
RConfirmed			-0.000	***		
Pandemic					-3.962	***
Stringency					0.104	***
Health					-0.116	***
EconSupport					-0.030	***
_cons	2.540		3.884		12.660	***
N	1526		1526		1526	
r2_o	0.233		0.263		0.518	
r2_w	0.365		0.376		0.574	
r2_b	0.109		0.140		0.362	

Notes: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level.

Table 4.11 The Interactive Impacts of E-Government and Pandemic

Variable	Eq4		Eq5		Eq6		Eq7	
GDPPC1	-1.814	**	2.332	***	-1.887	**	-2.009	***
lnCF	2.259	***	1.977	***	2.554	***	2.521	***
lnH1	0.923		5.757	**	1.409		1.454	
lnP	-2.275	***	-1.272	*	-2.681	***	-2.738	***
Open	-0.219		-0.138		-0.206		-0.224	
CPIYOY	-0.045		0.001		-0.039		-0.038	
Export	0.066	***	0.082	***	0.069	***	0.069	***
Import	0.097	***	0.133	***	0.088	***	0.090	***
lnDeposit	-0.143		-0.862	**	-0.059		0.061	
Pandemic	-12.476	***						
RConfirmed			0.001					
Stringency					-0.142		-0.053	
Health					-0.098		-0.169	
EconSupport					0.009		0.028	
EGOV	-5.445		-42.763	***	-10.038	**		
Epart	0.844		12.211	***	2.508			
*EGOV*Pandemic*	7.297	**						
*EPart*Pandemic*	1.831							
*EGOV*RConfirmed*			-0.001					
*EPart*RConfirmed*			0.000					
*EGOV*Stringency*					0.858	**		
*EGOV*Health*					-0.768			
*EGOV*EconSupport*					0.040			
*Epart*Stringency*					-0.486	*		
*Epart*Health*					0.637	*		
*Epart*EconSupport*					-0.100			
EServ							-0.923	
Tel							-5.140	**
*EServ*Stringency*							-0.227	
*EServ*Health*							0.444	
*EServ*EconSupport*							-0.142	**
*Tel*Stringency*							0.502	**
*Tel*Health*							-0.491	*
*Tel*EconSupport*							0.058	
_cons	9.006	**	-11.357	***	8.425	**	6.996	*
N	744		744		744		744	
r2_o	0.614		0.490		0.634		0.636	
r2_w	0.656		0.624		0.684		0.683	
r2_b	0.428		0.216		0.412		0.427	

Notes: *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level.

The estimation results in Table 4.8 shows that the improvement of E-Participation significantly increase the stringency of virus containment measures. This indicates that with better prepared E-Government, governments tend to be stricter in terms of controlling the virus spread. In the estimations shown in Table 4.9, we decompose the E-Government into the telecommunication connectivity and the online service provision. We can see that better online service provision significantly promote governments' response to pandemic in all aspects. However, the development of telecommunication connectivity has significantly negative impact on the stringency policies. This may because government can trace people's activity better with well-developed telecommunication connectivity, thus, no need to implement the high stringency policies.

Finally, to study the interactive impacts of the E-Government development and the pandemic on the economic growth, we add both the E-Government and pandemic related variables as well as their interactive variables into equation (1). Table 4.10 and 4.11 show our random effect panel data estimation results. First of all, we found that the impact of the share of the confirmed cases (Eq2) on the growth is more significant than that of the number of confirmed cases (Eq1). This is different from the impact of the pandemic severity on governments' response as shown in Table 4.7-9, where the number of confirmed cases tend to have more significant impacts. This may because that government to target the number of confirmed cases when they response to the pandemic.

Secondly, when we decompose governments responses, we found that the stringency policies have significantly positive impacts on the economic growth (Eq 3). This indicates that the stringency policy may effectively controlled the spread of varus and further alleviate the negative shock of the pandemic. On the other hand, the estimate coefficients for the containment health index are significantly negative (*Contain* in Eq3). This index includes information on both the activity restrictions and the health-related measures such as testing policy, contact tracing, short term investment in healthcare, and investments in vaccines. As the impacts of activity restrictions have been controlled by the stringency index, the estimated coefficients of *contain* should mainly reflected the impacts of health-related measures. Therefore, our estimation indicates that the health-related policies have negative impacts on the economic growth. This may because government spent lots of resources and money to implement the health policies, which decreases the resources for economic growth. The estimated coefficient for economic policy index in Eq3 is also significantly negative. The reason may be similar to that of the health policies. As government spent lots of resources and money to help and subsidize business and people in pandemic, the resources and money to support economic growth are less than usual. Therefore, the economic supporting policies in pandemic have negative impacts on the economic growth.

Eq 4-7 add both E-Government and pandemic related into equation (1). For Eq4, we can see that the estimated coefficient is till significantly negative for *pandemic* while insignificant for *EGOV* and *Epart*. But the sign of the estimated coefficient for *EGOV* become negative. For Eq5 and 6, the estimated coefficients are even significantly negative for *EGOV* in *Eq5* and *6* while significantly positive for *Epart* in Eq5. This may because the development of E-Government also spent lots of resources which is more critical for the economic growth in pandemic. We can also see that the estimated coefficients for telecommunication infrastructure in Eq7 is also significantly negative. This may also because the investment for telecommunication infrastructure has become a crucial burden in the pandemic. At the same time, the increase of public participation can help enhance positive growth impacts of E-Government. However, when we add the interactive variables in to the equation, we can see that the absolute values of the estimated coefficients for *pandemic*, *EGOV* and *Epart* increased or even doubled (comparing Eq 5 of Table 4.10 and the column 7 of Table 4.3). The goodness of fit (measured by r2_o and r2_w) for the estimations also doubled. Therefore, the E-Government does have impacts on the economic effects of the pandemic. The estimated coefficient of *EGOV*Pandemic* in Eq 4 shows that the E-Government significantly decreases pandemic's negative impacts on economic growth. The estimated coefficients for interactive variables in Eq6 show that E-Government can help enhance the positive impact of stringency policies on economic growth (*EGOV*Stringency*) while the public participation weaken it (*Epart*Stringency*). The public participation can also weaken the impacts of health policies (*Epart*Health*). As we have discussed in Table 4.6-8, countries with better E-Government development tend to have stricter policies. Therefore, the E-Government may help the implementation of stringency policies to be more efficient in terms of control the spread of virus. This can further help the economic growth. On the other hand, with better public participation, the split of public opinions may make it more difficult to implement the stringency policies.

In Eq7, we investigate the impacts of the two components of the E-Government index: the telecommunication infrastructure and online service provision. The estimation results show that the provision of online service increases the negative impact of economic supporting policies on economic growth. On the other hand, better telecommunication infrastructure strengthens both the stringency and the health policies' impacts.

6. Conclusion and Discussion

In this paper, based on countries' economic, E-Government and pandemic related data, we study the relationship between E-Government and the pandemic as well as their impacts on the economic growth. We have some interesting findings. First of all, the pandemic does have significant impacts on the economic growth. But the impacts are comprehensive, not straightforward. For governments' decision making in response to the pandemic, the share of confirmed cases should be a more important factor to be considered than the number of cases, because the former has more significant impacts on the economic growth. In terms of government responses, the stringency policies have significant positive impacts on the economic growth. On the other hand, the health policies and the economic policies have significant negative impacts.

Second, before pandemic, the development of E-Government had significantly positive impacts on economic growth. However, the huge infrastructure investment for the E-Government development has become a crucial burden in the pandemic and affected the economic growth negatively. As the public participation increases, the negative impacts of E-Government on economic growth can be partially alleviated. Therefore, in the long-run, E-Government should be good to the economic growth and welfare improvement. In the short run, for countries already have well developed E-Government infrastructure, to make the development of E-Government more helpful to the economic growth, more attention should be paid to the expansion of public participation in E-Government activities.

Third, the pandemic speedup the development of E-Government development overall. However, the expansion of public participation and the online service provision has been slower since the beginning of the pandemic. This may because of the reduce of normal public governance activities in the pandemic. At the same time, the stringency policy has negative impacts on all aspects of the E-Government development such as the telecommunication infrastructure, online services provision and the public participation. On the other hand, the health policies and the economic supporting policies promote the development of E-Government in all aspects. Therefore, the speedup of E-government development in pandemic are primarily due to the demand induced by of health policy implementation and the economic supporting policies. The stringency policies actually hindered the development of E-Government. The severity of pandemic also slower the expansion of E-Government utilization. After the pandemic, government should try to promote the development and utilization of E-Government in areas not related to the pandemic.

Forth, the development of E-Government does have significant impacts on governments' responses to the pandemic. For countries with better E-Government development, government tend to be more responsive, with stronger stringency, health and economic

supporting policies. The online service provision shows more significant impacts than other components of the E-Government. It promotes the implementation of governments' responses to pandemic in all aspects. At the same time, better public participation increases the strength of stringency policies while better telecommunication infrastructure decreases the strength of stringency policies.

Finally, we also find significant evidence for the impacts of the development of E-Government on the economic effects of the pandemic. The E-Government development help enhance the positive impacts of the stringency policies, but the public participation weakened the impacts of some policies. This indicates the dilemma of E-Government utilization in pandemic. Better development of E-Government, including the provision of online service and better telecommunication infrastructure can increase the efficiency of policy implementation, while better public participation may slower the decision-making process. Due to the data limitation, we are not able to find more evidence for the decomposed impacts of E-Government development. This can be done in future when more data are available.

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