The demographic and economic features the nexus with internet use

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The demographic and economic features: the nexus with internet use

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ABSTRACT

The goal of this study was to examine the nexus between demographic dividend type and economic features with internet use. The data source was from the World Development Indicator of the World Bank. The unit analysis was country. The panel data analysis method were used for the examination, employing fixed effects regression models using country income level, country regional group, and year as identifiers. The random effects regression model, pooled least square model, and static generalized method of moments were utilized for robustness checks. The dependent variable was the percentage of population using the internet. The independent variables consisted of demographic and economic variables. The demographic variable was the demographic dividend type, while the economic variables were access to electricity, GDP, inflation rate, and foreign direct investment. The results of fixed effects regression indicate that after controlling for the economic features, higher internet use in a country was associated with late- and post-demographic dividend type. Higher internet use was also associated with higher access to electricity, higher GDP, lower inflation rate, and higher foreign direct investment inflow. Robustness checks using random-effects and pooled least square models, using fixed-effects model by country income level, using two-stage least square, and using second stage regression by G20 and non-G20 country group division and year, similarly gave consistent results. The association of internet use with the demographic and economic features may imply that population-based and economic development program should be enhanced toward the favorable ones that increase internet usage among the population.

1. Introduction

The world is marked by a considerable inequality in human development achievement. The United Nations Development Programme (UNDP) reported that in 2019 the human development index (HDI) varied greatly from a lowest of 0.394 in Niger to a highest of 0.957 in Norway (UNDP, 2020). This disparity could be attributed to the inequity in access to digital technology, including broadband internet.

Widespread access to broadband internet is a key driver of human development. Improving access to the internet is also identified as an instrument to achieve the Sustainable Development Goals (SDGs) in goal 4 (Quality education), goal 9 (Industry, innovation, and infrastructure), and goal 17 (Partnership for the Goals). Internet allows people to be connected, work, shop, and study especially during the COVID-19 pandemic lockdowns (United Nations, 2021).

Internet can be used as an instrument to develop an economy and to pursue a more developed economy. Adelore and Itasanmi (2016) argued that internet increases the participation and motivates illiteracy alleviation. Internet is also an effective means in adult literacy program. Further, study by Kouton (2019) found that the use of internet reduced energy demand used for heating and transportation. This saving allowed the government to allocate energy generator budget to other sectors.

The World Bank (2022) estimated that increasing internet penetration from 35% to 75% of the population in all developing countries could increase about US$2 trillion to their joined gross domestic product and generate more than 140 million works around the world. However, there was a great inequality in the internet access across the world. The World Bank (2021) reported that in 2019, among 174 countries in the world where the data was available, this access varied greatly across countries, lowest in Burundi (5.2%) and almost universal in Bahrain (99.7%).

Information and communication technology (ICT), in particular internet, is a most developed business and business product in this century. The study of ICT encounters economists and demographers with two sides, as consumers and producers. There was a rapid increase of internet consumers in the world. The percentage of internet users in the world from 1990–2018 increased from 0% in 1990 to 51% in 2018 only

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in 28 years. The time trends of the percentage of internet users was not the linear one, but the power one. Therefore, the internet business is a promising one.

On the other hand, decline in fertility and mortality level and change in migration patterns have caused countries to experience demographic change that has been related to demographic dividend. Demographic dividend is economic growth as the results of changes in age structure in a country due to the decline in family size and longer life that cause increase in the percentage of productive age population aged 15–64 years old. As a result, lower investment is needed for young population aged 0–14 years old. At the same time, productive age population increases that open the window of opportunity to accelerate economic growth and family welfare. At micro level, this demographic transition can result in family living standard improvement and higher income. At macro level, demographic transition can affect economic development in a country.

It is proposed that demographic change can have a positive contribution to development (e.g. Ahmed et al., 2016), including economic and information and communication technology development. Demographic change of fertility and mortality decline could help create a period of sustainable economic growth as happened in some East Asian economies (e.g. Bloom et al., 2020; Amornkitvikai, Y. et al., 2022; Hosan et al., 2022; Liu and McKibbin, 2022). The mechanism of growth that is the policy area is through public health, family planning, economic policy that promote labor market flexibility, trade openness, and saving. The government of countries has window of opportunity to capitalize productive age population to reap the demographic dividend of economic growth and family welfare acceleration. This economic growth then enables countries to enlarge their heavily internet-based economies and consequently rises internet usage (Pradhan et al., 2017; Anuj et al., 2018; Amaluddin 2020).

Ahmed et al. (2016) grouped countries into four demographic dividend type based on the demographic change and economic development achievement. The demographic dividend typology is classified as the pre-, early-, late-, and post-demographic dividend. Countries with a fertility level above four children per woman, increasing percentage of working age population (15–64 years), and low income level are categorized as the pre-demographic dividend countries. Meanwhile, countries with a fertility level between 2.1 and four children per woman, increasing percentage of working age population, and low-middle and middle-high income level are categorized as the early-demographic dividend countries. Further, countries with a fertility level below 2.1 children per woman, increasing percentage of working age population, and high income level are also categorized as the early-demographic dividend countries. Furthermore, countries with a fertility level between 2.1 children and four per woman, declining percentage of working age population, and low, low-middle, and middle-high income level are categorized as the late-demographic dividend countries. Lastly, countries with a fertility level below 2.1 children per woman, decreasing percentage of working age population, and high income level are categorized as the post-demographic dividend countries.

There was a significant difference in the percentage of internet users and its trends across the demographic dividend typologies. The percentage of internet users was consistently highest in the post-demographic dividend countries, followed by in the late- and early-demographic dividend countries, and lowest in the pre-demographic dividend countries. The percentage of internet users during 1990–2018 increased more rapidly in more developed countries, the post-demographic dividend typology countries.

The determinants of internet use have been proposed (e.g. Scheerder et al., 2017). These include demographic and socioeconomic factors. The association between demographic and economic features and information and communication technology has also been studied (e.g. Bianchini et al., 2021; Yesuf, 2021; Singh et al., 2020; Baumann et al., 2017). However, a summary of the reviewed literature revealed that no study on demographic dividend type and internet use had been carried out. In order to address the gap indicated above, in general this study sought to investigate the relationship between demographic and economic features and internet use. Specifically, the objectives of this study were to examine the differentials in internet use by demographic and economic features and to analyze the effects of demographic and economic features on internet use. It is hoped that the findings of this study will contribute to the understanding of the association between demographic change and economic features and internet usage. In addition, it is hoped that the recommendation from this study will support the government of countries in order to improve internet usage in their countries in order to accelerate their development.

This paper consists of five sections. In Section 2 the related literature was reviewed. Data and methods used in this study were discussed in Section 3. The results of analyses were presented in Section 4. Conclusion of the study was given in Section 5.

2. Literature review

Bianchini et al. (2021) studied the impacts of age and ideological identification on the use online social network to obtain political information. They found that socio-demographic factors had strong impacts on internet use. Meanwhile, a study in Ethiopia by Yesuf (2021) found higher internet use among those who were aged 20–24 years, had higher education, lived in urban areas, had a mobile phone, literate, had a personal computer, and worked in formal sectors. Further, a study by Singh et al. (2020) found that perceived usefulness and social influence were the key determinants of the use of Fintech services. They also found that age and gender also influenced this behaviour.

The importance of demographic and socioeconomic factors on internet use for health purposes were also found. Studies by Baumann et al. (2017) found age, gender, and socioeconomic factors were important determinants of online health information-seeking behaviour.

Studies also found the significance of demographic and socioeconomic determinants in internet use for financial purposes. A study in Russia by Filippova and Turutina (2015) found that age, gender, financial status, and education level were the determinants of internet use for education purposes. Meanwhile, Sharma et al. (2015) found the importance of demographic variables in internet use for banking purposes.

A study by Burragoni (2017) found that demographic dividend played an important role in 850 million cellular subscriptions in India. In the post-economic liberalization, banking system development grew together with the population. Together with economic growth, demand and challenges in banking and payment system development also grew.

Myovella et al. (2021) studied the effects of demographic and economic features on digitalization and digital divide in Sub-Saharan African economies. They found that GDP per capita, gross capital formation, trade openness, population growth, and electricity infrastructure influenced digital divide. Meanwhile, low internet use was found related to low economic, social, and cultural development. A study in Yaman by Isaac et al. (2018) found that low internet use was associated with low economic, social, and cultural development. Another study in Indonesia also found the importance of access to electricity in internet use (Amaluddin, 2020).

Salahuddin and Alam (2015) studied the association between the internet usage and economic growth in Australia. They found bidirectional causal link between internet usage and economic growth.

Stork et al. (2013) analyzed internet access and use trends in some African countries in 2007/2008 and 2011/2012. They found that the use of internet increased very significantly in these countries despite of some barriers, such as large-scale computers and expensive connectivity costs. In addition, mobile phone had been used as key entry point to internet use. As a result, the internet penetration increased by 11.5% in these countries from 2007/2008 to 2011/2012.

Meanwhile, Nigeria experienced economic growth as an impact of ICT business and telecommunication liberalization during the 2000s (Akinwale et al., 2018). There was a co-integration between ICT and economic growth in the long run. In the short run, only with secure

internet server per 1 million and mobile cellular subscription per 100 people resulted in positive and significant impact on economic growth.

Gholizadeh et al. (2014) studied the relationship between gross domestic product (GDP) and internet use in some ASEAN countries during 1996–2011. They found that there was a positive and significant association between internet use and GDP, although there were differences between those ASEAN countries. Meanwhile, a study by Bahrini and Qaffas (2019) in the Middle East and North Africa (MENA) and Sub-saharan Africa (SSA) found that ICT, i.e. mobile phone, internet usage, and broadband adoption were the main driver of economic growth during 2007–2016.

Internet fosters economic growth (Jiménez et al., 2014). An increase of 10% in internet connectivity was found to boost up GDP growth by 1.38% in the world. In OECD countries, high internet access generated GDP by 2%.

Meanwhile, Salahuddin et al. (2016) studied the effects of internet and real GDP on social capital creation measured by trust in Australia during 1985–2013. They found that internet increased social capital in the short run, but reduced social capital in the long run. In addition, there was a short and long run positive relationship between internet and GDP per capita.

Not only in developing countries that internet affects economic growth. Amiri and Reif (2013) in their study in Nordic region found that in countries with highest internet penetration there was an association between highest internet penetration and highest GDP per capita in the world.

Internet penetration is determined by a number of factors. Feng (2015) studied the factors influencing internet penetration in China. It was found that internet penetration was mainly affected by internet access cost, internet content, and GDP per capita.

Meanwhile, a study by Lera-López et al. (2011) found that socioeconomic, demographic, and regional factors influenced internet use. The use of internet was primarily associated with education, age, occupation, employment in service sector, nationality, living in urban areas, and regional GDP per capita. They also found that internet use was positively related with broadband connection and education, while internet skill was influenced by gender and population size.

The relationship between inflation and internet use has also been studied. Yi & Choi (2003) found that internet improved productivity and reduced inflation. An increase of 1% in the ratio of the internet users to total population reduced inflation from 0.04264% point to 0.13193% point. Subsequently, inflation has a positive effect on internet demand.

The new economic theory proposed that humankind is entering an era with high output growth, low unemployment, and low inflation (Meijers, 2006). It is described that inflation suppresses internet growth and on the other side, internet will increase inflation in the long run. Sharma et al. (2014) studied the relationship between inflation and internet use through online shopping in India. They found that inflation had an indirect effect on internet growth.

Choi (2003) investigated the effects of internet on the volume of inward foreign direct investment (FDI). Internet was assumed to boost up higher FDI through productivity improvement. Using 53 FDI recipient country data and FDI gravity equation it was found that when the number of hosts and internet users in a country increased by 10%, FDI inflow increased by more than 2%.

The international community supports developing countries by building up digital infrastructure and regulation in order to be able to participate in international trade, in particular through larger diversification series in export. The study by Gnangnon (2020) using panel data from 131 countries during 1995–2014 found that greater internet access was positively associated with export diversification in particular both in less developed and developed countries. Internet access creates innovation level of a country, merchandise export including its concentration export products, and the size of inflow FDI. The results of this study emphasized the need of digital infrastructure development and regulation that facilitate access to the internet.

Pradhan et al. (2017) also studied the association between FDI, economic growth, and use of communication technology in 21 Asian countries during 1965–2012. Communication technology included fixed telephone, mobile phone, and internet use and service including fixed broadband. The results of the study show that there was a positive association between FDI, economic growth, and communication technology. Using the Granger causality analysis, these three variables were positively related.

A study on the association between FDI and internet use in 10 ASEAN countries had been carried out (Ramdan et al., 2020). It was found that higher internet use was associated with higher FDI. A 1% increase in FDI was associated with a 0.0681 increase in internet use.

Based on the above literature review, it is hypothesized that higher internet use is associated with higher demographic dividend type, higher access to electricity, higher GDP, lower inflation, and higher FDI.

3. Data and methods

This study used data from the World Bank (2021). The unit of analysis was country, covering 186 countries in the world. The study period was from 2001 through 2017. Therefore, there were 3,162 observations in this study. The countries and study period were selected based on the availability of data on variables used in the study. In addition, the selected countries were classified by demographic dividend type by the World Bank (Appendix Table A).

The dependent variable was the information technology, that is the individuals using the internet (% of population). The independent variables were the demographic variable and economic variables. The demographic variable was the type of demographic dividend (TDD) which was a categorical variable (=0 if pre, = 1 if early, = 2 if late, and = 3 if post). Therefore, there were three (3) dummy variables for TDD, that is *EarlyDD* (=1 if early, = 0 otherwise), *LateDD* (=1 if late, = 0 otherwise), and *PostDD* (=1 if post, = 0 otherwise), and pre-demographic dividend was the reference category. Meanwhile, the economic variables included access to electricity (% of population, *Electric*), gross domestic product (constant 2010 US$, *GDP*), inflation, consumer prices (annual %) (*Inflation*), and foreign direct investment (*FDI*), net inflows (% of GDP).

This study employed panel data analyses. The econometric model used was a fixed effects regression model using income level group, regional group, and year as identifiers. This model was also carried out based on G20 country group and income level group. The proposed model in this study was as follows.

$$Internet_{it} = \beta_0 + \beta_{11} EarlyDD_{it} + \beta_{12} LateDD_{it} + \beta_{13} PostDD_{it} + \beta_2 Electric_{it} + \beta_3 ln(GDP)_{it} + \beta_4 Inflation_{it} + \beta_5 FDI_{it} + \varepsilon$$

This fixed effects regression model still had endogeneity problem and measurement errors

in the variables used. The demographic dividend type can influence internet use and on the other hand internet use can affect the demographic dividend type. In addition, the demographic dividend type is endogenous, that is a variable that is influenced by other variables. Therefore, other approaches were employed as robustness checks using the static generalized method of moment (GMM). This GMM is a simultaneous model between an endogenous variable and instrument or exogenous variables in the first stage regression and an endogenous model between the dependent variable and independent variables in the second stage regression. The instrument variables used consisted of crude death rate (deaths per 1,000 people, CDR), population density (population per km^2, Density), and crude birth rate (births per 1,000 people, CBR).

The first stage regression model was as follows.

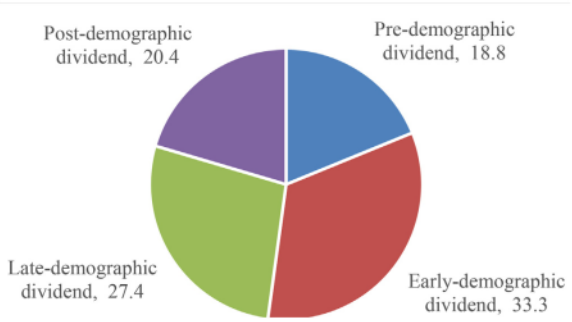

Figure 1. Percentage distribution of countries by demographic dividend typology (%): World 2001–2017

$$TDD_{it} = \alpha_0 + \alpha_{11} CDR_{it} + \alpha_{12} Density_{it} + \alpha_{13} CBR_{it} + \alpha_2 Electric_{it} + \alpha_3 ln(GDP)_{it} + \alpha_4 Inflation_{it} + \alpha_5 FDI_{it} + \varepsilon$$

The second stage regression model was as follows.

$$Internet_{it} = \beta_0 + \beta_{11} EarlyDD_{it} + \beta_{12} LateDD_{it} + \beta_{13} PostDD_{it} + \beta_2 Electric_{it} + \beta_3 ln(GDP)_{it} + \beta_4 Inflation_{it} + \beta_5 FDI_{it} + \varepsilon$$

The endogenity problem can result in biased and inconsistent estimates when there is lag in dependent variable. This problem can be solved by employing the dynamic panel GMM model. Arellano and Bond (1991) proposed the GMM approach. There are two reasons of applying GMM approach. First, GMM is a common estimator that gives a framework for comparison and evaluation. Second, GMM gives simple alternative to other estimators in particular maximum likelihood.

However, GMM estimators also have some limitations. First, GMM estimator is asymptotically efficient if the sample size is large, but inefficient if the sample size is finite. Second, the estimator sometimes needs a number of programming implementation so that it needs software that can support GMM approach application.

There are three estimation methods that are commonly used in GMM framework, that is first-differences GMM (FD-GMM) or Arellano-Bond GMM (AB-GMM), system GMM (SYS-GMM), and "difference" and "system" GMM dynamic panel estimator. This study employed "difference" and "system" GMM dynamic panel estimator to analyze the estimators. This model was selected because the demographic dividend type was time invariant and the model can solve this problem.

4. Results

It can be seen from Figure 1 the majority of countries in the world were in early-demographic dividend type (33.3%), followed by in late-demographic dividend type (27.4%), in post-demographic dividend type (20.4%), and in pre-demographic dividend type (18.8%). The majority of countries in early-demographic dividend type were African countries, such as Angola, Benin, Chad, Eritrea, Kenya, Niger, Sudan, Togo, Uganda, and Zambia (Appendix Table A). Meanwhile, most developed countries were in post-demographic dividend countries, such as Australia, Belgium, Canada, Denmark, Germany, Japan, Norway, Singapore, United Kingdom, and United States.

The number of observation and mean of variables used in the study both for full observations and by demographic dividend type was presented in Table 1. It can be seen that there was a significant variation in internet use across countries in the world and across demographic dividend types. The mean of individuals using the internet was 30.5% for full observations, lowest in pre-demographic dividend countries (only 5.5%), 18.3% in early-demographic dividend countries, 39.7% in late-demographic dividend countries, and highest in post-demographic dividend countries (61.4%). Other variables also show disparities in demographic and economic features across countries and demographic dividend types that reflects better development achievement in more developed countries.

The results of diagnostic tests show that the residual approached normal distribution but statistically not normal (Jarque-Bera normality test was 52.24 and = 4.5E-12). But, this assumption only applies for certain models. This assumption is not used if random effects regression, GMM, instrumental variables, and two-stage least squares (2SLS) are used.

The results of multicollinearity test show that there was no variance inflation factor (VIF) that was greater than 10. The mean of VIF was 2.650. In addition, there was no pairwise correlations that was greater than 0.5. It means there was no multicollinearity indication in the model.

There was heteroscedasticity in the model.= 1,726.32 and Prob > = 0.000. This problem was solved by using STATA application by making the model that improved standard errors (robust standard errors).

The results of Chow test show that fixed effects model was better than pooled least squares model (F (3, 3151) = 181.13, Prob > F = 0.000). In addition, the results of Hausman test show that fixed effects model was better than random effects model (= 817.94 and Prob > = 0.000). Further, the results of Breusch and Pagan Lagrangian multiplier test show that random effects model was better than pooled least squares model.

The results of fixed effect regression using income level group, regional group, and year as identifiers show that in general demographic dividend had significant positive association with internet use (Table 2). After controlling for the economic features, the percentage of individuals using the internet was, respectively 6.5%–21% higher and 15%–39% higher in late-demographic dividend and post-demographic dividend countries than in pre-demographic dividend countries. This finding supported the results of a study by Lera-López et al. (2011) and Myovella et al. (2021) that found the role of demographic factor in increasing internet use in the world. More favorable demographic features,

Table 1. Number of observations (*n*) and mean of variables in the study for full observation and by demographic dividend type.

Variable	Full Observation		Pre-Demographic Dividend		Early-Demographic Dividend		Late-Demographic Dividend		Post- Demographic Dividend	
	n	Mean	*n*	Mean	*n*	Mean	*n*	Mean	*n*	Mean
Individuals using the internet (% of population)	3,162	30.5	595	5.5	1,054	18.3	867	39.7	646	61.4
Access to electricity (% of population)	3,162	78.3	595	31.4	1,054	75.7	867	97.5	646	99.9
GDP (constant 2010 US$)	3,162	3.47E+11	595	2.76E+10	1,054	1.34E+11	867	2.52E+11	646	1.12E+12
Inflation, consumer prices (annual %)	3,162	6.0	595	8.3	1,054	7.10	867	5.0	646	3.2
Foreign direct investment, net inflows (% of GDP)	3,162	6.2	595	4.7	1,054	3.36	867	8.3	646	9.3
Death rate, crude (per 1,000 people)	3,162	8.3	595	10.9	1,054	7.00	867	7.4	646	9.1
Population density (people per sq. km of land area)	3,162	312.5	595	73.3	1,054	162.05	867	140.2	646	1,009.8
Birth rate, crude (per 1,000 people)	3,162	22.4	595	39.7	1,054	25.50	867	15.3	646	10.7

Source: World Bank (2021) (Author's compilation).

Table 2. Results of Fixed Effects Regression based on Identifier.

Covariates	Identifier		
	Income level group	Regional group	Year
Early-Demographic Dividend	0.317	1.398	4.409***
	(1.221)	(1.425)	(0.921)
Late-Demographic Dividend	6.507***	14.398***	21.101***
	(1.542)	(1.749)	(1.588)
Post-Demographic Dividend	15.142***	30.349***	39.005***
	(1.721)	(1.939)	(0.691)
Access to electricity (% of population)	0.216***	0.290***	0.161***
	(0.021)	(0.022)	(0.035)
Inflation, consumer prices (annual %)	-0.115***	-0.176***	-0.070
	(0.028)	(0.030)	(0.051)
log (gdpconstant2010us)	1.650***	1.958***	1.666***
	(0.166)	(0.183)	(0.059)
Foreign direct investment, net inflows (% of GDP)	0.017	0.048**	0.052***
	(0.018)	(0.019)	(0.015)
Constant	-30.610***	-49.345***	-37.480***
	(4.017)	(4.340)	(4.490)
Observations	3,162	3,162	3,162
R-squared	0.165	0.340	0.656
Fixed effects in income level group	Yes	No	No
Fixed effects in regional group	No	Yes	No
Fixed effects in year	No	No	Yes

Standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.
Source: World Bank (2021) (Author's compilation).

including being a late- and post-demographic dividend country, had been an important factor of better development that could enhance access to information and communication technology including internet use.

Access to electricity influenced internet use positively. The higher the percentage of population who had access to electricity, the higher the percentage of individuals using the internet. Other things being the same, an increase of one percent in the access to electricity was related to an increase of 0.161%–0.290% in the internet use. This finding is in accordance with the finding by Myovella et al. (2021) that found the positive association between electricity consumption and internet use. Access to electricity can boost the electricity-based economic activity and in today's industrial internet of things era, it is a key factor of internet use since the internet cannot be used without electricity.

Economic growth had positive effect on the internet use. The higher the economic growth, the higher the percentage of internet use. *Ceteris paribus*, an increase of one percent in economic growth was associated

Table 3. Comparison between the results of fixed effects, random effects, and pooled least square model.

Covariate	(1) Fixed Effects	(2) Random Effects	(3) Pooled Least Square
Early-Demographic Dividend	1.398	-0.917	-0.917
	(1.425)	(1.288)	(0.734)
Late-Demographic Dividend	14.398***	12.957***	12.957***
	(1.749)	(1.614)	(1.344)
Post-Demographic Dividend	30.349***	29.737***	29.737***
	(1.939)	(1.708)	(1.513)
Access to electricity (% of population)	0.290***	0.273***	0.273***
	(0.022)	(0.020)	(0.015)
Inflation, consumer prices (annual %)	-0.176***	-0.178***	-0.178**
	(0.030)	(0.030)	(0.079)
Log (gdpconstant2010us)	1.958***	2.010***	2.010***
	(0.183)	(0.179)	(0.181)
Foreign direct investment, net inflows (% of GDP)	0.048**	0.051***	0.051**
	(0.019)	(0.019)	(0.025)
Constant	-49.345***	-47.954***	-47.954***
	(4.340)	(4.061)	(4.027)
Observations	3,162	3,162	3,162
R-squared	0.340		0.549
Number of id_regional	Yes	No	No

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

Table 4. Results of Fix Effects Regression for full observation and by income level.

	(1)	(2)	(3)	(4)	(5)
Covariate	Full Observation	High Income	Low Income	Lower Middle Income	Upper Middle Income
Early-Demographic Dividend	1.398		-0.429	3.168**	11.689***
	(1.425)		(0.986)	(1.351)	(3.587)
Late-Demographic Dividend	14.398***	-0.635		6.025***	20.667***
	(1.749)	(3.713)		(1.942)	(3.846)
Post-Demographic Dividend	30.349***	4.907		4.133	15.432***
	(1.939)	(3.909)		(3.655)	(4.449)
Access to electricity (% of population)	0.290***	1.950***	0.201***	0.322***	0.717***
	(0.022)	(0.487)	(0.019)	(0.024)	(0.089)
Inflation, consumer prices (annual %)	-0.176***	-0.746***	-0.004	-0.086*	-0.093*
	(0.030)	(0.180)	(0.014)	(0.046)	(0.049)
lgdpconstant2010us	1.958***	1.524***	1.687***	0.438*	0.763**
	(0.183)	(0.423)	(0.252)	(0.245)	(0.323)
Foreign direct investment, net inflows (% of GDP)	0.048**	0.018	0.027	0.014	-0.321***
	(0.019)	(0.024)	(0.027)	(0.089)	(0.119)
Constant	-49.345***	-174.760***	-38.590***	-20.003***	-70.770***
	(4.340)	(48.125)	(5.630)	(5.709)	(10.270)
Observations	3,162	1,020	442	833	867
R-squared	0.340	0.071	0.286	0.258	0.155
Number of id_regional	7	6	5	6	6

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

with an increase of internet use by 1.650%–1.958%. This result supports the study result by Pradhan et al. (2017) and Amaluddin (2020) that found a positive relationship between economic growth and internet use. Economic growth allows a country to expand its economy that today heavily depends on the internet and hence increases internet use.

Inflation had a negative relationship with the percentage of individuals using the internet. The higher the inflation in a demographic dividend topology, the lower the percentage of individuals using the internet. After controlling for the effects of other factors, an increase of one percent in inflation was associated with a decline of the percentage of individuals using the internet by 0.115%–0.176%. This finding confirms the results of study by Yi and Choi (2005) that found a negative association between inflation and internet use. This is because inflation is a contributor of cost and price rise including internet cost that reduces internet use through the decline in people's purchasing power including purchasing the internet because of the price rise across the economies.

Foreign direct investment (FDI) had a positive influence on internet use. The higher the FDI, the higher the internet use. An increase of one percent in FDI was related with an increase of the percentage of individuals using the internet by 0.048%–0.052%. This results strengthens the study finding by Gnangnon (2020) and Ramdan et al. (2020) that found a positive relationship between FDI and internet use through the

Table 5. Results of fixed effects regression for full observations and by year.

	(1)	(2)	(3)	(4)
Covariate	All Observation	2001–2006	2007–2012	2013–2017
Early-Demographic Dividend	1.398	0.118	3.289*	6.819***
	(1.425)	(1.638)	(1.839)	(1.965)
Late-Demographic Dividend	14.398***	9.510***	19.678***	25.449***
	(1.749)	(2.046)	(2.267)	(2.387)
Post-Demographic Dividend	30.349***	28.334***	38.265***	37.249***
	(1.939)	(2.283)	(2.500)	(2.631)
Access to electricity (% of population)	0.290***	0.083***	0.212***	0.430***
	(0.022)	(0.025)	(0.030)	(0.035)
Inflation, consumer prices (annual %)	-0.176***	-0.078***	-0.494***	-0.027
	(0.030)	(0.027)	(0.068)	(0.042)
lgdpconstant2010us	1.958***	1.418***	1.648***	1.782***
	(0.183)	(0.216)	(0.234)	(0.244)
Foreign direct investment, net inflows (% of GDP)	0.048**	0.088***	0.028	0.093**
	(0.019)	(0.023)	(0.020)	(0.039)
Constant	-49.345***	-32.532***	-36.721***	-48.902***
	(4.340)	(5.022)	(5.601)	(6.037)
Observations	3,162	1,116	1,116	930
R-squared	0.340	0.407	0.502	0.535
Number of id-_regional	7	7	7	7

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

Table 6. The results of first stage regression of 2SLS model.

	(1)	(2)	(3)
Covariate	Early-Demographic Dividend	Late -Demographic Dividend	Post-Demographic Dividend
Death rate, crude (per 1,000 people)	-0.0447***	-0.00571**	0.0305***
	(0.00269)	(0.00246)	(0.00187)
Population density (people per sq. km of land area)	-2.33E-05***	-4.35E-05***	5.07E-05***
	(5.24E-06)	(4.80E-06)	(3.64E-06)
Birth rate, crude (per 1,000 people)	0.0137***	-0.0152***	-0.0213***
	(0.00145)	(0.00133)	(0.00101)
Access to electricity (% of population)	0.00213***	0.00244***	-0.00227***
	(0.000547)	(0.000501)	(0.000380)
Inflation, consumer prices (annual %)	0.00278***	0.000831	-0.00246***
	(0.000687)	(0.000629)	(0.000477)
lgdpconstant2010us	-0.0215***	-0.0476***	0.0490***
	(0.00383)	(0.00351)	(0.00266)
Foreign direct investment, net inflows (% of GDP)	-0.00216***	0.000313	0.000781***
	(0.000432)	(0.000396)	(0.000300)
Constant	0.755***	1.629***	-0.586***
	(0.125)	(0.115)	(0.0871)
Observations	3,162	3,162	3,162

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

capital accumulation in an economy that can increase individuals' access to the internet use.

The results of the above analyses also show that 16.5%–65.6% of variation in internet use was explained by demographic dividend type and economic features.

The above results still had heteroscedasticity and endogeneity effects problem. To obtain consistent and robust results, this study conducted robustness checks by employing other approaches and different subsamples. The results were as follows.

This study presented the results of analyses employing fixed effects, random effects, and pooled least square model. The results of the three models gave consistent results that demographic dividend type had positive effects on internet use significantly. The percentage of individuals using internet was 13%–14% and around 30% higher in, respectively, late- and post-demographic dividend countries than in pre-demographic dividend countries (Table 3). In addition, higher percentage of individuals using internet was associated with higher percentage of access to electricity, economic growth, and FDI and associated with lower inflation. A one percent increase in, respectively, access to electricity, economic growth, FDI, and inflation was associated with, respectively, an increase of about 0.3%, 2%, and 0.05% individuals using internet and a decline of 0.2% individuals using internet.

In Table 4, the results of analyses of fixed effects regressions for full observation and by income group were presented. It can be seen that the results were consistent with the previous results of the positive association between demographic dividend type, electricity, economic growth, and FDI with internet use and negative association between inflation and internet use. In addition, the effect of demographic dividend was largest

Table 7. The Results of Second Stage Regression for Full Observations and based on Income Group.

	(1)	(2)	(3)	(4)	(5)
Covariate	Full Observation	High Income	Low Income	Lower Middle Income	Upper Middle Income
Early-Demographic Dividend	33.32***		7.684***	-4.024	266.7
	(5.728)		(1.429)	(3.523)	(495.7)
Late-Demographic Dividend	34.63***	58.57***		10.17	83.94
	(4.269)	(11.17)		(9.063)	(115.5)
Post-Demographic Dividend	60.09***	49.14***		-5.432	390.4
	(5.328)	(7.119)		(10.67)	(720.7)
Access to electricity (% of population)	0.0335	-0.772	0.0599***	0.242***	1.181
	(0.0357)	(0.715)	(0.0177)	(0.0431)	(1.712)
Inflation, consumer prices (annual %)	-0.180***	-1.225***	-0.00716	-0.107**	-0.877
	(0.0350)	(0.232)	(0.0160)	(0.0500)	(1.596)
lgdpconstant2010us	2.134***	4.411***	1.267***	0.179	5.844
	(0.332)	(0.764)	(0.291)	(0.268)	(9.764)
Foreign direct investment, net inflows (% of GDP)	0.0797***	0.0319	0.0416	-0.0174	4.808
	(0.0232)	(0.0274)	(0.0305)	(0.133)	(10.14)
Constant	-55.96***	-22.53	-27.04***	-4.932	-433.5
	(6.753)	(57.65)	(6.542)	(7.799)	(765.6)
Observations	3,162	1,020	442	833	867
R-squared	0.422	-0.064	0.193	0.259	-25.924

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

Table 8. The Results of Second Stage Regression based on G20 Country Group.

	(2)	(3)	(4)	(5)
	Non-G20 countries		G20-countries	
Covariate	Fixed Effects	2SLS	Fixed Effects	2SLS
Early-Demographic Dividend	29.82***	1.945		
	(5.812)	(1.935)		
Late-Demographic Dividend	32.61***	15.23**	0.0687	0.105
	(3.882)	(4.467)	(9.069)	(2.700)
Post-Demographic Dividend	56.73***	28.52***	37.58***	31.35**
	(5.297)	(4.097)	(4.276)	(11.99)
Access to electricity (% of population)	0.0490	0.284**	0.934***	1.936*
	(0.0335)	(0.0806)	(0.164)	(0.898)
Inflation, consumer prices (annual %)	-0.163***	-0.162	-0.620***	-0.619*
	(0.0346)	(0.140)	(0.235)	(0.317)
lgdpconstant2010us	2.635***	2.367*	-0.742	0.926
	(0.304)	(0.930)	(1.743)	(2.186)
Foreign direct investment, net inflows (% of GDP)	0.0752***	0.0528	-0.135	-0.334
	(0.0227)	(0.0502)	(0.681)	(0.470)
Constant	-66.32***	-58.68**	-35.65	-176.3
	(6.717)	(20.34)	(52.39)	(96.33)
Observations	2,839	2,839	323	323
R-squared	0.414	0.317	0.598	0.480
Number of id_regional		6		7

Robust standard errors in parentheses ***p < 0.01, **p < 0.05, *p < 0.1.

in upper middle income countries and insignificant in high income countries.

In Table 5, the results of analyses of fixed effects regression for full observation and by year were presented. It can be seen that the results were also consistent with the previous results of the positive association between demographic dividend type, electricity, economic growth, and FDI with internet use and negative association between inflation and internet use. In addition, the percentage of individuals using internet was significantly higher in early-demographic dividend countries than in pre-demographic dividend countries in 2007–2012 and in 2013–2017 with an increasing effect.

The 2SLS model used CDR, population density, and CBR as instrumental variables. The results of diagnostic test for instrumental variable in 2SLS and GMM model show that F (1, 3154) = 69.68, which was greater than 10, and Prob > F = 0.0000, meaning that the models had strong instrumental variables. In addition, the results for first stage regression show that Sanderson-Windmeijer (SW) first-stage chi-squared and F statistic was significant, meaning that all instrument variables were relevant or valid to explain the endogeneous variable (demographic dividend type). The results of the first stage regression of 2SLS model were presented in Table 6.

Table 9. The results of second stage regression by year.

	(1)	(2)	(3)	(4)
Covariate	Full observation	2001–2006	2007–2012	2013–2017
Early-Demographic Dividend	33.32***	14.754***	31.418***	50.229***
	(5.728)	(4.870)	(7.580)	(10.606)
Late-Demographic Dividend	34.63***	19.456***	37.989***	52.855***
	(4.269)	(4.548)	(5.539)	(7.230)
Post-Demographic Dividend	60.09***	41.210***	60.701***	76.687***
	(5.328)	(4.867)	(6.973)	(10.030)
Access to electricity (% of population)	0.0335	-0.014	0.023	0.014
	(0.0357)	(0.034)	(0.048)	(0.075)
Inflation, consumer prices (annual %)	-0.180***	-0.060**	-0.623***	-0.079
	(0.0350)	(0.030)	(0.085)	(0.064)
lgdpconstant2010us	2.134***	1.750***	2.132***	1.914***
	(0.332)	(0.397)	(0.429)	(0.503)
Foreign direct investment, net inflows (% of GDP)	0.0797***	0.101***	0.062**	0.135**
	(0.0232)	(0.026)	(0.025)	(0.060)
Constant	-55.96***	-43.695***	-52.040***	-47.861***
	(6.753)	(8.003)	(8.643)	(10.402)
Observations	3,162	1,116	1,116	930
R-squared	0.422	0.548	0.613	0.518

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

The results of second stage regression for full observations and based on income group were given in Table 7. It can be seen that the 2SLS method results for full observations were also consistent with the previous results. The percentage individuals using the internet was significantly higher in early-, late-, and post-demographic dividend countries than in pre-demographic dividend countries, but with much higher percentages than in the previous models. In addition, the percentage individuals using the internet was also significantly higher in countries with lower inflation and higher economic growth and FDI. By income group, demographic dividend type had significant positive effects on internet use in low and high income countries.

In this study, the comparison between the results of fixed-effects regression and 2SLS method based on G20 and non-G20 group was also carried out. The results were presented in Table 8. It can be seen that the results were consistent with the previous results that demographic dividend type had significant positive influence on internet use both in non-G20 and G20 countries.

The 2SLS method by year was also done. The results were presented in Table 9. It can be seen that the results were also consistent with the previous results that demographic dividend type had significant positive influence on internet use in all years. In addition, the percentage individuals using the internet was also significantly higher in countries with lower inflation and higher economic growth and FDI in all years.

5. Conclusions

In this study the nexus between demographic and economic features with internet use in countries during 2001–2017 was investigated. A fixed effects regression model using income level group, regional group, and year as identifiers was employed to study the association between the type of demographic dividend, access to electricity, gross domestic product, inflation, and foreign direct investment and internet use. Robustness checks were also carried out using the static generalized method of moment between the type of demographic dividend and instrument variables (crude death rate, population density, and crude birth rate) in the first stage regression and between the type of demographic dividend, access to electricity, gross domestic product, inflation, and foreign direct investment and internet use in the second stage regression.

The results of this study confirms the previous studies on the nexus between demographic and economic features with internet use (e.g. Filippova and Turutina (2015); Sharma et al. (2015); Baumann et al. (2017); Pradhan et al. (2017); Scheerder et al. (2017); Singh et al. (2020); Bianchini et al. (2021); Myovella et al. (2021); Yesuf (2021)). It was found that internet use was higher in countries from late- and post-demographic dividend type. Meanwhile, access to electricity, economic growth, and foreign direct investment had a positive association with internet use and inflation was negatively associated with internet use.

Therefore, it is recommended that in order to boost up internet use, which is essential for better development achievement, government of countries, in particular countries in the pre- and early-demographic dividend type, should manage its demographic features to the more favorable ones, i.e. lower fertility and mortality. In addition, the window of opportunity due to the decline of fertility and mortality should be capitalized in order to reap the demographic dividend of economic growth and family welfare acceleration by improving access to quality health, education, and employment opportunity. Regarding economic features, in order to foster internet use, government of countries should improve access to electricity, raise economic growth, reduce inflation, and enhance foreign direct investment.

6. Limitations

A limitation of this study is that the demographic dividend type was a time invariant variable, while other variables were time variant. However, this limitation should not significantly affect the findings and this study still provides an essential contribution to the study of internet usage. So, it is suggested that further research on the determinants of internet usage should employ time variant demographic change variable.

Declarations

Author contribution statement

Wilson Rajagukguk, Ph. D: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data associated with this study has been deposited at http://repository.uki.ac.id/5918/1/DemographicDividendandInternet.xlsx.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Appendix

Countries in the Study by Demographic Dividend Type

No	Pre-Demographic Dividend	Early-Demographic Dividend	Late-Demographic Dividend	Post-Demographic Dividend
1	Afghanistan	Algeria	Albania	Antigua and Barbuda
2	Angola	Argentina	Armenia	Australia
3	Benin	Bahrain	Aruba	Austria
4	Burkina Faso	Bangladesh	Azerbaijan	Barbados
5	Burundi	Belize	Bahamas, The	Belarus
6	Cameroon	Bhutan	Brazil	Belgium
7	Central African Republic	Bolivia	Brunei Darussalam	Bosnia and Herzegovina
8	Chad	Botswana	Chile	Bulgaria

(*continued on next column*)

(continued)

No	Pre-Demographic Dividend	Early-Demographic Dividend	Late-Demographic Dividend	Post-Demographic Dividend
9	Comoros	Cabo Verde	China	Canada
10	Congo, Dem. Rep.	Cambodia	Colombia	Croatia
11	Congo, Rep.	Djibouti	Costa Rica	Cuba
12	Cote d'Ivoire	Dominican Republic	Cyprus	Czech Republic
13	Equatorial Guinea	Ecuador	Estonia	Denmark
14	Eritrea	Egypt, Arab Rep.	Fiji	Finland
15	Gambia, The	El Salvador	Georgia	France
16	Guinea	Eswatini	Guam	Germany
17	Guinea-Bissau	Ethiopia	Guyana	Greece
18	Iraq	Gabon	Iceland	Hong Kong SAR, China
19	Kenya	Ghana	Ireland	Hungary
20	Liberia	Grenada	Jamaica	Italy
21	Madagascar	Guatemala	Kazakhstan	Japan
22	Malawi	Haiti	Kuwait	Korea, Rep.
23	Mali	Honduras	Kyrgyz Republic	Lithuania
24	Mauritania	India	Latvia	Luxembourg
25	Mozambique	Indonesia	Lebanon	Macao SAR, China
26	Niger	Iran, Islamic Rep.	Malaysia	Malta
27	Nigeria	Israel	Mauritius	Netherlands
28	Senegal	Jordan	Moldova	New Zealand
29	Sierra Leone	Kiribati	Mongolia	Norway
30	Sudan	Lao PDR	Montenegro	Portugal
31	Tanzania	Lesotho	Morocco	Singapore
32	Timor-Leste	Libya	North Macedonia	Slovenia
33	Togo	Maldives	Oman	Spain
34	Uganda	Mexico	Poland	Sweden
35	Zambia	Micronesia, Fed. Sts.	Puerto Rico	Switzerland
36		Myanmar	Qatar	Ukraine
37		Namibia	Romania	United Kingdom
38		Nepal	Russian Federation	United States
39		Nicaragua	Serbia	
40		Pakistan	Seychelles	
41		Panama	Slovak Republic	
42		Papua New Guinea	Sri Lanka	
43		Paraguay	St. Lucia	
44		Peru	St. Vincent and the Grenadines	
45		Philippines	Thailand	
46		Rwanda	Trinidad and Tobago	
47		Samoa	Tunisia	
48		Saudi Arabia	United Arab Emirates	
49		Solomon Islands	Uruguay	
50		South Africa	Vietnam	
51		Suriname	Virgin Islands (U.S.)	
52		Syrian Arab Republic		
53		Tajikistan		
54		Tonga		
55		Turkey		
56		Turkmenistan		
57		Uzbekistan		
58		Vanuatu		
59		Venezuela, RB		
60		West Bank and Gaza		
61		Yemen, Rep.		
62		Zimbabwe		

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