Research article

Generation mix and GDP growth in OECD countries

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ABSTRACT

This study investigates whether generation diversity in workforce can influence economic growth. Using a panel data of 37 OECD countries over the years 1979–2019, it is found that the effect of generation diversity on economic growth depends on the development level of a country. Essentially, the generation diversity has a positive impact on economic growth in developed countries, but a negative impact on economic growth in developing countries.

1. Introduction

The demographic shift is an important issue that is widely studied in economics looking at its impact on the economic growth of countries. Since population is an important factor of production, the demographic change will affect the country's production capacity. Bloom and Williamson (1998) indicate that population growth has a purely transitional effect on economic growth. Lindh (1999) shows that the age structure of the population contains information correlated to medium-term trends in growth, inflation, and other macroeconomic data. Kim (2016) finds the relationship between population structural change in OECD countries its economic growth. Fent et al. (2008) show a positive impact of the age group 50–64 on economic growth and estimate age-productivity profiles at the firm level.

The current literature explains that due to a demographic change through a decline in fertility and mortality, an increase in dependency ratio, and a reduction in the number of working population, labor productivity and the size of labor force will be affected (see An and Jeon, 2006; Maestas et al., 2016; Bawazir et al., 2020 among others). In addition, OECD (2020) suggests that the labor productivity is determined by 2 components: own individual contribution such as effort and skill, and collective contribution from the interactions with other workers. For the second component of the labor productivity, the interactions with other workers, can be affected by the demographic change. Changing in demographic structure of the population leads to an increase in the diversity of generations in labor force and workplaces where workers interact. Positive interactions among workers can increase morale and improve labor productivity, while negative interactions can create confusion, tension, and uncertainty that reduce productivity of workers. Nonetheless, this second component of the labor productivity, even though is widely discussed in the literature, most of them are without empirical evidence.

The generational difference that leads to generation gap[1] is a topical issue in the management field (Joshi et al., 2011; Lyons et al., 2015; Campbell et al., 2017 among others). Due to differences between generations in the way each generation works, their beliefs, their attitudes, and how they respond to different situations, an increase in the diversity of generations in the workforce can bring about conflicts between generations especially between the youngs and the olds. Research in management discussed ways to mitigate conflicts in workplaces due to generation gaps (Subramanian, 2017; Jirasevijinda, 2018; Cismaru and Iunius, 2020, etc.). In economics, there were discussions on how different generations vary in their wages, earnings, employment, and financial management (Alfonso and Torrini, 2007; Pisani-Ferry, 2016; Carlin et al., 2019). However, the impact of generational differences on economic growth has not been analyzed widely in the literature. To the best of our knowledge, only Harnphattananusorn and Puttitanun (2021b) use several measures of generational differences generated in Harnphattananusorn and Puttitanun (2021a) to analyze the impact of generation gap on economic growth in Thailand. They found that an increase in generation diversity leads to a reduction in Thai economic growth. However, their results are based on an analysis of just one country and might not be able to identify the variation in the impact of generation diversity on economic growth in different development levels.

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[1] Generation gap refers to the rift that divides the thoughts, actions, beliefs, and tastes exhibited by members of different generations. Generation gap is important in business world as firms need to find ways to balance the needs and views of individuals from different generations, both their clients and their workers (Kenton, 2021).

As pointed out by United Nations (2013), developed and developing countries have different demographic changes. Most of the developed countries are fully aged societies, while developing countries are still moving toward an aging society, and some of the developing countries still have an increase in working-age population. Wongboonsin et al. (2017) also found that the effect of population structure change on economic growth are different between developed and developing. Therefore, this study aims to fill the gap in the literature by providing empirical evidence on the relationship between generation diversity and economic growth in developed and developing countries using OECD data.

The rest of the paper is organized as followed. Section 2 provides information on definition of generations and their differences. Section 3 provides the estimation model. Section 4 described data and methodology. Results are presented in Section 5, and conclusion is in Section 6.

2. Generation differences

Generational cohort theory discussed by researchers in anthropology, sociology, and psychology suggests that people in each cohort exhibit similar characteristics, preferences, and values toward different aspects of life, and each cohort thinks and behaves differently. Not only people of different age group usually have different aspects of life, but their thoughts or how people feel about a given issue is also shaped by their historical and life events when they grow up (Becton et al., 2014; The Pew Research Center, 2015). Strauss and Howe (1991, 1997) discussed the generation gap issue where different generations developed different ways of looking at the world and the way they work. Hence, when their work values differ, their behavior towards work can lead to strategic problems in organizations. This so-called generation gap can drive poor performance and low morale in the workplace and can lower productivities of workers. However, OECD (2020) suggests that with the right policies and practices, workers from different generations can complement each other's skills and enhance performances and productivities. Therefore, during the time where people are living and working longer than ever before, where four to five generations are working side by side in the labor force, it is essential to understand the effect of generation diversity on economic growth. In this paper, we define each generation based on the literature as shown in Table 1.

3. Model

Harnphattananusorn and Puttitanun (2021b) modified the standard growth model to estimate the relationship between generation mix indices, measures of the intensity of generation diversity in each year, and Thailand GDP growth rate as shown in Eq. (1). Following Harnphattananusorn and Puttitanun (2021b), we study the relationship between generation diversity in OECD countries to see whether there are any differences between the impact of generation diversity on growth between developed and developing countries.

$$\text{GDPgrowth}_{it} = f(\text{techno}_{it}, K_{it}, L_{it}, \text{Gindex}_{it}) \tag{1}$$

where $GDPgrowth_{it}$ is the GDP growth rate of country i in year t measuring economic growth of each country in each year, $techno_{it}$ is technology level of each country in each year proxied by the number of patent applications by citizens of country i in year t in natural log form, K_{it} is the ratio of gross fixed capital formation per GDP of country i in year t measuring the capital stock of each country in each period, L_{it} is the labor force growth rate of country i in year t measuring the size of labor of each country in each period, $Gindex_{it}$ is a measure of generation diversity in country i in year t. We follow the Harnphattananusorn and Puttitanun (2021a, b) and calculate 4 generation mix indices that quantify the level of generation diversity in country i in year t, namely: HS_{it}, HB_{it}, D_{it}, and J_{it}. These indices use the same methods that Biologists measure the diversity of different species in a community using biodiversity indices. These biodiversity indices consider of the relative

Table 1. Lists of generations.

Generations	Years Born
Greatest Generation	1901–1927
Silent Generation	1928–1945
Baby Boomer	1946–1964
Generation X	1965–1980
Generation Y	1981–1996
Generation Z	1997–2012

Source: The Pew Research Center (2015, 2019).

abundances of different species as well as species equitability. Applying the biodiversity concept to generation diversity in population, the 4 generation mix indices take into account of the number of generations, the size of each generation, and how they compared to one another at a given period in each country. The calculation methods of 4 indices are shown in the Appendix. The higher the *HS*, *HB*, and *J* indices signify higher generation diversity, while the lower the *D* index indicates higher generation diversity.

OECD (2020) suggests that generation diversity in the workforce can help increase productivity, but this will depend on policies and working styles of employers, governments, and internal communication within the organization. And since there are distinct differences between economic environments, problems, population structures, and hence policies between developed and developing countries. The impact of generation diversity might differ between these two sets of countries. Therefore, we take into consideration of the claim in OECD (2020) by adding an interaction term between the $Gindex_{it}$ and a dummy variable signifying whether a country is a developing country when we estimate Eq. (1). In OECD, there are three developing countries: Mexico, Turkey, and Colombia.

4. Data and methodology

The data used in this study were obtained from the World Development Indicators data set (WDI) covering 50 years (1979–2019) and 37 countries in OECD (34 developed countries and 3 developing countries). However, some data series are limited in some countries in some years. Table 2 shows the descriptive statistical values of our data set[2].

Table 3 shows the correlation matrix among the variables. Based on Table2, there seems to be no multicollinearity problem among variables. Estimated coefficients will be free from stability problem.

Due to the nature of our data set with 37 countries over 50 years period, the appropriate estimation method is a panel regression. We focused on two models: fixed effect and random effect models. The assumption that distinguishes the fixed effect model from the random effect model is whether the country specific effect (α_i) is correlated with the set of explanatory variables or not. The assumption behind the random effect model, α_i must be uncorrelated with the set of explanatory variables, while the fixed effect model allows for α_i to be correlated with the set of explanatory variables. We use the Hausman test (Hausman, 1978) to determine whether the fixed or random effect model is appropriate.

We also check for the stationary of our data using the Fisher-type test statistics to perform the augmented Dickey-Fuller tests (ADF) for unit-root. The results in Table 4 show that all variables do not have unit root at the 5% significant level.

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[2] The data for Techno variable in some countries began in 1980, and some in 1990, therefore in the appendix, we extrapolate the missing values using its mean and use it in the analysis. The results of the extrapolated data, which is similar to the results in the main analysis, is reported in the Appendix.

Table 2. Descriptive statistics.

Variable		Mean	Std. Dev.	Min	Max	Observations		
GDPgrowth	overall	3.034	3.207	-14.839	25.163	N	=	1662
	between		1.119	1.664	6.987	n	=	37
	within		3.006	-16.124	23.199	T-bar	=	44.9189
K	overall	23.429	4.399	11.074	43.440	N	=	1667
	between		2.706	18.989	30.821	n	=	37
	within		3.514	11.717	43.566	T-bar	=	45.0541
L	overall	0.005	0.060	-0.549	1.279	N	=	1813
	between		0.012	-0.014	0.032	n	=	37
	within		0.059	-0.562	1.265	T	=	49
Techno	overall	7.262	2.195	2.485	12.859	N	=	1339
	between		2.153	3.284	12.629	n	=	37
	within		0.560	3.956	9.869	T-bar	=	36.1892
	within		0.488	3.713	9.549	T	=	50
HS	overall	1.172	0.084	0.887	1.343	N	=	1850
	between		0.014	1.131	1.187	n	=	37
	within		0.083	0.928	1.358	T	=	50
HB	overall	2.724	5.862	0.034	39.937	N	=	1850
	between		5.849	0.052	31.227	n	=	37
	within		1.025	-8.620	11.434	T	=	50
D	overall	0.330	0.025	0.271	0.473	N	=	1850
	between		0.008	0.322	0.354	n	=	37
	within		0.024	0.261	0.449	T	=	50
J	overall	0.845	0.060	0.640	0.969	N	=	1850
	between		0.010	0.816	0.856	n	=	37
	within		0.060	0.669	0.979	T	=	50

Source: WDI data set.

Table 3. Correlation matrix.

Variables	(1) GDPgrowth	(2) K	(3) L	(4) Techno	(5) HS	(6) HB	(7) D	(8) J
(1) GDPgrowth	1.000							
(2) K	0.290	1.000						
(3) L	0.061	0.032	1.000					
(4) Techno	-0.128	0.089	0.006	1.000				
(5) HS	0.069	0.021	0.024	0.024	1.000			
(6) HB	0.074	-0.018	0.020	-0.494	0.024	1.000		
(7) D	0.008	0.022	0.044	-0.056	-0.885	0.009	1.000	
(8) J	0.069	0.021	0.012	0.024	1.000	0.024	-0.885	1.000

Source: Authors' calculation.

5. Results

The estimation results are shown in Table 5 where we estimated Eq. (1) using both fixed effect and random effect models[3]. Results from fixed effect models for each of the generation diversity index (*HS*, *HB*, *D*, and *J*) are reported in columns 1, 3, 5, and 7, while those from random effect models are shown in columns 2, 4, 6, and 8. Based on the Hausman tests, the fixed effect models are the appropriate estimation technique in all

four generation diversity indices. Therefore, we will only discuss the results from fixed effect models (shown in bold columns).

Based on the fixed effect models in Table 5, there is a significant positive relationship between the gross fixed capital formation-to-GDP

Table 4. Unit root test.

variable	p-value	Panels	Chi2	Time Trend
GDPgrowth	0.000	37	494.171	included
K	0.000	37	194.831	included
L	0.000	37	1147.866	included
Techno	0.000	37	194.3472	included
D	0.000	37	364.392	included
HS	0.000	37	222.572	included
HB	0.000	37	154.037	included
J	0.000	37	222.569	included

Source: Authors' calculation.

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[3] We also did the same analyses as in Table 5 using "Techno2" variable to control for the technology level in each country over time, where the missing data were extrapolated from the mean of each country, and therefore, the number of observations for each estimation is 1630 as shown in Table A1 in the appendix. The results are qualitatively the same as those in Table 5 suggesting that the number of observations do not affect the direction of the relationships between dependent and independent variables. However, ones need to be careful interpreting the results of the extrapolating data as it might produces errors.

Table 5. The effect of generation diversity on economic growth.

GDP growth	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	HS_fe	HS_re	HB_fe	HB_re	D_fe	D_re	J_fe	J_re
K	.263***	.251***	.258***	.256***	.273***	.257***	.263***	.251***
	(.024)	(.023)	(.025)	(.023)	(.025)	(.023)	(.024)	(.023)
L	1.117	1.438	1.442	1.528	1.273	1.487	1.117	1.438
	(1.118)	(1.116)	(1.123)	(1.122)	(1.118)	(1.119)	(1.118)	(1.116)
Techno	-.714***	-.333***	-.701***	-.310**	-.776***	-.325***	-.714***	-.333***
	(.136)	(.070)	(.141)	(.080)	(.141)	(.071)	(.136)	(.070)
HS	4.909***	3.543***						
	(1.111)	(1.037)						
HSinteract	-6.175**	.496						
	(3.133)	(.534)						
HB			.028	-0.004				
			(.065)	(.030)				
HBinteract			-1.906	2.477				
			(3.861)	(2.122)				
D					-15.077***	-8.197**		
					(3.928)	(3.487)		
Dinteract					17.274**	3.462*		
					(8.612)	(1.871)		
J							6.805***	4.912***
							(1.540)	(1.438)
Jinteract							-8.561**	.688
							(4.343)	(.741)
Constant term	-3.326**	-4.891***	1.875	-0.909	6.465***	1.754	-3.326**	-4.891***
	(1.604)	(1.416)	(1.253)	(0.847)	(1.817)	(1.372)	(1.604)	(1.416)
Observations	1301	1301	1301	1301	1301	1301	1301	1301
R2_within	0.119		0.106		0.116		0.119	
Hausman Test								
Chi square	21.24		13.46		21.79		21.24	21.24
P > Chi square	0.0007		0.0194		0.0006		0.0007	

Note: Standard errors are shown in parentheses. ***, **, * denote significant levels at 1%, 5%, and 10%, respectively.

ratio (K) and GDP growth. An increase in K will positively affect the rate of change in GDP from 0.258 to 0.273 percent. Labor force growth is consistently being insignificant in all models.

The number of resident patents (*Techno*) measuring technology level was negatively statistically significant suggesting that a 1% increase in the number of patents will lead to a decrease in the rate of change in GDP at approximately 0.7%. Even though such results might not be as what we generally would expect, according to the Growth Model with human capital augmented in Mankiw et al. (1992), to create innovation, country needs time to accumulate knowledge, and there would be less resources to produce consumption goods, which in the long run can result in a lower long-term equilibrium output.[4]

As for the main variable of interest, a measure of generation diversity, *HS, D* and *J* indices are statistically significant.[5] An increase in generation diversity in the labor force (an increase in *HS* and *J* indices, and a reduction in *D* index) leads to an increase in GDP growth, which is inconsistent with Harnphattananusorn and Puttitanun (2021b). However, as proposed in OECD (2020), generation diversity in the workforce can help increase productivity depending on policies and working styles of employers, governments, and internal communication within the organization. Therefore, as in the case of Harnphattananusorn and

Puttitanun (2021b) where their study used Thai data, a developing country where there might be a large difference in policies, and contexts, from most of the OECD countries, results might differ from what was found here. To explore this concept, we consider of the interaction term between the generation diversity index and a dummy variable signifying whether a country is a developing country. In OECD, there are three developing countries: Mexico, Turkey, and Colombia. The results show that the interaction terms between the generation diversity index and developing country dummy variable (*HSinteract*, *Dinteract*, and *Jinteract*) not only have the opposite sign to the generation diversity index, but also have larger size when compared to the generation diversity index coefficients, which confirm the finding in Harnphattananusorn and Puttitanun (2021b) and support the claim by OECD (2020). To be precise, in developing countries, when generation diversity increases, it leads to a reduction in GDP growth rate. This might be due to conflicts between workers from different generations (generation gap) that results in lower labor productivity and hence lower growth rate. However, in developed countries, there might be policies both from the public and private sectors that encourage workers to learn from each other, complementing one another, and manage the age gap that allow workers to complement one another's skills and improve productivities. Therefore, developed countries may be able to take advantage of the generation diversity in their labor force, so when generation diversity increases, it can lead to an increase in economic growth. As Anderson (2019) reports, younger generations can learn from older workers through a mentoring relationship at work. Not only younger workers can learn from the older workers' experience, but the older workers can also learn new skills from the younger generations.

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[4] We also control for country's trade openness, proxied by the share of trade as a percentage of GDP, the openness variable is insignificant in all models and other results are qualitatively the same as shown in Table 5.

[5] Only *HB* index and its interaction term with developing country dummy are statistically insignificant.

6. Conclusion

This study investigates the relationship between generation diversity and economic growth using 37 OECD countries data. We find that the effect of generation diversity on economic growth rates depends on the development level of the country. For developing countries, the diversity of generations negatively affects the GDP growth, consistent with Harnphattananusorn and Puttitanun (2021b). However, in developed countries, generation diversity turns out to have a positive impact on economic growth, consistent with OECD (2020)'s suggestion. This result shows that generation diversity can be an important tool to generate better economic growth for any country. If the country can manage the generation gap well, engaging in policies that encourage workers from different generations to complement each other and learn from one another, the economic growth of the country can be increased. During a period of demographic shifts where countries experience rapid population ageing, older workers remain active and continue to work, the generation diversity in the labor force should not be overlooked. As shown in the results of this paper, economic growth can be either negatively or positively affected by generation diversity in the workforce. If managed well, organizations and countries can benefit from this increasingly important demographic change.

Declarations

Author contribution statement

Supanee Harnphattanatnusorn; Thitima Puttitanun: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Appendix. Indices Formulae

Simpson's index measures the probability that any two individuals drawn at random from a large community belong to the same species.

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

where n = total number of individuals of each generation, N = total number of population of all generations.

The value of D ranges between 0 and 1 where 0 represents infinite diversity and 1 represents no diversity. The drawback of Simpson's diversity index is that it is heavily weighted toward the most abundant generation.

Shannon Index accounts for smaller generations in a community.

$$HS = -\sum_{i=1}^{s} p_i \ln p_i$$

where p_i is the proportion of individuals found in the ith generation. The values of Shannon index are often found to fall between 1.5 and 3.5.

Brillouin Index is calculated using the following formula:

$$HB = \frac{\ln(N!) - \sum \ln(n_i!)}{N}$$

where N is the total number of individuals in the community and n_i is the number of individuals in the ith generation. This index places more emphasis on generations richness and is sensitive to sample size. Since the population in each generation reach millions, therefore, to directly use the index as-is is impossible. Harnphattananusorn and Puttitanun (2021a, b) made an adjustment and calculated it as: $HB = \frac{\ln(N^2) - \sum \ln(n_i^2)}{N}$ where n_i is the total working population for generation i in each year and N is the total working population for each year. The value was extremely small, so they multiply it by -10^6.

Pielou's evenness index measures how close in numbers each generation in a society is. Pielou's evenness ranges between 0 and 1 where 0 means no evenness and 1 means complete evenness.

$$J = \frac{HS}{H_{max}}$$

Where *HS* is the Shannon index and H_{max} is the maximum possible value of *HS*, calculated from $H_{max} = \ln S$, S is the total number of generations.

Table A1. Estimation Results Using Number of Extrapolate Patent Applications as a Proxy for Technology (Techno2)

GDP growth	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	HS_fe	HS_re	HB_fe	**HB_re**	**D_fe**	D_re	**J_fe**	J_re
K	**0.258***	0.233***	0.247***	**0.241***	**0.256***	0.237***	**0.258***	0.233***
	(0.021)	(0.020)	(0.021)	**(0.020)**	**(0.021)**	(0.020)	**(0.021)**	(0.020)
L	**1.994***	2.510**	2.319**	**2.379****	**2.131***	2.352**	**1.994***	2.510**
	(1.147)	(1.148)	(1.149)	**(1.146)**	**(1.148)**	(1.147)	**(1.147)**	(1.148)
Techno2	**-0.437***	-0.247***	-0.408***	**-0.192****	**-0.447***	-0.219***	**-0.437***	-0.247***
	(0.141)	(0.074)	(0.145)	**(0.084)**	**(0.143)**	(0.074)	**(0.141)**	(0.074)
HS	**2.082****	0.102						
	(0.954)	(0.875)						
HSinteract	**-10.933***	0.534						
	(2.511)	(0.574)						
HB			0.072	**0.017**				
			(0.067)	**(0.032)**				
HBinteract			6.982**	**6.096***				
			(3.557)	**(2.060)**				
D					**-5.568**	0.920		
					(3.513)	(3.057)		
Dinteract					**25.243***	5.186***		
					(6.986)	(1.883)		
J							**2.886****	0.141
							(1.323)	(1.213)
Jinteract							**-15.157***	0.740
							(3.481)	(0.795)
Constant term	**-1.157**	-0.821	-0.152	**-1.429***	**1.322**	-1.418	**-1.157**	-0.821
	(1.597)	(1.306)	(1.246)	**(0.830)**	**(1.620)**	(1.198)	**(1.597)**	(1.306)
Observations	**1,630**	1,630	1,630	**1,630**	**1,630**	1,630	**1,630**	1,630
R2_within	**0.103**		0.095		**0.100**		**0.103**	
Hausman Test								
Chi square	29.14		7.66		17.15		29.14	
P > Chi square	0.0000		0.1762		0.0042		0.0000	

Note: Standard errors are shown in parentheses. ***, **, * denote significant levels at 1%, 5%, and 10%, respectively.

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