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What Will Be the Impact of the COVID-19 Pandemic on the Human Capital and Economic Growth? Evidence from Eurozone

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Abstract

This study provides new empirical evidence concerning the relationship between human capital and economic growth for 17 European countries over the periods 2015–2019 and 2019–2022. The results show that both education and health have a positive and significant impact on economic growth, and thus support higher growth. Also, our empirical results before COVID-19 show that there is bidirectional causality between economic growth and health, as well as education and economic growth, and there is unidirectional causal relationship running from education to health. After COVID-19, there is no significant causality between economic growth education and health. The results of this study may be of great importance for policy and decision makers in developing policies to foster human capital for European countries.

Keywords Economic growth · Human capital · European countries · GMM model

Introduction

The COVID-19 (coronavirus) pandemic has dealt serious blows to the health and education systems, the labor market, and social protection, both in developed and developing countries. Thus, 70% of regular medical examinations have not been

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carried out, and more than 168 million of young people have not been able to follow their courses at school and in universities for almost an entire year due to COVID-19 lockdown. But despite these challenges, the pandemic has nonetheless provided an opportunity to accelerate reforms that arguably would not have been adopted so quickly under ordinary circumstances, whether in the use of technology in education, telemedicine, or even the rise of monetary transfers intended for vulnerable people. Investing in human capital helps transform economies and promote growth, with broad positive impacts on people's well-being and prosperity. Goldin (2016) conceptualizes human capital as "the set of intangible resources embedded in the labor factors which have improved its productivity." He further stated that these are related to knowledge and skills acquired through education, experience, and health care.

The empirical outcomes of the studies have provided convincing evidence to support the view that human capital can have a major effect on economic growth (Glaeser et al., 2004; Goetz & Hu, 1996; Bassanin & Scarpetta, 2002; Ciccone and Papaioannou, 2009; Zhang & Wang, 2021). However, Klaitzidakis et al. (2001) argue that the impact of human capital accumulation on economic growth remains controversial. Enhancing human capital can therefore have both indirect and direct effects on economic growth. As a first indirect effect, Silva & Teixeira (2012) findings show that by the productive structure of countries, human capital indirectly increases the growth rate. Concretely, the specialization of a country in technologically advanced activities improves the impact (positive) of human capital on economic growth. Studies that consider direct channels through which human capital affects growth suggests that individuals with more education are more productive and innovative leading to the creation of new products and improving the productivity of factors (Romer, 1989; Benhabib & Spiegel, 1994; Teixeira & Fortuna, 2011; Bodman & Le, 2013). Furthermore, Sasso & Ritzen (2019) find that human capital, in most times, explained a large amount of variation in labor productivity and economic growth when measured by skills of the workforce, whereas it appears statistically insignificant when measured by school level. Recently, Sultana et al. (2022) studied the linkage between human capital and economic growth for both developing and developed countries. They found that the impact of human capital on growth is not the same for all stages of development. These differences in results stem certainly from different time periods, different variables used, countries studied, and different econometric methodologies used. For this reason, we used, as an investigate technique, a dynamic panel data model, which follows the spirit of the conventional "growth model" framework.

Dynamic econometric models and methods provide an advantage in determining the time-dependent effects in variables and threshold relationship between variables at the time of COVID-19, which are also crucial for policy-makers. From this point of view, our study considers the relationship between the composition of human capital and economic growth in eurozone countries with dynamic simultaneous-equation models. Unlike the single-equation method, the system estimation can bring up the simultaneities among of the endogenous variables specified in the system and identify the likely two-way effects between them. We analyze the dynamic direct and indirect effects of human capital on economic growth, while taking into account the interaction between education and health interventions. However, to the best of our knowledge, none of the empirical studies have focused to investigating the nexus between education-health-growth via the dynamic simultaneous equations models. In addition, the current study is different from the previous studies that uses system generalized method of moment technique to explore the channel variable (economic growth) through which education may likely affect health. This channel variable is employed to track down the effect of education on health and to allow if increased education level is linked to more health in euro zone countries or vice versa.

The remainder of this paper is organized as follows: Section 2 gives a brief literature review. Section 3 talks about the data and methodology used in the study. Section 4 discusses the results in detail, while Section 5 concludes the study with some policy implications.

Related Literature

There is a fair amount of research on the relationship between human capital and economic growth. This stream of work generated by neoclassical and endogenous growth in the 1990s had produced several models relating human capital with economic growth. In the literature, one might well notice the persistence of three types of relationships between education, health, and economic growth.

Education and Economic Growth

The first strand of the literature suggests that education and economic growth are closely related. Education is widely agreed to affect economic growth both directly and indirectly in the production process as a complement to labor and capital. To date, the empirical work on the relationship between education and economic growth can be divided into three categories of empirical approaches: cross-section, panel data, and time-series ones (Benos & Zotou, 2014). For instance, with cross-section, Romer (1989) used a data of 112 countries to examine the relationship between education capital and economic growth for the period 1960–1985. Empirical result shows that literacy has positively impacted economic growth. The results for 71 low- and middle-income countries by Azariadis & Drazen (1990) seem to support the findings in Romer (1989). For 98 countries during 1960–1985, Barro (1991) found a positive effect of primary and secondary enrollments and a negative effect of student-teacher ratios on economic growth. Lee (2010) shows that growth is positively associated with schooling years in 75 countries for the period of 1960–2000.

Dhrifi et al. (2021) studied the links among economic growth, education, and health in both developed and developing countries. They found a bidirectional causal link between education and economic growth appears in both samples. For the nexus among health and education, their results show bidirectional causality in middle- and high-income countries and a unidirectional causality running from education to health in low-income ones.

With panel data, several studies have confirmed the positive relationship between education capital and economic growth, including Barro (1996, 1996, 2001), Agiomirgianakis et al. (2002), Jamison, et al. (2007), Li and Huang (2009), Hanushek and Woessmann (2011), Zhang and Zhuang (2011), Hanushek (2013), Siddiqui and Rehman (2016), and Zhang and Wang (2021). With time-series data, we can observe also that education stock was more prominent in explaining the fluctuations of economic growth (Musila & Belassi, 2004 ; Dauda, 2010; Jalil & Idrees, 2013; Qadri & Waheed, 2014; Breton, 2015; Camps & Engerman, 2017; Dhrifi et al., 2021; Awad, 2021).

However, there are a number of important issues that arise from these empirical analyses considering the relationship between education and economic growth. First, there is issue of country heterogeneity. In light of this heterogeneity, Jones & Olken (2005) support that the within-country dimension is critical for explaining the determinants of growth. Second, there are differences in measures used for education capital. We have identified nine different measures of education ranging from years of schooling through enrolment rates to education expenditures. Finally, we can observe that most previous studies have focused on the effect of the education on economic growth. Just a few empirical studies have focused on the interaction between these variables. We can thus conclude after the economic literature that economic growth necessitated a well-qualified workforce, and this can be improved by investing in people's education. The relationships between these two variables are not only difficult to shape but they can also interact simultaneously.

Health and Economic Growth

The second focus on the nexus between health and economic growth pertains to the main finding of predominant faction of empirical growth works stressing the prevalence of a two-way relationship between health and economic growth. Increasing economic growth, measured through gross domestic product (GDP), is often considered as a key policy instrument for improving population health. The rationale is that increases in economic growth will lead to increases in health expenditure, which will, in turn, improve health status. Still, the empirical evidence promoting such a strategy finds positive income elasticity as regards health expenditures, but do not reach a consensus as to whether health care is a "necessary" or a "luxury" good. In the other hands, a reverse causation from health and economic growth tests heavily on the work elaborated by Romer (1986) and Lucas (1988), which developed a theoretical model emphasizing the role of human capital in stimulating economic growth. Regarding the effect of health on economic growth, Ridhwan et al. (2022) affirmed that health affects economic growth directly by increasing labor productivity and decreasing the costs of illnesses. In fact, healthy individuals also indirectly impact economic growth by having a healthy family, which may subsequently create healthier future generations (Fortune Ganda, 2022).

Therefore, besides physical health, mental health is an important part of human well-being as an improvement in individual's mental state can give an increase in social and economic participation, engagement and connectedness, and work productivity (Doran & Kinchin, 2020).

Indeed, health can well affect income growth through increased effort and productivity of human resources and also through increased investment in both human and physical capital (Funke & Strulik, 2000; Bhargava et al., 2001; Grossmann, 2007; Gong et al., 2012; Bucci, 2013). In addition, increase in health expenditure could possibly increase labor supply and productivity, which eventually must lead to a higher income (Gerdtham & Lothgren, 2000; Weil, 2007; Baltagi & Moscone, 2010; Fan & Savedoff, 2014; Khan et al., 2016; Nghiem & Connelly, 2017; Awad, 2021; Zhao & Zhou, 2021).

However, the empirical analyses indicate that the relationship between health and economic growth is influenced by sample, econometric techniques, period specifications, and different variables for various countries/country groups (Halici-Tülüce et al., 2016). These different methods and variables give different results for different time intervals. Thus, in order to obtain reliable results and to implement appropriate policies, it is important to choose the right method and variables for the given countries.

Education, Health, and Economic Growth

In 1992, Mankiw, Romer, and Weil first augmented Solow's (1956) neoclassical growth model to incorporate human capital in education. Knowles & Owen (1997) further extended the neoclassical growth model by incorporating both health and education. Their results show a significant statistical relationship between health and growth with education having a modest role. McDonald & Roberts (2002) supported the results found by Knowles & Owen (1997). Sun et al. (2020) affirmed technology and human capital as the key driving forces to promote economic growth. They proved also that higher workforce human capital led to a higher quantity of patents and a higher probability to innovate and therefore human health. More recently, Awad (2021) studied the effect of health and education on economic growth in MENA economies, and the results of his study showed that education has a positive and significant effect on economic growth at long run. However, health has a negative but negligible influence on such growth in MENA countries. As well, the findings reported by Webber (2002) are different and indicated that growth-oriented policies should favor investments in education over health. Subsequent to this, Baldacci et al. (2008), Li & Huang (2009), and Maitra & Mukhopadhyay (2012) show that both health and education have positive significant effects on economic growth in China and East Asia.

Methods and Data

Modeling Approach

In this sub-section, we examine the relationship between human capital and economic growth within the following Cobb–Douglas production function:

$$Y_t = A_{it} K_t^{\alpha} \left(L_t \right)^{1-\alpha}$$

where Y is output, K is the stock of capital use to produce output, L is the labor force use to produce output, and A is a labor-augmenting factor indicating the level of technology innovation and efficiency in the economy. In the model developed by this study, technology was allowed to be endogenously determined by the human capital and macro and institutional control variables within an extended Cobb–Douglas production function. We believe that this extension is relevant and help to stimulate labor-augmenting technological change because human capital, which is proxied by health and education (Benhabib & Spiegel, 1994; Teixeira & Fortuna, 2011), and macro and institutional factors such as such as the fiscal balance, inflation rate, trade openness, and governance (Barro, 1996; Baldacci et al., 2008) serve as a key input to support the development of modern technology.

Following Baldacci et al. (2008), Zhang & Zhuang (2011), Tan et al. (2014), and Teixeira & Queirós (2016), the study divides both sides by population and obtained each series in per capita terms. However, the impact of labor was left constant. By taking log, the linearized Cobb-Douglas production function is

$$\text{In } Y_t = \beta_1 + \beta_2 \text{In } K_t + \beta_3 H_t + \beta_3 E_t + \beta_4 W_t + \varepsilon_t$$

where In Y and In K represent real GDP and real capital use, respectively; each is transformed into logarithm and expressed in per capita terms. E refers to the stock of education capital, which is proxied by the sum of the gross primary and secondary enrollment rate. The stock of health capital (H) is proxied by the logarithm of under-5 child mortality. The control variables (W) are trade openness (OPEN), fiscal balance (FB), and inflation (INF) that were included, as they have been frequently identified as key determinants of growth (Baldacci et al., 2008; Barro, 1996; Teixeira & Fortuna, 2011; Zhang & Zhuang, 2011).

The econometric approach in this paper aims to capture the dynamic relationship between human capital and economic growth in the context of an endogenous growth model. For this purpose, we use general specifications for real per capita income growth, education capital, and health status equations, drawing on a set of robust explanatory variables used in the existing literature. We also include controls for the quality of governance in all the following three equations:

- Growth equation

$$\text{In GDP}_{it} = \beta_1 + \beta_2 \text{In } K_{it} + \beta_3 H_{it} + \beta_4 E_{it} + \beta_5 W_{it} + \varepsilon_{it}$$

The growth equation is based on a neoclassical growth framework augmented by the separate inclusion of education capital and health capital and governance (McDonald & Roberts, 2002, Bloom et al. (2004), Baldacci et al., 2008; Hartwig (2015).

- Education equation

$$E_{it} = \beta_1 + \beta_2 \mathrm{GDP}_{it} + \beta_3 H_{it} + \beta_4\ U_{it} + \beta_5\ \mathrm{Qua}_{it} + \beta_6\ \mathrm{EXPE}_{it} + \varepsilon_{it}$$

Education equation states that economic growth, health capital indicator, urbanization, quality indicator measured by the primary completion rate, and education spending are key determinants of education capital (Baldacci et al., 2008; Zhang & Zhuang, 2011, Benos & Zotou, 2014).

- Health equation

$$H_{it} = \beta_1 + \beta_2 \mathrm{GDP}_{it} + \beta_3 Fert_{it} + \beta_4 E_{it} + \beta_5 U_{it} + \beta_6 \mathrm{EXPH}_{it} + \varepsilon_{it}$$

Equation (3) states that economic growth, education capital, fertility rate, urbanization, health expenditures, and governance are the driving forces of healthy capital (Barro, 1996, 1996; Bloom et al., 2004; Baldacci et al., 2008; Zhang & Wang, 2021).

For the sake of comparison, we seek to identify the impact of the COVID-19 pandemic on the relationship between health-education and economic growth. For that purpose, COVID-19 confirmed cases, and COVID-19 deaths are taken as independent variables in the analysis.

Panel Unit Root Testing

The panel unit root tests are simply multiple-series unit roots that are modified for the panel structure in which the presence of cross-sections is generated from a single series. There exist a number of methods for panel unit root tests. In this study, we choose the two kinds of panel unit root tests, namely, Breitung (2001) and Im et al. (2003) tests. Analytical results of Breitung test are founded on a model of the following type:

$$\mathrm{W}_{\mathrm{it}} = \alpha_{\mathrm{it}} + \sum_{j=1}^{k+1} \beta_{ij} \Delta X_{i,t-j} + \varepsilon_{it} \quad (4)$$

where Δ is the first difference operator, W_{it} is the dependent variable, X_{it} is the independent variable, ε_{it} refers to white-noise error terms with a variance of σ^2, i refers to country ($i = 1, 2, ..., N$), t refers to the time period ($t = 1, 2, ..., T$), and j refers to the lag. The test statistic of Breitung assumes the null hypothesis H0:$\sum_{j=1}^{k+1} \beta_{ij} - 1 = 0$, while the alternative hypothesis H1:$\sum_{j=1}^{k+1} \beta_{ij} - 1 < 0$ and assumed that W_{it} is stationary.

The IPS test is based on the conventional augmented Dickey–Fuller (*ADF*) test for the following equation:

$$\Delta W_{it} = \alpha_i + \beta_i W_{i,t-1} + \gamma_i t + \sum_{j=1}^{k} \theta_{ij} \Delta W_{i,t-j} + \epsilon_{it} \tag{5}$$

The test statistic of IPS assumed the following hypothesis: the null hypothesis is specified by H0: $\beta_i = 0$ whereas the alternative hypothesis is specified by H1: $\beta_i < 0$ for each individual *i*. The test is based on the statistic test $t_{\beta_i} = \frac{\hat{\beta}_i}{\sqrt{\sigma^2(\hat{\beta}_i)}}$ and the mean group approach.

Estimation Approach

In methodological terms, we employed the generalized method of moment technique proposed by Arellano & Bond (1991) and Arellano & Bover (1995) for the purpose estimating the prevailing interrelationship. This method is usefully effective for correcting unobserved country heterogeneity, omitted variable bias, measurement error, and potential endogeneity, which frequently impact growth estimation (Blundell & Bond, 1998).

In fact, this technique simultaneously combines the relevant regression systems expressed in first-differences and in levels, i.e., the first-difference checks the relevant unobserved heterogeneity and omitted variable bias, as well as those related to time-invariant component of the measurement error time. In addition, it helps correct endogeneity bias (time-varying component) via incrementing the explanatory variables. Thus, instruments pertaining to differenced equations can be drawn from the values (levels) of the explanatory variables lagged at least twice, and instruments for level equations are lagged differences of the variable. In this way, estimating two equations in a generalized method of moments system helps greatly reduce potential bias and imprecision associated with a simple first difference generalized method of moment estimator (Arellano & Bover, 1995).

Data

To investigate the relationship between human capital and economic growth, which is a synthesis of the growth literature, we use the following variables for all studied euro zone countries: gross domestic product measured in constant 2000 US dollars (GDP); the stock of education capital, which is proxied by the sum of the gross primary and secondary enrollment rate; the stock of health capital, which is proxied by the logarithm of under-5 child mortality; trade openness (TO); fiscal balance (FB); inflation (I); school age population (POP15); urbanization (U); quality indicator measured by the school repetition rate (Q); education spending (ES); female enrollment rate; fertility rate; health expenditures; and a dummy for poor governance (Lowgov) was also included, based on the anticorruption and democratic accountability index from International Country Risk Guide (ICRG) compiled by the Political Risk Services group. Both indexes give a more complete measure of governance. The dummy takes the value of one (zero otherwise) when the index value is lower than the mean. The annual data covering the periods from 2015–2019 and 2019–2022 (before and after the COVID-19) for the following eurozone countries: Germany, Austria, Belgium, Cyprus, Spain, Estonia, Finland, France, Greece, Ireland, Italy, Lithuania, Luxembourg, Malta, Netherlands, Portugal, and Slovakia, are sourced from World Development Indicators online database. The economic variable data are downloaded from Development Indicators by the World Bank database. Data on COVID-19 cases and COVID-19 deaths are extracted from "WHO Official COVID-19 info - World Health Organization." To reduce the instability and heteroscedasticity, all variables were employed their natural logarithms. Table 1 provides the descriptive statistics of the series used in this study. In fact, the number of observations for each variable is 85 for the period before COVID-19 and 68 observations after COVID-19.

Results and Discussions

In order to analyze the relationship between GDP, health, and education, testing for a unit root of each series is necessary. Nevertheless, the usable panel unit root tests are mainly considered for panels where both the time dimension and the cross-section dimension are relatively large. For this purpose, the analysis of panel data can proceed only under restrictive assumptions like, for example, dynamic homogeneity. We will keep this in mind when interpreting the results of panel unit root tests. The results of Breitung and IPS tests suggested that all variables were not integrated of order one, I (1). For what they are worth, these test results at least do speak proceeding to the dynamic panel data analysis (generalized method of moments).

The results from estimating growth, education, and health equations using generalized method of moments are contained in Table 2. The bottom of this table reports specification test results of the system generalized method of moments. The Sargan test is a test the validity of the instrumental variables with a null hypothesis of "the instruments as a group are exogenous." As seen in Table 3, the null hypothesis is accepted, indicating that the Sargan test accepts the over-identifying restrictions in the generalized method of moment estimations. The test of Arellano-Bond accepts the hypothesis of no second-order serial correlation of the error term. Furthermore, to other standard statistics at the bottom of the Table 3, some diagnosis tests have been performed. The test for autoregressive (1) process in first differences usually rejects the null hypothesis of no first-order serial correlation in three models. The test for autoregressive (2) process in first differences accepts the null hypothesis of no second-order serial correlation (p-values > 0.1 for three models). The Hansen test accepts the null hypothesis of exogenous instruments with p-values greater than 1 for three models.

From the estimated results, we find that the coefficients are statistically significant, and growth, education, and heath equations have a good fit. Growth equation shows that the composition of human capital has a positive and significant impact on GDP growth. A 1% increase in education and health raises the economic growth by 0.0.341% and 0.086%, respectively. This result meets the expectation that a higher

Table 1 Descriptive statistics of the variables

Variables		Mean	Std. dev.	Maximum	Minimum	Observations
Log real per capita GDP	Before	4.450	0.1974	5.021	3.7910	85
	After	4.596	0.1492	5.418	4.414	68
Investment ratio (in percent of GDP)	Before	10.5578	0.7995	11.890	8.8878	85
	After	10.612	0.748	11.825	9.393	68
Primary and secondary gross enrollment rate (in percent)	Before	101.239	5.4873	108.511	87.614	85
	After	100.484	3.434	123.212	95.145	68
Under-5 child mortality (per 1000 live births)	Before	3.712	2.2687	6.5	1.9	85
	After	5.5392	0.984	16.5	3.2	68
Education spending (in percent of GDP)	Before	5.128	1.004	8.14	2.892	85
	After	5.669	1.150	8.51	2.99	68
Health spending (in percent of GDP)	Before	8.3925	1.6676	11.71	4.73555	85
	After	8.890	1.788	12.3	6.18	68
Fertility rate (per 1000 people per year)	Before	1.5332	0.2385	2.12	1.09	85
	After	1.59	0.2689	2.21	1.35	68
Trade openness (in percent of GDP)	Before	59.5799	36.4681	200.015	18.5539	85
	After	70.832	44.657	200.015	28.519	68
Fiscal balance (in percent of GDP)	Before	-2.4333	3.9754	7.2963	-31.4086	85
	After	-3.7	3.918	1.056	-16.92	68
Urbanization (share of urban population)	Before	73.651	12.277	97.897	49.65	85
	After	75.405	12.865	97.9	50.1	68
Primary completion rate, total (% of relevant age group)	Before	101.991	3.068	107.254	87.6145	85
	After	102.652	5.2973	123.212	96.543	68
COVID-19 deaths		339.783	3.8887	1318.52	560	68
COVID-19 cases		2758.675	7.7049	20147.341	68.647	68

Table 2 GMM estimation results with total samples

	Before COVID-19			After COVID-19		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
GDP(-1)	0.688***	--	--	0.587***	--	--
E(-1)	--	0.527***	--	--	0.435***	--
H(-1)	--	--	0.819***	--	--	0.623***
GDP	Dependent variable	4.438***	-1.091***	Dependent variable	2.55***	-1.45**
E	0.0002**	Dependent variable	0.003*	-0.005***	Dependent variable	0.002**
H	0.014***	-0.46***	Dependent variable	-0.025***	-0.99**	Dependent variable
K	0.047***	--	--	0.165**	--	--
TO	0.009***	--	--	0.002***	--	--
FB	0.0023***	--	--	-0.001***	--	--
INF	-0.002*	--	--	-0.023***	--	--
FER	--	--	0.308*	--	--	0.018**
U	--	-0.025**	-0.022*	--	-0.029	
QUA	--	0.402***	--	--	0.031***	--
EXPE	--	-0.206*	--	--	-0.42**	--
EXPH	--	--	-0.019	--	--	-0.09**
COVID-cases	--	--	--		-0.07**	-0.71**
COVID-deaths	--	--	--		-0.94**	-0.81**
Constant	0.915***	-13.75***	6.618***	2.265***	3.70***	1.33***
Goodness of fit						
Sargan test	9.46	14.73	13.77	12.2	13.6	11.7
AR(1)	-1.67*	1.365*	-1.88*	-1.912*	-1.56*	-1.81*
AR(2)	-2.08**	-1.25*	-0.148	--	--	--

Table 3 Results of causality test

Before COVID-19				After COVID-19			
Null hypothesis:	F-Stat	Prob.		Null hypothesis:	F-stat	Prob.	
GDP→H	2.966	0.087	Yes	GDP→H	1.059	0.375	No
H→GDP	6.762	0.010	Yes	H→GDP	1.440	0.272	No
GDP→E	2.095	0.08	Yes	GDP→E	2.211	0.149	No
E→GDP	3.854	0.039	Yes	E→GDP	1.550	0.249	No
E→H	2.966	0.087	Yes	E→H	2.244	0.146	No
H→E	1.265	0.307	No	H→E	1.160	0.344	No

stock of human capital improves the workforce's skills, which has a positive impact on its productivity (Baldacci et al., 2008 and Teixeira & Queirós, 2016). The impact of health capital on growth differs from that of education capital. Changes in the health capital indicator positively affect growth with a coefficient of about 1, but the coefficient on the level of health capital is insignificant. This seems to be consistent with a much faster rate of depreciation of health capital, consistent with the findings in Baldacci et al. (2008) and Barro (1996). With regard to other variables, the coefficient of physical capital is significantly positive, resembling previous studies which conclude that economic growth is mostly driven by fixed asset investment (Zhang & Zhuang, 2011). In addition, it was found that trade openness and fiscal balance boost economic performance. In the case of education equation, health capital and economic growth each have a positive and statistically significant impact on education capital. This result confirms a very strong link between mortality rate, per capita GDP, and the enrollment rate. The coefficient of education capital in response to improvement in health capital and economic growth indicates that a drop in the mortality rate and an increase in economic growth by 1% are typically associated with an increase in the enrollment rate of 1.3% and 2%, respectively. Education spending also positively affects education capital. The effects of education spending are observed significantly in a good-governance environment, higher levels of health, and greater social cohesion. The primary completion rate is found to have a positive and significant effect, consistent with notion that a good quality education can catalyze a virtuous cycle between growth and investments in human capital. In addition, the vast development of urbanization made the education more available, and this allows children have the opportunity to continue their education further than previous generation. In health equation, consistent with the literature, per capita GDP and education capital are negatively associated with child mortality rates, whereas fertility rates raise them. In addition, a higher share of health expenditures allows to reduce infant mortality rate (per 1000 live births) with 1% level of significance. A 1% increase in total health expenditure reduced infant mortality rate by approximately 3 infants per 1000 live births. The result is consistent with finding of Grossmann (2007), Baldacci et al. (2008), Narayan et al. (2010), and Novignon et al. (2012). On the contrary, the coefficient of urbanization is found to be positive and significant at the 1% level. As argued by Eckert & Kohler (2014), unplanned and rapid urbanization is prone to producing poor sanitary conditions and changes in the physical and social environment, all of which can accelerate the spread of diseases.

Following the inclusion of the COVID-19 variable, the models 1-2-3, the current study used the GMM estimator, which reflects nearly the same impact with a slight change in the coefficients' magnitude. Here, the relationship between economic growth and human capital is found to be positive, while the influence of COVID-19 cases and deaths is found to be negative. Although the impact stays the same, there has been a minor shift in the magnitude numbers. However, at the 1%, 5%, and 10% levels, the results are determined to be significant. In particular, a one percent rise in the COVID-19 accidents (including cases and deaths) reduces economic performance by 0.05 (education) and 0.0025 percent (health), respectively. The findings are statistically significant at the 1% level. This suggests that the COVID-19 epidemic poses a threat to human capital and economic growth by causing the determinants of human capital to become negative. Furthermore, education and health have a detrimental impact on economic growth.

It can also be seem from Table 3 that there is bidirectional causality between education capital and economic growth. This is in line with the findings of Agiomirgianakis et al. (2002), Afzal et al. (2010), and Forgha et al. (2016). We may therefore validate the feedback hypothesis whereby education and economic growth are interdependent. This interdependency indicates that used education policies in euro zone will have a positive impact on economic growth. Table 3 also reveals there is bidirectional causality between health and economic growth, and there is unidirectional causal relationship from education to health without feedback. This is line with the findings of Grossmann (2007), Silles (2009), Lager et al. (2012), and Brunello et al. (2016). From Table 3, we also gather that there is no significant causality between economic growth, education, and health during the pandemic.

Conclusion

There is a growing literature that discusses the relationship between human capital, which is represented by health and education, and economic growth. The majority of empirical growth studies that incorporate elements of human capital focus on developing, developed, and emerging countries. This understanding is important for policymakers in order to implement effective economic and social policies. However, despite the large literatures on the human capital-growth nexus, the direction of causality between education, health, and economic growth remains an unsettled issue.

In this paper, we have investigated the linkage between the composition of human capital on economic growth in eurozone using the dynamic simultaneous-equation models for the periods of 2015–2019 and 2019–2022. We used the GMM estimator in order to study the effect of human capital and health on economic growth before and after COVID-19 crisis, which reflects nearly the same impact with a slight change in the coefficients' magnitude. Here, the relationship between economic growth and human capital is found to be positive, while the influence of COVID-19 cases and deaths is found to be negative. In fact, the impact stays the same; there has been a minor shift in the magnitude numbers. However, at the 1%, 5%, and 10% levels, the results are determined to be significant. To conclude, the main results confirm that education and health affect economic growth before COVID-19 crisis; this effect deteriorates after the crisis.

To the best of our knowledge, our study is one of the first attempts performed to investigate the three-way linkages between to both composition of human capita-economic growth, education-economic growth, and health- economic growth using three structural equations and causation. In contrast to some previous studies, we use several new proxy variables for the composition of human capital. Therefore, "the sum of the gross primary and secondary enrollment rate" and "the percentage of the population 6 years old above with education attainment of secondary or above" are used as proxies for education capital. For the health capital, we use two proxies "the under-5 child mortality rate" and "health expenditures."

The main results show evidence of bidirectional causality between human capital and economic growth. This result suggests that for eurozone, education, health, and economic growth are endogenous, indicating that this factors mutually influence each other, and that this reinforcement may have important implications for the conduct of economic policies in this region during the pandemic. This result also confirm the existence of a virtuous cycle suggests that human capital contributes to economic growth and higher growth will lead to more investment in physical and human capital, which in turn stimulates growth further. This is a useful finding to the extent that it justifies the importance of education and health and the efforts that ought to be taken to achieve higher level of human capital. Findings of the study reveal also that COVID-19 is considered as one of the foremost economic challenges that not only the zone euro government but also most governments across the globe have failed to overcome to era.

Our results suggest some clear and important policy implications. First, when human capital simultaneously includes both education and health variables, its significant level is not reduced. But, the significant level of education variable is higher than that of health variable. Hence, we suggest policymakers of eurozone to promote economic growth by reinforcing either the health or the education development with education investment statistically more important than health investment after COVID-19 pandemic. Second, our estimation results show that on the whole, tertiary education plays a more important role than primary and secondary education on economic growth. In other words, the more developed countries benefit more from tertiary education, while underdeveloped ones depend more on primary and secondary education. Moreover, in order to decrease regional disparities, it is better to invest more in all educational levels of the poor countries, especially to improve primary and secondary education. Finally, the promotion of economic growth should not consider only investment in human capital but also investment in employment, trade, governance, and technology, generating high value added to the economies (i.e., foreign direct investment inflows, research, and development). Due to the dynamic relationship between human capital and economic growth, these elements will influence human capital into the country and potentially stimulate economic growth through a "brain drain." Thus, all governments should commit to generate and maintain the availability of labor force and good macroeconomic environment and diminish trade barriers. These policies appear to make important contributions to per capita income growth and eventually reduce interregional gaps after COVID-19 pandemic.

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