INTERRELATIONSHIPS BETWEEN HUMAN CAPITAL AND INTELLECTUAL CAPITAL: EVIDENCE FROM THE PANEL OF HIGH-INCOME AND LOW AND MIDDLE-INCOME GROUPS OF THE WORLD

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Abstract

The competitiveness in production sector is increasing significantly due to the openness of the economies in the world. Importance of intellectual capital (IC) thus has been mounting continuously and human capital formation (HCF) is considered as the main source of it. IC, an advanced version of human capital, is formed by the efforts upon research and development (RD) activities. It is a natural question whether HCF helps in the formation of intellectual capital in the countries of different status. Under the backdrop, the study examines the long-term relationship between intellectual capital and HCF in case of some countries from the high-income group (HIG) and low and middle-income group (LMIG) during the period of 1998 to 2018. It employs panel unit root, panel cointegration and panel causality techniques for examining the long run associations and short run dynamics between human capital and intellectual capital for the two groups of the economies. The findings of the study show that long-term association exists between these two forms of capital for both the panels of high and low and middle-income nations. But the short-run causal interplay works in high-income group only where human capital formation is making a cause to the intellectual capital formation. A one-unit increase in the change of HCF at period t-1 results in a 0.05 unit rise in the change of current year intellectual capital in the high-income group. The governments of the countries are suggested to make more human capital formation via increasing expenditures on both education and health sector to assure more intellectual capital.

Keywords: Human capital, intellectual capital, growth, panel cointegration, panel causality, high and middle income countries

JEL classification: R10, R11, O30, C33

1. Introduction

The historical growth records of the so called developed economies in the phase of the post-world war II has established the role of human as well as intellectual capital in the generation of human resource as well as helping the economies in boosting up their income levels. With the emergence of endogenous growth theory (1980's), the importance of intellectual capital in economic development has been increasing. Intellectual capital had a positive effect on organizational performance (Jardon and Cobas, 2021; Abualoush and Obeidat, 2018). The level of the development of intellectual capital determines the competitiveness of an economy (Dzhioev and Gurieva, 2019). Human capital is one of the most important resources in the economy because it allows people to respond to environmental changes in innovative ways (Kong, 2010). Furthermore, human capital is seen as crucial because it has an impact on an organization's performance (Bolen et al., 2005; Zeghal, Maaloul 2010; Rodrigues, Faria, Cranfield and Morais, 2013). De Pablos (2003) stated that the value of human capital is derived from its ability to improve the efficacy and

efficiency of enterprises, hence gaining a competitive advantage. As a result, human capital is regarded as the most important component of intellectual capital because the firm's existence is dependent on it (Kianto and Ritala, 2010).

Education spending, in particular, reflects human capital development because it can aid in advancing educational outcomes. The importance of education in expanding human capital stock has long been recognised, both theoretically and empirically (Scultz, 1960; Becker, 1964; Barro, 1991; Benhabib and Spiegel, 1994). Healthy individuals are more physically and psychologically fit than sick people, and they are expected to contribute more to production, boost productivity, and have a beneficial impact on human capital formation. Increases in health spending allow for increased supply of labour and productivity, which must eventually lead to increased wealth (Bleakley, 2010; Muysken, Yetkiner, and Ziesemer, 2003; Heshmati, 2001; Kurt, 2015; Elmi and Sadeghi, 2012). As a result, the present study focuses on two major drivers of human capital formation (HCF): government spending on education and health sector.

Intellectual capital is constituted by efforts on research and development which means all human capitals are not necessarily intellectual capital (Cohen & Levinthal, 1989). It is thus a natural question whether HCF helps in the formation of intellectual capital in all the countries of the world.

The present study evaluates the long-run relationship between intellectual capital and human capital formation separately taking the panel of some of the countries from the high-income group (HIG) and low and middle-income group (LMIG) for the period of 1998 to 2018 by employing panel cointegration and causality techniques for the groups. Countries belonging to the high-income group are: The Canada, United Kingdom, Ireland, Germany, Austria, Norway, Finland, Spain, Portugal, Hungary, Estonia and Cyprus. And countries belonging to the low and middle-income group are: Argentina, Armenia, Brazil, Azerbaijan, Belarus, Colombia, China, India, Kazakhstan, Mexico, Kyrgyz Republic and South Africa. The countries are selected on the basis of the data availabilities on the selected indicators for the period of the study. Table 1 presents the spatial/geographical identities of the selected countries in the world map.

Table 1. Geographical location of selected countries under HIG and MIG

HIG		LMIG	
Countries	**Geographical Location**	**Countries**	**Geographical Location**
Canada	North America	Argentina	South America
United Kingdom	North-western Europe	Armenia	Western Asia
Ireland	North-western Europe	Brazil	South America
Germany	Western Europe	Azerbaijan	Eastern Europe
Austria	Central Europe	Belarus	Eastern Europe
Norway	Northern Europe	Colombia	South America
Finland	Northern Europe	China	Central Asia
Spain	South-western Europe	India	South Asia
Portugal	South-western Europe	Kazakhstan	Central Asia
Hungary	Central Europe	Mexico	North America
Estonia	Northern Europe	Kyrgyzstan	Central Asia
Cyprus	Western Asia	South Africa	Africa

Note: The countries belong to high income and middle income groups are as per the World Bank.

Source: Prepared by the authors using world map

2. Review of Literature

The extant literature mainly reveals the studies on the impacts of human and intellectual capitals on the income growth and other sectors but studies on the associations between human capital and intellectual capital are too limited. The present study reviews some of the related literatures for the purpose of finding the research gaps.

Rodrigues et al. (2015) investigated the impact of intellectual capital on product and process innovation and concluded that, only human capital was an essential component of intellectual capital which had a direct and positive impact on product and process innovativeness. According to Bontis (1998), there was a large and meaningful causal relationship between several aspects of intellectual capital and corporate performance. These findings ought to make it easier for academics and professionals to comprehend the parts of intellectual capital and offered guidance on fostering and boosting it within a corporation. Dzhioev and Gurieva (2019) studied the impacts of intellectual capital on company's performance in developed and emerging markets and discovered that intellectual capital had a beneficial impact. According to Sullivan (2000), intellectual capital was a valuable resource for many businesses, and a company could profit from the advantages that intellectual capital would provide. He proposed two types of strategies for extracting the value of intellectual capital: tactical (short-term) and strategic (long-term), with strategic value extraction generally concerned with intellectual capital. According to Bukowska (2019), the most influential multinational firms were all aware of the expanding significance of intellectual capital in business of today, which was defined as the activation of cross-border transfers of human capital.

Vasyltsiv et al (2021) looked at how the national economy's technical competitiveness impacted fundamental measures of social and economic growth such GDP per capita, the proportion of high-tech exports, capital investment, and quality of life for fostering technological advancement. The consequences of innovative activities on the process of regional convergence were elucidated by Korres and Kokkinou (2011). In the Troso traditional waving business, where human capital had a substantial impact on competitive advantages and company success, Ngatindriatun et al. (2020) examined the relationship between intellectual capital and competitive advantage and company performance.

Lu, Kweh, and Huang (2014) attempted to evaluate the R&D efficiency and economic efficiency of the national innovation system (NIS) in 30 nations from 2007 to 2009, and found that the R&D efficiencies of the NIS outperformed the economic efficiencies. It discovered that intellectual capital had substantial impacts on NIS performance. For 328 high-tech enterprises in China, Wang and Wang (2016) investigated the effects of intellectual capital and knowledge management on company performance. They discovered that the more a firm's intellectual capital matches its knowledge management strategy type, the better its operational and financial success.

Todericiu and Serban (2015) investigated the significance of intellectual capital in educational institutions and its relevance and found that educational institutions, such as universities, was the gateway for intellectual capital since human capital was generated there and used to produce high-quality research outcomes. Also Secundo, Lombardi and Dumay (2018) looked at the relevance of intellectual capital in education, arguing that treating educational institutions as investors within a wide variety of platforms could assist to tackle societal concerns.

The best reason to measure intellectual capital is to consider the risks of not measuring it (Konticand Cabrilo, 2009). Labor shortages, skill mismatches, ability avoidance to rivals, and low productivity are just a few of the repercussions of failing to assess intellectual capital indicators. In spite of this, Zeng, Tan, and Liu (2021) discussed the rationale for regional differences in intellectual capital and proposed how economic development could be achieved by dividing intellectual capital into human, structural and relational capital, finding that structural capital had the greatest impact on GDP of all types of capital. They do, however, proposed that human capital should be considered while increasing intellectual capital. In a knowledge-based economy, education is a prerequisite for building human capital on a national, organizational, and individual level. The mechanism that underlies the operation of the contemporary labour market includes accumulated educational capital. It will be challenging for graduates to obtain a satisfying job in their profession if the profile of educational career capital is not tailored to the profile of requirements stated by the labour market (Małajowıcz and Tęcza, 2019).

Lopez et al. (2011) examined whether it was possible to measure development and management of knowledge in a country using indicators of intellectual capital, such as human capital and structural capital, using a cross section series of 2006 for 82 countries, and found

that structural factors were more closely related to a country's wealth, while human capital did not contribute significantly to economic development. On the other hand, Perez et al. (2012) tried to explain the impact of human capital on the innovation capacity of companies where they found human capital, the element of intellectual capital, contributed to the innovation capacity of companies. Beyer and Leonski (2017) studied that, human capital management was difficult since it was difficult to control further because it was not a company's property. Also the study found that, barrier to efficient human capital management might be a lack of infrastructure to facilitate the process of information sharing, and suggested that a proper motivational strategy should be offered by human capital management to promote employee loyalty and job satisfaction. Alfaro et al. (2011) used human capital and structural capital as intangible assets to estimate the worth of a nation's intellectual capital. They found that the relationships between wealth and efficiency in the management of intangibles were always positive, with the case of image, processes, human administration, and R&D having the greatest significance. In the words of Bradley (1997), 'intellectual capital is the capacity to transform knowledge and intangible assets into resources that can be used to create wealth for both organizations and governments'.

According to Purnastuti (2016), education had a large positive impact on labour productivity, which was a key factor in both economic growth and overall human development. More attention was paid to the effects of higher education by Bajrami and Leka (2020). The model revealed substantial relationships and a positive correlation between the variables mean years of education and enrolment in higher education and GDP per capita. Malesevic Perovic et al (2019) obtained the results for EU15 countries during 1995-2014, where the single most important government expenditure item was education among aggregate expenditure for economic growth. Avdi (2013) concentrated on the health insurance system's contribution structure. Little economic development and a challenge that Albania had already started to face are the primary economic factors. One of Albanian politics' biggest issues had been and will continue to be the need for healthcare reform.

Alawamleh et al. (2019) studied how innovation and human capital investment contributed to Jordan's economic development. They argued that a beneficial influence on a country's economy might be done by improving the educational system (by doing more practical things), providing more possibilities for young people, and decreasing power distance. Dias and Tebaldi (2012), on the other hand, used cross-country panel data from 1965 to 2005 to describe the development process of an economy by focusing on the relevance of institutions for human capital accumulation. In general, they discovered that structural institutions had a long-term favorable influence on economic growth, however more gains might be achieved by increasing the pace of human capital growth. There is a list of studies on the interrelationships between R&D activity, a source of knowledge capital, economic growth and innovative capital, and trade liberalizations in worlds leading countries that demonstrate no linkage from R&D to income, etc, and the employment generating factors in the phase of globalization. (Das and Mukherjee, 2019; Das & Ray, 2019; Das, 2020; Das and Chatterjee, 2020; Rahmi & Alliasuddin, 2020; Myzrova et al, 2020).

Todericiu and Serban (2015) investigated the role of intellectual capital and its significance for education institutions. They considered educational institutions like universities to be a linkage of intellectual capital because human capital was generated there in accomplishing high quality research outcomes. Career capital was the subject of study by Yavuz Aksakal (2020), which was conducted with the understanding that it could be treated as a distinct essential factor. Career capital is a stock built up along the path created by individual qualities, whereas a career is a path in which all of a person's traits form and change as a result. Cesen (2014) studied whether the gender gap in intellectual capital was responsible for the limited impact of innovation on productivity, though now-a-days labour market by gender shows high participation rate of woman, high educational involvement and success, but there was a persistent pay gap due to inferior positions in the work hierarchy. Uno and Kobayashi (2012) analysed the relationship between education and economic growth from the view point of human capital among emerging BRIC countries, and human capital considered as the important tool for keeping high productivity. They showed that higher quality of education brought to the positive effect on economic growth in these countries.

3. Rationale and Objective of the Study

According to the available studies, intellectual capital plays a key role in an economy's competitiveness since it has a significant influence on an organization's performance. As the human capital is a primary component of intellectual capital, no study so far was there on analyzing interrelationships between human and intellectual capitals. The present study aims to investigate empirically the existence of long-term interaction between intellectual capital and human capital accumulation for the countries from some of the high-income group (HIG) and low and middle-income group (LMIG), applying the tools of panel cointegration and causality test for the period 1998-2018.

4. Hypotheses of the Study

a. Is there any short-run and long-run relationship between human capital formation and intellectual capital formation in the countries under the panel of high and middle income groups?

b. Does human capital formation make a cause to the intellectual capital formation in the panel of both the high and middle income groups?

5. Theoretical Background

First, we consider the generation function of IC with the help of HCF by the following functional form given the other factors affecting IC.

1. $IC = f(HCF)$ *where* $f' > 0$ *and* $f'' < 0$.

The growth rate of IC ($dIC/dt/IC = (IC)^{\cdot}$) is proportional to the growth rate of HCF ($(HCF)^{\cdot}$). Here a dot in the top of the variables signifies the growth rate over time of that particular variable.

The production function using the Lucas version of endogenous growth with IC is thus-

2. $YIC = AK^{\alpha}L^{\beta}[IC(HCF)]^{1-\alpha-\beta}$

And that for using HCF is-

3. $YHCF = AK^{\alpha}L^{\beta}(HCF)^{1-\alpha-\beta}$

Where, $0 < \alpha, \beta < 1$, making the diminishing returns to each of the single factors. Further, K and L are the units of physical capital and physical labour respectively. In both the production functions, having $0 < 1-\alpha-\beta < 1$, there are increasing returns to scale making the growth of output larger than the production function having no such human capital factors, HCF or IC. Since IC is the advanced form of the HCF, hence the growth of output under HCF will be lesser than that under IC, or, $(YIC)^{\cdot} > (YHCF)^{\cdot}$. Hence it is justifiable why the policy makers should think of IC besides HCF.

6. Variables and their Measurements

Research and Development Expenditure (RD) [% of GDP current US dollar] is selected as the proxy variable of Intellectual Capital as it is the advanced form of human capital. The Human Capital Formation (HCF) is taken by summation of two heads- government expenditure on education, total (% of GDP in current US dollar) and domestic general government health expenditure (% of GDP in current US dollar).

[1] Research and Development Expenditure (RD) includes both capital and current expenditures in the four main sectors: Business enterprise, Government, Higher education and

Private non-profit. RD covers basic research, applied research, and experimental development.

[2] General government expenditure on education (current, capital, and transfers) is expressed as a percentage of GDP. It includes expenditure funded by transfers from international sources to government. General government usually refers to local, regional and central governments.

[3] Public expenditure on health from domestic sources as a share of the economy as measured by the GDP.

7. Data Source

The data regarding the variables under study, GDP current US dollar, Research and Development Expenditure (RD), Government Expenditure on Education and Government Expenditure on Health, are taken from the World Bank Open Data (https://data.worldbank.org).

8. Empirical Methodology

The study uses extensive empirical tools and techniques for the examinations of the above-mentioned objectives. They are briefly outlined below.

8.1. Cross Sectional Dependence Test

Investigating the cross-sectional dependency in the panel data is essential before examining the stationary features of the analysed variables. Without considering it, the cross-sectional dependency in the data may lead to inaccurate findings if the first generation unit root and cointegration techniques are applied. Taking the model as-

4. $(RD)_{it} = \theta_{ij} + \lambda_i (HCF)_{it} + \eta_{it}$

There may be the possibility of cross sectional dependency across states. This study does so by utilising the cross-sectional dependency and Lagrange multiplier (LM) techniques, both of which were proposed by Breusch and Pagan (1980) and Pesaran (2004), respectively.

5. $CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=0}^{N-1} \sum_{j=i+1}^{N} r_{ij}$

Where, N indicates the cross-sections (number of states) in the panel, T represents the total time periods and r_ij implies the cross-sectional correlation of residual of equation-1 between i and j. The null hypothesis (H0: r_ij=0 for i ≠j) explains that there does not exists any cross-sectional dependency in the panel. Since the results shows that there is no presence of cross sectional dependency in the panel of both high income group and middle income group, thus the study continues along with first generation methods of panel unit root and causality test.

8.2. Panel Unit Root Test

The result of the panel unit root test is determined by applying Levin, Lin & Chut* statistic; Im, Pesaran and Shin W-statistic; Fisher Chi-square test and finally Hadri Z-statistic to check the stationarity of the variables.

Levin et al. (2002) (LLC) used the ADF equation as-

6. $M\Delta Y_i = \mu_i Me + \rho M Y_{it-1} + \sum_{j=1}^{p_i} \beta_{ij} M \Delta Y_{it-j} + M\varepsilon_i$

Where M is idempotent matrix and the null hypothesis that each individual time series contains a unit root in contradiction of the alternative hypothesis that each time series is stationary, H1: $\rho < 0$. The test statistics is specified as-

7. $t_\rho = \frac{\sum_{i=1}^{N} \hat{\sigma}_i^{-2} \Delta Y_i' M Y_{I,-1}}{\sqrt{\sum_{i=1}^{N} \hat{\sigma}_i^{-2} \Delta Y_i' M Y_{I,-1}}}$

where $\hat{\sigma}_i^2 = \frac{\Delta Y_i' M Y_i}{T-2}$.Using the likelihood technique, Im, Pesaran, and Shin (2003) (IPS) construct a more flexible and computationally simple unit root test for panels. The ADF tests make up the IPS test. The alternative hypotheses used in this test are H_1: $\rho_1 < 0, \rho_2 < 0$, …., $\rho_{N1} < 0$, where $N_1 < N$. The test statistic is $\bar{t} = \frac{1}{N}\sum_{i=1}^{N} t_i$ where t_i is the Dickey–Fuller t-statistic of cross section unit i and is assumed to be i.i.d. with finite mean and variance and $t_i = \frac{\Delta Y_i' M Y_{i,-1}}{\hat{\sigma}_i^2 \sqrt{\Delta Y_i' M Y_{i,-1}}}$. Individual ADF test statistics can have different levels of significance using the Fisher (1932)-type test. Assume we wish to test the identical hypothesis that was tested in the IPS test H_0: $\rho_i = 0$ for all i = 1, …, N against the alternative hypothesis H_1: $\rho_i < 0$ for i = 1, … N_1 and $\rho_i = 0$ for i = N_1+ 1, …, N, with $0 < N_1 \leq N$. The Fisher-type test statistic in Choi (2001) model is P = -2 $\sum_{i=1}^{N} \log(P_i)$. Breitung (2005) applied the pooled proxy equation as $\Delta Y_{it}^* = \rho Y_{it-1}^* + v_{it}$ where $Y_{it}^* = \tilde{Y}_{it} - \tilde{Y}_{i1} - \frac{t-1}{T-1}(\tilde{Y}_{iT} - \tilde{Y}_{i1})$. Under the null, the ensuing estimator $\rho^*$is asymptotically distributed as a standard normal. It necessitates only a specification of the number of lags used in each cross-section ADF regression, ρ_i, and the exogenous regressors. Hadri (2000) LM test is based on residual. The stationary null hypothesis means the variance of the randomwalk equals zero. Therefore, in Hadri LM test the hypothesis can be stated as H_0: $\lambda = \frac{\sigma_u^2}{\sigma_e^2} = 0$ and H_1: $\lambda > 0$. The LM statistic is-

8. $LM = \frac{1}{\hat{\sigma}_e^2} \frac{1}{NT^2} \left(\sum_{i=1}^{N} \sum_{t=1}^{T} S_{it}^2 \right)$.

Here Levin, Lin & Chu t*; Breitung t-stat and Hadri Z-stat assumes common unit root process and in contrast of these Im, Pesaran and Shin W-stat; ADF-Fisher Chi-square and PP-Fisher Chi-square assumes individual unit root process.

8.3. Panel Cointegration Test

Pedroni (1999, 2004) proposes a set of cointegration tests that account for varied intercepts and trend coefficients across cross-sections. Following the regression-

9. $Y_{it} = a_i + b_i t + \beta_{1i} X_{1i,t} + \beta_{2i} X_{2i,t} + \ldots + \beta_{Zi} X_{Zi,t} + e_{it}$

Where Y denotes investment in research and development (RD), X implies human capital formation (HCF), t = 1,..., T; i = 1,..., N; z = 1,..., Z; Y and X are assumed to be I (1). The parameters $a_i$andb_i, which can be set to zero if desired, regulate individual and trend effects. The residuals e_{it} will be I(1) under the null hypothesis of no cointegration and the auxiliary regression of the residuals are$e_{it} = \rho_i e_{it-1} + \sum_{j=1}^{\rho_i} \phi_{ij} \Delta e_{it-j} + v_{it}$.For each cross-section, Pedroni describes various methods of constructing statistics for testing for null hypothesis of no cointegration ($\rho_i = 1$) against the two alternative hypotheses- homogenous alternative, ($\rho_i = \rho$) < 1 for all i (within-dimension test or panel statistics test)and the heterogeneous alternative, $\rho_i < 1$ for all i (between-dimension or group statistics test).Under the null of no cointegration, Kao shows that following augmented version statistic, for ρ > 0,

10. $ADF = \frac{t_{\bar{\rho}} + \sqrt{6N}\hat{\sigma}_v / (2\hat{\sigma}_{0v}}{\sqrt{\hat{\sigma}_{0v}^2 / 2\,\hat{\sigma}_v^2 + 3\hat{\sigma}_v^2 / (10\hat{\sigma}_{0v}^2)}}$

Fisher (1932) derives a combined test that uses the results of the individual independent tests. If Ω_i is the *p*-value from an individual cointegration test for cross-section, then under the

null hypothesis for the panel is -2 $\sum_{i=1}^{N} \log(\Omega_i) \rightarrow \chi^2 2N$. Based on MacKinnon-Haug-Michelis (1999) p-values, EViews defaults to reporting the χ^2 value for Johansen's cointegration trace test and maximum eigenvalue test.

8.4. Wald Test

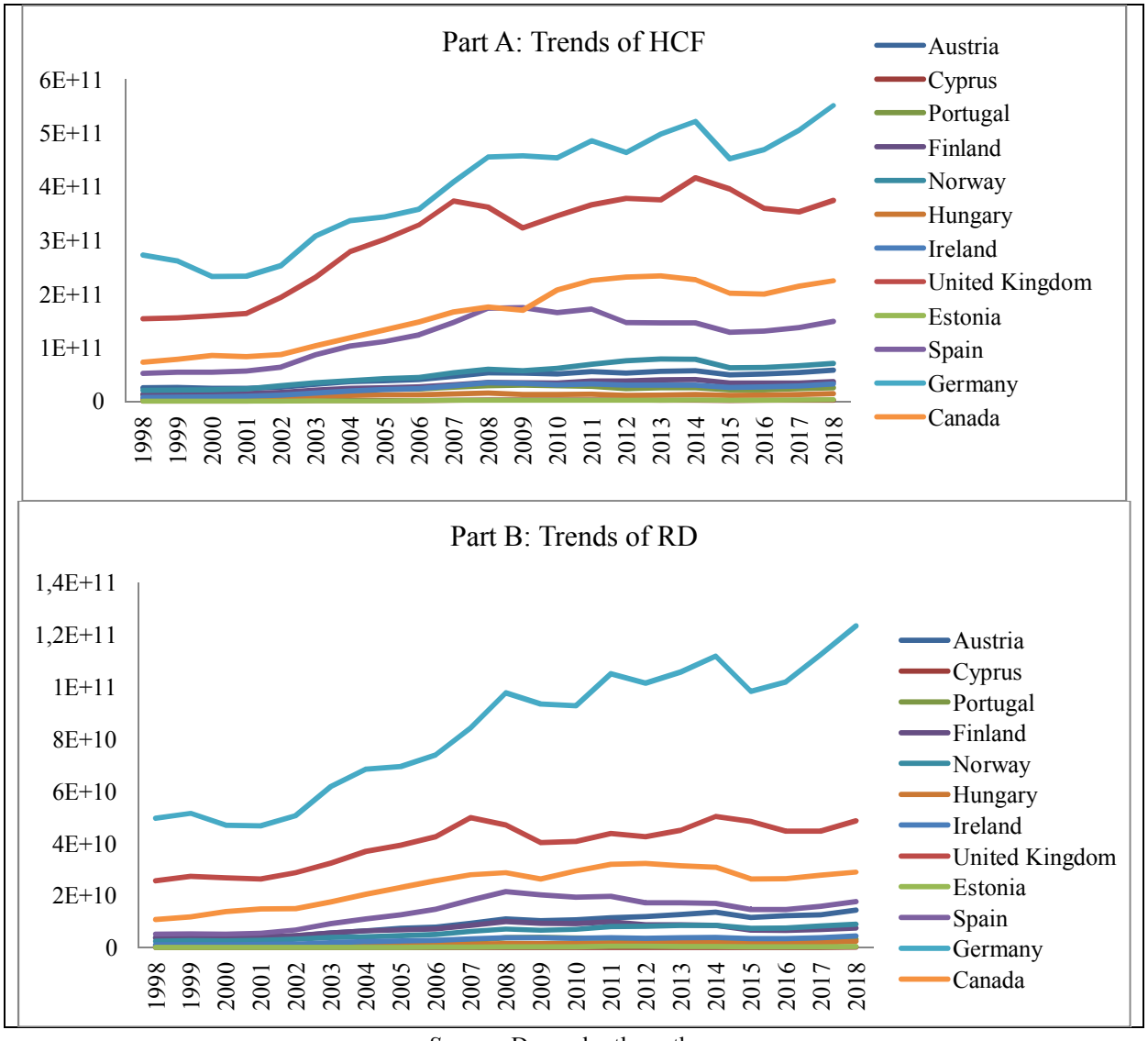
Once the existence of co integration between variables is established, the next step is to develop a vector error correction mechanism to describe dynamic relationships. The Vector Error Correction Model's goal is to show how quickly a system adjusts from short-run equilibrium to long-run equilibrium. Finally, the Wald test is used to demonstrate short-run causality between independent and dependent variables.

9. Empirical Results and Discussion

9.1. Graphical presentation of the variables

The patterns of the series HCF and RD for both high and low and middle income countries, as illustrated in both the parts of Figure 1 and Figure 2, show that the two series move in the upward directions side by side, which may establish meaningful long-term relations between the production of human capital and intellectual capital. Additionally, there are some parallel features between the fluctuations in the two series, which prompts us to look into whether there are causal interactions in the short runs.

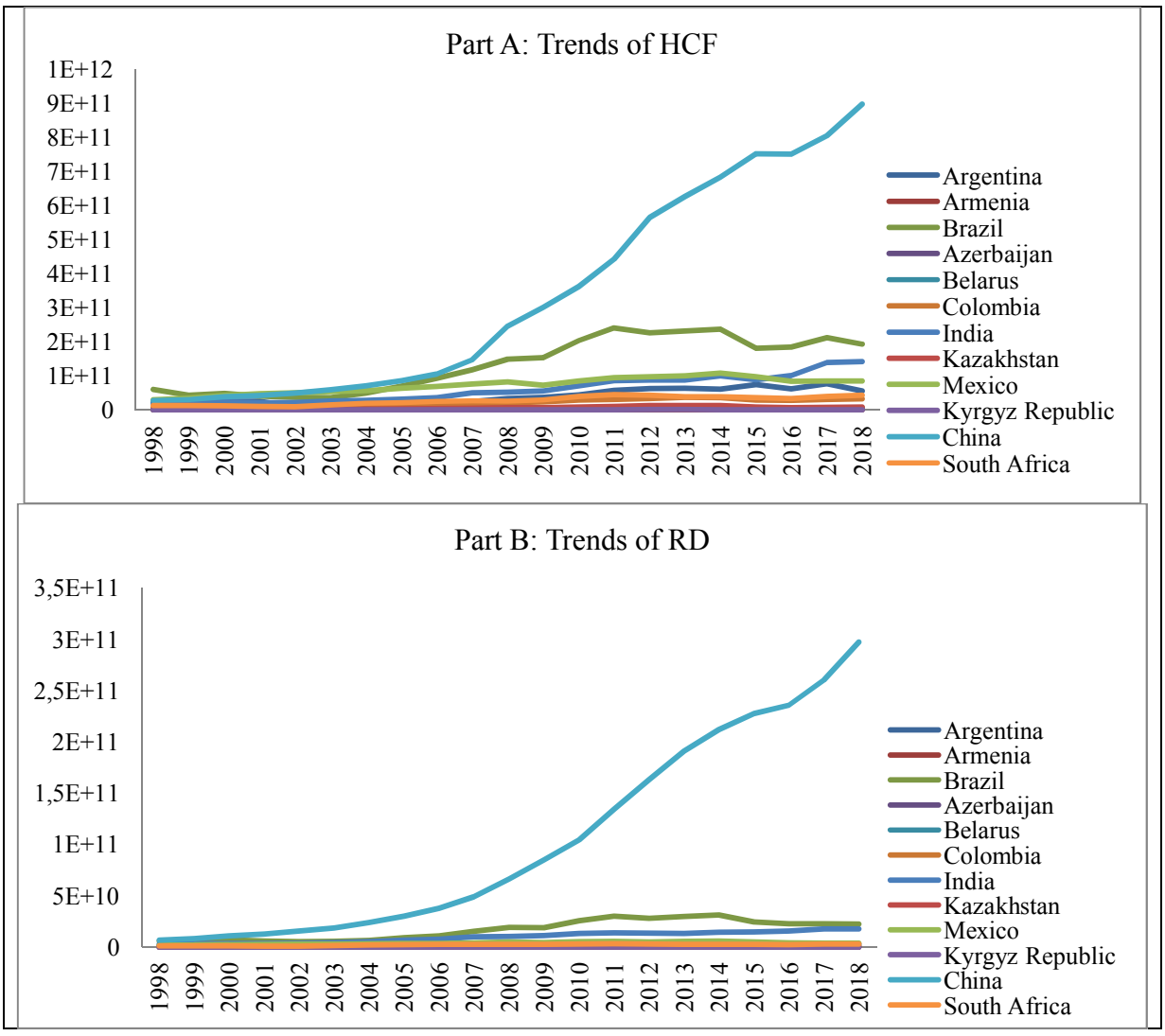
Figure 1. Trends of HCF and RD of high income countries



Source: Drawn by the authors

The levels of both HCF and IC are larger in the countries in the HIG compared to that of the LMIG, although the case of China is different as its level values are greater than Germany, the highest value holders in the HIG. China belongs to the LMIG as because its per capita GDP is far below than the average per capita GDP of the countries from the HIG. The important point is that the countries from the LMIG are progressing at the greater rates in HCF and IC compared to that of the countries from the HIG.

Figure 2. Trends of HCF and RD of low and middle income countries



Source: Drawn by the authors

Out of the countries from the LMIG, Brazil and India follow China in to some extent in respect to the HCF and IC. South Africa stands at the bottom line.

9.2. Cross-sectional dependence test

The findings of the LM tests conducted by Breusch and Pagan (1980) and Pesaran (2004) are shown in Table2. The Pesaran scaled LM and CD test statistics are not significant ($p > 0.10$), while the Breusch-Pagan LM statistic has been shown to be significant ($p < 0.01$).

Table 2. Residual cross section dependence test results

HIG	Statistics	df	Probability
Breusch-Pagan LM	116.5680	45	0.0000
Pesaran scaled LM	05.43895		0.1143
Pesaran CD	0.340253		0.7337
MIG	Statistics	df	Probability
Breusch-Pagan LM	362.7028	45	0.0000
Pesaran scaled LM	05.3321		0.1021
Pesaran CD	03.1423		0.3642

Note: HIG-High-income group; MIG-Middle-income group
Source: Authors' calculations

Thus, taking into account the majority of the findings, the study came to the conclusion that there was no cross-sectional dependence between investment in research and development (RD) and the formation of human capital (HCF) among the countries under study, both for the high income group and the middle income group, in the heterogeneous panel data. Thus the study conducted the first generation panel unit root, cointegration and causality test methods as follows.

9.3. Panel unit root test results

When the variables RD and HCF are considered in their first differences for both the high-income and middle-income groups, the findings reject the unit-root hypothesis (Table3). It means that the series RD and HCF for both the high-income and middle-income groups are stationary in first difference, i.e., they are integrated of order one, I(1).

Table 3. Panel unit root test results for HIG and MIG

Exogenous variables: Individual effects, individual linear trend
Automatic lag selection based on SIC: 0 to 2 for RD and 0 to 1 for HCF (For HIG)
: 0 to 1 for both RD and HCF (For MIG)
Cross-sections: 10

Series D(RD)		HIG		MIG	
Hypotheses	Methods	Statistic	Prob	Statistic	Prob
H_0: Unit root (Assumes common unit root process)	Levin, Lin & Chu t*	-5.41397	0.0000	-5.98761	0.0000
	Breitung t-stat	-3.02525	0.0012	-4.05989	0.0000
H_0: Unit root (Assumes individual unit root process)	Im, Pesaran and Shin W-stat	-4.32971	0.0000	-4.50430	0.0000
	ADF-Fisher Chi-square	51.3669	0.0001	56.7117	0.0000
	PP- Fisher Chi-square	40.3862	0.0045	60.6371	0.0000
H_0: No unit root (Assumes common unit root process)	Hadri Z-stat	6.08393	0.0000	7.15411	0.0000
Series D(HCF)					
Hypotheses	Methods	Statistic	Prob	Statistic	Prob
H_0: Unit root (Assumes common unit root process)	Levin, Lin & Chu t*	-6.78229	0.0000	-6.78229	0.0000
	Breitung t-stat	-4.48721	0.0000	-4.48721	0.0000
H_0: Unit root (Assumes individual unit root process)	Im, Pesaran and Shin W-stat	-3.92892	0.0000	-3.92892	0.0000
	ADF-Fisher Chi-square	46.8619	0.0006	46.8619	0.0006
	PP- Fisher Chi-square	43.9000	0.0016	43.9000	0.0016
H_0: No unit root (Assumes common unit root process)	Hadri Z-stat	2.14612	0.0159	2.14612	0.0159

Note: HIG-High-income group; MIG-Middle-income group
Source: Author's calculations

9.4. Results of lag length selection

The variables RD and HCF are now rendered stationary for both high-income group and middle-income group, the study then test for the existence of a cointegrating relationship between these two variables. The Lag Selection Criteria test is used to determine the lag duration before analysing the cointegration test. Three lag length selection criteria have been

employed in this study to assess the optimum autoregressive (AR) lag length of our variables-Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn Information Criterion (HQIC).The results are given in Table4.

Table 4. Results of lag length selection criteria for HIG and MIG

	HIG			MIG		
Lag	AIC	SIC	HQIC	AIC	SIC	HQIC
0	99.26	99.29	99.27	101.67	101.71	101.68
1	92.22	92.33	92.27	93.47	93.58	93.51
2	92.14	92.34	92.22	93.34	93.54	93.42
3	91.68	91.94	91.78	93.36	93.63	93.47
4	91.59	91.94*	91.73*	93.06	93.40*	93.20*
5	91.57*	91.99	91.74	93.04*	93.46	93.21

Note: * implies the criterion's chosen lag order.
HIG-High-income group; *MIG*-Middle-income group; *AIC*: Akaike information criterion; *SIC*: Schwarz information criterion; *HQIC*: Hannan-Quinn information criterion
Source: Author's calculations

It is observed that at lag four, two criteria, SIC and HQIC, yield the lowest values, implying that the four-year-lag factors have a considerable impact on the present period's values of the variables in the panel.

9.5. Panel Cointegration Test Results

The Pedroni and Kao tests, which are based on the Engle Granger residual test and the Fisher Johansen test, are used in this panel cointegration investigation. Individual intercepts are taken into account when performing the Pedroni and Kao tests. The results are given in Table5.

Table 5. Panel cointegration test results for HIG and MIG

		HIG		MIG	
	Methods	Statistic	Probability	Statistic	Probability
Pedroni(Individual intercept)	Panel v-Statistic	3.1570	0.0008	-1.1718	0.8794
	Panel rho-Statistic	-1.2917	0.0982	1.3788	0.9160
	Panel PP-Statistic	-0.9587	0.1688	1.3950	0.9185
	Panel ADF-Statistic	-3.0724	0.0011	-1.8966	0.0289
	Group rho-Statistic	1.9759	0.9759	1.4601	0.9279
	Group PP-Statistic	2.6084	0.9955	1.1786	0.9279
	Group ADF-Statistic	-0.0377	0.4850	-1.0825	0.8807
Kao	ADF- Statistic	-3.4487	0.0003	-2.9886	0.0014
Fisher (Combined Johansen)	Fisher Stat (Trace)	144.8	0.0000	187.2	0.0000
	At most 1	59.18	0.0000	94.67	0.0000
	Fisher Stat (Max. Eigenvalue)	125.5	0.0000	157.0	0.0000
	At most 1	59.18	0.0000	94.67	0.0000

Note: HIG-High-income group; MIG-Middle-income group
Source: Authors' calculations

The majority of statistics in the Pedroni panel cointegration test cannot reject the null hypothesis of no cointegration in both the high-income and middle-income groups. This means that there is no long-term association between the variables HCF and RD for both groups in this test. According to the Kao ADF-Statistic and Fisher combination tests, the null hypothesis of no cointegration is rejected for these two groups at a significance level of less than one percent. There is a long-term relationship between HCF and RD in these two categories, according to these statistics. Considering Pedroni, Kao and Fisher combined test, the last two test results reject the null hypothesis of no cointegration. The study, therefore, concludes that the two unit root variables RD and HCF are cointegrated. In other words, there is a long-run relationship between human capital formation and intellectual capital in the panel of nations belonging to both the high-income and middle-income groups. The increase in expenditure on education and health sector aggravates human capital formation and thus has a permanent effect on the intellectual capital for high income nations as well as middle income nations. The stable relation between human capital formation and intellectual capital

formation supports the argument of extension version of human capital theory by Nerdrum and Erikson (2001).

9.6. Vector error correction model estimation

The VEC model is built in the following procedure to analyse the dynamics of long run associations in the panel of nations for both high-income group and middle-income group, using a four-year lag (as the lag length selection criteria shown in Table4). The model is-

11. $\Delta RD_t = \lambda\hat{\varepsilon}_{t-1} + \pi_1\Delta(RD)_{t-1} + \pi_2\Delta(RD)_{t-2} + \pi_3\Delta(RD)_{t-3} + \pi_4\Delta(RD)_{t-4} + \mu_1\Delta(HCF)_{t-1} + \mu_2\Delta(HCF)_{t-2} + \mu_3\Delta(HCF)_{t-3} + \mu_4\Delta(HCF)_{t-4} + C$

Table 6. The estimated coefficients of VEC model for HIG and MIG

	HIG		MIG	
	Value	Probability	Value	Probability
λ	0.0581	0.2360	0.0122	0.2626
π_1	0.2035	0.2319	0.3990	0.0000
π_2	-0.8498	0.0000	-0.1086	0.1391
π_3	0.2795	0.1735	0.5461	0.0000
π_4	-0.4736	0.0264	-0.4312	0.0002
μ_1	0.0479	0.0558	0.0039	0.6105
μ_2	0.0306	0.2212	-0.0033	0.6866
μ_3	0.0254	0.3316	0.0064	0.4517
μ_4	0.0305	0.2577	-0.0012	0.8897
C	287754860.47	0.0045	137492942.20	0.1010

HIG-High-income group; MIG-Middle-income group
Source: Authors' calculations

The coefficient of $\hat{\varepsilon}_{t-1}$ is positive but not significant both in panel of high-income nations and middle-income nations. The positive coefficient of $\hat{\varepsilon}_{t-1}$ (λ= 0.0581) implies the long-run stable relationship wouldn't be restored (Table6). The coefficient of ΔHCF such as μ_1, μ_2, μ_3 and $\mu_4$corresponding to t-1, t-2, t-3 and t-4 gives the short-run relationship between research and development and human capital formation. Individual coefficients are found to be statistically insignificant, with the exception of μ_1 for the high-income group, indicating the absence of short-run causation from human capital formation to research and development. The current study used the Wald test to assess the short-run causality running from human capital formation to research and development, and the results are shown in Table7.

The null hypothesis and alternative hypothesis for the panel causality test are respectively as-

H_0: No short-run causality running from HCF to RD and H_1: There is short-run causality running from HCF to RD

Table 7. Wald test results

	HIG			MIG		
Test Statistic	Value	df	Probability	Value	df	Probability
Chi-square	15.01803	4	0.0047	0.729095	4	0.9477

HIG-High-income group; MIG-Middle-income group
Source: Authors' calculations

The results in the table clearly show that there is short term causal interplay in the direction from human capital formation to intellectual capital of the panel of nations for high-income group as because the p-value is at the less than 1% level of significance. It is insignificant for the middle-income group. The coefficient of the lag terms of HCF, μ_1, is shown to be positive and significant for the high-income group, indicating the positive degree of influence of human capital formation on intellectual capital formation of panel of nations. A one-unit increase in the change of HCF at t-1 lag period results in a 0.05unit increase in the change of current-year intellectual capital in the high-income group. Hence, it is reasonable to conclude that human capital formed in high-income countries is one of the causes of increases in the intellectual capital formation. The huge growth history of the so called developed economies could thus be explained with the generation of large intellectual capital formation. The medium and low income countries will thus have to go for continuous investment on human capital formation and converting them into intellectual capitals to make them at par with the world's high income countries.

10. Conclusion and Policy Recommendations

Intellectual capital has been increasingly essential in the production process in recent years, since it drives market innovation. Human capital formation is thought to be the primary source of intellectual capital growth. As a result, the current panel analysis presents empirical evidence on the inter-relationship between human capital investment and intellectual capital for a panel of high-income and middle-income countries from 1998 to 2018. In this regard, the study employed the panel cointegration approach to establish long-run relationship, followed by the Wald test to prove short-run causality between intellectual capital and human capital. Both high-income and middle-income groups exhibit a long-run relationship between intellectual capital and human capital, according to the empirical findings. However, using the Wald test, it was shown that there is a short-run association between human capital investment and intellectual capital, with the causation going from human capital investment to intellectual capital only for a panel of high-income countries. To ensure larger intellectual capital, governments should adopt policy to increasing investments in human capital via education and health spending.

Because of the empirical findings which reveal that there is a long-run positive relationship between intellectual capital and human capital production, the government should place a greater emphasis on human capital by increasing expenditure in both education and health sector. As the immediate influence of human capital on intellectual capital arises in high-income countries, it makes sense for middle-income countries to increase their economy in order to catch up the high-income countries through investment in HCF as well as to IC formation.

11. Disclosure Statements

It is declared that the authors did not face any conflict of interests with anybody while developing the full paper. Also, it is disclosed that there was no funding agency behind the work, and there was no use of animals/human beings in the work.

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