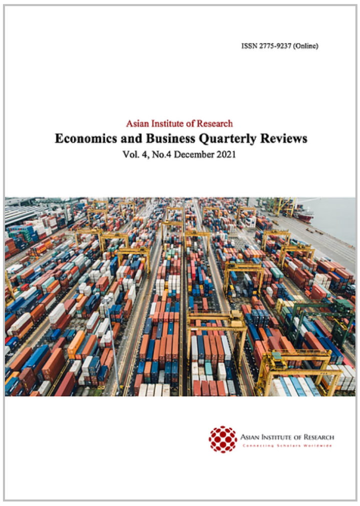

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An Empirical Study of National Education and Economic Development Based on a Variable Coefficient Model

Liuyuan Han[1], Guangming Deng[1,2]

[1] College of Science, Guilin University of Technology, Guilin, China
[2] Institute of Applied Statistics, Guilin University of Technology, Guilin, China

Correspondence: Guangming Deng, College of Science, Guilin University of Technology, Guilin, Guangxi, 541006, China. Tel: 18076761871. E-mail: dgm@glut.edu.cn

Abstract
This paper studies the relationship between the level of national education and economic development in 31 provinces and cities in China from 2012 to 2019. Principal component analysis is used to comprehensively evaluate the level of national education, on the basis of which a variable coefficient model is tested and a constant coefficient model is established for comparison. The results show that: (1) there is a co-integration relationship between the level of national education and economic development, i.e. the two are in equilibrium in the long run. (2) In some provinces and cities in China, economic development is positively correlated with the level of national education, and some provinces and cities are negatively correlated. (3) Economic development has different effects on the level of national education in the east, middle and west. (4) Economic development and national education level are positively correlated in the average sense in China.

Keywords: Economic Development, National Education, Indicator System, Variable Coefficient Model

1. Introduction

The level of national education is an important measure of a country's wealth and strength. "Education is a major plan for the country and for the Party" is the original and important assertion made by General Secretary Jinping Xi at the National Education Conference. China needs education to pass on its excellent history and culture, and to stimulate the creativity of its people. The development of education in a country requires economic support, so without economic development, there can be no development of education. In turn, for a country to develop economically, it needs not only the previous economy as support, but it must also promote the development and innovation of science and technology, and education is the basic way to promote technological progress. Economic development is the material basis for educational advancement, while the rate of economic growth determines the scale of educational development.

In recent years, many domestic scholars have conducted research on the relationship between education and economic development, and the relevant literature is mainly reflected in the following two aspects: firstly, research is conducted from the perspective of education investment and economic growth, and the methods used are mainly Granger causality test (Zhou, 2007), multiple linear regression model (Xi & Lu, 2019), Harold Domar model (Tian, 2017), spatial econometric model (Xie, 2015), etc. Secondly, research is conducted from the perspective of higher education and economic growth, and the main methods used are fixed-effects models (Qin & Wang, 2017), C-D production function models (Fan & Ma, 2017), VEC models (Liu, 2016), etc.

A very small number of scholars abroad have also studied the relationship between education and economic development. Nicholas (2020) investigated the dynamic causal relationship between education and economic growth in South Africa, using the ARDL boundary test method and an ECM-based Granger causality model. Agasisti and Bertoletti (2020) investigated the impact of higher education systems on economic growth in 184 European regions, finding that an increase in the number of universities in a region is beneficial to the region's economic growth.

The above literature shows that there is less research on the relationship between the level of national education and economic development, both domestically and abroad, focusing instead on aspects such as investment in education or higher education. Based on this, this paper expands the scope of the study to examine the relationship between the level of national education and economic development in 31 provinces and cities in China from 2012 to 2019. Firstly, seven indicators are selected to comprehensively evaluate the national education level of 31 provinces and cities in China, and then a variable coefficient model is established on the basis of unit root test and co-integration test to explore the relationship between the two.

2. Selection of indicators

This paper focuses on the relationship between the level of national education and economic development in 31 provinces, autonomous regions and municipalities directly under the central government in China, so the indicators are selected mainly from the two aspects of national education level and economic development. We usually use the regional gross domestic product per capital (GDP per capital, in yuan) of the region to measure the economic strength of the region. Therefore, this paper selects the GDP per capital of 31 provinces, autonomous regions and municipalities directly under the central government in China to measure local economic development. In terms of national education, seven indicators are selected in this paper, namely the proportion of education expenditure to GDP X1, the average number of students enrolled in higher education per 100,000 people (number) X2, the proportion of those who have obtained a higher degree X3, the number of public library collections per capital (volumes) X4, the ratio of student teachers in primary education X5, the ratio of student teachers in higher education X6, and the proportion of illiterate people X7 (Zhang & You, 2018). The data for the above indicators are selected for the years 2012-2019. The data were obtained from the China Statistical Yearbook and the China Education Statistical Yearbook.

Table 1: National education level indicator system

	Indicators		Indicator Direction
National education level	Share of GDP spent on education X1	Expenditure on education as a percentage of GDP, %	Positive
	Average number of students enrolled in tertiary education per 100,000 people X2		Positive
	Percentage of those who have obtained tertiary qualifications X3	Proportion of the population that has obtained tertiary education and above	Positive
	Public library holdings per capital X4		Positive
	Student teacher ratio (primary education) X5	Number of pupils per teacher (primary education including general primary schools)	Positive

Student teacher ratio (secondary education) X6	Number of students per teacher (secondary education includes general high school, secondary vocational education and general lower secondary school)	Positive
Illiteracy rate X7	Illiterate population as a proportion of population aged 15 and over, %	Negative

3. Data processing

First, the data need to be normalized and different formulas need to be used for positive and negative indicators (Jia, He & Jin, 2018):

Positive indicators:

$$x_{ij}=\frac{x_{ij}-min(x_{1j},x_{2j},\cdots\cdots,x_{nj})}{max(x_{1j},x_{2j},\cdots\cdots,x_{nj})-min(x_{1j},x_{2j},\cdots\cdots,x_{nj})} \quad (1)$$

Negative indicators:

$$x_{ij}=\frac{max(x_{1j},x_{2j},\cdots\cdots,x_{nj})-x_{ij}}{max(x_{1j},x_{2j},\cdots\cdots,x_{nj})-min(x_{1j},x_{2j},\cdots\cdots,x_{nj})} \quad (2)$$

Where, x_{ij} denotes data for the first indicator j for the first i province.

4. Comprehensive evaluation of the level of national education

In this paper, principal component analysis is used to make a comprehensive evaluation of the level of national education. Before the principal component analysis, the data were standardized. KMO and Bartlett tests were performed on the data to determine whether the data could be analysed using principal component analysis. In this paper, principal component analysis was conducted on the data for 2019 . As can be seen from Table 2, the KMO value is 0.544, the value of the statistic of Bartlett's test is large and the p-value is less than 0.05, indicating that there is a correlation between the quantities and that it is suitable for principal component analysis.

Table 2: KMO and Bartlett's test

KMO sampling suitability number		0.544
Bartlett Sphericity Test	Approximate cardinality	130.704
	Freedom	21
	Significance	0.000

Table 3: Results of principal component analysis

Total variance explained						
Ingredients	Initial Eigenvalue			Extraction of sum of squares of loads		
	Total	Percentage variance	Cumulative %	Total	Percentage variance	Cumulative %
1	3.273	46.755	46.755	3.273	46.755	46.755
2	1.863	26.617	73.372	1.863	26.617	73.372
3	0.811	11.588	84.960	0.811	11.588	84.960
4	0.540	7.719	92.679			
5	0.281	4.017	96.696			
6	0.172	2.457	99.153			
7	0.059	0.847	100.000			

Table 4: Principal component coefficient matrix

	Ingredients		
	1	2	3
X1	-0.182	-0.391	0.149
X2	0.252	0.097	0.099
X3	0.264	0.091	0.287
X4	0.198	0.114	0.718
X5	-0.144	0.358	0.619
X6	0.213	0.304	0.255
X7	0.185	0.363	-0.392

Using principal component analysis to extract the common factors, the results are shown in Table 3 (Tian, Sun & Zhan, 2017; Zhou & Lin, 2020) It can be seen that the cumulative contribution rate of the first three principal components is 84.96%, which can retain the information of the original variables better, and the seven original variables can be replaced by three principal components. The cumulative contribution rate of the three selected principal components was set at 1, and the weight of the cumulative contribution rate was calculated as the weight of each principal component, and the comprehensive score of the national education level of each region was calculated separately to obtain the following function: $W = 0.551F_1+0.313F_2+0.136F_3$. where F_1, F_2, F_3 is the factor score function, and $X1^*$, $X2^*$, $X3^*$, $X4^*$, $X5^*$, $X6^*$, $X7^*$ are the standardized variables.

$$F_1=-0.182X1^*+0.252X2^*+0.264X3^*+0.198X4^*-0.144X5^*-0.213X6^*+0.185X7^* \quad (3)$$
$$F_2=-0.391X1^*+0.097X2^*-0.091X3^*-0.114X4^*+0.358X5^*+0.304X6^*+0.363X7^* \quad (4)$$
$$F_3=0.149X1^*+0.099X2^*+0.287X3^*+0.718X4^*+0.619X5^*+0.255X6^*-0.392X7^* \quad (5)$$

The same method was used to obtain the overall score and ranking of the national education level for the other years, and the results are shown in Table 5.

Table 5: Overall score and ranking of national education levels, 2012-2019

	2012	2013	2014	2015	2016	2017	2018	2019	Variance
Beijing	0.573(2)	0.582(2)	0.582(2)	0.501(1)	0.568(2)	0.525(2)	0.623(1)	0.579(1)	0.268
Tianjin	0.472(3)	0.459(3)	0.465(3)	0.389(2)	0.466(3)	0.385(3)	0.446(3)	0.448(3)	0.125
Hebei	0.274(22)	0.298(18)	0.299(20)	0.287(18)	0.285(18)	0.196(19)	0.160(19)	0.249(15)	3.982
Shanxi	0.263(24)	0.251(23)	0.254(26)	0.231(23)	0.244(24)	0.210(14)	0.192(15)	0.236(23)	19.714
Inner Mongolia	0.275(21)	0.250(24)	0.260(24)	0.231(24)	0.276(21)	0.200(18)	0.199(14)	0.238(21)	12.125
Liaoning	0.386(5)	0.390(5)	0.385(6)	0.314(12)	0.353(7)	0.268(7)	0.282(5)	0.328(8)	5.554
Jilin	0.291(16)	0.290(20)	0.286(21)	0.244(21)	0.280(19)	0.205(16)	0.249(9)	0.246(17)	15.696
Heilongjiang	0.274(23)	0.257(22)	0.257(25)	0.222(25)	0.241(25)	0.162(26)	0.191(16)	0.203(25)	10.554
Shanghai	0.595(1)	0.584(1)	0.608(1)	0.358(3)	0.573(1)	0.541(1)	0.533(2)	0.532(2)	0.571
Jiangsu	0.374(6)	0.385(6)	0.398(5)	0.350(4)	0.400(4)	0.288(4)	0.307(4)	0.387(4)	0.839

Zhejiang	0.397(4)	0.424(4)	0.417(4)	0.318(11)	0.379(5)	0.278(5)	0.267(6)	0.352(5)	5.429
Anhui	0.256(25)	0.279(21)	0.311(18)	0.292(17)	0.279(20)	0.169(24)	0.131(23)	0.243(19)	8.411
Fujian	0.319(9)	0.335(10)	0.366(9)	0.309(14)	0.342(8)	0.244(9)	0.222(10)	0.318(9)	3.357
Jiangxi	0.309(10)	0.340(9)	0.360(11)	0.327(8)	0.320(12)	0.226(12)	0.123(24)	0.247(16)	26.500
Shandong	0.297(12)	0.312(15)	0.326(16)	0.300(16)	0.317(15)	0.208(15)	0.216(12)	0.279(13)	2.786
Henan	0.295(14)	0.308(16)	0.337(15)	0.303(15)	0.300(17)	0.190(21)	0.149(20)	0.260(14)	7.143
Hubei	0.335(8)	0.355(7)	0.343(14)	0.325(9)	0.340(11)	0.251(8)	0.266(7)	0.339(6)	6.786
Hunan	0.296(13)	0.330(11)	0.352(13)	0.341(5)	0.341(9)	0.238(10)	0.186(17)	0.302(11)	12.125
Guangdong	0.346(7)	0.349(8)	0.371(7)	0.337(6)	0.368(6)	0.274(6)	0.221(11)	0.337(7)	2.786
Guangxi	0.280(19)	0.323(14)	0.361(10)	0.310(13)	0.311(16)	0.214(13)	0.105(26)	0.242(20)	25.986
Hainan	0.282(18)	0.233(25)	0.266(22)	0.232(22)	0.250(23)	0.204(17)	0.145(21)	0.219(24)	7.714
Chongqing	0.306(11)	0.329(12)	0.368(8)	0.328(7)	0.340(10)	0.229(11)	0.214(13)	0.294(12)	4.286
Sichuan	0.279(20)	0.291(19)	0.307(19)	0.273(19)	0.269(22)	0.180(23)	0.143(22)	0.237(22)	2.786
Guizhou	0.163(28)	0.211(29)	0.253(27)	0.189(27)	0.187(29)	0.162(25)	0.049(28)	0.164(28)	1.696
Yunnan	0.152(29)	0.218(27)	0.246(28)	0.208(26)	0.206(27)	0.133(27)	-0.036(30)	0.191(26)	2.000
Tibet	-0.126(31)	-0.102(31)	-0.088(31)	-0.128(31)	-0.113(31)	0.118(30)	-0.112(31)	-0.145(31)	0.125
Shaanxi	0.289(17)	0.303(17)	0.314(17)	0.324(10)	0.317(14)	0.194(20)	0.253(8)	0.316(10)	18.696
Gansu	0.195(27)	0.195(30)	0.208(30)	0.315(30)	0.150(30)	0.118(31)	0.081(27)	0.119(29)	2.125
Qinghai	0.152(30)	0.230(26)	0.264(23)	0.148(29)	0.188(28)	0.124(28)	0.046(29)	0.118(30)	5.554
Ningxia	0.291(15)	0.327(13)	0.356(12)	0.268(20)	0.319(13)	0.185(22)	0.165(18)	0.244(18)	13.411
Xinjiang	0.231(26)	0.211(28)	0.242(29)	0.189(28)	0.210(26)	0.121(29)	0.107(25)	0.187(27)	2.214

Overall, the top 10 regions in terms of overall score during 2012-2019 are Shanghai, Beijing, Tianjin, Jiangsu, Zhejiang, Liaoning, Guangdong, Hubei, Fujian and Chongqing. Hunan, Jiangxi, Shaanxi, Shandong, Ningxia, Guangxi, Henan, Jilin, Hebei and Sichuan have composite scores between 11th and 20th for. The last 11 places in the overall score are Tibet, Gansu, Qinghai, Guizhou, Yunnan, Xinjiang, Heilongjiang, Shanxi, Hainan, Inner Mongolia and Anhui, indicating that the national education level in these regions is low and needs to be strengthened.

The variance in Table 5 shows that the national education level of Beijing, Tianjin, Shanghai, Jiangsu and other provinces and cities maintain the top and steadily growing in China. Jiangxi and Guangxi have the most unstable national education levels, followed by provinces such as Shanxi, Shaanxi, Jilin and Heilongjiang, for which national education should be strengthened so that the national education level grows steadily.

5. Panel Model of National Education Level and Economic Development

5.1 Unit root test

Before modelling, a unit root test was conducted for the stationarity of the variables in each of the 31 regions to avoid "pseudo-regressions". In order to ensure the accuracy of the unit root test, two methods are used: the LLC test, which contains the same unit root, and the Fisher-PP test, which contains different unit roots. In this case, the composite score of the previous national education level (JY) was chosen as the indicator of national education level and economic development was measured by GDP per capital (GDPPC) (unit: yuan). Natural logarithms were done for GDPPC to eliminate the interference of exponential growth trends and heteroskedasticity in data processing. Each tested separately using Eviews 8.0. The results of the tests for each variable are shown in Table 6.

Table 6: Panel unit root test results

Variables	LLC test	PP Inspection	Stability
JY	-10.118 4 (0.000 0)	138.709 (0.000 0)	Stable
LNGDPPC	39.527 4 (1.000 0)	4.079 52 (1.000 0)	non-stationary
Variables	First order differential LLC test	First order differential PP test	
LNGDPPC	-2.809 23 (0.002 5)	82.153 3 (0.044 3)	Stable

As can be seen from the results in Table 6, national education levels all reject the existence of a unit root at the 5% level of significance, so the national education levels series is a smooth series. The economic development series is non-stationary at the 5% level of significance. The series obtained by first-order differencing is smooth at the 5% level of significance, so economic development is a first-order single integer series.

5.2 Co-integration test

Cointegration tests are performed before building the model to test whether the causal relationship described by their regression equation is a pseudo-regression. The purpose of the cointegration test is to determine whether a linear combination of a set of non-stationary series has a stable equilibrium relationship. Since the two series LNGDPPC is a first-order single integer process and JY is not, and the series obtained by performing a first-order difference on JY is also smooth, the series LNGDPPC and JY are both first-order single integer processes. We can therefore perform a panel cointegration test on them. Through the p-value of the test results of the Kao test we can see that, given a significance level of 5%, the original hypothesis is rejected, i.e. there is a cointegration relationship between the level of national education and economic development, which is able to ensure that the model constructed below in this paper is meaningful.

Table 7: Results of the Kao test for panel cointegration

Test methods	Testing the hypothesis	Statistical quantities	Statistical values	P-value
Kao test	The original hypothesis is that there is no co-integration relationship	ADF	2.169 603	0.015

5.3 Model setting and construction

As panel data contains both cross-sectional data and time series data, a panel model is a model that combines cross-sectional data with time series data and can improve the reliability of data analysis. Panel models can be classified into variable coefficient models, variable intercept models and constant coefficient models according to the form of the model. In this paper, the model form is determined using the F-test. To conduct the F-test, two original hypotheses are first proposed:(1) $\beta_1 = \beta_2 = \beta_3 = \cdots = \beta_N$ (2)$\alpha_1 = \alpha_2 = \alpha_3 = \cdots = \alpha_N$,$\beta_1 = \beta_2 = \beta_3 = \cdots = \beta_N$. Accept (2), then it is a constant coefficient model and the test is completed. Reject (2), and (1) is tested. If (1) is accepted, the model is a variable intercept model, otherwise it is a variable coefficient model. Calculate the test statistics F_1 and F_2.

$$F_2 = \frac{(S_3\text{-}S_1)/[(N\text{-}1)(k+1)]}{S_1/(NT\text{-}N(k+1))} \sim F[(N\text{-}1)(k+1), N(T\text{-}k\text{-}1)] \tag{6}$$

$$F_1 = \frac{(S_2\text{-}S_1)/[(N\text{-}1)k]}{S_1/(NT\text{-}N(k+1))} \sim F[(N\text{-}1)k, N(T\text{-}k\text{-}1)] \tag{7}$$

The sum of squared residuals for the variable coefficient model is S_1, the sum of squared residuals for the variable intercept model is S_2, and the sum of squared residuals for the constant coefficient is S_3. N is the number of cross-sectional members, T is the number of periods in each variable series, and k is the number of explanatory variables. In this paper, we study the impact of economic growth on national education, and we first obtain the residual sums of squares for each model estimate, S_1=0.837 133, S_2=1.057 950, S_3=3.755 354。 Based on the above equation, we obtain, and therefor F_2=10.806 5 > $F_{0.05}$(60,186)=1.39 reject (2). F_1=1.635 4 > $F_{0.05}$(30,186)=1.52 , so rejecting (1) suggests that the model should choose a fixed effects variable coefficient model as the set-up form of the panel regression model.

The results of the model estimation are shown in the table 8, using the economic development status of each region of China as the explanatory variable and the level of national education as the explanatory variable in a panel regression with variable coefficients, categorised by the central and eastern regions (Wang, 2017).

Table 8: Estimation results of the variable coefficient panel model

Eastern Region		Central Region		Western Region	
Province	Coefficient	Province	Coefficient	Province	Coefficient
Jiangsu	1.620 152	Hunan	1.363 586	Guizhou	2.092 149
Hebei	1.181 252	Shanxi	-0.024 959	Ningxia	1.436 034
Shandong	1.007 127	Hubei	-1.449 372	Tibet	1.363 790
Heilongjiang	0.679 879	Anhui	-1.257 532	Guangxi	1.228 091
Jilin	0.492 251	Jiangxi	-2.143 476	Qinghai	1.132 396
Guangdong	0.329 972	Henan	-2.924 739	Gansu	0.328 215
Shanghai	0.288 143			InnerMongolia	0.237 980
Tianjin	0.286 637			Chongqing	0.011 701
Hainan	0.199 414			Shaanxi	-0.327 565
Liaoning	-0.032 782			Yunnan	-0.494 856
Beijing	-0.388 376			Xinjiang	-0.507 273
Zhejiang	-0.779 309			Sichuan	-2.101 560
Fujian	-1.693 139				
Extreme difference: 3.313 291		Extreme difference: 4.288 325		Extreme difference:4.193 809	

The regression equation estimated by the model is as follows.

$$JY_{i,t} = 0.262\ 623 + \alpha_i^* + \beta_i LNGDPPC_{i,t} + u_{i,t} \tag{8}$$

The goodness of fit R^2=0.777, with a good fit, indicates that the model has a good degree of interpretability. The following conclusions can be drawn about the impact of economic development on the level of national education in the 31 regions of China.

First, the data from the provinces and municipalities verify that the level of national education is influenced by the state of economic development, and it is clear from the results that in some of our provinces and municipalities economic development is positively correlated with the level of national education, and some negatively. Their coefficients vary considerably. Among the provinces with positive correlations, the coefficients are, from largest to smallest, Guizhou, Jiangsu, Ningxia, Tibet, Hunan, Guangxi, Hebei, Qinghai, Shandong, Heilongjiang, Jilin, Guangdong, Gansu, Shanghai, Tianjin, Inner Mongolia, Hainan and Chongqing. Among the provinces with a negative correlation, the coefficients in descending order are Shanxi, Liaoning, Shaanxi, Beijing, Yunnan, Xinjiang, Zhejiang, Hubei, Anhui, Fujian, Sichuan, Jiangxi and Henan, indicating that the economic development of these provinces has not led to an increase in the level of national education in the province, but rather a downward trend in the level of national education.

Second, The effect of economic development on the level of national education varies between the East, Central and West. In the East, the difference in the effect of economic development on the level of national education in each province is the smallest in the Central and Western regions. In the central region, the coefficient is negative in all provinces except Hunan, and the difference is the largest in the central and western regions, i.e. in the central region, the level of national education is negatively correlated with economic development in all provinces except Hunan. In the western region, such as: Guizhou, Ningxia, Tibet and Guangxi, their coefficients are larger and they can improve the level of national education by means of economic development. However, compared to central China, most of the provinces and cities cannot improve national education by developing their economy, which requires them to adopt other policies or measures to strengthen national education.

In order to reflect the degree of influence of China's economic development on the level of national education, this paper continues to build a constant coefficient model and obtains the following regression equation.

$$JY_{i,t}=0.244\ 307+0.161\ 007LNGDPPC_{i,t} \tag{9}$$

The fit of R^2=0.777 the variable coefficient model is smaller than that of the variable coefficient panel regression model. The variable coefficient model only gives the impact of economic development on the level of national education in a single average sense, and is not able to see the difference between different provinces and cities. The variable coefficient model gives the magnitude of the impact of economic development on the level of national education under different provinces and cities, and also gives the coefficient of the degree of impact, which can better analyse the impact between the level of national education and economic development in different regions and different economic development areas.

6. Summary

This paper studies the relationship between the level of national education and economic development. Firstly, we select the relevant indicators that can reflect the level of national education and measure the level of national education in 31 provinces and cities in China through principal component analysis. The results show that there is a co-integration relationship between the level of national education and economic development, i.e. the two are in equilibrium in the long run, so we can establish a regression model for it. In this paper, we establish a variable coefficient model through the test and draw the analysis results: in some provinces and cities in China, economic development is positively correlated with the level of national education, and some are Some are negatively correlated. In provinces with a positive correlation, such as Guizhou, Jiangsu and Ningxia, the level of national education can be enhanced by increasing economic growth. In the provinces with a negative correlation, economic growth is not enough to improve national education, but requires the support of various parties and national policies or other measures to strengthen national education.

The economic development of different regions and economic development areas has different degrees of effect on the level of national education. Therefore, the 31 provinces and cities in China cannot formulate a uniform programme, but should formulate different national education programmes according to the sub-regional situation and economic development of each province and city, so that the national education level of each province and city can be improved to a higher level. For example, some provinces in the west can develop their economies to raise the level of national education, while this approach is not feasible in the centre. However, economic development in the average sense of the word in China is positively correlated with the level of national education.

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