Natural Resource Dependence and Life Expectancy Nexus: The Role of Education

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Abstract

Natural resources could be beneficial for human and economic development if the revenue of natural resource sectors is used in the government's productive investments. This study examines the association between natural resource dependence (NRD), public education investment (PEI), and life expectancy (LE) in China and across gender. We find a negative association between NRD and life expectancy, while the increase in life expectancy stems from the enhancement of PEI. We find that the combined effect of NRD and PEI on LE is positive in China and across gender. Our findings are robust after the inclusion of other control variables. Our findings indicate that NRD without PEI would not contribute to increased longevity. The policy insinuation that government should utilize the revenue of the natural resource sector to enhance investment in education to obtain the real benefits from natural resources as it plays a key role in improving life expectancy.

Keywords*: NRD, LE, PEI, GDP, CO_2, Health, Urbanization, Fixed Effect, China*
Jell Code: *O15, O13, Q33, I15*

1. Introduction

Natural resources as naturally gifted, constitute a momentous material basis for a healthier livelihood and social progress of economies. Indeed, excessive natural resource endowments play an imperative role in the development of countries as well as the enhancement of quality of life. Theoretically, natural resources are a valuable source of revenue and are anticipated to stimulate economic development and improve life expectancy. However, existing literature observes a puzzling scenario in the sense that countries with rich resources seem to experience slow economic growth as compared to those with fewer natural resources. This phenomenon is specifically known as the resource curse in the literature on natural resources (Badeeb, Lean, & Clark, 2017; Sun, Sun, Geng, Yang, & Edziah, 2019).

Perhaps, the foremost essential issue is how to sustain the natural resources of an economy while improving the well-being or health of the population. This monumental task comes under the concept of sustainable development. However, world organizations have agreed to address sustainable development (SD) through international treaties. As a consequence, education for sustainable development (ESD) has been launched to cope with sustainability (Arbuthnott, 2009; Pauw, Gericke, Olsson, & Berglund, 2015; Venkataraman, 2009).

The existing literature emerged as another strand of research that investigates the central role that natural resource plays in deciding the quality of life across nations. These studies establish a link between NRD with the numerous life quality measures, such as civil war probability (Ross, 2004), human development index (Pineda & Rodríguez, 2010), infant mortality (Wigley, 2017), and life expectancy (Pendergast, Clarke, & Van Kooten, 2011). Enjoying the higher rents from natural resources allows for increasing the spending on healthcare (Acemoglu, Finkelstein, & Notowidigdo, 2013), which should transform into greater economic growth and improve the quality of life (Cotet & Tsui, 2013). Additionally, it has been noted that economies that achieve economic growth from NRD do not seem to convert this revenue into upgraded health (Cockx & Francken, 2014). Moreover, Karl (2007) also stated that the natural oil-dependent countries have low living standards instead of a significant rise in income. Various studies have found an inverse relationship among several health outcomes and natural resource wealth as well as the provision of quality healthcare (APR, 2013; Chang & Wei, 2019; Stretesky, Long, & Lynch, 2017).

The research on the relationship between dependence on natural resources and life expectancy is limited and ongoing literature on this association has revealed inconclusive pieces of evidence (Madreimov & Li, 2019). The study close to this research is the Cotet and Tsui (2013). By utilizing the dynamic panel methods, the authors found that natural resource wealth has improved the quality of life through significant gains in longevity and a decline in infant mortality; especially in the less democratic resource (oil) rich economies where the resource was controlled by the ruling elite and the preliminary health conditions were critically poor. El Anshasy and Katsaiti (2015) examined the effect of the natural resource on life expectancy by taking the 118 nations panel dataset for the time frame of 1990 to 2008. The study found no compelling indications in support of the negative influence of resources on life expectancy. Moreover, the study by Stretesky et al. (2017) found an inverse relationship between NRD and life expectancy across countries through the death effect by utilizing the data of 173 countries during 2000-2012. Also, Madreimov and Li (2019) indicate a negative relationship in the link between NRD and longevity by utilizing the data from 1990 to 2011 and employing the fixed effect and PCSE techniques. The paper's empirical outcome reveals the inverted U-shaped liaison between NRD and life expectancy.

Another study by Aljarallah (2020) considered the Gulf economic effects of NRD by taking the total factor productivity and GDP per capita as explained variables. The paper utilized the ARDL and ECM by taking the annual datasets

for the period 1984 to 2014. The NRD indicates the positive impacts for total factor productivity in UAE and Saudi Arabia and negative for Kuwait. Lyatuu, Loss, Farnham, Winkler, and Fink (2021) probed the effect of natural resource rents on the life expectancy through the panel data cross country analysis. The time frame of study from 1970 to 2015 and used the 2-stage least square estimation approach. The empirical outcome reveals the promoting effect of natural resource rents for the life expectancy. Oduyemi, Owoeye, and Adekoya (2021) examined the paradox of resource curse and health (mortality rates, death rates, life expectancy) in African economies by applying the threshold model. The results indicate the adverse influence of resource rents on the health outcome. Rahman, Rana, and Khanam (2022) explored the deriving factors of life expectancy in 31 polluted economies. The research utilized the annual datasets during 2000 to 2017. The empirical exploration on the basis of the Preston curve model and PCSE and FGLS techniques are employed. The outcome confirms the Preston curve, indicating the positive liaison between life expectancy and economic growth and environmental degradation reveals a thread for life expectancy. However, improved sanitation, clean water, and health spending are positively related to life expectancy. Ha and Nam (2022) investigated the association between life expectancy and world economic sanctions for the 148 sanctioned economies for a sample period of 1995 to 2018 by utilizing the fixed effect approach. The outcome indicates the negative impact of world economic sanctions on life expectancy. Furthermore, they explored that do institutional and financial system matter and found that critically influence the association between world economic sanctions and life expectancy.

Similarly, Rahman and Alam (2022) empirical review the crucial role of economic growth, urbanization, good governance, renewable energy, and environmental pollution on life expectancy in Anzus-Benelux economies utilizing the yearly 1996 to 2019 dataset by applying the DKSE and FGLS approaches. The study reveals the positive influence of all the variables except environmental degradation for life expectancy. Mahalik, Le, Le, and Mallick (2022) examined the environmental pollution (proxied by CO_2 emissions consumption and production) effect on health (proxied by life expectancy) in 68 middle and lower income group during 1990 to 2017. The research shows the negative liaison of CO_2 emissions and life expectancy, meaning the CO_2 emissions causes to reduce life expectancy.

Specifically, in countries of rich resources, the focus on PEI originates from the intimation that natural resources could be beneficial to improving life expectancy if the revenue of natural resource sectors is used in PEI. In less developed resource-rich economies, there is a persistent need to enlarge the public investment in visible and invisible assets that come under the public goods, particularly education (Collier, Van Der Ploeg, Spence, & Venables, 2010). Moreover, various studies established encouraging evidence regarding the effectiveness of government investment on education that results in the improvement of schooling as well as health status (Baldacci, Guin-Siu, & Mello, 2003; Conti, Heckman, & Urzua, 2010; Gupta, Verhoeven, & Tiongson, 2002).

Life expectancy is deliberated as the most widely used helpful index to gauge the country's healthcare development (Zarulli, Sopina, Toffolutti, & Lenart, 2021). Thus, it has been fused slowly but surely into the evaluation system of government enactment. Life expectancy had improved progressively in many nations in the past including China, which has made super progress in life expectancy from 60.9-78.3 years during 1970-2022 (Xinhua, 2022). Since the establishment of the Republic of China (1949), it has remarkably improved people's health. Life expectancy in China has dramatically increased, because of the reduction of death probability favored by the technology and medical advancement, changes in dietary behavior and way of life, improvement of everyday environments and schooling, decrease in infant mortality rates, and the increase in facilities of health services (Martín Cervantes, Rueda López, & Cruz Rambaud, 2020).

Our study finds that the impact of NRD is statistically significant and negative on life expectancy as long as PEI leads to an increase in life expectancy in China and across gender. Moreover, the interactive effect of NRD*PEI supports the phenomena of resource blessing; if the revenue of the natural resource sector is invested in education, it contributes to improved longevity. Our baseline results are robust after the inclusion of several control variables such as urbanization, economic growth, environmental degradation, and health and do not alter the sign of our main findings. Our findings are in line with Madreimov and Li (2019); Stretesky et al. (2017) for NRD (i.e. negative relation) and Bulled and Sosis (2010); Steingrímsdóttir et al. (2012) for PEI (i.e. positive relation) and contrast the studies of Sanginabadi (2017) and Kabir (2008), respectively.

This study contributes to the ongoing research threefold: First, our study investigates the impact of NRD and PEI on life expectancy in China using a more disaggregated (i.e. province-level Chinese census data) dataset over the sample periods of 2001-2011. Second, we examine the role of NRD and PEI on life expectancy across gender (i.e. female & male). Third, we are adding to the literature by investigating whether NRD is a curse or blessing by investigating the combined effect of NRD and PEI (the interactive variable i.e. NRD*PEI) on life expectancy.

The ongoing research is settled as: the theoretical framework is described in subsequent section two. Data sources and methodology are in section three. The result is presented in section four and then, section five closes the study.

2. Theoretical Framework

Our study follows the Grossman (1972) health production function, on the association between health inputs and output of individual health. According to Grossman (1972), the health production function depends on individual behavior, health facilities, and constraints. The model of health production function is as follows:

$$H = f(HI) \quad (1)$$

In a health production function, H indicates the output of individual health and HI indicates the inputs necessary for the health of the individual. The inputs of health are the factors that significantly contribute to the health status of the population. This health production function is at the micro-level. Our study uses the macro-level health production function. The health production function converted the micro to macro level by expressing health inputs in per capita form. The inputs of health are broadly designed into three types of factors namely: economic, social, and environmental factors (Fayissa* & Gutema, 2005).

$$H = f(Y, S, E) \quad (2)$$

In equation 2, Y, S, and E indicate the economic, social, and environmental indicators of health respectively. These vectors include diverse variables but due to research and data limitations, empirical studies have utilized the different indicators. The vector for economic factors comprises NRD, economic growth, and health. The vector for social factors comprises urbanization and PEI and the last vector for environmental factors comprises CO_2 (carbon dioxide) emission. This study empirically investigates the health status, measured by life expectancy, primarily focused on the relation between life expectancy, NRD, and PEI. To evaluate the robustness of this association, some other control variables are introduced such as urbanization, economic growth, environmental degradation, and health in the empirical model.

2.1 Theoretical Channels

Theoretically, natural resources are considered to provide valuable revenue that may improve the health of the population. For example, the consumption of natural resources enhances economic growth (Solarin & Shahbaz, 2015), which in turn, improves life expectancy (Lin, Chen, Chien, & Chan, 2012; Shaw, Horrace, & Vogel, 2005). Contrary to this, another research contends that greater dependence on natural resources impedes economic growth and thus may have negatively impacted life expectancy in nations that are more reliant on a natural resources as well as low levels of modification in revenues of government (Mavrotas, Murshed, & Torres, 2011). Moreover, the endowments of natural resources in a country increase government revenue that could be spent to enhance the development of public health by investing the revenue in the health sector which in turn, leads to the improvement in life expectancy (El Anshasy & Katsaiti, 2015). On the other hand, NRD possibly affects longevity drives through public spending on education. If the revenue from the natural resource is spent on human capital such as education, it would work as a fuel to improve longevity. Additionally, education offers socio-psychological resources that participate in health outcomes as well as improve life expectancy through instrumental support (House, Landis, & Umberson, 1988). To promote life expectancy NRD, PEI, economic growth, health, environmental degradation and urbanization also play a crucial role such as:

I. The revenue from the natural resource sectors ⟶ allows the government to increase the spending on healthcare, ⟶ which could transform into greater economic growth ⟶ and improved life expectancy (Cotet & Tsui, 2013). Additionally, it has been noted that economies that achieved economic growth from NRD do not seem to have converted this revenue into upgraded health and do not promote life expectancy (Cockx & Francken, 2014).

II. Education develops basic cognitive skills ⟶ provide better jobs rising ⟶ income allows for the better nutritious food, housing, medical care ⟶ promotes healthy lifestyles ⟶ avoid risky factors related to health, and engaging to improving health behaviors ⟶ increased life expectancy (Mirowsky & Ross, 2003).

III. The development in the health sector ⟶ improves the availability of medical advanced healthcare services ⟶ as well accessibility and affordability of better nutrition, housing, and sanitation, which enhance the chances to more longevity (Filmer & Pritchett, 1999).

IV. Environmental quality can affect the population health ⟶ as the extreme climate changes ⟶ are likely to increase the risk of water-borne viruses as a result of increasing water temperature and flooding the higher temperature increases ground-level pollution, including airway inflammation, breathing problems, and also reduces resistance to infections ⟶ that will result in more mortality instead to longevity (Comrie, 2007).

V. Urbanization ⟶ leads to great social and economic ⟶ progress and related to a series of human welfare outcomes, its influence on population health ⟶ urban residents may benefit from improved sanitation, infrastructure, and access to health services and will result in an improvement in life expectancy (Qing, 2018).

VI. The enhancement of economic growth will increase the GDP PC ⟶ when individual income increase, it increases the purchasing ability of the individuals ⟶ people start to improve their living style with better diet, education, housing, and health facilities ⟶ this will lead to better health outcomes (Fayissa* & Gutema, 2005; Majeed & Gillani, 2017). To sum up, education is deliberated as a fundamental determinant that promotes life expectancy if the revenue from natural resources is spent on education. Also, economic growth, health, environmental degradation, and urbanization play a mixed role in promoting life expectancy. However, empirics can guide us about this ambiguity.

3. Data and Methodology

3.1 Life Expectancy (LE)

Total life expectancy at birth (years) is the explained variable of this study over the sample period of 2001-2011.[4] We use a panel dataset that includes 31 administrative provinces of China. We choose China as a sample for study because China is a fast-growing economy and fast improving the life expectancy rate in the world, therefore it is interesting to gauge the current situation of life expectancy. Moreover, our study uses the provincial data to capture a clear picture of life expectancy because heterogeneity exists across Chinese provinces (Dou, Ul-Haq, Visas, Aslam, & Khanum, 2022; Shi, Visas, Ul-Haq, Abbas, & Khanum, 2022). A comprehensive empirical study on the factors that promote life expectancy is still a necessity (Rahman & Alam, 2022). Life expectancy data are from the 2000 and 2010 censuses of China's National Bureau of Statistics (CNBS). Life expectancy is the most essential index used to measure population health status (Egidi & Spizzichino, 2012; Wang et al., 2015). It is one of the three major indicators indicating the individual's health, economic and social status as well as quality of life (Zarulli et al., 2021).

3.2 Natural Resource Dependence (NRD)

Natural resource dependence is the main explanatory variable computed as the ratio of the mining industry's employees to the labor force of the whole province. Data on natural resource dependence is taken from the study of Sun et al. (2019). Many other studies utilized the share of resource exports in GDP to measure natural resource dependence but it's not free from several shortcomings (Cockx & Francken, 2014). The study of Madreimov and Li (2019) used the Extractives Dependence Index (EDI) for natural resources dependence (NRD) as established by Hailu and Kipgen (2017).

3.3 Public Education Investment (PEI)

The share of public expenditure in education to GDP (PEI) is the second explanatory variable of our study as it plays a major role just like natural resource dependence on life expectancy. Generally speaking, education plays an even more significant role in enhancing life expectancy as compared to wealth. As suggested by the mother's detailed survey, a child with more education has more chances to survive than a child with more wealth (Mackenzie, 2018). Thus,

[4] Data on life expectancy are collected from the census of 2000 and 2010. The life expectancy data from the census are more reliable (Bezy, 2020; Huang, Yang, & Liu, 2020) as it provides comprehensive detail about life expectancy as compared to time series data and they interpolate the data that does not give clear indications about life expectancy. Therefore, our study selects this sample period to predict the clear scenario of life expectancy.

education spending is the basic key determinant of life expectancy. The data on public education investment is collected from the CNBS .

3.4 Control Variables

We additionally incorporate a cluster of control variables that are viewed as indicators of life expectancy and that may help as likely mediators through which natural-resource reliance impacts life expectancy. For robustness checks of our findings, we include urbanization ratio (a proxy of urbanization), GDP per capita (a proxy of economic growth), log of CO_2 emission (a proxy of environmental degradation)[5], and log of the number of health personnel (a proxy of health). Furthermore, the selection of these variables is in line with existing research (Madreimov & Li, 2019). Data on these control variables are from (CNBS) as shown in the variables' definition table below.

Table 1: Variables Definition

Variable	Symbol	Definition	Data sources
Life Expectancy	LE	The average life span of a particular population of the same age in the future on the basis of specific mortality levels.	CNBS
Natural Resource Dependence	NRD	The ratio of the mining industry's employees to the labor force of the whole province.	Sun et al. (2019)
Public Education Investment	PEI	Refers to the share of public expenditure in education to GDP and is perceived as the best proxy of PEI.	CNBS
Urbanization Ratio	Urbanization	The ratio of the urban population to the total population.	CNBS
Economic Growth	GDPPC	Gross domestic product of a country divided by its population and is seen as a more reliable proxy for gauging the economic growth of a country.	CNBS
Environmental Degradation	CO_2 Emission	We measured the environmental degradation by using the proxy of log of CO_2 (carbon dioxide) emission (10000 tons).	CNBS
Health	Health	We calculated the variable of health by taking the log of the number of health personnel (10,000 people).	CNBS

[5] Our study used the 2004 data on environmental degradation for the year 2000 as the data is not available for this year.

The descriptive statistics are based on 31 provinces of China comprising 62 observations. The descriptive statistics for the overall case of China and both female and male, NRD, PEI, GDP per capita, urbanization, health, and CO_2 emission are provided in table 2. Our descriptive shows the average life expectancy of 73 years approximately in China and higher for females than males as practicing in China (Hao, 1995).

Table 2: Descriptive Statistics

Variables	N	Mean	Std. Dev.	Min	Max
Overall	62	73.075	3.4826	64.37	80.26
Female	62	75.311	3.8056	66.15	82.44
Male	62	71.067	3.2590	62.52	78.28
NRD	62	0.0329	0.0281	0.00011	0.1408
PEI	62	0.0287	0.0174	0.0129	0.1198
Urbanization	62	0.4501	0.1617	0.1860	0.8928
GDPPC	62	20971.45	17927.23	2661.56	76074
CO_2 emission	62	12.6466	0.8983	9.5324	13.8095
Health	62		0.8574	9.3056	
		12.04288			13.3784

Source: Author's calculation.

3.5 Empirical Framework

To empirically examine the impact of natural resource dependence and public education investment on life expectancy in China, we evaluate the following empirical model by using the fixed effect regression as suggested by the Hausman test:

$$LE_{jt} = \beta_0 + \beta_1 NRD_{jt} + \beta_2 PEI_{jt} + \beta_3 NRD^{*} PEI_{jt} + \beta_4 X_{jt}\gamma + \varepsilon_{jt} \quad (3)$$

where LE is the life expectancy in province j at time t. NRD is the natural resource dependence that represents the core explanatory variable of our study. Natural resources of any economy play an imperative role in affecting the health status of its population. PEI is public education investment considered as the other explanatory variable in our model. We use the share of education expenditure to GDP as a proxy for public education investment (PEI). Thus, we introduce an interactive term of the PEI*NRD as an explanatory variable to check their combined effect on life expectancy and expect that the interactive term will positively impact life expectancy. Generally, it is anticipated that if the revenue from natural resources is invested in education, it will result in the improvement of life expectancy. Vector X indicates the set of control variables in our empirical model. ε is the noised and fulfills the normality assumptions. Furthermore, the life expectancy factors have different impacts across gender, which need to be addressed separately. To check these impacts across gender (i.e. female, male), by following the study of Madreimov and Li (2019) the models are:

$$FLE_{jt} = \beta_0 + \beta_1 NRD_{jt} + \beta_2 PEI_{jt} + \beta_3 NRD^{*} PEI_{jt} + \beta_4 X_{jt}\gamma + \varepsilon_{jt} \quad (4)$$

$$MLE_{jt} = \beta_0 + \beta_1 NRD_{jt} + \beta_2 PEI_{jt} + \beta_3 NRD^{*} PEI_{jt} + \beta_4 X_{jt}\gamma + \varepsilon_{jt} \quad (5)$$

where equations (4,5) represent the female and male model, in which FLE indicates female life expectancy and MLE reveals male life expectancy. Like many other factors that affect life expectancy, we introduce control variables in our main and across-gender models for robustness checks. First, we introduce the urbanization ratio as a control in our empirical model to test these impacts on life expectancy as urbanization in developing nations is directly related to the quality of life (Eckert & Kohler, 2014). Furthermore, in the United States, Singh and Siahpush (2014) determined that the difference between urban and rural life expectancy exceeds three years. Next, we include GDP per capita to measure the economic growth impacts on life expectancy. GDP per capita is positively related to life expectancy in existing research (Lin et al., 2012).

Then, we introduce environmental degradation in the model. It is calculated by taking the log of CO_2 (carbon dioxide) emission (10000 tons). The destruction of the environment reduces the chances of improvement in life expectancy. Feachem (1994) _ENREF_43 pointed out that environmental disadvantage creates a detrimental effect on longevity among the post-socialist countries' residents. Moreover, Gulis (2000) conducted a study on 156 nations and reported that a pure environment significantly contributes to enhancing life expectancy. Northern China residents have a five-year shorter life expectancy due to its status of air pollution compared to southern China residents (Chen, Ebenstein, Greenstone, & Li, 2013). Environmental development plays a crucial role in promoting life expectancy (Batool et al., 2019) and the benefits from environmental investment have been improving in China over the years but still need further development (Feng & Sun, 2020). Finally, we include health to measure this, using the log of the number of health personnel (10,000 people) as it is associated with longevity in prevailing research (van den Heuvel & Olaroiu, 2017). The health variable is positively related to longevity as improvement in health enhances life expectancy.

4. Results and Discussion

4.1 Hausman Test Results

We ran the Hausman test to select a fixed effect (FE) or random effect (RE). The null for this test is equal to RE and the alternate is equal to FE. However, the Hausman test further suggested the fixed-effects model. If the probability value is lower than 0.05 we reject the null for the random-effects model and suggest a fixed effect model. We also apply the diagnostics test as shown in Table 4.

Table 3: Hausman Test

Test	Overall	Female	Male
Hausman test	32.85	31.07	34.82
Prob. value	0.0000	0.0000	0.0000

Table 4: Diagnostics test

Variable	Overall	Female	Male
Modified Wald Test	3.3e+29 0.0000	3.5e+28 0.0000	6.2e+28 0.0000
VIF			
NRD*EDI	6.46	6.46	6.46
NRD	6.38	6.38	6.38
URB	3.62	3.62	3.62
GDP_PC	3.52	3.52	3.52
EDUEXPGDP	2.15	2.15	2.15

Note: We use the option "robust: for the issue of heteroscedasticity. For interdependence, we check the multicollinearity for all three models and the score of VIF under a limit or less than 7.

Life expectancy is pondered to be one of the best-used measures to gauge the quality of life (Egidi & Spizzichino, 2012). The empirical results are presented in Table 5. First, we investigate the relationship between NRD and life expectancy in China. As shown in column (1), we find a negative association between NRD and life expectancy and the result is statistically significant at 1%. NRD alone does not improve life expectancy. In existing studies, the study of Madreimov and Li (2019) also found a negative relationship in the link between NRD and longevity. In column 2 of Table 5, we added PEI which shows a positive impact on life expectancy and is also statistically significant at the 1% level. PEI leads to an increase in life expectancy in China. Existing literature also found a positive relationship between life expectancy and education (Khan & Majeed, 2018; Rogot, Sorlie, & Johnson, 1992; Silles, 2009).

In column (3) we check the combined effect of NRD and PEI by introducing the interactive term NRD*PEI, to check whether natural resources combined with PEI play a role in promoting life expectancy. Column (3) (the combined effect of NRD*PEI) shows a positive effect on life expectancy. The findings revealed that NRD does not have any influential effect on improving life expectancy without PEI. However, the combination of PEI and NRD has a strong positive effect on life expectancy.

For robustness checks of our baseline findings whether our results are robust in the overall case of china, we introduce some major factors that affect life expectancy as control variables. In column 4 of Table 5, we add the urbanization ratio which displays a positive relationship with life expectancy. Urbanization leads to the improvement of life expectancy (Qing, 2018).

Table 5: Life Expectancy and NRD in China

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NRD	-121.0***	-56.08***	-93.27***	-38.15***	-34.20***	-31.52***	-31.64***
	(27.56)	(19.55)	(28.97)	(11.07)	(8.320)	(7.809)	(7.991)
PEI		139.7***	100.6***	62.82***	63.26***	81.94***	77.00***
		(32.33)	(29.00)	(10.75)	(12.44)	(11.80)	(13.86)
NRD*PEI			1,881***	696.2**	833.7***	665.0**	680.5**
			(663.4)	(262.1)	(290.6)	(268.2)	(276.9)
Urbanization				16.59***	9.011***	8.479***	7.354**
				(2.186)	(3.082)	(3.004)	(3.509)
GDPPC					4.03e-05***	3.41e-05***	3.35e-05***
					(1.12e-05)	(1.13e-05)	(1.08e-05)
CO_2 emission						-1.619***	-1.477***
						(0.458)	(0.496)
Health							0.638
							(0.911)
Constant	77.06***	70.91***	71.56***	64.43***	66.73***	87.11***	78.27***
	(0.908)	(1.416)	(1.176)	(0.976)	(1.041)	(5.433)	(13.32)
F-Statistic	19.28	33.23	62.88	150.34	145.75	177.29	148.01

Note: LE is regressand for model. Standard errors (S.E) in parentheses. N is 62 and the prob. value is less than 0.05. *** p<0.01, ** p<0.05, * p<0.1 reveal significance.

The study of Kim and Kim (2016) also established a positive relationship between life expectancy and socioeconomic factors including urbanization at the country level. In column (5) we incorporate GDP per capita to assess the impact of economic growth on life expectancy and found a direct association between GDP per capita and life expectancy. For instance, Asiedu, Gaekwad, Nanivazo, Nkusu, and Jin (2015) used an overlapping generations model to evaluate the association between health status and economic development in Sub-Saharan

Africa and found a positive effect of GDP per capita on numerous health indicators, including life expectancy. In column (6) we find that CO_2 emission reduces the life expectancy in China. The increase in environmental degradation leads to a decrease in longevity (negative relation) and the result is statistically significant. The health variable included in column (7) indicates that it contributes to the promotion of life expectancy. Moreover, the transnational study of van den Heuvel and Olaroiu (2017) contented that healthcare spending slightly promotes life expectancy in Europe. The findings of our study are robust after adding these several controls.

Table 6: Life Expectancy and NRD in China (Female Case)

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
NRD	-145.5***	-68.09**	-113.6***	-48.37***	-45.99***	-41.55***	-41.72***
	(34.66)	(24.94)	(38.54)	(12.64)	(12.37)	(11.92)	(12.10)
PEI		-166.5***	-118.7***	-74.01***	-74.28***	-105.2***	-97.88***
		(41.98)	(40.17)	(19.23)	(20.52)	(17.57)	(19.02)
NRD*PEI			-2,299**	-898.3**	-981.3**	-701.6*	-724.7*
			(908.8)	(402.0)	(441.8)	(396.7)	(404.7)
Urbanization				-19.61***	-15.04***	-14.16***	-12.48**
				(2.939)	(4.779)	(4.604)	(5.260)
GDPPC					2.43e-05	1.40e-05	1.31e-05
					(1.64e-05)	(1.63e-05)	(1.56e-05)
CO_2 emission						-2.685***	-2.473***
						(0.623)	(0.633)
Health							0.952
							(1.191)
Constant	80.11***	72.77***	73.57***	65.14***	66.53***	100.3***	87.14***
	(1.143)	(1.813)	(1.576)	(1.158)	(1.590)	(7.170)	(16.43)
F-Statistic	17.61	27.09	51.52	112.34	99.42	129.10	109.46

Note: LE is regressand for model. S.E in parentheses. N is 62 and the prob. value is less than 0.05. *** p<0.01, ** p<0.05, * p<0.1 reveal significance.

Life expectancy also differs across gender. Therefore, to separately examine the association between NRD, PEI, and life expectancy across gender we re-estimate equation (3) for both females and males respectively by following the study of Madreimov and Li (2019). Generally, females' life expectancy level is higher as compared to males in China. Table 6 describes the results for the

female case. Column (1) for female shows the negative impacts of NRD on female life expectancy at the 1% significance level.

Here, we equally find an inverse correlation between NRD and female life expectancy in column (1) and a direct association between PEI and female life expectancy in column (2). In column (3) with the interactive term NRD*PEI, we find that the combined effect of NRD and PEI on female life expectancy is positive and significant. For robustness checks, we include urbanization, GDP per capita, CO_2 emission, and the health variable. Also, our findings are robust after including these control variables in the case of females. The inclusion of these controls does not alter the signs and significance of our core variables on female life expectancy as shown in Table 6.

Table 7: Life Expectancy and NRD in China (Male Case)

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
NRD	-100.8***	45.47**	74.76***	-27.18**	-21.88***	-20.51***	-20.61***
	(22.33)	(15.55)	(21.46)	(11.84)	(5.758)	(5.299)	(5.545)
PEI		119.1***	88.28***	55.68***	56.27***	65.82***	61.57***
		(24.40)	(20.63)	(5.594)	(6.554)	(8.343)	(11.28)
NRD*PEI			1,481***	458.4**	642.8***	556.6***	569.9***
			(479.0)	(221.5)	(176.4)	(177.4)	(188.4)
Urbanization				14.32***	4.155**	3.883*	2.915
				(2.015)	(1.995)	(2.005)	(2.398)
GDPPC					5.41e-05***	5.09e-05***	5.04e-05***
					(8.40e-06)	(8.55e-06)	(8.13e-06)
CO_2 emission						-0.828*	-0.706
						(0.406)	(0.473)
Health							0.549
							(0.770)
Constant	74.39***	69.14***	69.66***	63.51***	66.59***	77.01***	69.40***
	(0.736)	(1.095)	(0.869)	(1.013)	(0.685)	(5.023)	(12.44)
F-Statistic	20.38	40.55	71.85	187.17	229.86	282.12	222.92

Note: LE is regressand for model. S.E in parentheses. N is 62 and the prob. value is less than 0.05. *** p<0.01, ** p<0.05, * p<0.1 reveal significance.

Table 7 shows the results for the case of males' life expectancy; column (1) shows that there is a negative relationship between NRD and life expectancy. Column (2) with PEI and column (3) with the interactive term (NRD*PEI) show

a positive and significant relationship between these variables and male life expectancy. PEI, as well as the interactive term, plays a vital role in promoting life expectancy. Arendt (2005) explored the causal relationship between health and education and found that education is related to better health outcomes for both males and females. This finding revealed that individuals with more education have better health even when job characteristics, income, and family background are controlled (Cutler & Lleras-Muney, 2006). We find the same empirical evidence about the association between NRD, PEI, and NRD*PEI with life expectancy.

Columns (4-7) for robustness checks show that urbanization, GDP per capita, and health are positively correlated to life expectancy while CO_2 emission is not. With these positively related variables, we found that these are powerfully impacting life expectancy by enhancing the average age of a person in the case of males. We find a negative association between CO_2 emission and life expectancy. Also in existing research, life expectancy is decreased by air pollution by more than a year (Apte, Brauer, Cohen, Ezzati, & Pope, 2018). Bayati, Akbarian, and Kavosi (2013) found an insignificant relation between CO_2 emission and life expectancy in the Eastern Mediterranean nations.

To sum up, we discover a significant link between NRD and public education spending that has an expressive effect on life expectancy. NRD decreases life expectancy while PEI increases life expectancy in China and across gender. The findings of this study are in line with the work of Madreimov and Li (2019) that found a negative relation between NRD and life expectancy and contrast with the study of Sanginabadi (2017). We can say that NRD alone does not have an imposing effect on life expectancy but the combination of other variables such as PEI (interactive effect i.e. NRD*PEI), helps to improve longevity. Our findings are in line with those of Bulled and Sosis (2010); Steingrímsdóttir et al. (2012) and contrast those of Kabir (2008). The research on this association argued that education development and healthcare in developing economies are more important as they could gain by directly benefitting from the use of advanced medicated technologies from more developed economies to improve the population's health.

4. Conclusion and Policy Recommendations

Interestingly, with the rising trend of life expectancy in China, we investigated the impacts of NRD and PEI on life expectancy to ascertain whether NRD and PEI contribute to increasing life expectancy. Unfortunately, we find that NRD negatively impacts life expectancy while PEI positively impacts life expectancy in China. NRD does not help in promoting life expectancy. However, the combined effect of PEI*NRD significantly improved life expectancy as shown in our findings. Moreover, we again observed similar impacts of NRD on life expectancy across gender and that PEI leads to an improvement in life expectancy. However, after a set of robustness control, we evaluate a one-by-one liaison among life expectancy urbanization, per capita GDP, and health in all

models and find that they contribute to the enhancement of life expectancy whereas CO_2 emission negatively affected life expectancy. The findings of our study are robust after including the controls.

Although natural resources lead the countries towards more economic development, the results of our study insinuate that the government should invest more of the revenue of natural resource sectors in education to obtain the real benefits from NRD as a key determinant in improving life expectancy.

Acknowledgment

We would like to thank Huaping Sun, Farwa Wajid, and seminar participants at the Department of Economics, University of Sargodha for their helpful comments and suggestions.

Disclosure statement

The authors declare that they have no conflict of interest.

Funding

This research is not supported by any research agency or institution.

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