International Journal of Management and Sustainability
2019 Vol. 8, No. 1, pp. 20-31
ISSN(e): 2306-0662
ISSN(p): 2306-9856
DOI: 10.18488/journal.11.2019.81.20.31

A COMPARISON OF IMPACTS OF CLIMATE CHANGE ON URBAN POVERTY AND RURAL POVERTY IN THE NORTH-WEST CHINA

Xiaoxue Zhou[1]
Jiancheng Chen[2+]

[1,2]*School of Economic & Management, Beijing Forestry University, Beijing 100083, China*
[1]*Email: zhouxx_simlab@163.com Tel: +861068798651*
[2]*Email: chenjc_bjfu@hotmail.com Tel: +861062337236*

(+ Corresponding author)

Article History
Received: 10 October 2018
Revised: 26 November 2018
Accepted: 31 December 2018
Published: 22 March 2019

Keywords
Climate change
Carbon emissions
Ecological environment
Poverty alleviation.
Regional differences
Rural poverty
Urban poor.

ABSTRACT

This paper explores the contrast between urban poverty and rural poverty under climate change in north-west China based on association theory. In order to effectively evaluate the different impacts of climate change on rural and urban poverty, this paper establishes a dynamic GMM regression model of climate change, uses the north-west region panel data to clarify the relationship of ecological environment, carbon emissions and poverty alleviation in north-west China. The empirical test results show there exists an inverted U-shaped curve relationship between carbon emissions and the rural poor income, but there is no significant correlation between carbon emissions and that of the urban poor. There is an obvious intertemporal transmission of poverty, and that of rural poverty is more obvious than urban poverty. Economic growth is still the most important power source of poverty reduction in urban and rural areas in north-west China, however, the number of years of education had no obvious influences on the income of urban and rural poor population.

Contribution/Originality: This study is one of very few studies which have investigated the contrast between urban poverty and rural poverty under climate change in north-west China through empirical analysis, and analyzes whether the region has obtained a broader poverty alleviation through the consumption of natural resources.

1. INTRODUCTION

Climate change is one of the most pressing global environmental issues (Liu and Deng, 2011). The north-west provinces in China have encountered the dual challenge of ecological production and poverty alleviation (Glomsrød *et al.*, 2016). The deterioration of the ecological environment that Carbon emissions as the characterization and poverty alleviation happened at the same time in 2001-2014 (Zanin and Marra, 2012; Zhang *et al.*, 2015). The rural poverty slowed down, while the annual growth rate of GDP per million yuan (RMB) of carbon emissions is 8.58%, the average annual growth rate of per capita carbon emissions is 13.2% (Wossen and Berger, 2015). It shows that the region has the possibility of short-term poverty reduction at the cost of ecological destruction (Wang *et al.*, 2017). In order to better set the target of policy choice, it is necessary to determine the relationship between poverty and ecological environment (Turpie *et al.*, 2008; Suich *et al.*, 2015). Poverty, degradation of ecological environment and the relationship between them have occupied the mainstream research since the 1980s, however, there are different views on the relationship between poverty and ecological environment (Fisher *et al.*, 2013; Diswandi, 2017).

Throughout the study of the relationship between poverty and ecological environment, there are two relatively clear theoretical origins and research context, One is the pessimism of the argument, mainly affected by the "poverty trap" (Njuguna and McSharry, 2017) and "Environmental Kuznets Curve" (Apergis and Ozturk, 2015); the other is the view of relative optimism, it is emphasized that the progress of technical means that is necessary and possible to coordinate poverty alleviation and ecological environment protection (Sandhu and Sandhu, 2014; Suich *et al*., 2015). Poverty is a result of the degradation of the ecological environment or the poor are the victims of ecological degradation and the view has aroused many scholars' resonance (Pinho *et al*., 2014; Chen *et al*., 2015). Poor families are more dependent on natural resources and environment relative to the rich families (Howe *et al*., 2013). Obviously, the resource environment as an important livelihood capital, its degradation will lead to the occurrence of poverty or intensify the degree of poverty (Njuguna and McSharry, 2017). The main argument focus on whether poverty leads to the ecological environment degradation, the standpoint of the schools of thought is in widely divergent.

The poverty in north-west China mainly refers to income poverty and consumption poverty, income increase is the main driving force for poverty alleviation, it is along with the path of economic "growth—factor participation—primary allocation—secondary allocation—income increase" to achieve endogenous poverty alleviation (Hanjra *et al*., 2009; Hertel and Lobell, 2014). Because of the economic basement, the particularity of factor endowments and industrial structure of the north-west region, local factor inputs in the low skilled labor and natural resources, industrial structure and low skilled labor heavy industrialization absorbing ability is poor, so the income of the poor population increase will rely more on the consumption of natural resource income overflow, resulting in the poverty of north-west China slow down the area with the consumption of natural resources and the deterioration of the ecological environment (Fisher *et al*., 2014; Zhang *et al*., 2015). Secondly, if the economic growth of the north-west region come up with the path of dependence on natural resources, it will limit the supply of local labor quality. The north-west region is generally in an ecologically fragile area and there is no objective condition for pollution treatment. The north-west region is bound to face the bottom line of environmental destruction in the process of development (Friend and Moench, 2013; Barbier, 2015). Once the environmental problems hit the bottom line, economic transformation will experience a shock, seek sustainable ecological environment is on the target of economic development, no more the industrial structure depends on the consumption of natural resources for economic growth, which leads to the mismatch problem the quality of labor supply and a new mode of economic development (Hanjra *et al*., 2009; Howe *et al*., 2013). The existing income growth model of the poor is not sustainable and the ability to resist the ecological risk become lesser force. Therefore, the poor people in the north-west region will increase the depth of poverty under the dual role of labor supply and demand mismatch and the ecological environment risk, which will result in the deterioration of ecological quality and the increase of poverty (Fisher *et al*., 2013). These two mechanisms have potential relevance that can be approximated represented by environment-poverty U-shaped curve (Glomsrød *et al*., 2016) if the poor revenue increases through natural resources consumed in the north-west region, then in an U-shaped curve, the relationship is represented on the left in the U-shaped curve. If the north-west area is facing the second association mechanism, the quality of the ecological environment decreased will exacerbate poverty, thus in a U-shaped curve, it is presented on the right. The relationship between the ecological environment and poverty alleviation in north-west China depends on the current economic growth mode, the supply of labor and the change of ecological environment quality (Hertel and Lobell, 2014).

The less developed north-west region is not a major contributor to greenhouse gas emissions, however, it could be the biggest victims of climate change. The ecological system is relatively weak in underdeveloped areas and the natural environment, social economic support system is relatively sensitive (Chen and Ge, 2015). The fact that climate change may not have a big impact in the developed region but could pose a huge risk in less developed regions (Yang *et al*., 2015). Less developed areas need to pay more attention to the impact of climate change and

more thoroughly to promote and implement climate change response actions (Wan and Zhang, 2013; Ward, 2016). Then, this paper will explore the relationship between the ecological environment and poverty alleviation through empirical analysis of the urban poor and rural poor, analysis whether consumption of natural resources gained a wider range of poverty alleviation and whether the existing mode of economic growth makes the poor arrive the process of initial positive promotion.

2. METHODOLOGY

2.1. Study Area

The geographic location of the study area is shown in Figure 1.

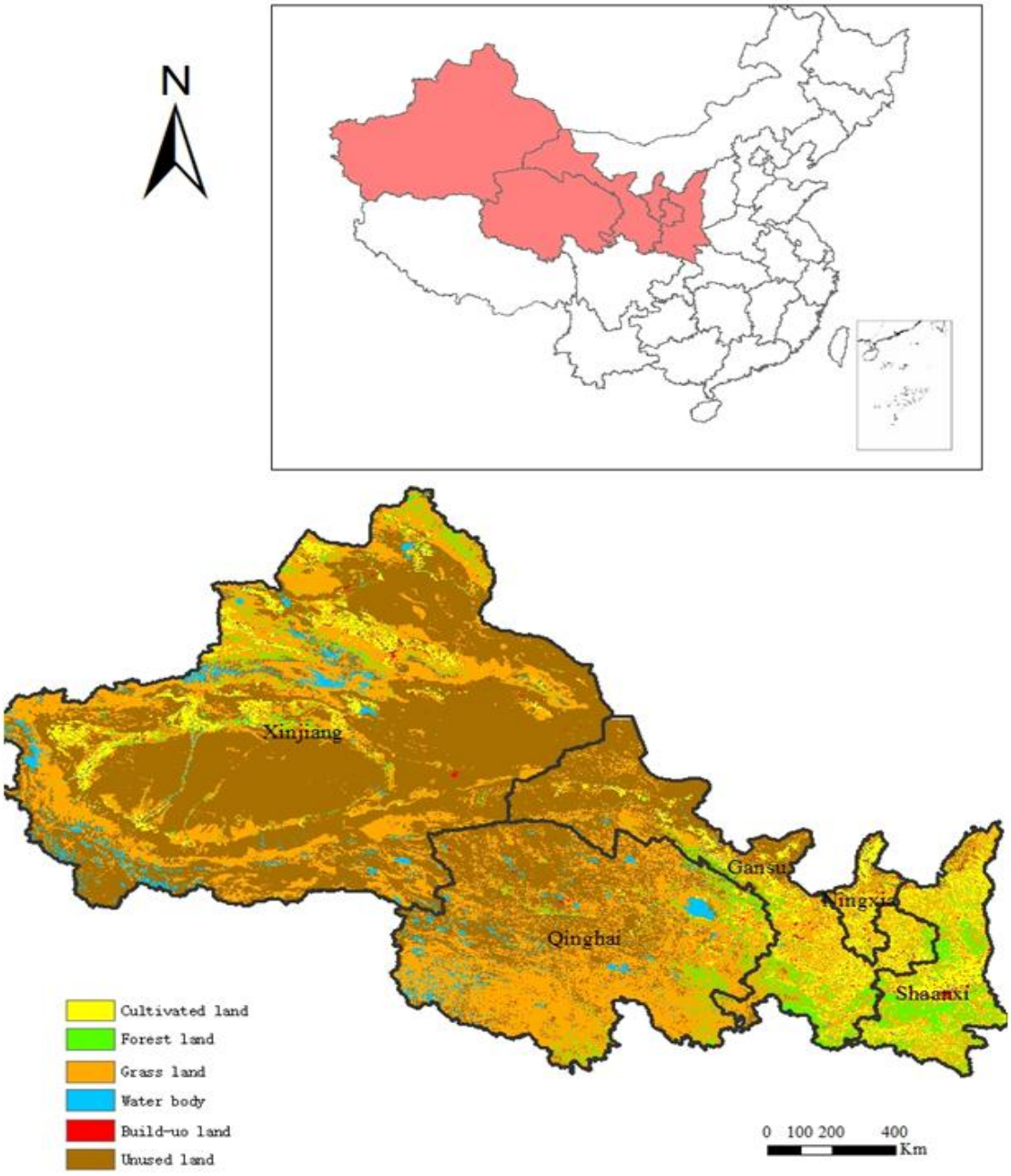

Figure-1. Study area of north-west China.
Source: National Geomatics Center of China: http://www.ngcc.cn/.

The natural and socio-economic characteristics of this study area is shown in Table 1. The north-west region is consist of Xinjiang, Gansu, Qinghai, Ningxia and Shaanxi five provinces with vast land. The region is most in dry

climate and it has scarce water resources and the ecological system is fragile (Ge *et al.*, 2017). How to protect and rebuild the ecological environment in the development of the social economy condition, get sustainable development, it is a great challenge to the north-west. North-west China has unique natural and geographical conditions, abundant energy resources, the variety is complete, both conventional energy, petroleum, natural gas, coal, oil shale, peat, and hydropower, nuclear power, solar, wind, geothermal and biomass resources (Gao *et al.*, 2015). The resources have the characteristics of relatively concentrated distribution, low development cost and great development potential. The north-west region is mainly formed by agriculture and the coordination of heavy industry including coal, petroleum, electric power, metallurgy, machinery, chemical industry, building materials, food, textile and papermaking forest, ten departments, production system through making use of abundant resources in recent years. North-west China has become an important basement for nonferrous metals, petroleum, chemical industry, petroleum machinery manufacturing and building materials. At present, north-west China has initially formed a relatively reasonable institutions, relatively complete categories of industrial systems and built a large number of large backbone enterprises and industrial cities.

Table-1. Natural and socio-economic characteristics of five provinces in North-west China.

Natural and socio-economic characteristics	Shaanxi Province	Gansu Province	Qinghai Province	Ningxia Autonomous Region	Xinjiang Autonomous Region
Average annual precipitation	600	300	380	200	154
Average annual temperature (℃)	7.5	7	2-9	5.3-9.9	2.5-10.5
Non-frost days (d)	140-245	140-280	0-150	90-150	120-240
Total population (million)	37.93	26	5.88	6.88	23.6
Rural population (million)	17.48	14.77	2.92	2.99	12.45
Population density (p/km2)	185	57	7.2	85	13.8
Main crops	Rice, maize	Wheat, millet, corn, barley, potatoes	Wheat, barley, millet, beans, potato	Rice, sorghum, maize, millet	Wheat, corn
Livestock	Cattle, donkey	Yak, cattle, horses, sheep	Sheep, cattle, goats, horses, donkeys	Flocks and herds	Wool sheep, horses, cattle

Source: Thematic Database for Human-earth System: http://www.data.ac.cn/zrzy/G03.asp.

2.2. Data Sources and Variable Descriptions

2.2.1. Poverty

This proxy for poverty is the income of the poor population in the north-west region. The rural poverty is the per capita net income of farmers in poverty stricken counties derived from the data of China's poverty monitoring report. The urban poverty is per capita disposable income of the 20% of the lowest urban population in the provincial statistical yearbook (Zhang *et al.*, 2014; Chen and Ge, 2015).

2.2.2. Ecological Environment

The ecological environment quality can be measured by the three wastes, land desertification, forest coverage and other aspects, however, there is a strong correlation between these different measures. Due to the availability of data and base on the scientificity of indicators, we choose CO_2 emissions as a measure index of ecological environment in north-west area, analyze CO_2 emission changes only caused by the energy consumption for economic activity so that we can avoid the inherent differences in the ecological environment. This paper estimates CO_2 emissions not only produced by the coal, crude oil and natural gas of the three large consumption of primary energy also the process of cement production CO_2 emissions taken into account. The data for the estimation of energy consumption is derived from China energy statistical yearbook and the cement production data is derived from industrial economy statistical yearbook.

CO_2 emissions were calculated through the general method:

$$CO_{2i} = \sum_{i=1}^{i} C_i \times E_i \quad (1)$$

CO_{2i} represents the sum CO_2 emissions of various energy, the unit is of 10^4t; C_i represents the consumption of the energy "i", the unit is 10^4t; E_i represents the coal, oil, gas and electricity CO_2 emission coefficient, the unit is 10^4t/ 10^4 tce (ton-coal equivalent). Various energy conversion standard coal coefficient is shown in Table 2.

Table-2. Carbon emission factor for different types of fuels.

Energy	IPCC factor /(kgC/GJ)	This project's factor/ (t/tce)	Energy	IPCC factor /(kgC/GJ)	This project's factor/ (t/tce)
Raw coal	25.8	0.76	Kerosene	19.6	0.5743
Coke	29.2	0.86	Diesel	20.2	0.5918
Crude oil	20.0	0.59	Fuel oil	21.1	0.6182
Gasoline	18.9	0.55	Natural gas	15.3	0.4483

Source: IPCC. Climate Change 2007

The situation of CO_2 emissions of five provinces from 1990-2014 in north-west region are shown in Figure 2. The total of CO_2 emissions of five provinces in north-west China has shown a trend of growth in addition to a few years (1990~2014).

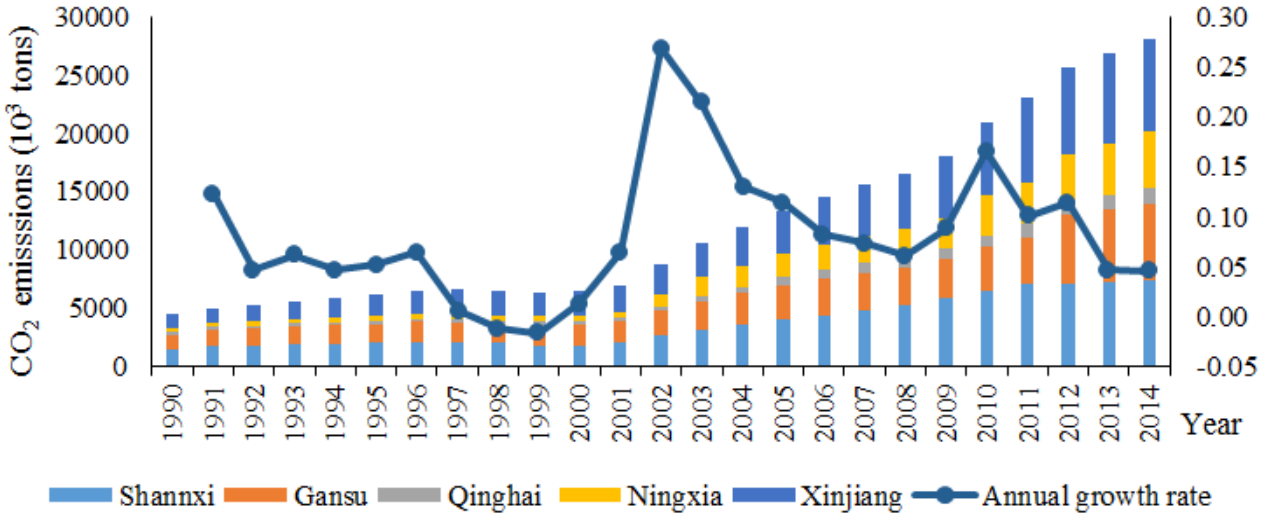

Figure-2. CO_2 emissions of five provinces in north-west China, 1990-2014.

Source: National Bureau of Statistics of China: http://www.stats.gov.cn/tjsj./tjcbw/201806/t20180612_1604117.html

CO2 emissions per billion yuan (RMB) of five provinces in north-west China from 1990-2014 are shown in Figure 3. Gansu had the highest carbon emissions per billion yuan (RMB) in the early twenty and twenty-first Century. Carbon emission intensity showed a downward trend as a whole in north- west.

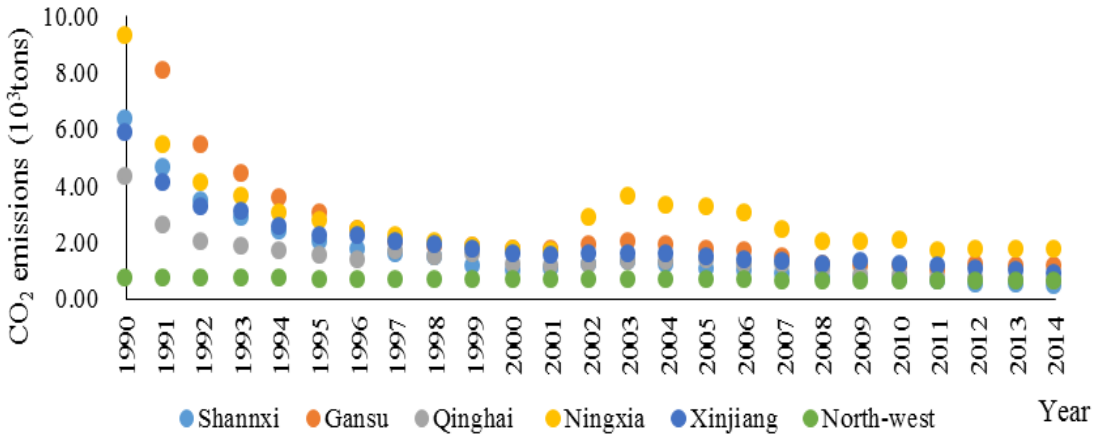

Figure-3. CO_2 emissions per billion yuan of five provinces in north-west China, 1990-2014.
Source: National Bureau of Statistics of China: http://www.stats.gov.cn/tjsj./tjcbw/201806/t20180612_1604117.html.

2.2.3. Years of Education

The length of schooling is one of the most important explanatory variables that use the average number of years of education to measure the amount of Education (Zhang, 2017). The data of years of education in 2001-2014 is derived from the labour force survey data and census data.

2.2.4. Economic Development Level

The economic development level of each province can affect and reflect the change of the income of the poor, so the real per capita GDP of each province as the index is used to measure the level of economic development. Although per capita GDP is an average concept and it is influenced by the structure of income distribution, the existing empirical studies have shown that per capita GDP can have a positive effect on poverty alleviation despite the economic growth elasticity of poverty reduction has decreased .

2.2.5. Infrastructure Construction

Infrastructure is not only an important variable that affects the development of regional economy, but also can affect the economic activities of the poor. It is not a simple relationship between Infrastructure investment and poverty alleviation, it depends on the type of infrastructure and new infrastructure sector (Qi and Wu, 2015; Ren *et al.*, 2017).

Table-3. Descriptive statistics of the variables of north-west China.

Variable	Min	Max	Mean	Std. Dve.	Obs
Poverty index					
The per capita net income of rural residents(yuan RMB): y_1	430	8724	2458.3	1939.2	125
The per capita disposable income of urban poor residents (yuanRMB): y_2	1197	23214	8095.6	5866.9	125
Eco-environmental index					
CO_2 emissions per capita (ton): x_1	0.39	3.46	1.157	0.6864	125
Years of schooling					
The most per capita on education (years): x_2	4.66	9.28	7.11	1.188	125
Index of economic development level					
GDP per capita (yuanRMB): x_3	0 .03	4.69	1.17	1.17	125
Infrastructure metrics					
Mileage per square kilometer (km): x_4	0.82	17.55	5.644	4.815	125

Source: National Bureau of Statistics of China: http://www.stats.gov.cn/tjsj./tjcbw/201806/t20180612_1604117.html.

2.3. Econometric Models

In order to identify the two mechanisms mentioned above in the instruction, this paper constructs the econometric model in the following aspects: Firstly, determine the linear relationship between the ecological environment and poverty alleviation (Chen *et al*., 2015; Cao *et al*., 2016) secondly, test the U-shaped curve may be exist between ecological environment and poverty reduction. According to the relationship between ecological environment and poverty, the linear relationship can be expressed as:

$$\ln y = \theta_0 + \theta_1 \ln x_{1rt} + v_i x_{rit} + u_{rt} \quad (2)$$

$$u_{rt} = \eta_r + \mu_t + \varepsilon_{rt} \quad (3)$$

The subscript r and t respectively represent the provinces (autonomous regions) and the years; y is the variable being explained, the income of the poor used to measure the poverty alleviation of the poor areas. The urban poor and rural poverty can be expressed by y_1 and y_2 respectively; CO_2 is the main explanatory variable of this paper, which reflects the ecological environment of the provinces (autonomous regions); x_{irt} Indicates other control variables, including the level of economic development in each region , years of education (x_2) and Infrastructure (x_3); u_{rt} represents integrated error terms, including regional fixed effects (η_r), time effect (μ_t)and random disturbance term (ε_{rt}).

There are two problems in the process of empirical test based on the existing linear setting: Firstly, there is an inherent relationship between the ecological environment and the level of economic development of the environmental Kuznets curve; secondly, the existing studies also show that there is no mobility and convergence of poverty, that is, poverty is intertemporal correlation. In order to avoid the error of the econometric model such as the mobility and convergence of poverty, the Equation 2 is used to extend the dynamic model. It can also restrict the level of economic development and the endogeneity of ecological environment so that we can obtain the consistency of the main explanatory variables. Based on the discussion above and the method ofwe establish the first order dynamic autoregressive model and the Equation 2 is extended to:

$$\ln pov_{rt} = \theta_0 + \theta_1 \ln pov_{r,t-1} + \theta_2 \ln x_{1rt} + v_i x_{rit} + u_{rt} \quad (4)$$

The ecological environment and poverty alleviation may change as the U-shape in a long term. In order to analyze the possible evolution trend of the existing industrial structure and endowment characteristics, two items of ecological environment are introduced, and the Equation 4 is further extended to:

$$\ln y_{rt} = \theta_0 + \theta_1 \ln y_{r,t-1} + \theta_2 \ln co_{2rt} + \theta_3 (\ln^2 x_{1rt}) \quad v_i x_{rit} + u_{rt} \quad (5)$$

The number $\ln y_{r,t-1}$ represents a second order lag of the explained variable. We will focus on the Equation 4 and Equation 5 in the following empirical test part.

2.4. Empirical Test

In this paper, dynamic panel model is used as the basic model of empirical test. In order to avoid the intertemporal correlation of variables and the estimation error caused by endogeneity, we use the generalized distance method (SYS-GMM) to test the Equation 4 and 5 and then test the robustness of the measurement results.

Firstly, we use the Equation 4 to estimate the linear relationship between CO_2 emissions and the income of the poor in the north-west region, and make a comparative study of urban poverty and rural poverty. The results are shown in the first column of Table 1 and Table 3. The results show that there is a positive correlation between the income of the rural poor and the CO_2 emissions in the north-west region, but the CO_2 emission is negatively correlated with the income of the urban poor. The statistical significance and economic significance of CO_2 emissions in urban and rural poverty model are not significant. The parameter estimation value of the lag term is

positive, which indicates that it is necessary to introduce the lag term of the variable to construct the dynamic panel model.

Secondly, we use model (5) to test the possibility of the changes in U-shape between CO_2 emissions and urban and rural poor population. The results are shown in the second column in Table 2 and Table 3. Then we test the desirability of the model (4) and model (5) compared by goodness-of -fit and parameter estimation efficiency. The results show that the parameters of the main explanatory variables are more efficient after the two term of CO_2 emission. The first order lag of poverty continues to be statistically significant, and reflects the significant economic significance of the positive correlation between the income of the poor population.

Thirdly, in order to test the desirability of the generalized distance method of dynamic panel system, we test the validity of added new tool variables by using sargan test. The results are shown in the last column in Table 2 and Table 4. The original hypothesis of H0 of sargan test is effective for over recognition constraint. The results show that all the dynamic panel models can not reject the original assumptions of the new instrumental variables at the commonly used level.

Finally, we also test the robustness of the Equation 4 and the robustness of the method is as follows: First, do urban and rural distinguish quantitative analysis by the use of OLS estimation Equation 5; secondly, estimate with the method of generalized distance, using total CO_2 emission index as the reference index of per capita carbon emissions. The results are shown in the last two columns in Table 3 and Table 4.

In the empirical test of OLS regression based on the total amount of CO_2 emissions, the positive and negative sign of the main parameters of the explanatory variables are consistent with the results of the GMM analysis of the system. The result has the stability when the generalized distance method is used to test the two terms Equation 4.

Table-4. Carbon emissions and rural poverty: Dynamic GMM regression.

Variables	(2)	(3)	(4)	(5)
L. y_1	0.41**	0.46**	0.77**	0.39**
	(2.12)	(2.10)	(2.21)	(2.11)
ln x_1	0.17	0.33***	0.18***	0.42***
	(0.39)	(3.28)	(3.12)	(4.09)
Ln^2 x_1		-0.11*	-0.18**	-0.21**
		(-1.87)	(-2.01)	(-2.16)
ln x_2	-1.23*	-0.84*	-0.42*	-0.90**
	(-1.93)	(-1.88)	(-1.93)	(-2.33)
ln x_3	0.25	0.04	0.18	0.23
	(0.33)	(0.68)	(1.68)	(1.28)
ln x_4	-0.93	-0.14	-0.02	-0.19*
	(0.11)	(0.11)	(0.05)	(0.11)
_cons	2.61***	3.62***	2.47**	3.01**
	(4.83)	(4.44)	(2.44)	(2.27)
Obs	125	125	125	125
Sargan	0.29	0.22		0.23

Notes: T value is in parentheses, *, **, * * * representing 10%, 5%, 1% significant level respectively. Lnco2_per^2 is the square of lnco2_per, which is used to examine the possible nonlinear relationship.

Table-5. Carbon emissions and urban poverty: Dynamic GMM regression.

Variables	(2)	(3)	(4)	(5)
L. y_2	0.34**	0.36**	0.57**	0.38**
	(2.13)	(2.10)	(2.22)	(2.41)
ln x_1	0.47	0.53***	0.57***	0.41***
	(0.39)	(3.28)	(3.12)	(4.09)
Ln^2 x_1		-0.04*	-0.08**	-0.14**
		(-1.86)	(-2.12)	(-2.10)
ln x_2	0.86*	0.62*	0.57*	0.90**
	(1.93)	(1.88)	(1.93)	(2.33)
ln x_3	0.67***	0.64***	0.78***	0.83***
	(4.37)	(3.60)	(5.65)	(3.23)
ln x_4	0.30	0.31	0.15	0.48*
	(0.27)	(0.28)	(0.14)	(0.28)
_cons	2.64***	1.50***	2.38**	2.05**
	(4.83)	(4.44)	(2.44)	(2.27)
Obs.	125	125	125	125
Sargan	0.39	0.46		0.65

Notes: T value is in parentheses, *, **, * * * representing 10%, 5%, 1% significant level respectively. Lnco2_per^2 is the square of lnco2_per, which is used to examine the possible nonlinear relationship.

3. RESULTS ANALYSIS AND DISCUSSION

3.1. The Intertemporal Correlation of the Income of the Poor in North-West China

In all econometric models, the first lag of the income of the poor population is significantly positive and there is a correlation between the income of the poor in the north-west China. The former poverty population has a significant positive effect on the current income, which indicates that the north-west region has the possibility to fall into poverty trap. There is an obvious intertemporal transmission of poverty, and rural poverty is more obvious than urban poverty. Therefore, we should take full account of the special feature of poverty in the north-west region in the selection and implementation of poverty reduction targets. Deep poverty population will be the most important target in the future.

3.2. The Relationship between Carbon Emissions and the Income of the Poor in North-West China

The function fitting image of the relationship between carbon emissions and rural poverty is the downward parabola, that is to say, with the increase of carbon emissions in the initial stage, the income level of the poor people in the north-west rural areas increased significantly but it will lead to a decline in the income of the poor when the carbon emissions hit the critical point. The empirical results are statistically significant and robust. This conclusion is consistent with the theoretical analysis. The reason for the positive correlation between carbon emissions and income increase in the first half is that the endowment structure of the rural poor population in the north-west region is dominated by low skilled labor and natural resources and mainly rely on the high energy consumption industry development brought about by the economic overflow to get income. The reason for the negative correlation between carbon emissions and income increase in the other half is that the skill level of the poor people in the north-west region could not be adapt to the industrial structure transformation. The industrial structure of the north-west region needs to undergo a hard transition because of the highlight of ecological problems and the improvement of ecological hard constraints. The cost caused by transformation of industrial structure and ecological environment become much more serious, the ability of rural poverty people to withstand environmental problems become worse so that the income levels of the rural poverty population declined. From the view of the turning point of the inverted U-shaped curve, the poor are still on the left side of the curve, the increase in carbon emissions is still able to bring about an increase in the income of the rural poor. However, the rural poor will be poorer because of ecological problems, we should abolish the idea that pollution will be solved by the development itself.

3.3. Other Explanatory Variables on the Income of Urban and Rural Poor in the North-West Region

Economic growth is the most significant variable of the income of urban and rural poor in the north-west region. This conclusion is consistent with the existing research and the economic growth is the primary endogenous driving force for poverty reduction in the north-west region. However, we should also be aware of the economic growth dose not always improve the poverty reduction efficiency under any industrial structure, the negative effects of industrial structure with high energy consumption and high carbon emissions on the rural poor will offset the positive spillover effect of economic growth in a long term. Therefore, the choice of industry for economic growth should reflect the scientific concept of development, rather than get economic growth simply by receiving the high energy consumption industries of the eastern region. Although the infrastructure has no significant effect on the income increase of the rural poor in the north-west, it can bring about a significant poverty reduction effect to the urban poor. The situation is also because of the different ways that urban and rural poor population participate in economic growth. Infrastructure is the important input element when employment choice made by city poverty population while rural poor population is mainly dependent on neutral overflow of economic growth. It should be noted that the number of years of education has no significant effect on the income of the poor in the north-west region. The main reason is that the quality of education in the north-west region and the distortion of the whole social education return. Only the appropriate level of education will be able to have the greatest effect on the income of the poor.

4. CONCLUSION

In this paper, we use the dynamic panel data of the north-west region to test the relationship between the changes of the ecological environment, especially the carbon emissions and the income of the poor in the north-west region. There are two kinds of theoretical connection between ecological environment and poverty alleviation, one point is the increase of income is the main driving force for poverty alleviation, the poverty population will follow the path of "economic growth - factor participation - the primary distribution - the two distribution - income increase" to achieve endogenous poverty reduction. The other point is believed that because of the poor ability of the poor to resist the ecological risk, the poverty of the poor will be intensified under the influence of the ecological environment. The relationship between carbon emissions and income of the rural poor population exists as an inverted U curve in the north-west region. The increase in carbon emissions will lead to the upgrading of rural poor before the turning point and then ecological environmental problems will worsen the income of rural poor. Due to the different economic growth mode, there is no significant correlation between carbon emissions and the income of the urban poor in the north-west region. There is a significant positive intertemporal correlation in the north-west poverty especially the rural poverty is likely to fall into poverty trap. The focus of future poverty reduction should be the depth of poverty population rather than the poverty population near the poverty line. Economic growth is still the most important source of energy for urban and rural poverty reduction in the north-west region, the number of years of education has no obvious effect on the income of urban and rural poor. Infrastructure is only to improve the income of urban poor people and no correlation to that of the poor rural population. In the north-west region, we should abandon the traditional concept of development and management, and realize that it will easily reduce the quality of labor supply result in the worse the poor people's ability to withstand ecological risks in the industrial structure of high carbon emissions and high energy consumption. Simple to undertake the eastern part of the relevant industries can bring economic growth and poverty alleviation, but it will not offer a sustained endogenous force to poverty reduction in a long run. How to guide the formation of reasonable industrial structure based on scientific development and improve the endowment conditions of the poverty is the key to sustainable poverty reduction in the north-west region.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Contributors/Acknowledgement: Both authors contributed equally to the conception and design of the study.

REFERENCES

Apergis, N. and I. Ozturk, 2015. Testing environmental Kuznets curve hypothesis in Asian countries. Ecological Indicators, 52: 16-22.Available at: https://doi.org/10.1016/j.ecolind.2014.11.026.

Barbier, E.B., 2015. Climate change impacts on rural poverty in low-elevation coastal zones. Estuarine, Coastal and Shelf Science, 165: A1-A13.Available at: https://doi.org/10.1016/j.ecss.2015.05.035.

Cao, M., D. Xu, F. Xie, E. Liu and S. Liu, 2016. The influence factors analysis of households' poverty vulnerability in southwest ethnic areas of China based on the hierarchical linear model: A case study of Liangshan Yi autonomous prefecture. Applied Geography, 66: 144-152.Available at: https://doi.org/10.1016/j.apgeog.2015.11.016.

Chen, X., Z. Pei, A.L. Chen, F. Wang, K. Shen, Q. Zhou and L. Sun, 2015. Spatial distribution patterns and influencing factors of poverty-a case study on key country from national contiguous special poverty-stricken areas in China. Procedia Environmental Sciences, 26: 82-90.Available at: https://doi.org/10.1016/j.proenv.2015.05.005.

Chen, Y. and Y. Ge, 2015. Spatial point pattern analysis on the villages in China's poverty-stricken areas. Procedia Environmental Sciences, 27: 98-105.Available at: https://doi.org/10.1016/j.proenv.2015.07.098.

Diswandi, D., 2017. Alleviation? A hybrid Coasean and Pigouvian approach to payment for ecosystem services program in West Lombok: Does it contribute to poverty . Ecosystem Services, 23: 138-145.Available at: https://doi.org/10.1016/j.ecoser.2016.12.005.

Fisher, J.A., G. Patenaude, K. Giri, K. Lewis, P. Meir, P. Pinho, M.D. Rounsevell and M. Williams, 2014. Understanding the relationships between ecosystem services and poverty alleviation: A conceptual framework. Ecosystem Services, 7: 34-45.Available at: https://doi.org/10.1016/j.ecoser.2013.08.002.

Fisher, J.A., G. Patenaude, P. Meir, A.J. Nightingale, M.D. Rounsevell, M. Williams and I.H. Woodhouse, 2013. Strengthening conceptual foundations: Analysing frameworks for ecosystem services and poverty alleviation research. Global Environmental Change, 23(5): 1098-1111.Available at: https://doi.org/10.1016/j.gloenvcha.2013.04.002.

Friend, R. and M. Moench, 2013. What is the purpose of urban climate resilience? Implications for addressing poverty and vulnerability. Urban Climate, 6: 98-113.Available at: https://doi.org/10.1016/j.uclim.2013.09.002.

Gao, Q., S. Yang and S. Li, 2015. Welfare, targeting, and anti-poverty effectiveness: The case of urban China. The Quarterly Review of Economics and Finance, 56: 30-42.Available at: https://doi.org/10.1016/j.qref.2014.06.005.

Ge, Y., Y. Yuan, S. Hu, Z. Ren, X. Wang and Y. Wu, 2017. Space–time variability analysis of poverty alleviation performance in China's poverty-stricken areas. Spatial Statistics, 21: 460-474.Available at: https://doi.org/10.1016/j.spasta.2017.02.010.

Glomsrød, S., T. Wei, B. Aamaas, M.T. Lund and B.H. Samset, 2016. A warmer policy for a colder climate: Can China both reduce poverty and cap carbon emissions? Science of the Total Environment, 568: 236-244.Available at: https://doi.org/10.1016/j.scitotenv.2016.06.005.

Hanjra, M.A., T. Ferede and D.G. Gutta, 2009. Pathways to breaking the poverty trap in Ethiopia: Investments in agricultural water, education, and markets. Agricultural Water Management, 96(11): 1596-1604.Available at: https://doi.org/10.1016/j.agwat.2009.06.008.

Hertel, T.W. and D.B. Lobell, 2014. Agricultural adaptation to climate change in rich and poor countries: Current modeling practice and potential for empirical contributions. Energy Economics, 46: 562-575.Available at: https://doi.org/10.1016/j.eneco.2014.04.014.

Howe, C., H. Suich, P. van Gardingen, A. Rahman and G.M. Mace, 2013. Elucidating the pathways between climate change, ecosystem services and poverty alleviation. Current Opinion in Environmental Sustainability, 5(1): 102-107.Available at: https://doi.org/10.1016/j.cosust.2013.02.004.

Liu, J. and X. Deng, 2011. Impacts and mitigation of climate change on Chinese cities. Current Opinion in Environmental Sustainability, 3(3): 188-192.

Njuguna, C. and P. McSharry, 2017. Constructing spatiotemporal poverty indices from big data. Journal of Business Research, 70: 318-327.Available at: https://doi.org/10.1016/j.jbusres.2016.08.005.

Pinho, P.F., G. Patenaude, J.P. Ometto, P. Meir, P.M. Toledo, A. Coelho and C.E.F. Young, 2014. Ecosystem protection and poverty alleviation in the tropics: Perspective from a historical evolution of policy-making in the Brazilian Amazon. Ecosystem Services, 8: 97-109.Available at: https://doi.org/10.1016/j.ecoser.2014.03.002.

Qi, D. and Y. Wu, 2015. A multidimensional child poverty index in China. Children and Youth Services Review, 57: 159-170.Available at: https://doi.org/10.1016/j.childyouth.2015.08.011.

Ren, Z., Y. Ge, J. Wang, J. Mao and Q. Zhang, 2017. Understanding the inconsistent relationships between socioeconomic factors and poverty incidence across contiguous poverty-stricken regions in China: Multilevel modelling. Spatial Statistics, 21: 406-420.Available at: https://doi.org/10.1016/j.spasta.2017.02.009.

Sandhu, H. and S. Sandhu, 2014. Linking ecosystem services with the constituents of human well-being for poverty alleviation in Eastern Himalayas. Ecological Economics, 107: 65-75.Available at: https://doi.org/10.1016/j.ecolecon.2014.08.005.

Suich, H., C. Howe and G. Mace, 2015. Ecosystem services and poverty alleviation: A review of the empirical links. Ecosystem Services, 12: 137-147.Available at: https://doi.org/10.1016/j.ecoser.2015.02.005.

Turpie, J., C. Marais and J.N. Blignaut, 2008. The working for water programme: Evolution of a payments for ecosystem services mechanism that addresses both poverty and ecosystem service delivery in South Africa. Ecological Economics, 65(4): 788-798.Available at: https://doi.org/10.1016/j.ecolecon.2007.12.024.

Wan, G. and Y. Zhang, 2013. Chronic and transient poverty in rural China. Economics Letters, 119(3): 284-286.Available at: https://doi.org/10.1016/j.econlet.2013.02.036.

Wang, P., G.L. Poe and S.A. Wolf, 2017. Payments for ecosystem services and wealth distribution. Ecological Economics, 132: 63-68.Available at: https://doi.org/10.1016/j.ecolecon.2016.10.009.

Ward, P.S., 2016. Transient poverty, poverty dynamics, and vulnerability to poverty: An empirical analysis using a balanced panel from rural China. World Development, 78: 541-553.Available at: https://doi.org/10.1016/j.worlddev.2015.10.022.

Wossen, T. and T. Berger, 2015. Climate variability, food security and poverty: Agent-based assessment of policy options for farm households in Northern Ghana. Environmental Science & Policy, 47: 95-107.Available at: https://doi.org/10.1016/j.envsci.2014.11.009.

Yang, G.-J., J. Utzinger and X.-N. Zhou, 2015. Interplay between environment, agriculture and infectious diseases of poverty: Case studies in China. Acta Tropica, 141: 399-406.Available at: https://doi.org/10.1016/j.actatropica.2013.07.009.

Zanin, L. and G. Marra, 2012. Assessing the functional relationship between CO2 emissions and economic development using an additive mixed model approach. Economic Modelling, 29(4): 1328-1337.Available at: https://doi.org/10.1016/j.econmod.2012.03.007.

Zhang, C., Q. Xu, X. Zhou, X. Zhang and Y. Xie, 2014. Are poverty rates underestimated in China? New evidence from four recent surveys. China Economic Review, 31: 410-425.Available at: https://doi.org/10.1016/j.chieco.2014.05.017.

Zhang, H., 2017. Opportunity or new poverty trap: Rural-urban education disparity and internal migration in China. China Economic Review, 44: 112-124.Available at: https://doi.org/10.1016/j.chieco.2017.03.011.

Zhang, K., J.A. Dearing, T.P. Dawson, X. Dong, X. Yang and W. Zhang, 2015. Poverty alleviation strategies in eastern China lead to critical ecological dynamics. Science of the Total Environment, 506(507): 164-181.Available at: https://doi.org/10.1016/j.scitotenv.2014.10.096.