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Does institutional freedom matter for global forest carbon sinks in the face of economic development disparity?

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ABSTRACT

Mitigating global warming is the responsibility of all countries. Moreover, the role of forests in sequestrating carbon is very crucial. Most environmental organizations are active in protecting the environment according to their objectives. This paper investigates the relationship between institutional freedom and forest carbon sinks by using a panel threshold model with 139 countries to verify the U-shaped relationship between forest carbon sinks and economic development. The U-shaped curve between forest carbon sinks and economic development is the same as the environmental Kuznets curve. The impact of institutional freedom on forest carbon sinks under different economic development thresholds is analyzed. Institutional freedom harms forest carbon sinks when the country experiences lower economic growth. Further analysis shows that when economic development is high, there are positive effects, and the beneficial effects of institutional freedom on the forest carbon sink gradually enhance as the threshold value increases. The article clarifies the relationship between institutional freedom and forest carbon sinks and also provides implications for making forest management strategies and climate mitigation policies.

Keywords: Institutional freedom, Global forest carbon sinks, Economic development disparity

NONMENCLATURE

Abbreviations	
CS	Carbon Sinks
FAO	Food and Agriculture Organization of the United Nations
GDP	real Gross Domestic Product
NGOs	Non-governmental organizations
REDD	Reducing Emissions from Deforestation and forest Degradation
REDD+	Reducing Emissions from Deforestation and forest Degradation plus
Symbols	
t	Year
i	Country

1. INTRODUCTION

The Climate warming problem is the responsibility of every country. Therefore, all the countries must tackle it together. One of the most proposed climate change mitigation strategies is carbon sequestration by vegetation. To meet the Paris climate agreement, forest carbon offsetting strategies had been developed. The forest as a natural carbon sink can be considered as the benefit of sequestrating carbon from the atmosphere. A forest carbon sink is the mechanism that refers to activities that use plant photosynthesis to absorb carbon dioxide in the atmosphere and fix them to vegetation and the soil through forest management, vegetation restoration, and other measures. Thereby, reducing carbon dioxide in the atmosphere. A forest carbon sink was proposed from the Kyoto Protocol. Bali Roadmap determined an action plan of mitigating climate change in developing countries that which Reducing Emissions from Deforestation and forest Degradation (REDD). Then

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Copenhagen Accord proposed REDD+ and the idea of plus is to improve forest carbon sinks. The global forest area accounts for about one-third of the land area. The Intergovernmental Panel on Climate Change (IPCC, 2007) had predicted that by 2030 the global carbon sink capacity would range from 1.27 to 4.30 billion tons of carbon dioxide per year. Maintaining forest biodiversity is a key issue in environmental protection (Yang et al., 2019). Forest carbon sinks are considered presently since its function of addressing climate change, and it is pursued together with the other carbon emissions reductions policies (Mu et al., 2013). From a global perspective, there is a large potential demand increasing for forest biomass to make forest carbon sequestration (Jin et al., 2018). And the existence of an environmental Kuznets curve between environmental quality and income is inverted U-shaped while the index of environment quality is pollution. The shape given a forest carbon sink index is worth studying while expecting a U-shaped curve.

It is worthy to explore how to develop forest carbon sinks effectively. The institutions also have effects on forest resource management (Kahsay and Bulte, 2019). It will raise public awareness to encourage environmental legislation when the country is more democracy and information is more freedom which works through non-governmental organizations (NGOs) or some environmental groups, and public opinion. Therefore, it is usually more successful to organize activities that protect the environment under such a setting (Schultz & Crockett, 1990). Kannan, Leong, Osman, & Ho (2007) suggested that NGOs were anxious about global warming increasingly and therefore, mount pressure on companies to reduce emissions significantly. There are different levels of organizations freedom and economic growth in every country. These may affect the forest biomass increment. Policymakers should exert the role of institutional quality to improve the environment (Andersson, 2018). Therefore, the relationships between institutional freedom and forest management are worth investigating.

The contribution of this paper is that it investigates the relationship between institutional freedom and environmental resources from the perspective of forest carbon sinks, which is different from previous studies. Also, this paper studies the effects of institutional freedom towards forest carbon sinks at different levels of economic development based on 139 countries using the panel threshold regression models. Meanwhile, some studies have verified the Environmental Kuznets Curve which is the inverted U-shaped relationship between environmental pollution and economic development. This paper examines the shape of the relationship between forest carbon sinks and economic development.

2. PAPER STRUCTURE

2.1 Material and methods

To evaluate the effects of institutional freedom and economic development on forest carbon sinks, the following equation is used to examine the empirical relationships between these variables.

$$CS_{it} = \alpha + \beta_1 IF_{it} + \beta_2 GDP_{it} + \beta_3 IF_{it} * GDP_{it} + \beta_4 GDP_{it}^2 + \beta_5 X_{it} + \eta_i + \varepsilon_{it}$$

Threshold models can be considered as follows: Double threshold values model specification where there are two threshold values is:

$$CS_{it} = \alpha + \beta_{11} IF_{it}(GDP_{it} \le \gamma_1) + \beta_{12} IF_{it}(\gamma_1 < GDP_{it} \le \gamma_2) + \beta_{13} IF_{it}(GDP_{it} > \gamma_2) + \beta_2 GDP_{it} + \beta_3 GDP_{it}^2 + \beta_4 X_{it} + \eta_i + \varepsilon_{it}$$

2.2 Data and sample period

The value of carbon sink is the increment of forest carbon stock over a particular time. The effects of these factors on forest carbon sinks production are through affecting carbon stock of forest biomass. Therefore, this paper selects carbon stock as the dependent variable. The data of forest carbon stock is from Global Forest Resources Assessment 2015 (the data is recorded every five years). It includes 1990, 2000, 2005, 2010, and 2015 dataset. The missing periods are from 1991 to 1999 which are supplemented by the average annual change rate between 1990 and 2000. The rest is done in the same manner which is based on the derivation of forest carbon stock volume proposed by Buongiorno et al., 2003. This paper normalized forest carbon stock by forest area as carbon stock density. The data of forest area is from the database of Food and Agriculture Organization of the United Nations (FAO).

The main independent variable is institutional freedom. This paper uses the democracy degree as an indicator of institutional freedom which is between 2 and 14 from Freedom House2. Since lower scores represent higher democracy, they are transformed into -14, representing least democracy and -2, representing most democracy for easy analyze. This paper uses another indicator which is the average scores of political rights plus civil liberties from the Polity IV database to explore whether the choice of the index measurement affects

the effect of institutional freedom. This variable captures the regime authority spectrum ranging from −10 to +10. The data is transformed into 0 to 20 and the higher numbers represents higher level of democracy. Lv (2017) used these indicators to explore the relationship between democracy and the environment. Therefore, these indicators represent institutional freedom. GDP per capita (constant 2010 US$) is selected as an indicator of economic development which is from the World Bank.

The control variables selected include harvest, land-use structure, industrialization, urbanization, and energy consumption structure. This paper uses data of fuelwood per unit as the index of harvest since the data of industrial wood and other forest product are missing. The fuelwood data is from the FAO database. Land use structure (in %) is the ratio of forest area to land area which is also from the database of FAO. Industrialization (in %) is taken as the industrial value-added (including construction industry) that is from the database of World Bank. The urbanization rate (in %) is the proportion of urban population to the total population which comes from the World Bank database. Energy consumption structure (in %) is the ratio of renewable energy consumption to total energy consumption from the FAO database.

The sample data contains 139 countries from 1990 to 2015 with a few missing data points. This paper uses the three-year moving average method to fill in the missing data.

2.3 Results

According to the results of the first equation, it can be seen that the institutional freedom index harms the carbon stocks, but the interaction term coefficient is positive. And when the coefficients of institutional freedom and the interaction item are opposite, the value of GDP per capita affects the effects of institutional freedom towards forest carbon sinks. The coefficient of institutional freedom is negative and the coefficient of interaction is positive. Therefore, when GDP per capita is low, the total effect of institutional freedom on forest carbon stock density is negative. The total effect is positive when the value of GDP per capita is high. The signs and values of the control variables are consistent with the results of the model without the interaction term.

Considering the economic growth disparities worldwide, the impact of institutional freedom on forest carbon sinks may differ, Therefore, this paper uses the panel threshold regression model to modify the fixed effect model. The values and signs of the control variables are consistent with the results of the fixed-effect model. Also, the signs and values of the GDP per capita, and the interaction term coefficients are similar to the previous regression results. The U-shaped relationship between GDP per capita and carbon stock density also exists in the threshold regression models.

The results of setting GDP per capita as a threshold variable show that the institutional freedom impact on forest carbon sinks changes at different intervals. For countries with low GDP per capita, the effect and direction of institutional freedom on forest carbon stocks are reversed, which is not conducive to the forest carbon sinks development. However, it is beneficial for countries with high GDP per capita to developing forest carbon sinks. This is consistent with the result of institutional freedom and interaction item coefficients in the fixed-effect model. It can be seen that the logarithm of GDP per capita is lower than 8.632, the institutional freedom is not conducive to the development of forest carbon stocks based on the single threshold model results but its coefficient is smaller than that of the other two threshold models. According to the double threshold model regression results in countries with GDP per capita value below 7.797, the negative impact of institutional freedom on forest carbon stocks is greater than the impact in the lower interval of the single threshold model. In the second interval of the double threshold model, the logarithm of GDP per capita is greater than 7.797 and less than 8.632. The institutional freedom effect on the forest carbon stocks is positive. In the third interval of the GDP per capita of the double threshold model, the impact of institutional freedom is positive and the coefficient is larger than that in the second interval, indicating that institutional freedom of countries with the larger GDP value has the greater positive effects on the forest carbon stocks. The interval in which the GDP is greater than 8.632 in the double threshold model is further divided into the triple-threshold model. As shown by the results, when the logarithm of GDP per capita is greater than 10.185, the positive effect of institutional freedom on forest carbon stocks is further enhanced. Therefore, the increase in institutional freedom in low-GDP countries is not conducive to the growth of forest carbon stocks. The increment of institutional freedom in high-GDP countries has a positive impact on the development of forest carbon sinks and this effect gradually strengthens as the GDP per capita threshold increases.

2.4 Discussion

Since the triple threshold model contains information on the fixed-effect in the single threshold model and the double threshold model, this paper mainly analyzes the regression results of the triple threshold model. According to the results, three threshold values of the logarithm GDP per capita are 7.797, 8.632 and 10.185 respectively. The corresponding GDP per capita are 2433.29, 5608.28, and 26502.65 (constant 2010 US$). When the GDP per capita of a country is less than 2433.29, institutional freedom harms the development of national forest carbon sinks. When the GDP per capita is greater than 2433.29, the impact of institutional freedom is favorable. Further analysis shows that when GDP per capita is in the range of 2433.29 to 5608.28, 5608.28 to 26502.65 and greater than 26502.65, the effects of institutional freedom is gradually enhanced. When GDP per capita is in the range of 2433.29 and 5608.28, the institutional freedom impact on forest carbon sinks is 0.2454, that is when the institutional freedom increases by one unit, it will increase the forest carbon stock density by 0.2454 units. When GDP per capita is in the range of 5608.28 and 26502.65, the elasticity of carbon stock density to institutional freedom is 1.1068. Better still, when the GDP per capita continues to rise, that is more than 26502.65, the elasticity of carbon stock density to institutional freedom expands to 3.1722. The World Bank announced in 2015 that the international poverty line would be raised from the previous daily living expenses of $1.25 to $1.9 in terms of purchasing power parity, and the calculated poverty line would be lower than the first threshold value of GDP. All countries are classified based on the estimated thresholds value of GDP per capita with 44 countries in the first interval, 26 countries in the second interval, 44 countries in the third interval, and 25 countries in the fourth interval.

At present, many scholars have studied the impact of democracy and institutional freedom on resources and the environment. They have not reached a consistent conclusion. The results of this study reveal that the economic development affects the impact of institutional freedom on the environment. Institutional freedom is democratic freedom granted to a society, but the institutional freedom impact on the environment is different when the national economic development is at different stages. The impact of institutional freedom on forest carbon sinks in some countries is negative, Hardin (1968) and Gleditsch and Sverdrup (2003) argued that the countries give some groups or organizations greater right without clear natural resource property rights. The activity rights will cause over-exploitation of resources resulting in the waste of resources. Therefore, when a country's economic development is relatively backward, more freedom will allow enterprises to use natural resources to obtain economic income without restraint. Moreover, more organized activities are aimed at improving poverty rather than protecting the environment. It may require more resources to help the poor and may cause resource loss. Jagger et al. (2014) studied to explore the forests and poverty by analyzing the relationship between tenure and forest income. When the country's GDP per capita is low, the country is still in the process of pursuing economic development. More institutional freedom causes environmental damage. Many countries have experienced the path of first development and then protection in the course of economic development. However, some scholars argue that the higher the institutional freedom, the more it promotes the forest carbon sinks for the countries. When institutional freedom is higher, some environmental organizations are allowed to move freely and effectively protect the environment (Torras and Boyce, 1998; Farzin and Bond, 2006). Farzin and Bond (2006) believe that the relationship between income and environmental quality mainly depends on the demand and supply of environmental quality. Since the environmental quality is a public goods, the capital cost of the infrastructure needed to reduce pollution is huge. And Sturm, Pei, Wang, Löschel, & Zhao (2019) did an experimental study which investigated whether when subjects are willing to pay for carbon emissions regarding environmental quality as global public good. When economic development is at a relatively higher level, the country and society can protect the environment to improve the quality of life. Magnani (2000) proposed that clear property rights, democratic systems, and respect for human rights could produce synergies to improve the effectiveness of environmental policies, and thus it helps to improve the environment. Groups or organizations in the field of environmental protection will be more active in countries with high GDP per capita. Increased institutional freedom will promote environmental protection. Hence when the government allows non-governmental organizations to operate freely, the organizations aim to protect the environment and resources which can effectively reduce deforestation and increase forest biomass.

Therefore, the results of this paper are consistent. There are two situations, favorable and unfavorable cases. The results of this study show that when economic

development is backward, institutional freedom is not beneficial to the forest carbon sinks development. Institutional freedom improves forest development when economic development reaches a certain level where this threshold of GDP per capita is 2433.29. Furthermore, with a gradual increase in GDP per capita, the promotion of institutional freedom to forest carbon sinks is further enhanced. According to the list of countries, the countries in the fourth interval are mainly developed countries. When economic development is at a high level, the government and residents should pay more attention to environmental protection. Higher institutional freedom will protect the environment and resources better and its promotion effect on forest carbon sinks is also greater. In addition, countries within the third threshold interval are mostly developing countries and a small number are developed countries, such as Greece, the Republic of Korea, Portugal, Slovakia, and Slovenia. China, in the third interval of the threshold value is pursuing economic development currently while focusing on the protection of resources and the environment. More environmental organizations are constantly established. Therefore, institutional freedom is beneficial to the development of forest carbon sinks. However, its promotion is smaller than that of the fourth zone. The GDP per capita of the second interval is at a general level and increasing institutional freedom is also conducive to the protection of the resource and environment. The freedom to improve their activities is helpful for environmental protection. When the level of economic development is low, it is more important for residents to solve basic living problems and environmental protection will be relatively weak, which is a problem since it is the environment and resources that will be damaged in such a country's process of economic development.

2.5 Conclusions

The relationship between institutional freedom and forest carbon sinks is investigated using panel data from 139 countries. This article verifies the U-shaped relationship between forest carbon sinks and GDP per capita. The U-shaped curve between forest carbon sinks and GDP per capita is the same as that expressed by the environmental Kuznets curve. Therefore, the environmental Kuznets curve is further confirmed in the forest carbon sink analysis.

This paper mainly proposes that the value of GDP per capita affects the effect of institutional freedom on forest carbon sinks by setting the GDP per capita as the threshold variable. The threshold model regression results show that when the national GDP per capita is less than 2433.29, institutional freedom harms the development of forest carbon sinks. When the GDP per capita is greater than 2433.29, institutional freedom has a favorable impact. When GDP per capita is in the range of 2433.29 to 5608.28, 5608.28 to 26502.65 and more than 26502.65, the elasticity coefficients of institutional freedom are 0.2454, 1.1068 and 3.1722, respectively. The contribution of institutional freedom to forest carbon sinks gradually increases as the threshold increases. According to the discussion of the results, when a country's economic development is at a lower level, more freedom will allow enterprises to use natural resources for income. More activities are aimed at improving poverty rather than protecting the environment. When economic development reaches a threshold, people gradually realize the importance of the environment and its quality, and try to improve environmental quality. At this stage, governments can improve the environment. Therefore, more institutional freedom is conducive for organizations and groups to make efforts towards improving the environment. Moreover, with the development of an economy, the effect of institutional freedom on environmental protection is greater.

These conclusions provide some references for understanding the relationship between institutional freedom and forest carbon sinks. The results provide some implications for making policies of climate mitigation and resource protection. Firstly, when economic development is at a low level, the environment protection strategies are to clarify resource property rights and further standardize the requirements for enterprises to use resources. Reducing the freedom of enterprises and organizations can benefit the development of forests. In the process of economic development, more enterprises would use excess resources to obtain more income and some groups try to overcome the problem of poverty when institutional freedom is high. Secondly, when the country's GDP per capita is high, institutional freedom has a synergistic effect on environmental policy. The freedom of environmental organizations activities will adopt relevant energy or environmental resource conservation and emission reduction strategies, which will benefit the development of forest carbon sinks and environment protection. In addition, the government can further give environmental organizations more freedom to improve environment and protect resources when countries are developed, which is conducive to the improvement of

local environmental quality. Finally, according to the U-shaped relationship between forest carbon sinks and GDP per capita, the government should pay attention to the protection of resources and environment while pursuing economic development to avoid the situation of "grow first, clean up later". The development of forest carbon sinks is an important measurement for reducing carbon dioxide and mitigating climate warming. Countries should jointly address the issue of global warming and pay attention to the protection of resources and the environment while pursuing economic development.

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