

The economic effects of clean development mechanism afforestation and reforestation project: evidence from China

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Abstract

Purpose – Forestry carbon sink (FCS) is not only an important measure to deal with the current global climate change but also an effective way to build an ecological civilization. As an important form of implementation of FCS, the afforestation and reforestation projects under the clean development mechanism (CDM A/R) have important functions such as ecological protection and economic growth. This paper aims to evaluate the short-term and long-term impact of CDM on the county economy and its impact mechanism.

Design/methodology/approach – This paper first uses propensity score matching to match the county (treatment group). Second, this paper uses difference in difference to estimate the net effect of CDM A/R project on county economic development to reduce estimation error. Finally, the impact mechanism of implementing CDM A/R project on county economic development was tested.

Findings – The CDM A/R project has significantly promoted the development of real gross domestic product (GDP) and per capita real GDP in the region. Because of the long project cycle, this promotion is not immediate in the short term and has an obvious hysteresis effect. The longer the implementation time, the greater the promotion of the local economy will develop. The results are robust after the robustness test that uses the single-difference method. The CDM A/R project has promoted local economic growth by optimizing the local industrial structure, increasing the regional capital stock and raising the regional government's fiscal revenue and expenditure.

Originality/value – This paper provides a critical overview of the relationship between clean development mechanism and local economic development.

Keywords PSM, Economic effects, DID, CDM A/R project, County economy

Paper type Research paper

1. Introduction

Climate mitigation efforts are increasingly involving forests. In particular, forests in developing countries are seen as a key for both sequestering carbon and halting increased



emissions from deforestation that threaten to undo achievements in emission reductions (Pistorius, 2012). Reconciling the needs to reduce poverty and to protect natural resources is one of the most serious challenges which many countries are facing today (Anil, 2016; Daregot *et al.*, 2013; Reardon, 2007; Schleicher *et al.*, 2018). These apparently conflicting needs are precisely those meant to be addressed by sinks projects under the clean development mechanism (CDM) – that is, improvement of livelihood conditions in developing countries, through a market mechanism aimed at mitigating climate change through sustainable use of natural resources (Skrupsky *et al.*, 2013; Wood *et al.*, 2016). Within CDM, which is currently the most widely tested scheme for global cooperation to mitigate climate change, there are some forest-related projects at present (Gong *et al.*, 2010; Hajdu *et al.*, 2016; Pistorius, 2012). Forestry is allowed as a sink measure under the CDM only in the form of afforestation and reforestation (A/R), emulating community-based forest management projects (Nijnik and Halder, 2013; Thomas *et al.*, 2010).

The CDM is aiming at realizing the goal of emission reduction and sustainable development, therefore mitigating climate change (Bayer *et al.*, 2013; Mori-Clement, 2019). Conclusions from some studies have indicated that CDM can directly make positive contributions to local environmental amenities, for instance, reducing greenhouse gas, purifying water and improving land quality, and this also have some regional overflow effects of in which the CDM projects amassed at the community level (Benites-Lazaro *et al.*, 2018; Du and Takeuchi, 2019; Subbarao and Lloyd, 2011). Wood (2011) confirms that the CDM projects that involve technology transfer can indirectly reduce rural households carbon emission, mainly by supplying farmers with more energy efficient or renewable energy-oriented cookstoves, hence prominently promoting their air quality inside houses and reducing household consumption on fuel. Cui *et al.* (2020) concluded that, promoted by the CDM projects, corporations can facilitate innovation in technical domains related to renewable energy and energy efficiency, which have expanded climate action in a more efficient way.

CDM A/R project is not only an important measure to deal with the current global climate change but also an effective way to build an ecological civilization. It plays an important role in improving biodiversity and climate change in poverty-stricken areas, improving community ecology and economic and social conditions. The Kyoto Protocol also proposed the objective that investments in CDM A/R projects in developing countries must consider socio-economic and environmental impacts. According to the 2000 IPCC special report on LULUCF, forestry projects in the CDM may also provide socioeconomic and environmental benefits primarily within project boundaries.

The empirical work to date has focused on the effects of CDM on the emission reductions. Lewis (2010) found that the CDM has provided a useful subsidy for renewable energy projects in China. Huang and Barker (2012) empirically investigate the long-run impacts of CDM projects on CO₂ emission reductions for 80 eligible CDM host countries over 1993–2009. Lim and Lam (2014) argued that it helps in large amount of emission reductions in Malaysia. However, some scholars have questioned the effect of CDM projects Lim and Lam (2014). Besides, there are also other environmental impacts. Trabucco *et al.* (2008) present estimates of the impacts of CDM A/R on global, regional and local water cycles by applying a hydrologic spatial model to the results of this land suitability analysis.

In addition, numerous researchers have emphasized that CDM projects have impacts on the economic development (Balat, 2009; Cavanagh and Benjaminsen, 2014; Nakicenovic and Swart, 2000), and enhance rural livelihoods (Boyd and Goodman, 2011; Gundimeda, 2004; Lobovikov, 2012; Patel, 2014; Pfaff *et al.*, 2007; Teixeira *et al.*, 2007). The main influencing mechanism includes employment opportunities (Bakker *et al.*, 2011; Dinar *et al.*, 2011; Jindal *et al.*, 2008; Newell, 2012; Thurner and Varughese, 2013), financial public, household income

(Balat, 2009; Balat and Ayar, 2005) and investments (Lewis, 2010). They are, however, merely theoretical and have not through the empirical to test this influencing mechanism. On the one hand, the existing literature lacks the macroscopic level to explore the impact of CDM A/R project on regional economic development. On the other hand, the empirical research on the effectiveness of existing research often adopts the single difference method, that is, the regional economical difference before and after the implementation of the project. The changes in the situation cannot accurately identify the net effect of implementing CDM A/R project on local economic development.

The goal of this paper is to evaluate the net effects of CDM A/R project on local economic development. based on the analysis of project background and theoretical framework, this paper firstly uses PSM to match the county (treatment group) that implements the CDM A/R project to the unimplemented county (control group) to solve the carbon sink in the treatment group and the control group. Secondly, this paper uses difference in difference (DID) to estimate the net effect of CDM A/R project on county economic development to reduce estimation error. Finally, the impact mechanism of implementing CDM A/R project on county economic development was tested. The authors hope that this study can bridge the gap of the current literature in CDM A/R project and economic development.

2. Theoretical framework

The purpose of CDM A/R project is mainly reflected in four aspects. First, it can restore forest vegetation with multiple benefits, enhance the ability to absorb carbon dioxide from the atmosphere, and mitigate climate change (Poffenberger, 2010). Second, it can enhance the soil and water conservation capacity of the forest and improve the regional ecological environment (Ma *et al.*, 2014). Third, it can improve the connectivity of forest ecosystems around protected areas and promote biodiversity conservation. Fourth, it also can increase the income of residents and alleviate poverty (Rueff *et al.*, 2008). Therefore, it is not difficult to see that the implementation of the CDM A/R project has a strong role in promoting the development of the county economy. A simple framework of potential pathways is illustrated in Figure 1.

The CDM A/R project has transformed the local agricultural-oriented industrial layout and promoted the optimization and upgrading of the three industrial structures (Antle, 2010; Behan *et al.*, 2006; Duesberg *et al.*, 2014; Kula and Mckillop, 2010). It is very intuitive to see that the continued development of afforestation projects will reduce the use of some agricultural arable land and improve farmers' non-agricultural employment (Eiser and Roberts, 2010). Then, because forestry carbon can offset the emissions of industrial and energy companies to a certain extent, it has become a low-cost option for industrial and energy companies, thereby indirectly promoting the development of the secondary industry. Therefore, the implementation of the CDM A/R project can promote the optimization and upgrading of the regional industrial structure through the spillover effect of the primary industry and the promotion effect of the secondary industry.

The implementation of CDM A/R project can improve the financing level of local governments. Enterprises with social responsibility and environmental responsibility, non-governmental organizations, individuals and some investors constitute the main body of diversified CDM A/R project, which provides a diversified financing channel for the local (Der Gaast *et al.*, 2018). Carbon finance innovations such as CDM project financing, corporate low-carbon transformation financing and emission rights financing can effectively improve local financing levels and promote regional economic development (Wood *et al.*, 2016).

The implementation of the project provides residents with local employment opportunities and increases the economic income of residents. According to the theory of

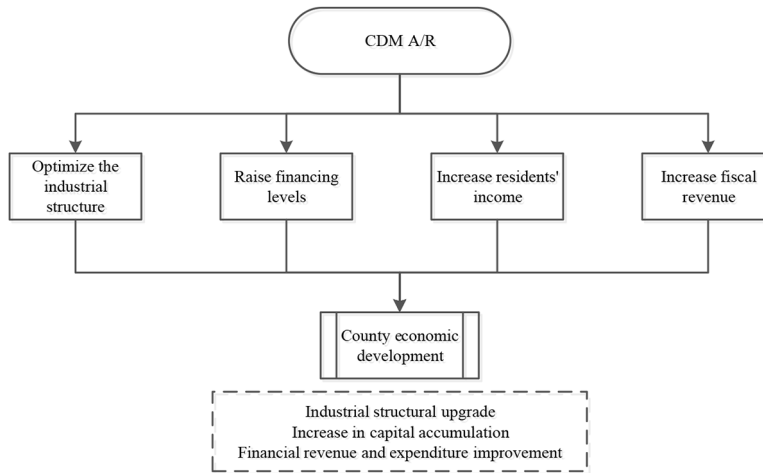


Figure 1.
Theoretic framework
of CDM A/R project
on county economic

sustainable livelihood, the change of livelihood capital will lead to the change of livelihood strategy. Farmers in the project area will receive economic benefits from labor, carbon sinks, timber and forest by-products, as well as short-term or long-term job opportunities, thereby increasing the overall income and savings of residents (Jindal *et al.*, 2012). Furthermore, the project can bring advanced afforestation technology to the project area, cultivate local forestry afforestation skills, and improve local human capital, thereby indirectly promoting regional economic development.

It can increase government revenues, which, in turn, will encourage local governments to increase capital investment in local economic construction. Ecological systems theory points out that the ecological environment can affect the development of individuals and regions. The government can integrate FCS into the carbon trading market through market mechanisms, and effectively convert high-quality ecological resources into economic benefits to increase local government revenue (Pandit *et al.*, 2017). Along with the increase in local government fiscal revenue, the fiscal expenditures used for regional economic construction will also increase accordingly, thus driving the sustainable development of the regional economy and society.

In summary, the CDM A/R project can have an important impact on local economic development by promoting industrial structure optimization and upgrading, raising financing levels, increasing regional residents' income and savings and improving fiscal revenue. However, it is worth noting that carbon sinking is a long-term, sustained low-carbon economy project and the promotion of local economic development will not be immediately apparent in the short term. Based on this, this paper constructs a theoretical analysis framework for the CDM A/R project to influence local economic development (Figure 1) and proposes the following research hypothesis:

- H1. The CDM A/R project has no economic impact in the short term.
- H2. The CDM A/R Project has a significant positive impact on the regional economy in the long term.

H3. The CDM A/R project can promote local economic development by optimizing local industrial structure, increasing capital accumulation and improving fiscal revenue and expenditure.

3. Materials and methods

3.1 Data source

Up to now, there are two CDM A/R projects officially implemented in Sichuan province and filed with the National Development and Reform Commission showed in Table 1. Specifically, the “Afforestation and Reforestation on Degraded Lands in Northwest Sichuan, China,” officially launched in 2004, is the first CDM A/R registration project in the world with a Climate and Community and Biodiversity (CCB) standard. The project area is located in the southwestern mountainous area, one of the global biodiversity hot spots. It plans to implement 2,251.8 hectares of artificial afforestation in 28 villages in 21 townships in 5 counties of Sichuan Province. The “Forestry carbon sequestration, community and biodiversity projects in southwestern Novartis” officially launched in 2010 is the first forestry project in China that uses the CDM A/R mechanism and adopts the CCB standard to purchase carbon indicators from foreign companies for voluntary emission reduction. The project area is located in the upper reaches of the Yangtze River, with biodiversity-focused hotspots such as giant pandas and endangered species. The project is planned to be implemented in 27 administrative villages in 17 townships in 5 counties of Liangshan Yi Autonomous Prefecture, with a total area of 4,196.8 hectares.

Considering the availability of research data, this paper selects the time range from 2000 to 2016 as the sample. By the end of 2018, 10 counties in Sichuan Province had implemented CDM A/R project (see Figure 2 for spatial distribution). According to the provisions of the carbon source afforestation project methodology, the selection of the project site is based on objective factors such as natural conditions, such as: the project activity land does not include wetlands and organic soil. Therefore, this provides us with a relatively good “quasi-natural experiment.” In view of the existence of individual counties in Sichuan Province after 2000 (e.g. Qianfeng, Enyang, etc.), this paper will be excluded from the total sample and finally collected in 140 counties of Sichuan Province. This paper used the time when the CDM A/R project was implemented in each county as the external policy impact time. These 10 counties are treated as treatment groups. For the remaining samples, the authors use PSM to match the treatment group to the similar control group. In the end, 10 counties were matched to 10 control samples and 340 sample observations were obtained.

Table 1.
Basic situation of
Sichuan province

County	Time (year)	Poverty	Crediting period (year)	Area (hectare)
Lixian	2004	No	20	747.8
Maoxian	2004	No	20	234.9
Beichuan	2004	No	20	200.2
Qingchuan	2004	No	20	878.3
Pingwu	2004	No	20	190.6
Ganluo	2010	Yes	30	924.3
Yuxi	2010	Yes	30	1245
Meigu	2010	Yes	30	731.6
Zhaojue	2010	Yes	30	441.8
Leibo	2010	Yes	30	854.1

The data is mainly from the China County Statistical Yearbook from 2000 to 2016. The missing data is supplemented by the statistical bulletins of the national economic and social development of the counties or government work reports.

3.2 Variables

The authors focus on the role of CDM A/R project in county economic development. Considering other economic factors may also affect the development of county economy, this paper have introduced other control variables. The definition and assignment of all the variables are shown in Table 2.

3.2.1 Dependent variables. As an explanatory variable, Y_{it} is used to measure the economic growth of the county. In this paper, following the methods used in existing literature, the logarithmic value of the real GDP of each county ($\ln gdp_{it}$) and the logarithm of the real GDP per capita of each county ($\ln pgdp_{it}$) are used to measure regional economic

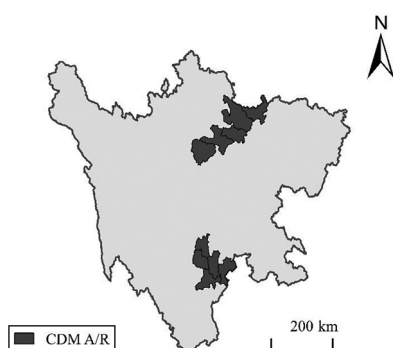


Figure 2.
Spatial distribution of
the CDM A/R project

Variables	Specific meaning	Calculation method
<i>Dependent variables</i>		
$\ln gdp$	Regional real GDP	The real regional GDP logarithm
$\ln pgdp$	Regional real GDP per capita	The real regional GDP per capita logarithm
<i>Focal variable</i>		
cdm	CDM A/R project	Dummy variable
<i>Control variables</i>		
$pfir$	Proportion of primary industries in local economy	The value-added of the primary industry/regional GDP
$psec$	Industrialization	The value-added of the secondary industry/regional GDP
$pfix$	Investment level	Total investment in fixed assets/regional GDP
$psav$	Saving level	The balance of residents' savings deposits/regional GDP
pfm	Financial level	Loans of financial institutions by region at year-end/regional GDP
$pinc$	Income level	Local government public-budgetary revenue/regional GDP
$pexp$	Expenditure level	General public budget expenditure/regional GDP
$dens$	Population density	Population density logarithm

Table 2.
Meaning and method
of calculating the
main variables

growth. Among them, to be able to compare the data accurately, 2000 is regarded as the base year and GDP growth rates are used to calculate the real GDP. The calculation method of the real GDP per capita is the same.

3.2.2 Focal variable. Dummy variable (*cdm*) is the focal variable and represents whether or not to implement the CDM A/R project. Among them, it is set in the same manner as in the existing literature, if the county has implemented the CDM A/R project, the dummy variable (*cdm*) is valued as 1, otherwise it is valued as 0. The coefficient estimates of the dummy variable, that is, the DID estimator β_1 , reflects the net impact of the implementation of the CDM A/R project on the economic growth.

3.2.3 Control variables. To control the influence of other factors on the economic growth of the county, the authors have a series of control variables (Table 3). The first type of control variables reflects the industrial structure of the county. The economic growth is often accompanied by changes in regional industrial structure (McMillan *et al.*, 2014). The county industrial structure is one of the important factors determining whether the county economy can growth healthily. This paper uses the ratios of the first and second industry added value to the nominal GDP (*pfir* and *psec*) to reflect the industrial structure of the county economy.

The second type of control variables reflects the accumulation of capital in each county. The amount of regional capital accumulation can have an important impact on the regional economy (Ayres and Voudouris, 2014; Baharumshah *et al.*, 2015; Ertur and Koch, 2007; Lucas, 2015; Perucca, 2012), especially in rural areas. On the one hand, the savings rate can directly or indirectly affect the level of investment and consumption of the society (Carbonell and Werner, 2018; Gunby *et al.*, 2017; Krieckhaus, 2002; Seyoum *et al.*, 2015). Therefore, this paper choose the ratio of the balance of residents' savings deposits to region GDP (*psav*) to measure the effect of savings levels on county economic growth. On the other hand, regional fixed asset investment and economic growth have mutually reinforcing effects (Barro, 1990; De Long and Summers, 1991; Shioji, 2001), which is a long-term driving force for regional economic development. Therefore, the authors calculate the ratio of total investment in fixed assets to regional GDP (*pfix*). Besides, the financial development is able to foster economic growth (Ben Jedidia *et al.*, 2014; Bongini *et al.*, 2017), so the authors used the variable that the ratio of loans of financial institutions by region at year-end to regional GDP (*pfin*) to measure the level of financial development.

The third type of control variables reflects the fiscal revenue and expenditure of each county. On the one hand, reasonable fiscal revenue and expenditure are conducive to maintaining the normal operation of regional administrative organs. On the other hand, it

Table 3.
Meaning and method
of calculating the
main variables

Variable	Maximum	Minimum	Average	Sd
<i>lngdp</i>	14.615	9.216	12.118	1.122
<i>lnpgdp</i>	11.022	7.355	9.075	0.899
<i>cdm</i>	1	0	0.500	0.500
<i>pfir</i>	0.687	0.032	0.325	0.154
<i>psec</i>	1.716	0.054	0.409	0.226
<i>pfix</i>	5.897	0.011	0.864	0.876
<i>psav</i>	1.703	0.121	0.593	0.328
<i>pfin</i>	2.989	0.096	0.568	0.508
<i>pinc</i>	0.185	0.010	0.046	0.022
<i>pexp</i>	2.849	0.064	0.441	0.471
<i>dens</i>	6.426	0.878	4.188	1.285

can ensure the smooth development of local science, education, culture and health and the normal operation of public infrastructure (Agasisti, 2014; Boateng, 2014; Cheng, 2014; Dufrechou, 2016; Terrelonge, 2014). Thus, it provides a good environment for local economic growth (Afonso *et al.*, 2014; Gangal and Gupta, 2013; Mendonça and Baca, 2017). The authors use the ratio of local government public-budgetary revenue to regional GDP (*pinc*) and general public budget expenditure to regional GDP (*pexp*) to measure the effect of government fiscal revenue and expenditure on county economic growth. In addition, when the authors matched the scores, this paper also used the population density (*denc*) to obtain a more similar control group.

3.3 Empirical model

To test the impact of the CDM A/R project on the county economic growth, the single difference method can be used to directly compare the level of economic growth before and after the implementation of the CDM A/R project. However, as it is not random, the use of the single difference method is prone to selectivity errors. Therefore, a better method is to use the “quasi-natural experiment” of the CDM A/R project and use the DID method to estimate the policy effect of implementing the CDM A/R project. In addition, there will be also some deviations if DID method is used in all sample ranges, which is due to the fact that there are significant differences in the level of county economic growth. There is a certain gap between the treatment group and the control group and the difference results obtained may also have certain deviation. Therefore, this paper uses the PSM method to match the treatment group with similar control group (Moncada *et al.*, 2019) and then uses the DID method to test the net impact of the CDM A/R project on the county economic growth within the matched sample range.

First, this paper examines the net effect of the CDM A/R project on county economic growth by constructing the following panel model:

$$Y_{it} = \beta_0 + \beta_1 \cdot cdm + \sum \beta_X \cdot control + r_i + y_t + \varepsilon_{it} \quad (1)$$

where the Y_{it} is the dependent variable that measures the level of county economic growth, and the specific indicators include real GDP in log and real GDP per capita in log. The subscripts i and t represent i county in the t year. β_1 measures the impact of the CDM A/R project on economic growth. If the CDM A/R project actually promoted county economic growth, the coefficient of β_1 should be significantly positive; *control* represents a series of control variables; r_i is used to control individual fixation effects that do not change over time and y_t represents the time trend effect. ε_{it} is a random error term.

In addition, the impact of CDM A/R project on county economic growth may have a long-term effect. To verify the $H1$ and $H2$, that is, to test this prediction, the authors transform model (1) as follows:

$$Y_{it} = \beta_0 + \sum \beta_k \cdot cdm^k + \sum \beta_X \cdot control + r_i + \varepsilon_{it} \quad (2)$$

where the cdm^k is the dummy variable of the county in the k th year after the CDM A/R project. For example, in 2007, exogenous shocks happened in the three years after the CDM A/R project, therefore $k=3$, and thereby the variable $cdm^3 = 1$, while cdm^k ($k \neq 3$) in the other years are given the value 0. Therefore, coefficient β_k measures the impact of the CDM A/R on economic growth in the k th year of the projects. At the same time, other control variables need to be controlled during the dynamic effect test.

To validate the *H3*, that is, to test the mechanism of the CDM A/R project affecting local economic growth, the empirical model is as follows:

$$control = \beta_0 + \beta_j \cdot cdm + \varepsilon_{it} \tag{3}$$

where the model is to use the control variables as the dependent variables, and dummy variable *cdm* as the independent variable. The authors used ordinary least squares regression model to verify the action mechanism of CDM A/R project on economic growth.

4. Results and discussion

4.1 Average effects

Table 4 shows the average effects of the CDM A/R project on local economic growth. Columns (1)–(4) are the results of implementation project in 2004. Among them, (1) and (2) are estimates of the absence of control variables and Columns (3) and (4) are estimates of the addition of control variables. It is not difficult to find that, regardless of whether or not the control variables, the coefficient of the *cdm* is positive and significant at the level of 1%. It indicates that the CDM A/R project has a significant role in promoting county economic growth. Where, before and after adding control variables, the net effect of *cdm* on *Ingdp* was 1.189 and 0.327, respectively, and the net effect on *lnpgdp* was 1.181 and 0.233, respectively. It can be seen that whether control variables are added or not, the net effect of *cdm* on *Ingdp* is always greater than that on *lnpgdp*, which indicates that the free trade zone has a greater promoting effect on regional GDP. Next, let’s turn our attention to 2010. In Columns (5) and (6) with no control variables, the estimated results are the same as in 2004. However, when the authors add the control variables, the coefficients of *cdm* become insignificant. This means that the CDM A/R project implemented in 2010 did not have a significant impact on the local economy. The likely explanation for the two very different estimates is that, because the CDM is a long-term project, its economic effects may take a long time to see. The project construction started in 2010, and the afforestation and reforestation work were completed in 2018. No significant economic gains have been made. Therefore, the authors will estimate the dynamic effects of the project in the next section to test our hypothesis.

The premise of the effectiveness of the DID method is to meet the assumption of parallel trend, that is, to meet the condition that the treatment group and the control group have the same trend before the occurrence of the event. Only when the two groups begin to show differences after the occurrence of the event, the difference in results can be attributed to the impact of the processing of the event. Therefore, this paper needs to verify the following proposition: the regional gross domestic product (GDP) of the treatment group and the control group has the same trend before the implementation, while there will be differences after the implementation. According to Figure 3, the authors can find that the treatment group and the control group had a parallel trend before 2004.

4.2 Dynamic effects

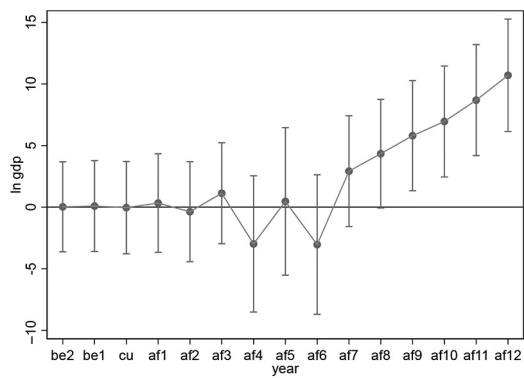
Table 4 shows the average effect of CDM A/R project on county economic development, but it does not indicate whether the CDM A/R project has a dynamic effect on county economic development. In addition, as can be seen from Figure 3, compared with the counties that did not implement the project, the treatment group did not significantly improve the local economic development level within six years after the implementation of the project. It was not until the seventh year that the trend began to increase gradually. Therefore, to verify the *H1* and *H2*, the authors use the (2) model to estimate the short and long-term effects of CDM A/R project on county economic development.

Variables	2004				2010			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	lngdp	lnpgdp	lngdp	lnpgdp	lngdp	lnpgdp	lngdp	lnpgdp
<i>cdm</i>	1.189*** (7.29)	1.181*** (7.05)	0.327*** (2.85)	0.233** (2.13)	1.219*** (8.44)	1.136*** (7.70)	0.030 (0.32)	-0.016 (-0.17)
<i>pfir</i>			-6.621*** (-14.24)	-6.644*** (-14.99)			-7.240*** (-12.91)	-7.625*** (-13.12)
<i>psec</i>			-0.233 (-0.78)	0.369 (1.29)			0.025 (0.06)	0.307 (0.67)
<i>pfir</i>			-0.038 (-0.93)	-0.040 (-1.02)			0.133 (1.55)	0.106 (1.19)
<i>psav</i>			0.237 (1.13)	0.344* (1.72)			0.703* (1.86)	0.566 (1.45)
<i>pfir</i>			-0.422*** (-4.04)	-0.485*** (-4.88)			0.481 (1.41)	0.712** (2.01)
<i>pinc</i>			12.942*** (6.81)	10.950*** (6.05)			0.298 (0.14)	-1.773 (-0.79)
<i>pexp</i>			-0.068 (-0.65)	-0.037 (-0.37)			0.714*** (5.23)	0.613*** (4.33)
<i>_cons</i>	11.592*** (146.21)	8.766*** (107.69)	13.604*** (63.39)	10.598*** (51.81)	11.938*** (204.44)	8.698*** (145.84)	13.992*** (40.70)	10.935*** (30.69)
<i>N</i>	170	170	170	170	170	170	170	170
<i>R</i> ²	0.250	0.238	0.788	0.814	0.309	0.272	0.881	0.870

Note: (1) the values of *t* are in parentheses; (2) *, ** and *** represent in significance at the 10%, 5% and 1% levels, respectively

Table 4.
The average effects
of CDM A/R project
on economic
development

Figure 3.
Dynamic effect of the
policy (2004)



The regression results are shown in [Table 5](#). In 2004, the estimation results of Column (1) and (2) show that the actual GDP and per capita real GDP of the project implementation county are improved every year compared with the counties that have not implemented the CDM A/R project. However, it is worth noting that after controlling for other influencing factors, although the coefficient of the intersection term gradually increases with time, the coefficients of *after₁* to *after₆* are not significant, and the coefficient of *after₇* is significant at the level of 5%. This shows that the implementation of CDM A/R project in the county cannot promote regional economic development in the short term, with obvious lag effect. In summary, the research *H2* was verified. In 2010, the estimated results without the control variables are similar to those in 2004, and the coefficients are higher. However, after the control variables are added, it can be seen that the economic effects are not significant within six years after the implementation of the CDM A/R project. It can be further confirmed that the project does not significantly promote the development of the local economy in the short term (six years on average), and the economic effects begin to show up gradually after seven years.

4.3 Robustness test using the single-difference method

To test whether DID is more effective in estimating the effect of the implementation of CDM A/R project on county economic development, the authors also use the traditional single-difference method to estimate this effect. After eliminating the areas where CDM A/R project were not implemented, the authors used the county area where the CDM A/R project was implemented as a sample to estimate the single-difference method to compare the changes in county economic development before and after the implementation of the CDM A/R project.

The estimation results are shown in [Table 6](#). Comparing [Table 3](#), it can be found that the estimation result of *cdm* is still significantly positive. In the case where other influencing factors are not controlled, the single difference method and the DID estimation result are not significantly different. However, when other factors are controlled, it can be found that the results of the single difference method are higher than DID. It can be seen that the estimation result of the traditional single difference method does have an overestimation of the effect of the CDM A/R project and DID method is more accurate.

4.4 Mechanism analysis

The results in the previous section have verified the effects of CDM A/R project. This section further discusses the mechanisms of these positive effects. According to the above empirical

Variables	2004				2010			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	lngdp	lnpgdp	lngdp	lnpgdp	lngdp	lnpgdp	lngdp	lnpgdp
<i>af1</i>	0.447* (1.71)	0.435 (1.59)	0.102 (0.62)	-0.012 (-0.08)	0.992*** (3.13)	0.924*** (2.87)	-0.030 (-0.21)	-0.086 (-0.58)
<i>af2</i>	0.606*** (2.32)	0.620*** (2.27)	0.029 (0.18)	-0.018 (-0.12)	1.155*** (3.65)	1.094*** (3.39)	0.116 (0.79)	0.112 (0.73)
<i>af3</i>	0.777*** (2.98)	0.806*** (2.95)	0.224 (1.33)	0.188 (1.17)	1.186*** (3.74)	1.121*** (3.48)	0.136 (0.86)	0.144 (0.89)
<i>af4</i>	0.446* (1.71)	0.498* (1.83)	-0.130 (-0.42)	-0.133 (-0.45)	1.238*** (3.91)	1.167*** (3.62)	0.154 (0.95)	0.156 (0.94)
<i>af5</i>	0.822*** (3.15)	0.868*** (3.18)	0.481 (1.56)	0.555* (1.89)	1.267*** (4.00)	1.181*** (3.66)	0.143 (0.86)	0.147 (0.85)
<i>af6</i>	1.126*** (4.31)	1.075*** (3.94)	0.102 (0.32)	0.075 (0.25)	1.329*** (4.20)	1.207*** (3.74)	0.091 (0.51)	0.057 (0.31)
<i>af7</i>	1.360*** (5.21)	1.361*** (4.98)	0.466** (2.38)	0.415** (2.24)				
<i>af8</i>	1.554*** (5.95)	1.558*** (5.71)	0.517*** (2.80)	0.445** (2.54)				
<i>af9</i>	1.693*** (6.48)	1.692*** (6.20)	0.611*** (3.36)	0.513*** (2.97)				
<i>af10</i>	1.801*** (6.89)	1.792*** (6.56)	0.768*** (4.20)	0.660*** (3.81)				
<i>af11</i>	1.871*** (7.16)	1.857*** (6.80)	0.843*** (4.68)	0.736*** (4.31)				
<i>af12</i>	2.017*** (7.72)	2.005*** (7.34)	1.031*** (5.67)	0.930*** (5.40)				
<i>control</i>	NO	NO	YES	YES	NO	NO	YES	YES
<i>_cons</i>	11.620*** (191.57)	8.789*** (138.62)	13.486*** (63.62)	10.501*** (52.29)	11.978*** (204.13)	8.735*** (146.27)	14.000*** (41.06)	10.918*** (30.97)
<i>N</i>	170	170	170	170	170	170	170	170
<i>R²</i>	0.513	0.487	0.835	0.858	0.284	0.250	0.882	0.873

Note: (1) the values of *t* are in parentheses; (2) *, ** and *** represent in significance at the 10%, 5% and 1% levels, respectively

Table 5.
Impact of the CDM
A/R project on the
dynamic effect of
economic
development

research, the implementation of the CDM A/R project can effectively promote the economic development of the county. So, what is the mechanism for implementing the CDM A/R project to promote county economic development? To validate the *H3*, the authors use Model (3) to estimate the effects of implementing CDM A/R project on various factors affecting county economic development.

The regression results are shown in Table 7. The coefficient of *cdm* represents the impact of project implementation on various economic growth drivers after the implementation of the CDM A/R project. In the short term, the coefficient of *pfir* is significantly negative; *psec* and *pfir* are all significantly positive. It indicates that after the implementation of the CDM A/R project in the county, the added value of the primary industry accounts for the proportion of the real GDP of the region decreases and the proportion of the added value of the secondary industry increases. It can be seen that the implementation of the CDM A/R project is conducive to improving the regional industrial structure. By comparing with Table 3, the authors can find that the optimization of industrial structure has obvious promotion effect on the county economy. Therefore, it is not difficult to see that the CDM A/R project can promote regional economic growth by improving the local industrial structure and raising the level of fixed-asset investment. However, other coefficients of variables are not significant, indicating that the project has no significant influence on other variables in the short term. In the long term, the coefficients of Columns (4) and (5) are all significantly positive and continue to increase, indicating that the implementation of the CDM A/R project can effectively increase the regional capital stock. The coefficients of Columns (6) and (7) are all significantly positive. According to Table 3, the implementation of the CDM A/R project can promote regional economic growth by raising the level of local government fiscal revenue and expenditure. In summary, the implementation of the CDM A/R project has promoted local economic development by optimizing the local industrial structure, increasing the regional capital stock, and raising the regional government's fiscal revenue and expenditure.

5. Conclusions

The CDM A/R project has important functions such as ecological protection, economic development and poverty alleviation. This paper uses the panel data of 140 cities in Sichuan Province from 2000 to 2016, and PSM-DID method to study the effect of the implementation of CDM A/R project on county economic growth. This paper not only enriches the ideas and methods of CDM project effect evaluation in the existing literature (Simsek *et al.*, 2018) but also explores the short-term and long-term impacts of CDM projects based on rich data set. Of course, due to data limitations, the authors also acknowledge that this paper only use the data from the first four years of policy implementation. In future research, if the authors can collect more years of data, it will make the estimation results more accurate.

Our results indicate that the implementation of the CDM A/R project has a significant role in promoting county economic development, and this conclusion is still established after the robustness test. This is consistent with the existing research results (Hejnowicz *et al.*, 2015). However, due to the long project cycle, this promotion cannot be immediately seen in the short term, with obvious lag effect, and the longer the implementation, the greater the promotion of local economic development. This paper should continue to expand the coverage area of CDM A/R project, increase special investment, guide CDM A/R project to the ecologically fragile deep poverty areas. Using the CDM A/R project to enhance local economic development capabilities, achieve the goal of ecological protection and poverty alleviation. At the same time, the authors should also establish and improve the long-term stability mechanism of project operation, prevent potential natural and market risks and ensure the long-term driving force of the project to

Table 7.
Test results of the
mechanism

Variables	(1) pfir	(2) psec	(3) pfix	(4) psav	(5) pfin	(6) pinc	(7) pexp
<i>af1</i>	-0.052* (-1.71)	0.195*** (3.03)	0.419* (1.70)	0.116 (1.17)	0.145 (1.03)	0.007 (0.81)	0.103 (1.08)
<i>af2</i>	-0.096*** (-3.17)	0.113* (1.75)	0.567** (2.29)	0.019 (0.19)	0.011 (0.08)	0.001 (0.07)	0.052 (0.55)
<i>af3</i>	-0.093*** (-3.09)	0.130** (2.03)	0.524** (2.12)	-0.016 (-0.16)	0.066 (0.47)	0.000 (0.05)	0.063 (0.66)
<i>af4</i>	-0.074** (-2.45)	0.047 (0.73)	1.020*** (4.13)	0.640*** (6.45)	0.618*** (4.37)	0.004 (0.50)	1.759*** (18.39)
<i>af5</i>	-0.112*** (-3.69)	0.103 (1.60)	4.416*** (17.89)	0.704*** (7.10)	0.995*** (7.04)	0.014 (1.61)	1.176*** (12.29)
<i>af6</i>	-0.135*** (-4.45)	0.148** (2.30)	3.562*** (14.43)	0.581*** (5.85)	0.942*** (6.66)	0.040*** (4.47)	1.725*** (18.02)
<i>af7</i>	-0.160*** (-5.28)	0.199*** (3.10)	1.562*** (6.33)	0.386*** (3.89)	0.688*** (4.87)	0.030*** (3.32)	0.295*** (3.08)
<i>af8</i>	-0.166*** (-5.47)	0.216*** (3.36)	0.986*** (3.99)	0.382*** (3.86)	0.582*** (4.12)	0.033*** (3.70)	0.250*** (2.61)
<i>af9</i>	-0.170*** (-5.61)	0.223*** (3.46)	0.520** (2.10)	0.415*** (4.18)	0.567*** (4.01)	0.033*** (3.65)	0.239** (2.49)
<i>af10</i>	-0.175*** (-5.79)	0.222*** (3.44)	0.632** (2.56)	0.411*** (4.14)	0.603*** (4.26)	0.027*** (3.04)	0.231** (2.41)
<i>af11</i>	-0.171*** (-5.64)	0.180*** (2.80)	0.485* (1.97)	0.490*** (4.94)	0.528*** (3.73)	0.028*** (3.14)	0.221** (2.31)
<i>af12</i>	-0.171*** (-5.65)	0.160** (2.49)	0.485* (1.96)	0.545*** (5.50)	0.558*** (3.94)	0.026*** (2.92)	0.242** (2.53)
<i>_cons</i>	0.331*** (47.09)	0.395*** (26.41)	0.706*** (12.31)	0.601*** (26.10)	0.685*** (20.88)	0.037*** (18.01)	0.291*** (13.09)
<i>N</i>	170	170	170	170	170	170	170
<i>R</i> ²	0.420	0.197	0.769	0.486	0.452	0.269	0.829

Note: (1) the values of *t* are in parentheses; (2) *, ** and *** represent in significance at the 10%, 5% and 1% levels, respectively

regional economic development. The effectiveness evaluation of CDM A/R project can not only be limited to the short-term stage after the project is launched, but should pay more attention to the long-term effects of the project. The government should moderately guide the project to participate in the farmers' attention to the long-term benefits of CDM A/R project and further increase their willingness to participate.

Further mechanism analysis results show that the CDM A/R project has promoted local economic development by optimizing the local industrial structure, increasing the regional capital stock and raising the regional government's fiscal revenue and expenditure. These findings confirm previous suggestions (Der Gaast, *et al.*, 2018; Pandit, *et al.*, 2017; Wood, *et al.*, 2016). Based on continuing to optimize the industrial structure and stimulating the local government to use fiscal expenditures for economic construction, it is necessary to actively improve the local financing environment and encourage local residents to effectively transform their savings and financing capabilities into investment capabilities and promote regional further economic development.

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