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Impacts of environmental conservation programs on regional economic structural change in Guizhou, China, from 2002 to 2012: an input–output analysis

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Abstract

In 1999, the Grain to Green Program (GTGP) was initiated in China as payment of ecosystem service and the largest land conservation program. This paper evaluates the impact of this conservation program on the regional economic structural change in Guizhou Province. We generate the agriculture-based regional input–output tables of 2002, 2007 and 2012. The production and employment inducements are calculated by using the Leontief inverse matrix. The key sectors are figured out by applying the linkage analysis. The RAS analysis is used for categorizing sectors as the potentially growing or shrinking industry. The results indicate the undesired effect of the GTGP and the EMP on the upstream supplier and downstream industries for agricultural production. Rural household expenditure was changed by the subsidies and shows negative effect on agricultural production. In the second stage of policy implementation, we found the depression of rural economies. The shrinking potential of the rural sector forced the further cutback of these upstream and downstream industries. The surplus rural labors find difficulties in searching for jobs in the local labor market and should move out of this region. From these results, we suggest the local government should reconsider the economic influence of the GTGP and EMP rather than emphasize the environmental issues and intend to improve rural welfare.

Keywords: Payment for ecosystem services (PES), Guizhou Province, RAS analysis, Agriculture-based IO tables, Net forward and backward linkage

1 Background

The Grain to Green Program (GTGP), which is also known as the Sloping Land Conversion Program (SLCP), is the largest Payment of Ecosystem Services (PES) and agricultural production regulation practices. The purpose of this environmental conservation program is not only to make ecological conservation efforts, but it also aims to promote the economic development in poor rural inland China.

Several researchers have discussed the impacts of the GTGP on rural household economic activity. Most of the results showed positive effects of the GTGP on rural economies. The effect of GTGP on China's grain production prices or food imports is

negligible. These studies focus on the impact of the GTGP on the agricultural sector and rural economy. However, neither of these studies dealt with the influences of the GTGP on the structural changes in the whole regional economy, especially its influence in various stages of policy implementation.

As the long-term policy, changes in rural communities which were caused by the GTGP continuously affect the rest of the economy through the economic and employment interindustrial linkage, in particular, in regions which agriculture is the key sector of the local economy and the participation is high. These impacts are regionally specified and depend on local policy practices. Measurement of their impacts on the specified regional economic structural change is needed.

In this paper, by utilizing the regional input–output model, we provide a starting point for discussion of the impacts of environmental conservation programs on the region wide economy in China. We generate agriculture-based regional input–output tables and conduct the ex-post policy evaluations for the structural changes in Guizhou Province, China, from 2002 to 2012. The agricultural sector is a key sector in this west inland province. Over 70% of the local population was living by farming before the policy implementation, and their income is the lowest in China. The participation of the GTGP and the related Environmental Migration Program (EMP) in this province is high; about 10% of cropland was converted to forest or grassland in this region.

The structure of the paper is as follows. The environmental conservation programs are explained in the next section. The third section describes their implementation in the study area and construction of agriculture-based regional input–output tables. In the fourth section, an overview of input–output models is provided, explaining what can be measured using the input–output method. The fifth section explains the analysis results. Then, we summarize the conclusion and discuss some limitations and precaution that need to be taken when applying input–output techniques for this research.

1.1 The Grain to Green Program (GTGP)

The Grain to Green Program was enacted by the State Forestry Administration of China in 1999 and aims to increase vegetation covered areas by converting steep slope cropland into forest or grassland. The government pays farmers participated in the GTGP for taking cropland afforestation practices. The GTGP should increase vegetative cover by 32 million ha by 2010 in China (Liu et al. 2008).

The Chinese central government also aims to promote rural development in its poor inland area by implementing the GTGP. In 2002, 25 provincial regions enrolled in this program, and 120 million farmers in 30 million households were involved. These provinces have agriculture-based backward economies, and most of the local populations are living by farming. Local farmer participated in the GTGP receives more subsidies while they use less labor and energy for unprofitable agricultural production (Oniki et al. 2007). The subsidies of the GTGP are supported by the central government. They should not affect the budget of the local government and are supposed to mitigate the income gap between developed coastal area and underdeveloped inland area.

The Environmental Migration Program (EMP) was accompanied with the GTGP and was initiated in 2000 in 12 of the 25 provinces enrolled in the GTGP. Participants of the

EMP receive subsidies for moving away from environmentally fragile areas to be conserved and resettled in ecologically sustainable rural or urban areas.

Most of the estimation for the economic impact of the GTGP showed it has impacts on the increase in rural household income and shifting of rural production activities (Uchida et al. 2005, 2007, 2009; Wang et al. 2007; Wang and Maclaren 2012; Liu et al. 2010). Regional difference in income improvement has been found in policy implementation (Uchida et al. 2005; Xu et al. 2010). Some evidence indicates that GTGP has intensified the income inequality between farmer participated and not participated in the GTGP (Li et al. 2011; Xu et al. 2004).

The effect of the GTGP on agricultural production and grain products has been studied as well. The results of Feng et al. (2005) suggest the GTGP might not have a major impact on China's future grain supply and the world grain market. Xu et al. (2006) reveal that agricultural production and grain price can be adjusted by the market. Thus, the GTGP has only a small effect on China's grain production and almost no effect on prices or food imports.

Neither of these studies dealt with the indirect impact of the GTGP on the overall regional economy. As a long-term policy, the GTGP and the EMP have repercussive impacts on the rest of the economy through demand–supply and employment linkages. Also, these impacts are highly dependent upon the actual level of program participation, the level of agricultural production regulation achieved, the expenditures generated by the subsidies and the local economy's ability to adapt to changes in the local expenditure patterns. The evaluation of the impact of the GTGP on the regional economy is needed. This study addresses this concern by investigating the regional economic structural change under the GTGP and the EMP implemented in various stages.

1.2 Description of the study area and data preparation

The study area Guizhou is a south-west inland province in China. This region covers 17.6 million ha. The estimated population is 38 million in 2002 (NBSC 2002), as the GTGP has been formally launched in this province. This region was chosen because participation in the GTGP and the EMP is high. About two million of rural households participated in the GTGP. Approximately 0.44 million ha cropland which accounts for 10% of the regional cropland area was converted (Finance Bureau of Guizhou 2012). The Guizhou economy largely depends on the primitive agricultural sector. Almost all farmers in Guizhou are small householders. Over 60% of the employment is in the farm sector. Rural household income in Guizhou is the lowest in China. Crop and livestock production accounted for 12% of the total gross output in Guizhou in 2002.

Guizhou government released three benchmark IO tables of 2002, 2007 and 2012, which presents at current prices. In this paper, we aggregate non-agricultural sectors to make consistent and comparable IO tables among three time points, because the coverage of non-agriculture sectors changed in different years, unlike the agricultural sector.[1] The current price IO tables are converted to constant price tables by using price

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[1] The original Guizhou IO tables of 2002, 2007 and 2012 have 122, 144 and 139 industrial sectors respectively. We aggregate those industrial sectors into 20 main industrial sectors according to China's National Industrial Classification (GB/T 4754) which was published in 2002 and 2011.

deflators and the double-deflation method. The price deflators are constructed following Sasaki and Ueyama (2009) (see Appendix 1). The sectoral employment requirement is calculated according to the statistical yearbook of Guizhou and the data from the original IO tables. The methods for estimating the labor requirement in each sector are given as the additional dataset (see Appendix 2) in IO tables.

In the reaggregated agriculture-based Guizhou IO tables (see Table 1), final demand consists of goods and services purchased by investments, government purchases, purchases made by outside consumers (exports) and purchases made by household consumers. Rural and urban household consumption is calculated separately for investigating the impact of subsidies on the rural household expenditure. The outside consumers (export) include abroad buyer and buyer from other provinces. The outside suppliers (import) included abroad one and domestic neighbor as well.

The implementation of the environmental conservation program in Guizhou from 2002 to 2007 and 2007 to 2012 is significantly different. Farmer received grain subsidies and seedling for cropland afforestation before 2008. Almost all the afforestation practices finished between 2002 and 2007. From 2007 to 2012, cropland conversion stopped. Subsidies from the central government were paid to the farmer in cash form instead of grain form until all the contraction of the GTGP expired (in 2016). In 2010, the local government began to promote a new EMP plan actively. Subsidies of the EMP are mainly used for resettlement practices.

1.3 Input–output model and impacts calculation

The economic impact of land retirement and environmental conservation programs such as the Conservation Reserve Program (CRP) in the USA has been widely estimated by utilizing IO analytical framework (Mortensen et al. 1990; Hyberg et al. 1991; Siegel and Johnson 1993; Leistritz 1998; Skaggs et al. 1994). The studies of the economic impact of CRP found negative impacts on both the production, employment and earning in the crop sector and its related upstream and downstream industries. Because of the rapid economic growth, evaluation of the economic impact of the GTGP and the EMP on the regional economy in China needs further consideration to distinguish their influences under dynamic condition.

1.4 Demand-driven inducement analysis

The Leontief demand-driven model establishes a relationship between output X and final consumption F by a fixed proportion of inputs. It shows economic impacts can be measured regarding the changes in sectoral gross output resulting from changes in final sectoral demand. In regional IO analysis, with the concern of the interregional input and output, we construct the revised Leontief demand-driven model.

Denote A as the matrix of input coefficients $A = \{a_{i,j}\} = x_{i,j}/x_j$. The final demand F includes local final demand Y and export (outflow) E. The import M should be subtracted from the total domestic demand; then, the balance equation between intermediate demand AX, final demand F, import (inflow) M and gross output X is:

$$AX + Y + E - M = X \qquad (1)$$

Table 1 Agriculture-based regional input–output table

	Intermediate demand (j = 1, 2, ..., n)		Final demand					Gross output	Imports	Employment
	Agriculture	Non-agriculture	Rural household	Urban household	Government	Investment	Exports			
Intermediate input (i = 1, 2, ..., n)										
Agriculture	X_{ij}	X_{ij}	$Y_{i,1}$	$Y_{i,2}$	$Y_{i,3}$	$Y_{i,4}$	E_i	X_i	M_i	L_i
Non-agriculture	X_{ij}	X_{ij}	$Y_{i,1}$	$Y_{i,2}$	$Y_{i,3}$	$Y_{i,5}$	E_i	X_i	M_i	L_i
Gross value added	V_j	V_j								
Gross input	X_j	X_j								

In the most practical case, import M is proportional to total demand. In "competing import type" IO table, import is a column vector and proportional to total demand. We define import coefficients as $\boldsymbol{m}_i = \frac{m_i}{\sum_j a_{i,j} x_i + y_i}$ (assuming no import or inflow is redirected for export or outflow). Putting $\boldsymbol{m}_i$ as diagonal elements of the diagonal

matrix $\hat{M} = \begin{matrix} \boldsymbol{m}_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & \boldsymbol{m}_i \end{matrix}$ and substituting $\hat{M}$ into Eq. (1), Eq. (1) can be transferred as

$$\left[I - \left(I - \hat{M} \right) A \right] X = \left(I - \hat{M} \right) Y + E \tag{2}$$

Solving Eq. (2) on X, the following balance equation can be derived.

$$X = \left[I - \left(I - \hat{M} \right) A \right]^{-1} \left[\left(I - \hat{M} \right) Y + E \right] \tag{3}$$

We denote the Leontief inverse matrix as $\boldsymbol{B} = \{b_{ij}\} = [I - (I - \hat{M})A]^{-1}$. Under the Hawkins–Simon condition, the induced production value that derives from each domestic final demand item is presented as

$$X_k = \boldsymbol{B}(I - \hat{M})Y_k, \quad k = (1, 2, \dots, n) \tag{4}$$

Here, k represents the domestic local demand item (government expenditure, investment and household consumption). Foreign and interregional purchase is exogenous to the local production process. Specifically, the induced production value by export E is expressed as follows:

$$X_E = \boldsymbol{B}E \tag{5}$$

By multiplying value-added coefficients with production inducement, we get gross value-added inducement. Denote $V = \{v_j\}$ as a vector of gross value added, and the gross value-added coefficient is $\boldsymbol{v}_j = \frac{v_j}{x_j}$. Putting $\boldsymbol{v}_j$ as diagonal elements of the diagonal

matrix $\hat{\boldsymbol{v}} = \begin{matrix} \boldsymbol{v}_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & \boldsymbol{v}_j \end{matrix}$ and substituting $\boldsymbol{B}$ and $\hat{\boldsymbol{v}}$ into Eq. (3), there is:

$$V = \hat{\boldsymbol{v}}\boldsymbol{B}[(I - \hat{M})Y + E] \tag{6}$$

The employment inducement is calculated by multiplying of employment coefficients as:

$$W = \hat{\boldsymbol{l}}X = \hat{\boldsymbol{l}}\boldsymbol{B}[(I - \hat{M})Y + E] \tag{7}$$

Denoting $\boldsymbol{C} = \hat{\boldsymbol{l}}\boldsymbol{B} = [c_{i,j}]$, $\bar{C}$ is the arithmetic mean of $\boldsymbol{C}$. The employment influence coefficients are presented as $\frac{C_j}{\bar{C}}$. The employment sensitivity coefficient is presented as $\frac{C_i}{\bar{C}}$.

During different stages, the proportion of productions are not fixed, and the technique coefficient changed. In this research, we compare the inducement changes

by final demand items at different time points, and the technological changes are included. The technological changes in Guizhou economy are discussed by the linkage and RAS analysis.

1.5 Net backward and forward linkage analysis

The backward and forward linkage analysis was constructed to figure out the key sector in the economy. Industries have effects on the whole economy through their demand and supply relations with other industries. This demand and supply dependencies are called the backward and forward linkage, respectively. Generally, the backward linkage is derived from the Leontief model (Jones 1976; Cella 1984; Miller and Blair 2009). Leontief inverse matrix B shows the direct and indirect requirements of domestic output per unit of final demand in each sector, and it is also referred as the output multiplier. Output multiplier defines the total backward linkage as $b_j^t = \sum_{i=1}^{n} b_{i,j}$. The superscript t refers to as the "total linkage" of each industry.

In recent years, researchers suggest the measurement of the forward linkage from the Ghosh supply-driven IO model (Andreosso-O'Callaghan and Yue 2004; Dietzenbacher 2005; Miller and Blair 2009). The solution of Ghosh supply-driven model is written as

$$X' = [I - D]^{-1} V' \tag{8}$$

In Eq. (8), X' is the reverse matrix of total input, and V' is the reverse matrix of gross value added. Matrix D is the output coefficients matrix. Denoting $F = [I - D]^{-1} = \{g_{i,j}\}$ as the Ghosh inverse matrix, the row sum of elements in F is referred as the input multiplier. It defines the total forward linkage as $f_i^t = \sum_{j=1}^{n} g_{i,j}$.

The total backward and forward linkages indicate only the one-side dependencies on a sector at hand and include the dependencies of this sector itself on the rest of the economy. The net backward and the net forward linkages are proposed to measure the two-sided nature of dependencies between a sector at hand and the economy at large to which it belongs (Oosterhaven 2004, 2007; Temurshoev and Oosterhaven 2014; Dietzenbacher 2005; Oosterhaven and Stelder 2002; Sonis et al. 1995). By correcting total impacts with the share of dependencies in a sector itself that is dependent on the performance of the rest of the economy, the net backward and net forward linkages are defined as, respectively,

$$b_i^n = b_i^t \frac{y_i}{x_i}, \quad \text{and} \quad f_i^n = f_i^t \frac{v_i}{x_i}. \tag{9}$$

The net backward linkage equals the output generated in all industries due to the final demand of one sector normalized by the output generated in this sector due to the final demand of all industries. A key sector with net backward linkage larger than 1 implies that this sector is a net demander for the rest of the economy. The net forward linkage equals to total inputs of all industries that utilize the primary input of a sector normalized by the total input of this sector that embodies the primary inputs of all industries. A key sector with net forward linkage larger than 1 implies that this sector is a net supplier to the rest of the economy.

1.6 RAS analysis

Originally, RAS was used in the early work of Stone (1961) for prediction of the input coefficient. Deming and Stephan (1940) applied this non-survey method to update IO tables from existing IO tables. Because the RAS analytical procedure is carried out iteratively on row sums and column sums, it is also known as the proportional matrix balancing technique (Miller and Blair 2009). Kagatsume (2004, 2006) suggested that the diagonal elements of R indicate the substitution change in each sector and the diagonal elements of S indicate the processing change in each sector. The substitution and processing effect change can be used to indicate a change of interstage input and output coefficient for each industrial sector.

In RAS analysis, R refers to a diagonal matrix of elements that modify rows. A is the coefficient matrix to be modified, and S refers to a diagonal matrix of column modifiers. This method can be shown in the following matrix form:

$$\begin{bmatrix} a_{1,1} & \cdots & a_{1,n} \\ \vdots & \ddots & \vdots \\ a_{n,1} & \cdots & a_{n,n} \end{bmatrix}_{t=T+m} = \begin{bmatrix} r_1 & \cdots & 0 \\ \vdots & \ddots & \cdots \vdots \\ 0 & \cdots & r_n \end{bmatrix}^m \cdot \begin{bmatrix} a_{1,1} & \cdots & a_{1,n} \\ \vdots & \ddots & \vdots \\ a_{n,1} & \cdots & a_{n,n} \end{bmatrix}_{t=T} \cdot \begin{bmatrix} s_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & s_n \end{bmatrix}^m$$

(10)

In Eq. (10), matrix A in right-hand side is the original input coefficient matrix in the base year T and matrix A' in the left-hand side is the coefficient matrix in the predicted year $(T+m)$. By solving the equation with the RAS method, matrices R and S are derived. Matrix R is a row-wise correction matrix of the original input coefficient matrix A and indicates the substitution effect. Similarly, matrix S is the column-wise correction matrix of A and indicates the processing degree change known as the fabrication effect. The substitution and fabrication factors are computed using the iterative RAS procedure.

Substitution effect factors represent the rate of increase in intermediate demand for sector i from all sectors. The fabrication effect factors represent the rate of increase in intermediate input to sector i from all sectors. Thus, the sectors with the combination of the diagonal elements in R larger than one and those in S smaller than one can be considered as the more promising sector in the next period, which means this sector is a potentially growing sector. Moreover, the sectors with the combination of diagonal elements in R less than one and those in S greater than one can be considered as a less promising sector, which means this sector is a potentially declining sector.

2 Results and analysis

We define from 2002 to 2007 as stage I and from 2007 to 2012 as stage II. In stage I, about 10% of the croplands in Guizhou have converted into forest or grassland, and 2 million of local farmers participated in the GTGP. Farmer received grain subsidies worth 7 billion Chinese yuan. In stage II, land afforestation practices stopped. Farmer received cash subsidies instead of grain. The total budget for the GTGP payment is about 2.5 billion Chinese yuan. The EMP has launched in stage II, 0.1 million farmers enrolled in the EMP, and they received 1.8 billion yuan of cash subsidies.

Table 2 Change of production inducement from 2002 to 2012

	Export	Government	Capital	Rural household	Urban household	Total
Stage I						
Crop	2546	538	1532	1593	6250	12,459
(%)	20	4	12	13	50	
Agri services	313	815	− 61	21	222	1310
(%)	24	62	− 5	2	17	
Agri industry	7733	68	1030	− 1661	3392	10,561
(%)	73	1	10	− 16	32	
Stage II						
Production						
Crop	13,209	168	636	− 983	299	13,328
(%)	99	1	5	− 7	2	
Agri services	− 62	466	60	62	− 11	515
(%)	− 12	90	12	12	− 2	
Agri industry	17,019	195	663	331	505	18,713
(%)	91	1	4	2	3	

Unit: million Chinese yuan

2.1 The impact of the GTGP and the EMP on production inducement change

Table 2 indicates the production inducement changes in crop, agriculture service and agricultural processing sectors. Production in the crop sector is directly regulated by the GTGP and the EMP. Agriculture service sector is the upstream supplier of crop production. Agriculture-related processing sector is the downstream demander of crop products. Note that a positive (negative) percentage in Table 2 indicates that the corresponding effect has the same (respectively, the opposite) sign as the total inducement change, be it an increase or decrease.

Results in Table 2 show the GTGP and the EMP have no effects on crop production. This result is consistent with the previous study on the impact of agriculture regulation of the GTGP on grain production. On the other hand, the subsidies of GTGP and the EMP, in grain or cash form, affected local agricultural production and rural household expenditure in different ways. In stage I, reduction in production induced by rural household consumption accounts for 16% of the total production change in the agriculture-related processing sector. Considering the total rural population in Guizhou decreased from 28 million to 26 million in this period, this change in agriculture-related processing industry is mixed with both the consumption reduction caused by the population decrease and the decrease in demand from the participants which received grain subsidies.

In stage II, when farmer received cash subsidies instead of grain subsidies, crop production induced by rural household consumption decreased by 9%, but production induced by rural household consumption in agriculture-related processing sector increased by 2%. This result suggests, with income from subsidies, local farmers changed their decision from crop-producing activities to purchasing grain products from the market. The reduction in crop production during stage II also relates to the decrease in rural population in Guizhou.

Table 3 Change of gross value-added inducement from 2002 to 2012

	Export	Government	Capital	Rural household	Urban household	Total
Stage I						
Crop	2670	376	1109	2313	4477	10,945
%	24	3	10	21	41	
Agri services	3	− 58	− 69	− 79	74	− 128
(%)	− 2	45	54	61	− 58	
Agri industry	6161	39	401	237	2006	8371
(%)	74	0	5	− 3	24	
Stage II						
Crop	6131	19	104	− 2010	− 816	3428
(%)	179	1	3	− 59	− 24	
Agri services	− 115	− 126	10	− 19	− 42	− 291
(%)	40	43	− 3	6	14	
Agri industry	4036	65	229	− 134	− 403	3793
(%)	106	2	6	− 4	− 11	

Unit: million Chinese yuan

The changes of production in term of gross value-added inducement provide a further understanding of the impact of GTGP and the EMP on agricultural and its related industries. Table 3 shows the gross value-added inducement changes in two stages. Results show the changes in gross value added in agriculture service sector are negative in stage I and II. The negative change of value added induced by rural household expenditure should be noted. In stage I, the value added induced by rural household demand in agricultural service and agriculture-related processing sector decreased. In stage II, except the reduction in agricultural service and agriculture-related processing sector, inducement by rural household demand accounts for 59% of the negative change of the gross value added in the crop sector.

When the GTGP and the EMP show no direct impacts on total production in crop sector, the gross value-added changes indicate their effect on agriculture service sector, which is the reduction in the primary input for agricultural production in its upstream industries. Furthermore, farmers continually received subsidies in Guizhou, but gross value-added inducement by rural household consumption declined in crop sector, the agriculture service and agriculture-related processing sector.

2.2 The impact of the GTGP and the EMP on employment reallocation in various stages

The employment inducement changes in stage I and II are presented in Table 4. We focus on the employment change in the rural sector and the rural labor receiving sector. In China, the rural worker is restricted to migrate to an urban area for searching long-term job. Most of the rural workers find a short-term job in construction, transport, commerce and social service sector.

Results show that a significant number of workers moved out from the rural sector. In the rural labor receiving sector, the employment inducement increased only during stage I. In stage II, the employment requirement in rural labor receiving sector decreased significantly. The GTGP and the EMP are designed to help a rural worker move out from the rural sector and work for profitable economic activities. However, when cropland

Table 4 Change of employment inducement from 2002 to 2012

	Export	Government	Capital	Rural household	Urban household	Total
Stage I						
Crop	− 105	9	20	− 173	90	− 158
(%)	66	− 6	− 13	109	− 57	
Agri services	3	9	0	1	2	15
(%)	22	61	− 1	5	13	
Agri industry	− 5	0	1	− 3	1	− 6
(%)	75	0	− 16	50	− 10	
Construction	1	0	48	0	3	53
(%)	3	0	91	1	6	
Transport	88	12	23	14	50	186
(%)	47	6	13	7	27	
Business	90	15	25	22	93	246
(%)	37	6	10	9	38	
Social services	31	18	11	4	19	83
(%)	37	22	13	5	23	
Stage II						
Crop	109	− 3	− 9	− 125	− 69	− 98
(%)	− 111	3	9	128	71	
Agri services	− 4	− 11	0	− 2	− 2	− 20
(%)	23	58	1	8	9	
Agri industry	4	0	0	0	− 1	4
(%)	115	2	7	− 6	− 18	
Construction	0	0	− 76	0	− 2	− 79
(%)	1	0	96	1	3	
Transport	− 41	− 4	31	− 9	− 31	− 54
(%)	75	7	− 58	17	58	
Business	− 52	− 9	− 8	− 17	− 62	− 149
(%)	35	6	6	12	42	
Social services	− 1	− 4	5	3	7	9
(%)	− 11	− 49	58	28	73	

Unit: ten thousand people/million Chinese yuan

afforestation practices finished, rural labor might find difficulties in searching for non-farming jobs in the regional labor market.

Moreover, Table 4 indicates employment influence and sensitivity coefficients of industries. Although worker moved out of the rural sector, the employment in the crop sector still has the strongest influence on the regional economy. Although the employment sensitivity and employment influence of the crop sector weakened in 2007, in the next stage, the larger sensitivity and influence show that crop sector still retained the most labor in Guizhou. The productivity of the crop sector is low.

2.3 The net backward and forward linkage in various stages

The net backward and forward linkages of each sector in 2002, 2007 and 2012 are presented in Table 5. In 2002 (the beginning year of the policy implementation), the crop and agricultural service sectors were the net supplier for the regional economy

Table 5 (a) Employment influence and sensitivity coefficients in 2002, 2007 and 2012 and (b) the net backward and forward linkages in 2002, 2007 and 2012

| Sector	Employment influence coefficient			Employment sensitivity coefficient		
	2002	2007	2012	2002	2007	2012
(a)						
Crop	4.71	3.7	4.48	7.76	6.6	7.32
Forestry	1.11	2.01	3.75	1.34	2.13	3.97
Livestock	3.49	2.98	2.75	2.94	2.34	2.1
Fisheries	0.84	0.74	1.42	0.63	0.56	1.23
Agri services	1.08	2.1	1.73	0.69	1.24	0.65
Mining	0.62	0.38	0.37	0.93	0.3	0.42
Agri industry	1.38	0.85	1.04	0.13	0.11	0.15
Fiber	0.76	0.71	0.29	0.48	0.12	0.06
Chemical	0.53	0.44	0.36	0.33	0.18	0.12
Metallic	0.3	0.28	0.22	0.14	0.05	0.08
Machinery	0.46	0.29	0.16	0.36	0.14	0.08
Other products	0.72	0.36	0.3	0.43	0.1	0.1
Energy and water	0.35	0.22	0.19	0.33	0.13	0.1
Construction	0.52	0.67	0.32	0.32	0.47	0.19
Transport	0.46	0.91	0.46	0.64	1.52	0.83
Commence	0.83	1.43	0.64	0.81	2.23	1.06
Finance	0.29	0.24	0.23	0.22	0.12	0.17
Real estate	0.3	0.21	0.2	0.31	0.11	0.1
Social services	0.55	1	0.59	0.48	1.17	0.81
Education	0.73	0.49	0.5	0.71	0.4	0.45
	Net backward linkage			Net forward linkage		
	2002	2007	2012	2002	2007	2012
(b)						
Crop	0.86	0.79	0.87	1.07	1.19	1.02
Forestry	0.37	0.33	0.46	3.25	3.14	3.08
Livestock	1.45	1.41	1.43	0.92	0.68	0.7
Agri services	0.9	0.96	1.12	1.19	0.77	0.54
Agri industry	1.85	1.65	1.69	0.47	0.67	0.52

because their net forward linkages are larger than 1. Agriculture-related processing sectors were the net demander of the regional economy because their net backward linkages are larger than 1.

In stage I, the value of net forward linkage of the crop sector changed from 1.07 to 1.19. Crop sector has strengthened forward linkage with the rest economy. The value of net forward linkage of the agricultural service sector changed from 1.19 to 0.77. The agricultural services sector was no longer the net supplier of the Guizhou economy. Results also show agriculture-related processing sector has weakened backward linkage with the rest of the economy in this stage.

In stage II, the net forward linkage of the crop sector with the rest economy has weakened remarkably. The value of net forward linkage is 1.02 and quite smaller than in 2002. The agricultural service sector has transformed from the net supplier to the whole economy to the net demander for the whole economy during stage II. Its net backward

Table 6 Relative growth potential of each industry (RAS analysis)

Sector	No.	Substitution effect (*R*)	Processing effects (*S*)	Substitution effect (*R*)	Processing effects (*S*)
		Stage I	Stage II	Stage I	Stage II
Crop	1	0.98	0.93	0.95	1.08
Forestry	2	0.93	1.05	0.95	1.04
Livestock	3	0.72	1.03	1.05	1.03
Fisheries	4	1.03	0.95	1.07	1.03
Agri services	5	1.12	1.19	0.89	1.06
Mining	6	0.89	1.09	1.02	1.01
Agri industry	7	1.05	0.96	0.98	1.04
Fiber	8	1.00	0.97	0.97	0.98
Chemical	9	1.02	1.02	0.99	1.02
Metallic	10	0.98	1.01	1.01	0.97
Machinery	11	0.97	0.97	1.04	0.97
Other products	12	1.06	0.98	1.03	0.93
Energy and water	13	1.10	1.04	0.98	1.02
Construction	14	0.86	0.97	1.25	0.99
Transport	15	1.01	0.99	1.05	0.98
Commerce	16	1.10	0.97	0.97	0.89
Finance	17	1.00	0.92	1.01	1.07
Real estate	18	0.92	1.26	0.98	1.08
Social services	19	0.97	0.96	1.05	1.01
Public service	20	1.04	0.99	0.98	0.99

Fig. 1 Indices of substitution and processing effects
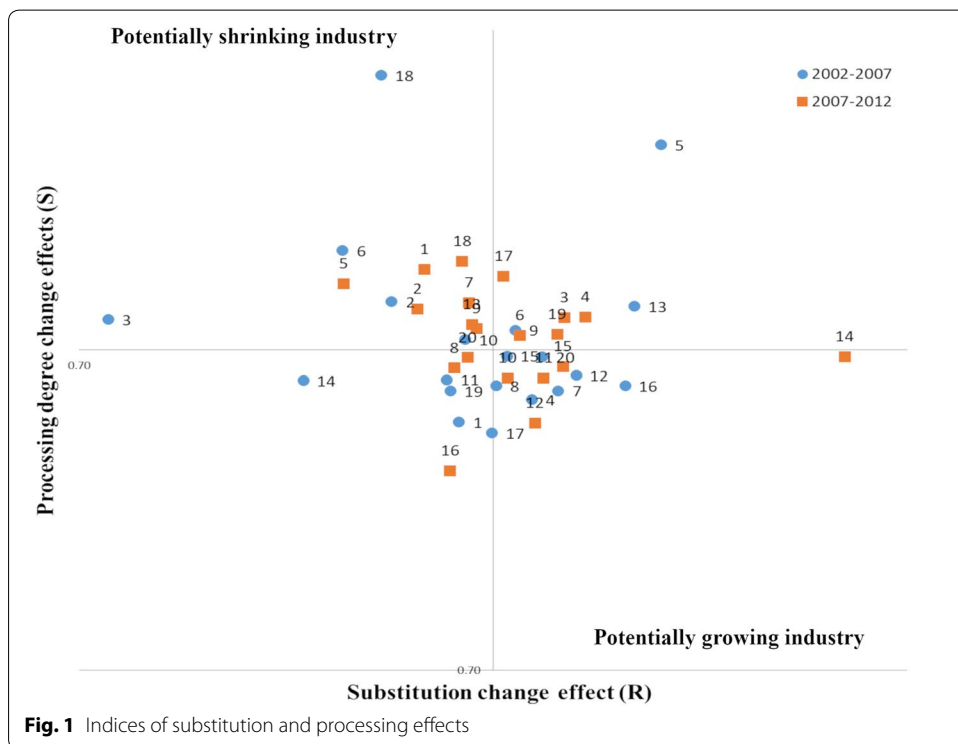
linkage changed from 0.9 in 2002 to 1.12 in 2012. Agriculture-related processing sector has stronger backward linkage than 2007. However, this linkage is still weaker than the first year (2002) of the implementation of the GTGP and the EMP.

2.4 Categorization of industries by relative growth potential: RAS analysis

Table 6 indicates the RAS analysis result. Figure 1 represents a chart that refers to Table 6. In stage I, substitution change effects (R) in forestry and livestock sector were smaller than one, while processing degree change effects (S) in these sectors were larger than one. This result indicates that at this stage, under the maintained equilibrium conditions, the intermediate demand has the potential to decrease, and the intermediate input has the potential to increase in these sectors. Therefore, the RAS analysis categorizes these sectors as the potentially shrinking industries. In this way, we find the direct and indirect impact on forestry and livestock sector in the first stage of policy implementation. On the contrary, substitution change effect (R) in the agriculture-related processing sector is larger than one, while processing degree change effects (S) in this sector is smaller than one. This result indicates that at this stage, the intermediate demand potentially increases, and the intermediate input potentially decreases in this sector. The RAS analysis categorizes these sectors as potentially growing industries.

In stage II, the substitution change effects (R) in the sectors of the crop, forestry, agricultural service and agriculture-related processing were smaller than one, while processing degree change effects (S) in these sectors were larger than one. These results indicate that not only the crop sector, but also the agricultural service and agriculture-related processing sector showed shrinking potential according to the RAS analysis. Even though the agriculture-related processing sector showed growing potential in stage I, this sector showed shrinking potential in stage II. These results suggest that the shrinking potential in the crop sector might lead to a cutback in industries which support regional economies as suppliers and use its product for processing.

3 Conclusions and limitations

This paper measures the impacts of the environmental conservation programs on a regional economy in China by utilizing the regional input–output model. Data were collected from 2002 to 2012 as the GTGP, and the EMP has launched in this province. The purpose of these programs is not only solving environmental issues. These programs have goals to increase local farmer's income and promote rural economic development in the backward west inland provinces.

In this study, we suggest these programs have an economy wide effect in Guizhou, and their impacts changed in various stages of policy implementation. At the first stages of the GTGP implementation, the GTGP has positive effect on promoting labor migration out of the agricultural sector. No direct effect of the GTGP on agricultural production has been found. However, grain subsidies affected rural household expenditure on processed agricultural products in the local market. In addition, gross value added in agriculture service sector decreased. This sector is the upstream supplier for agricultural production. The linkage analysis indicates its linkages with the economy have weakened.

At the second stage, when most of the cropland afforestation practices were stopped, and farmers received cash subsidies from the GTGP and the EMP, the improvement in efficiency in crop sector at the first stage has almost disappeared. Crop sector has weaker forward linkage with the rest of the economy. Rural household expenditure has induced less gross value added in crop, agriculture service and agriculture-related processing sector. These sectors have been categorized as shrinking industries in RAS analysis. The shrinking potential of the agricultural sector forced the further cutback of these upstream and downstream sectors.

When rural workers moved out of the agricultural sector in the second stage, surplus rural labor force did not participate in non-agricultural production significantly. Rural workers found difficulties in getting jobs in the local labor market, and they have to go to other regions for finding a job. Population decrease led to the further decline of local final demand and potentially harmed the local economic growth.

The local government needs to reconsider the economic influence of the GTGP and EMP rather than emphasizes the environmental issues. The implementation of environmental conservation programs in underdeveloped regions is cheaper and easier accessible, but this research demonstrates that the subsidies and the labor movement through GTGP and EMP should be reconsidered in economic activities efficiently to support the regional development. Otherwise, they have an undesired impact on rural economic activities and hinder the entire economic growth in the future. Successful implementation of the environmental conservation programs in the next stage in Guizhou requires that regional government pays attention to efficient resource reallocation such as supporting the development of agriculture-related service and industries and rural labor force training.

A limitation of this research is that there is a lack of detailed information on participants in the GTGP and EMP. The IO analysis provides a macrounderstanding of the changes in each sector. The measures of production, gross value added, earning and employment indicate only the changes among different policy periods. However, they cannot specify which change is related to the participants in the GTGP and the EMP.

Another limitation is that this structural analysis cannot find the trade-off between rural production activities which are resource based, and the activities based on environmental quality and amenities such as recreation or habitat preservation. As the GTGP and the EMP are implemented, the environment-related economic activities will increase in the future and need further investigation.

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Appendix 1

The double-deflation method has been used for calculating the constant price IO tables. We calculate the total output and the intermediate input–output matrix from the demand side by using price deflator. Following Sasaki and Ueyama (2009), we construct deflator for industries by using the producer price index (PPI) and GDP deflator. The base year is 2007, and the deflators used are presented in the table below. If more than one series of deflators are listed in sectors, the deflators of the sectors were constructed as a weighted average of the listed PPIs or GDP deflators. From the input side, gross value added is calculated as the difference between total output and total intermediate input, where the intermediate input is defined as expenditure on inputs used in the production process. Double deflated estimates of value added can overcome inconsistency in estimation.

No	Industry classification	2002	2012	Deflator
1	Crop	0.99	1.65	GDP •Crop
2	Forestry	0.60	1.37	GDP •Forestry
3	Livestock	0.80	1.36	GDP •Livestock
4	Fisheries	0.97	1.74	GDP •Fisheries
5	Agri services	0.86	1.63	GDP •Services
6	Mining	0.48	1.52	PPI •Mining and Quarrying
7	Agri industry	0.94	2.00	PPI •Food
8	Fiber	0.88	1.10	PPI •Textile •Tailoring •Leather
9	Chemical	0.66	1.25	PPI •Petrochemical •Chemical •Non-metallic
10	Metallic	0.64	0.98	PPI •Metallic •Metal smelting
11	Machinery	0.96	0.91	PPI •General equipment; •Specials equipment
12	Other products	0.96	1.17	GDP •Construction
13	Energy	0.83	1.22	GDP •Power
14	Construction	0.95	1.14	GDP •Construction
15	Transport	0.93	1.07	GDP •Transportation, •Postal and Telecommunication Service
16	Commerce	0.96	1.10	GDP •Tertiary Industry
17	Finance	0.87	1.11	GDP • Real Estate
18	Real estate	0.94	1.17	GDP •Financial Intermediation
19	Social services	0.94	1.05	GDP •Tertiary Industry
20	Education	0.93	1.11	GDP •Tertiary Industry

Appendix 2

The number of workers in each sector is an additional dataset which is applied to IO analysis. All available data for employment estimation are recorded in the statistical yearbook of Guizhou (from 2002 to 2012). We use three different data resources which are (1) the annual sectorial average wages, (2) the composition of farmers' income and (3) the total number of farmers. We divided the total compensation of employees of each sector in original current price IO tables by the annual sectoral wages to calculate the number of the regular employee in each sector. Besides, we estimated the number of rural employees for each agricultural and non-agricultural sector by allocating the total rural employee according to income resource ratio of the farmer. The total employee of each sector is the sum of the regular employee and the rural employee.

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