Supplementary Materials: Decomposing Industrial Energy-Related CO_2 Emissions in Yunnan Province, China: Switching to Low-Carbon Economic Growth

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1. Heading Discussions on the Technology Assumption about Imports

To focus on the domestic technical and structural changes, excluding imports from the direct requirement matrix A is essential. In this paper, the reasons why we did not exclude the imported products and services from matrix A were as follows: firstly, primary input-output tables (IOTs) in Yunnan were compiled based on the competitive import assumption, which implied that the imported products and services were competitive and alternative to the domestic products and services in Yunnan's IOTs. Since the proportion of imported products and services in different sectors was unavailable, it was difficult to exclude imports from Yunnan's primary IOTs. Secondly, in order to exclude the influence of imports, some studies assumed that the proportion of imports in sectoral intermediate inputs and final demands was the same as the share of the sectoral imports in the sum of the total output and imports [1,2]. According to this proportion, the imports were excluded from the intermediate inputs and final demands. However, this assumption did not conform to the actual situation and would lead to some uncertainties in the results. Thirdly, the information in imports was important for Yunnan, since its imports were always larger than exports [3]. Excluding imports from the IOTs would miss some important information for Yunnan. Because of the reasons above, many studies in China and its regions applied the primary competitive IOTs, which did not exclude imports, and we followed them in this study for Yunnan province [4–8].

Under the competitive import assumption, in order to estimate the embodied CO2 emissions in imports and to focus on the changes in domestic technology, previous studies often supposed the imported products and services were produced in the regions that had the same technology and input structure as in the studied region [4–8]. Thus, in this paper, imported products and services were supposed from regions that had the same technology and input structure as in Yunnan. Therefore, the emissions embodied in these imports were designated as the "emissions avoided in Yunnan through imports". If these imported products and services were produced domestically in Yunnan, the same amount of CO2 would be emitted. Under this assumption, the direct requirement coefficient matrix A would just represent the technology level and input structure in Yunnan, and we could focus our analysis on domestic technical and structural changes. However, we realize that these assumptions cannot be relaxed. They will bring uncertainties to the results. The greatest influence of these assumptions to the results is that they will exaggerate the embodied carbon in import products and services, because the production system in Yunnan is often more carbon intensive than its importers, as most of Yunnan's imports are manufactured products from the developed coastal regions (e.g., Guangdong province) with a high technical level. These exaggerated results of embodied carbon in imports have been found in China as a whole [4].

2. Discussions on the Advantages, Applications and Uncertainties of the Double Deflation Method

When SDA analysis is conducted, deflating IOTs in current prices in different years to a constant price in a benchmark year is essential to exclude the impact of price changes on the calculation results. The most popular methods applied in the literature to do this were the double deflation method and the generalized RAS method [9]. Compared to the generalized RAS method, the double deflation method requires less data. In the treatment process of the double deflation method, the sectoral values added are obtained as a residual of total inputs and the sum of sectoral intermediate inputs after the row deflation. However, in the treatment process of the generalized RAS method, detailed sectoral values added in constant price are needed to be used for setting column control numbers for the following RAS process. Unfortunately, detailed sectoral values added in constant price were unavailable in China and its regions. For example, only the GDP indices for the sectors of agriculture, industry, construction and service were available for calculating values added in constant price for these sectors in Yunnan [3]. The detailed value added indices for the sub-sectors in industry and service were unavailable. This meant that to obtain these sub-sectors' values added in constant price, some other estimation methods should be adopted. This would increase the uncertainties of the results. In addition, if all sectors' values added were obtained by different estimation methods, the generalized RAS method would still face the problem that the sum of sectoral values added was not equal to the sum of sectoral final demands [10]. This issue would also block the RAS process and needed to be optimized by other methods, which would further increase the uncertainties of the results. Due to the advantage of the less data requirement, the double deflation method was advocated by the United Nations for the estimation of IOTs in constant prices [11]. It was also the predominant method applied by studies in China [2,4] and its regions, such as Jiangsu province [5], Liaoning province [6] and Beijing municipality [7,8].

Although the double deflation method is a quite acceptable method, it also has three main drawbacks [2,4,9]. Firstly, the whole row of one specific sector's intermediate inputs, final demands and output is deflated by the same output price index. In this situation, the products or services in the sector are assumed to be homogeneous. However, one sector often does not produce just one product or service. Furthermore, the price changes in intermediate inputs to different sectors are often different, as well. Thus, using the same price index to do the deflation for the whole sector will make uncertainties in the results. Secondly, the sectoral values added in constant price are obtained as the residual of the total inputs and the sum of intermediate inputs after deflation. These data are not accurate, because the deflations in the first step have already caused uncertainties to the results of intermediate and total inputs. Thirdly, the order of deflation and sector aggregation will affect the results. To obtain IOTs in constant price, there are two methods. The first one is deflation before sector aggregation, which means that the original table with more sectors is deflated first; after that, sectoral values added in constant price are obtained, and then the sectors are aggregated to a less one. The second way is sector aggregation before deflation, which means that the original table with more sectors is aggregated to a table with fewer sectors and then deflation is conducted. These two methods will not obtain the same results unless stringent conditions are satisfied [9]. Because the detailed sectoral price indices were unavailable in Yunnan, the latter method was adopted in this paper, as this was the same chosen in many other studies in China and its regions [2,4,5].

3. Detailed Explanations about Direct and Indirect Carbon Intensity Figures and Their Changes from a Sectoral Perspective

From the perspective of sectoral carbon intensity, Sector 2, Sectors 11–14, Sectors 23 and 24 and Sector 27 not only have high direct carbon intensity (DCI), but also have high indirect carbon intensity (ICI). This indicates that these sectors not only consume much fossil energy, but also rely on fossil energy-intensive materials in their production processes. For example, the electricity sector (Sector 23) has the highest DCI, since much of the raw coal is consumed in the electricity production process, and raw coal is the most carbon-intensive energy. In addition, the electricity sector also has a high ICI, since carbon-intensive materials, such as electricity and metal products, are used in the electricity production and transmission process, and the CO2 emissions embodied in these products are indirect CO2 emissions caused by the electricity sector. From 1997–2012, most of these sectors' DCI decreased, except Sector 27. This indicates that most energy-intensive sectors consumed less fossil energy. However, Sector 27 should be paid more attention, since it consumed more gasoline and diesel. Although most of these sectors' ICI also decreased, the decreased range was smaller than the DCI in the same sector. This highlights to policy makers that more measures should be taken to reduce carbon-intensive materials' use in these sectors' supply chains. In Sector 2, when the DCI decreased, the ICI increased somehow in the same time. This is because more machines driven by electricity were used to replace machines driven by coal-steam in the mining and washing of coal.

In addition to the above sectors, the ICI in other sectors is much higher than their DCI. This indicates that although some sectors seem to consume less fossil energy and cause little direct CO2 emissions, they actually need some fossil energy-intensive materials to support their production. For example, the construction sector consumes little fossil energy and causes little direct CO2 emissions in its production process. However, the construction activity needs to consume many carbon-intensive products and services, such as electricity, cement, metal products and transportation services. For service sectors, much electricity and transportation are needed to support their operation. The CO2 emissions embodied in these products and services are indirect CO2 emissions for construction and service sectors.

4. More Information about the "One-Child Policy" in China

The "one-child policy" is a population control policy in China proposed by the Chinese leader Deng Xiaoping after 1980. Under this policy, one family is allowed to birth one child. The purpose of this policy is to reduce the population growth rate, since the population in China increased too quickly in the Mao Zedong Era. After Deng Xiaoping became the Chinese leader, too much population was seen as a burden for China's economy growth, social stability and environmental degradation. It is estimated that, after this policy was released, 400 million births were prevented by the "one child policy" as of 2011 in China (more detailed information about the "one child policy" in China is at [12]).

Figure S1. The location of Yunnan province in China (source: [13]).

Table S1. Contributions of 29 sectors to changes in CO_2 emissions and GDP during different periods from a production perspective (volume, Vol.: million tons; value, Val.: billion Yuan in 2002 constant price; proportion, Pro.: %).

Sectors	1997–2002				2002–2007				2007–2012				1997–2012			
	CO_2 Emissions		Value Added		CO_2 Emissions		Value Added		CO_2 Emissions		Value Added		CO_2 Emissions		Value Added	
	Vol.	Pro.	Val.	Pro.	Vol.	Pro.	Val.	Pro.	Vol.	Pro.	Val.	Pro.	Vol.	Pro.	Val.	Pro.
1-AGR	1.0	5.3	10.0	16.9	1.1	1.4	9.7	5.3	0.0	0.1	8.0	3.0	2.2	1.6	27.8	5.5
2-MWC	–0.1	–0.3	–0.2	–0.4	–0.2	–0.3	–0.5	–0.3	–0.7	–1.7	3.1	1.2	–1.0	–0.7	2.4	0.5
3-EPN	0.0	0.0	0.0	–0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-MPM	0.2	1.3	–0.1	–0.2	0.5	0.6	–1.7	–0.9	0.5	1.2	0.8	0.3	1.2	0.9	–1.1	–0.2
5-MPN	0.0	0.1	–0.9	–1.5	0.2	0.2	–1.2	–0.6	0.5	1.4	0.2	0.1	0.7	0.5	–1.9	–0.4
6-MFT	–0.1	–0.4	9.9	16.7	0.9	1.1	31.6	17.2	0.0	0.1	64.5	24.1	0.9	0.6	106.0	20.8
7-MOT	0.0	–0.1	0.0	–0.1	0.1	0.2	–0.1	–0.1	–0.1	–0.2	0.3	0.1	0.1	0.0	0.1	0.0
8-MCL	0.0	–0.1	0.0	0.0	0.0	0.0	–0.1	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.3	0.1
9-MWF	0.0	0.0	–1.0	–1.7	0.0	0.0	0.5	0.3	0.0	–0.1	3.8	1.4	0.0	0.0	3.2	0.6
10-PMP	–0.1	–0.3	–0.1	–0.2	0.6	0.8	2.6	1.4	0.3	0.9	7.4	2.8	0.9	0.7	9.8	1.9
11-PPC	–0.1	–0.7	0.0	0.0	0.6	0.8	3.5	1.9	1.1	2.7	5.2	1.9	1.6	1.1	8.6	1.7
12-CHE	3.2	16.7	1.8	3.0	–3.7	–4.6	–1.9	–1.0	6.9	17.5	12.5	4.7	6.4	4.6	12.4	2.4
13-MNM	–0.3	–1.4	0.4	0.6	8.2	10.1	–2.3	–1.2	6.9	17.5	4.7	1.8	14.8	10.6	2.8	0.6
14-SPM	3.3	16.9	1.6	2.7	25.7	31.7	51.4	28.0	12.4	31.4	11.2	4.2	41.4	29.6	64.2	12.6
15-MMP	0.0	0.3	0.2	0.4	–0.1	–0.1	–0.2	–0.1	0.0	0.1	2.2	0.8	0.0	0.0	2.3	0.4
16-MGS	0.1	0.3	0.3	0.5	0.0	0.0	1.3	0.7	0.0	–0.1	0.1	0.0	0.0	0.0	1.7	0.3
17-MTE	0.0	0.1	0.7	1.1	0.0	0.0	1.4	0.8	0.2	0.4	1.3	0.5	0.2	0.1	3.4	0.7
18-MEM	0.0	0.1	0.2	0.4	0.0	0.0	0.7	0.4	0.0	0.0	0.3	0.1	0.0	0.0	1.2	0.2
19-MCE	0.0	0.1	0.1	0.2	–0.1	–0.1	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.5	0.1
20-IMC	0.0	0.0	0.1	0.1	0.0	0.0	0.3	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.5	0.1
21-MAO	0.0	0.0	–1.7	–2.8	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	–1.5	–0.3
22-RDW	0.0	0.1	1.6	2.8	0.0	0.0	–0.5	–0.2	0.0	0.0	–0.2	–0.1	0.0	0.0	1.0	0.2
23-PSE	7.2	37.2	7.0	11.8	39.4	48.7	7.8	4.3	0.5	1.4	14.6	5.5	47.1	33.7	29.4	5.8

Table S1. *Cont.*

Sectors	1997–2002				2002–2007				2007–2012				1997–2012			
	CO_2 Emissions		Value Added		CO_2 Emissions		Value Added		CO_2 Emissions		Value Added		CO_2 Emissions		Value Added	
	Vol.	Pro.	Val.	Pro.	Vol.	Pro.	Val.	Pro.	Vol.	Pro.	Val.	Pro.	Vol.	Pro.	Val.	Pro.
24-PSG	0.0	0.1	0.0	0.0	0.4	0.6	0.5	0.3	–0.5	–1.2	0.9	0.3	0.0	0.0	1.4	0.3
25-PSW	0.0	0.0	0.4	0.7	0.0	0.0	0.4	0.2	0.0	0.0	1.8	0.7	0.0	0.0	2.6	0.5
26-CON	0.2	1.0	1.7	2.9	0.5	0.7	10.9	6.0	1.3	3.2	31.3	11.7	2.0	1.4	44.0	8.6
27-TSP	4.6	23.5	0.9	1.6	6.0	7.4	7.0	3.8	6.7	16.9	4.1	1.5	17.2	12.3	12.1	2.4
28-WRH	0.1	0.6	7.0	11.8	0.5	0.7	13.1	7.1	2.3	5.8	38.1	14.2	2.9	2.1	58.2	11.4
29-OSE	–0.1	–0.3	19.4	32.7	0.2	0.3	48.7	26.5	1.1	2.7	50.8	19.0	1.2	0.9	118.9	23.3
Total	19.4	100	59.4	100	80.9	100	183.5	100	39.5	100	267.5	100	139.8	100	510.4	100

Table S2. Contributions of 29 sectors to changes in CO2 emissions and GDP during different periods from a final demand perspective (volume, Vol.: million tons; value, Val.: billion Yuan in 2002 constant price; proportion, Pro.: %).

Sectors	1997–2002				2002–2007				2007–2012				1997–2012			
	CO_2 Emissions		Expenditures		CO_2 Emissions		Expenditures		CO_2 Emissions		Expenditures		CO_2 Emissions		Expenditures	
	Vol.	Pro.	Val.	Pro.	Vol.	Pro.	Val.	Pro.	Vol.	Pro.	Val.	Pro.	Vol.	Pro.	Val.	Pro.
1-AGR	7.2	36.9	16.3	27.4	–2.1	–2.5	7.1	3.9	2.7	6.7	16.7	6.2	7.8	5.6	40.0	7.8
2-MWC	–2.7	–13.8	–2.2	–3.8	0.2	0.2	–1.2	–0.7	4.9	12.3	8.3	3.1	2.3	1.7	4.8	0.9
3-EPN	0.0	0.0	0.6	0.9	0.0	0.0	–0.3	–0.2	0.0	0.0	–0.7	–0.3	0.0	0.0	–0.4	–0.1
4-MPM	–1.4	–7.4	–1.6	–2.8	–17.3	–21.4	–21.1	–11.5	13.4	34.0	14.7	5.5	–5.3	–3.8	–8.0	–1.6
5-MPN	–0.9	–4.4	–1.1	–1.8	–0.5	–0.6	–0.1	–0.1	–0.3	–0.6	–1.0	–0.4	–1.6	–1.1	–2.2	–0.4
6-MFT	8.7	44.6	27.4	46.2	–1.0	–1.3	30.1	16.4	3.0	7.7	65.2	24.4	10.7	7.6	122.7	24.0
7-MOT	–0.4	–2.0	–1.0	–1.7	–0.1	–0.2	–0.1	0.0	0.1	0.4	–0.1	–0.1	–0.4	–0.3	–1.2	–0.2
8-MCL	–0.2	–1.1	–0.7	–1.1	–0.6	–0.8	–1.7	–1.0	–0.5	–1.4	–5.1	–1.9	–1.4	–1.0	–7.6	–1.5
9-MWF	–1.3	–6.5	–2.7	–4.5	–0.8	–1.0	–2.3	–1.2	0.0	0.0	–3.6	–1.4	–2.1	–1.5	–8.6	–1.7
10-PMP	–0.8	–4.2	–1.7	–2.9	–0.9	–1.1	–4.5	–2.4	–3.0	–7.6	–13.5	–5.1	–4.7	–3.4	–19.7	–3.9
11-PPC	–18.6	–95.6	–8.9	–15.0	12.0	14.9	–7.7	–4.2	1.4	3.5	–2.1	–0.8	–5.2	–3.7	–18.7	–3.7

Table S2. *Cont.*

Sectors	1997–2002				2002–2007				2007–2012				1997–2012			
	CO_2 Emissions		Expenditures		CO_2 Emissions		Expenditures		CO_2 Emissions		Expenditures		CO_2 Emissions		Expenditures	
	Vol.	Pro.	Val.	Pro.	Vol.	Pro.	Val.	Pro.	Vol.	Pro.	Val.	Pro.	Vol.	Pro.	Val.	Pro.
12-CHE	0.9	4.5	0.8	1.3	2.4	3.0	3.5	1.9	–0.5	–1.2	1.0	0.4	2.8	2.0	5.3	1.0
13-MNM	–4.8	–24.7	–4.2	–7.0	0.2	0.2	2.0	1.1	–13.7	–34.7	–12.8	–4.8	–18.3	–13.1	–14.9	–2.9
14-SPM	1.7	8.7	1.0	1.8	54.9	67.9	84.5	46.0	–6.6	–16.8	–2.9	–1.1	50.0	35.7	82.7	16.2
15-MMP	–5.8	–29.8	–6.8	–11.4	0.9	1.1	–1.5	–0.8	–2.6	–6.5	–9.2	–3.4	–7.5	–5.3	–17.4	–3.4
16-MGS	–1.1	–5.4	–2.8	–4.7	–1.4	–1.7	–3.5	–1.9	–6.7	–16.9	–20.8	–7.8	–9.1	–6.5	–27.1	–5.3
17-MTE	–1.7	–8.8	–2.7	–4.6	2.1	2.6	4.1	2.2	0.9	2.3	3.3	1.2	1.3	0.9	4.6	0.9
18-MEM	–1.6	–8.4	–2.5	–4.3	–0.2	–0.2	–1.0	–0.6	–8.5	–21.6	–23.1	–8.6	–10.3	–7.4	–26.7	–5.2
19-MCE	–0.5	–2.4	–0.9	–1.5	–0.2	–0.2	–2.3	–1.3	–1.1	–2.8	–10.7	–4.0	–1.8	–1.3	–14.0	–2.7
20-IMC	–0.6	–2.8	–1.1	–1.8	–0.1	–0.1	–1.0	–0.6	–0.7	–1.7	–4.3	–1.6	–1.3	–1.0	–6.4	–1.3
21-MAO	–1.3	–6.6	–2.9	–4.9	–0.1	–0.1	–0.6	–0.3	–3.0	–7.7	–10.0	–3.7	–4.4	–3.2	–13.4	–2.6
22-RDW	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	–0.1	0.0	0.0	0.0	0.0	0.0
23-PSE	3.8	19.5	3.1	5.2	21.4	26.5	9.0	4.9	–10.2	–25.9	2.6	1.0	15.0	10.7	14.7	2.9
24-PSG	–0.1	–0.6	–0.1	–0.2	0.2	0.2	0.2	0.1	–0.4	–1.1	–1.9	–0.7	–0.4	–0.3	–1.8	–0.4
25-PSW	0.1	0.4	0.1	0.2	0.0	0.0	0.4	0.2	0.4	1.0	1.4	0.5	0.5	0.3	1.9	0.4
26-CON	29.7	153.0	32.7	55.0	12.7	15.7	37.4	20.4	48.2	122.0	132.3	49.5	90.7	64.8	202.4	39.7
27-TSP	–0.6	–3.2	–3.9	–6.5	–3.9	–4.9	–5.4	–2.9	3.0	7.5	4.9	1.8	–1.6	–1.1	–4.4	–0.9
28-WRH	–0.2	–0.9	–3.9	–6.5	0.8	0.9	9.2	5.0	6.1	15.4	46.3	17.3	6.7	4.8	51.6	10.1
29-OSE	11.9	61.1	29.1	48.9	2.2	2.8	50.4	27.5	13.3	33.7	92.8	34.7	27.4	19.6	172.2	33.7
Total	19.4	100	59.4	100	80.9	100	183.5	100	39.5	100	267.5	100	139.8	100	510.4	100

Table S3. Contributions of 29 sectors to changes in carbon intensity-related CO_2 emissions during different periods from a production perspective (volume: million tons; proportion: %).

Sectors	1997–2002	2002–2007	2007–2012	1997–2012	
	Volume	Volume	Volume	Volume	Proportion
1-AGR	0.4	0.4	–1.2	–0.5	0.4
2-MWC	–0.8	–0.6	–2.1	–3.4	3.0
3-EPN	0.0	0.0	0.0	0.0	0.0
4-MPM	0.1	0.1	–0.9	–0.7	0.6
5-MPN	0.0	0.6	–1.0	–0.4	0.3
6-MFT	–0.4	0.3	–1.2	–1.3	1.1
7-MOT	0.0	0.1	–0.2	0.0	0.0
8-MCL	0.0	0.0	0.0	0.0	0.0
9-MWF	0.1	0.0	–0.2	–0.1	0.1
10-PMP	0.0	0.3	–0.5	–0.2	0.1
11-PPC	0.2	–0.9	–0.2	–1.0	0.8
12-CHE	0.3	–5.4	0.0	–5.1	4.5
13-MNM	–1.5	10.9	–52.1	–42.6	37.1
14-SPM	–1.3	–13.2	0.6	–13.8	12.0
15-MMP	0.1	0.0	–0.1	–0.1	0.1
16-MGS	0.0	–0.1	–0.1	–0.2	0.2
17-MTE	0.0	0.0	0.2	0.2	–0.1
18-MEM	0.0	0.0	0.0	0.0	0.0
19-MCE	0.0	0.1	0.0	0.1	–0.1
20-IMC	0.0	0.0	0.0	0.0	0.0
21-MAO	0.0	0.0	0.0	0.1	0.0
22-RDW	0.0	0.0	0.0	0.0	0.0
23-PSE	–16.1	5.5	–41.3	–51.9	45.1
24-PSG	–0.1	0.1	–0.6	–0.6	0.5
25-PSW	0.0	0.0	0.0	0.0	0.0
26-CON	–0.1	0.1	–0.4	–0.5	0.4
27-TSP	3.4	0.9	1.6	5.9	–5.2
28-WRH	0.1	0.3	0.9	1.3	–1.1
29-OSE	–0.3	–0.2	0.4	0.0	0.0
Total	–16.1	–0.6	–98.4	–115.1	100

Table S4. Sectoral contributions to energy structure and intensity-related CO_2 emission changes during different periods (units: million tons).

Sectors	**Changes in Energy Structure**				**Changes in Energy Intensity**			
	1997–2002	**2002–2007**	**2007–2012**	**1997–2012**	**1997–2002**	**2002–2007**	**2007–2012**	**1997–2012**
1-AGR	–0.1	0.5	–0.1	0.3	0.5	–0.1	–1.1	–0.7
2-MWC	–0.1	–0.3	–1.3	–1.7	–0.7	–0.3	–0.8	–1.8
3-EPN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-MPM	0.0	0.1	–0.5	–0.4	0.1	0.0	–0.4	–0.3
5-MPN	0.0	–0.4	0.1	–0.3	0.0	1.0	–1.1	–0.1
6-MFT	–0.5	0.4	–1.3	–1.4	0.0	–0.1	0.1	0.0
7-MOT	0.0	0.1	–0.1	0.0	0.0	0.0	–0.1	–0.1
8-MCL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9-MWF	0.0	0.1	–0.2	–0.1	0.1	–0.1	0.0	0.0
10-PMP	0.0	0.3	–0.3	–0.1	0.0	0.0	–0.2	–0.1
11-PPC	0.0	0.0	–0.2	–0.3	0.2	–0.9	0.0	–0.6
12-CHE	0.1	–3.8	–1.6	–5.3	0.2	–1.6	1.6	0.2
13-MNM	–0.6	2.8	–16.2	–14.0	–0.9	8.1	–35.9	–28.7
14-SPM	–0.6	6.8	–26.2	–20.0	–0.7	–20.0	26.8	6.1
15-MMP	0.1	0.0	–0.1	0.0	0.0	0.0	0.0	0.0
16-MGS	0.0	0.0	–0.1	–0.1	0.0	–0.1	0.0	–0.1
17-MTE	0.0	0.1	0.0	0.1	0.0	–0.1	0.2	0.1
18-MEM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19-MCE	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0
20-IMC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21-MAO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22-RDW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-PSE	0.8	2.2	–13.4	–10.5	–16.9	3.3	–27.9	–41.4
24-PSG	–0.1	0.1	–0.3	–0.3	0.0	0.0	–0.3	–0.3
25-PSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26-CON	0.1	0.0	–0.3	–0.2	–0.2	0.1	–0.1	–0.2
27-TSP	1.2	0.6	–0.8	1.0	2.2	0.3	2.4	4.9
28-WRH	0.0	0.1	–0.4	–0.3	0.1	0.2	1.3	1.6
29-OSE	0.0	–0.1	1.6	1.5	–0.3	–0.1	–1.2	–1.6
Total	0.3	9.5	–61.8	–52.0	–16.3	–10.2	–36.6	–63.1

Table S5. Sectoral export value and structure in 1997, 2002, 2007 and 2012 in Yunnan (value: billion Yuan in 2002 constant price; proportion: %).

Sectors	1997		2002		2007		2012	
	Value	Proportion	Value	Proportion	Value	Proportion	Value	Proportion
1-AGR	3.3	6.1	3.2	3.6	12.3	4.8	30.6	8.1
2-MWC	0.1	0.1	0.0	0.1	0.2	0.1	4.1	1.1
3-EPN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4-MPM	0.1	0.1	0.0	0.1	0.4	0.1	0.7	0.2
5-MPN	0.3	0.6	0.1	0.1	0.2	0.1	0.1	0.0
6-MFT	25.4	46.8	54.4	61.7	79.2	30.6	113.1	30.0
7-MOT	0.3	0.5	0.1	0.1	0.4	0.2	0.3	0.1
8-MCL	0.1	0.2	0.1	0.1	0.1	0.0	0.7	0.2
9-MWF	0.4	0.8	0.6	0.6	0.4	0.1	1.2	0.3
10-PMP	0.4	0.7	0.4	0.5	1.9	0.7	0.5	0.1
11-PPC	0.1	0.1	0.0	0.0	1.6	0.6	12.4	3.3
12-CHE	3.3	6.2	4.0	4.5	10.4	4.0	20.6	5.4
13-MNM	0.1	0.2	0.1	0.1	0.5	0.2	0.6	0.2
14-SPM	5.0	9.2	8.3	9.4	100.0	38.7	100.3	26.6
15-MMP	0.1	0.2	0.0	0.0	0.1	0.0	0.5	0.1
16-MGS	1.2	2.3	0.9	1.1	4.0	1.6	3.5	0.9
17-MTE	0.5	0.9	0.4	0.5	4.5	1.7	1.5	0.4
18-MEM	0.6	1.2	0.7	0.8	0.7	0.3	0.7	0.2
19-MCE	0.2	0.5	0.3	0.3	0.9	0.3	0.7	0.2
20-IMC	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0
21-MAO	0.9	1.7	0.2	0.2	1.5	0.6	0.1	0.0
22-RDW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-PSE	0.2	0.3	2.4	2.7	8.7	3.4	9.0	2.4
24-PSG	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
25-PSW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26-CON	0.0	0.0	0.0	0.0	0.0	0.0	5.5	1.5
27-TSP	4.5	8.3	3.1	3.5	6.4	2.5	9.3	2.5
28-WRH	4.2	7.7	5.1	5.8	16.8	6.5	21.8	5.8
29-OSE	2.8	5.2	3.8	4.3	7.3	2.8	39.7	10.5
Total	54.2	100	88.1	100	258.6	100	377.5	100

Table S6. Selection of low-carbon industries in Yunnan according to the sectoral total carbon intensity (value: tons/10^4 Yuan of 2002 constant price).

Sectors	1997		2002		2007		2012	
	Value	Rank	Value	Rank	Value	Rank	Value	Rank
1-AGR	1.5	26	2.4	26	1.8	23	1.7	21
2-MWC	9.6	7	11.6	4	7.6	7	4.3	9
3-EPN	0.0	29	5.4	19	0.0	29	0.0	29
4-MPM	4.2	17	8.8	9	8.2	5	6.6	4
5-MPN	4.6	13	7.6	11	10.6	3	7.1	3
6-MFT	0.9	27	1.9	28	1.2	27	0.9	27
7-MOT	2.5	23	4.9	22	6.3	9	3.3	13
8-MCL	2.6	22	3.8	24	3.6	16	1.8	20
9-MWF	4.7	11	5.5	18	3.6	17	1.4	24
10-PMP	4.0	20	4.4	23	2.9	19	2.5	17
11-PPC	10.8	4	18.0	1	5.1	12	4.0	10
12-CHE	9.8	6	10.7	6	7.8	6	5.6	7
13-MNM	11.2	3	11.5	5	23.2	1	12.3	1
14-SPM	12.7	2	13.3	3	7.0	8	6.4	5
15-MMP	8.2	8	8.8	10	4.5	14	3.4	12
16-MGS	4.1	19	7.1	13	3.7	15	3.3	14
17-MTE	4.4	14	6.1	16	2.8	20	2.8	16
18-MEM	5.9	9	6.8	14	4.6	13	3.8	11
19-MCE	4.7	12	5.0	21	2.5	22	1.4	25
20-IMC	4.4	15	5.6	17	2.8	21	1.9	19
21-MAO	4.2	18	6.2	15	3.5	18	3.1	15
22-RDW	0.1	28	0.1	29	0.1	28	0.3	28
23-PSE	34.1	1	16.3	2	21.6	2	11.3	2
24-PSG	10.8	5	9.8	7	8.3	4	1.5	23
25-PSW	3.0	21	5.1	20	1.6	25	2.5	18
26-CON	5.5	10	7.3	12	5.9	11	4.6	8
27-TSP	4.3	16	9.6	8	6.0	10	6.3	6
28-WRH	1.7	24	2.2	27	1.5	26	1.4	26
29-OSE	1.6	25	2.8	25	1.7	24	1.6	22

Note: The sectors with a green background color represent low-carbon industries in Yunnan with a more than two years of total carbon intensity rank higher than 20. The sectors with an orange background color represent high-carbon industries in Yunnan with a more than two years of total carbon intensity rank lower than 10.

Table S7. Sectoral contributions to consumption expenditures and related CO_2 emissions in 2012 in Yunnan (unit: %).

Sectors	Rural Residential Consumption		Urban Residential Consumption		Government Consumption	
	Expenditures	CO_2 Emissions	Expenditures	CO_2 Emissions	Expenditures	CO_2 Emissions
1-AGR	31.3	19.0	16.9	9.6	0.0	0.0
2-MWC	0.5	0.6	0.1	0.1	0.0	0.0
3-EPN	0.0	0.0	0.0	0.0	0.0	0.0
4-MPM	0.0	0.0	0.0	0.0	0.0	0.0
5-MPN	0.0	0.1	0.0	0.0	0.0	0.0
6-MFT	12.9	7.7	10.6	5.8	0.0	0.0
7-MOT	0.8	1.2	0.4	0.5	0.0	0.0
8-MCL	3.4	3.5	10.3	9.8	0.0	0.0
9-MWF	1.3	1.3	0.8	0.8	0.0	0.0
10-PMP	1.0	1.9	1.5	2.8	0.0	0.0
11-PPC	2.6	5.7	3.3	6.6	0.0	0.0
12-CHE	1.7	4.0	2.6	5.7	0.0	0.0
13-MNM	1.1	5.6	0.4	2.0	0.0	0.0
14-SPM	0.0	0.0	0.0	0.0	0.0	0.0
15-MMP	0.1	0.2	0.2	0.4	0.0	0.0
16-MGS	0.7	1.3	0.3	0.4	0.0	0.0
17-MTE	2.9	4.3	5.9	8.0	0.0	0.0
18-MEM	1.2	2.4	1.4	2.6	0.0	0.0
19-MCE	0.9	0.8	1.5	1.2	0.0	0.0
20-IMC	0.0	0.0	0.0	0.0	0.0	0.0
21-MAO	0.1	0.1	0.1	0.2	0.0	0.0
22-RDW	0.0	0.0	0.0	0.0	0.0	0.0
23-PSE	2.1	13.1	1.8	10.4	0.0	0.0
24-PSG	0.1	0.2	0.8	0.8	0.0	0.0
25-PSW	0.1	0.3	0.6	1.0	0.0	0.0
26-CON	0.6	1.3	1.5	3.2	0.0	0.0
27-TSP	0.7	2.0	1.0	2.8	0.0	0.0
28-WRH	12.9	8.2	12.2	7.2	0.0	0.0
29-OSE	20.9	15.4	25.8	17.9	100	100
Total	100	100	100	100	100	100

References

1. Weber, C.L.; Peters, G.P.; Guan, D.B.; Hubacek, K. The contribution of Chinese exports to climate change. *Energy Policy* **2008**, *36*, 3572–3577.
2. Minx, J.C.; Baiocchi, G.; Peters, G.P.; Weber, C.L.; Guan, D.B.; Hubacek, K. A "Carbonizing Dragon": China's fast growing CO_2 emissions revisited. *Environ. Sci. Technol.* **2011**, *45*, 9144–9153.
3. Statistical Bureau of Yunnan Province (SBYP). *Yunnan Statistical Yearbook 1998–2013*; China Statistics Press: Beijing, China, 2013.
4. Peters, G.P.; Weber, C.L.; Guan, D.B.; Hubacek, K. China's growing CO_2 emissions-A race between increasing consumption and efficiency gains. *Environ. Sci. Technol.* **2007**, *41*, 5939–5944.
5. Liang, S.; Zhang, T.Z. What is driving CO_2 emissions in a typical manufacturing center of South China? The case of Jiangsu Province. *Energy Policy* **2011**, *39*, 7078–7083.
6. Geng, Y.; Zhao, H.Y.; Liu, Z.; Xue, B.; Fujita, T.; Xi, F.M. Exploring driving factors of energy-related CO_2 emissions in Chinese provinces: A case of Liaoning. *Energy Policy* **2013**, *60*, 820–826.
7. Tian, X.; Chang, M.; Tanikawa, H.; Shi, F.; Imura, H. Structural decomposition analysis of the carbonization process in Beijing: A regional explanation of rapid increasing carbon dioxide emission in China. *Energy Policy* **2013**, *53*, 279–286.
8. Wang, Y.F.; Zhao, H.Y.; Li, L.Y.; Liu, Z.; Liang, S. Carbon dioxide emission drivers for a typical metropolis using input-output structural decomposition analysis. *Energy Policy* **2013**, *58*, 312–318.

9. Dietzenbacher, E.; Hoen, A.R. Deflation of input-output tables from the user's point of view: A heuristic approach. *Rev. Income Wealth* **1998**, *44*, 111–122.
10. Durand, R. An alternative to double deflation for measuring real industry value-added. *Rev. Income Wealth* **1994**, *40*, 303–316.
11. United Nations Department for Economic and Social Affairs Statistics Division (UNDESASD). *Hand Book of Input-Output Table Compilation and Analysis*; United Nations: New York, NY, USA, 1999.
12. One-Child Policy. https://en.wikipedia.org/wiki/One-child_policy (accessed on 9 December 2015).
13. Map of the People's Repiblic of China. http://219.238.166.215/mcp/MapProduct/Cut/英文政区版/5000万英文政区版(南海诸岛)/Map.htm (accessed on 9 December 2015).