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From production-based to consumption-based regional carbon inventories: Insight from spatial production fragmentation

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HIGHLIGHTS

- We analyze the link from production-based to consumption-based accounting.
- We trace carbon transfer path along production chains at the spatial level.
- The average economic length of carbon transfer within China in 2010 was 1.34.
- Spatial production fragmentation hinders the shift of carbon accounting.
- There is a negative relation between economic length and magnitude of carbon transfer.

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ABSTRACT

The key distinction between production-based and consumption-based accounting lies in the way in which trade-embodied emissions are allocated between producer and consumer regions. Yet, these two regions are not necessarily directly connected to each other in supply chains, due to spatial production fragmentation. To better understand the link from the production-based to the consumption-based regional carbon inventories, this paper defines the economic length of carbon transfer (ELCT) as the number of administrative border-crossing involved in the influence process of a region's final demand on the carbon emissions of another region. Using a multi-regional input-output analysis framework for China, we propose an approach to calculating the ELCT related to a region's production or demand for domestic consumption or international export. We find that the average ELCT in 2010 is 1.34 and that more than a quarter of interregional carbon transfer crosses provincial borders twice or more. The provincial and sectoral analysis of ELCT reveals that spatial production fragmentation is an important challenge to be conquered for successful implementation of consumption-based climate regulations.

1. Introduction

To reflect consumers' responsibility for climate change, prior research [1–8] has proposed consumption-based accounting as an appropriate alternative to production-based accounting. The crucial difference between these two accounting approaches lies in the attribution of carbon transfer through cross-border trade flows. A growing number of previous studies [6,7,9–18] has evaluated the magnitude and direction of carbon transfer through interregional trade. Yet, little attention has been paid to an important feature of the modern economy, namely that the spatial production fragmentation has been significantly reshaping interregional trade patterns in recent decades [19]. For instance, trade in intermediate products accounts for approximately two thirds of the world gross trade, and intermediate products may cross provincial or national borders multiple times before they are finally absorbed into products purchased by consumers. A region's influence power on the carbon emitter decreases gradually with increasing border-crossing frequency because of international differences in fields of politics, economy and culture. Thus, this paper attempts to fill this research gap and analyzes the link from production-based to consumption-based accounting from the perspective of spatial production fragmentation.

For the traditional "Ricardian" trade pattern, only two regions are involved, and traded products cross their border only once [20,21]. The corresponding carbon transfer route is simple and allows an easy shift from the production-based to consumption-based accounting. With the

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development of spatial production fragmentation, several regions may be involved in the production chain of traded products, and the interregional carbon transfer routes become more complex. As noted by Turner et al. [22], regional jurisdictions provide the main reason for the difficulty in shifting from production-based to consumption-based accounting. With a greater number of regions/countries involved in the supply chains, it is more difficult to shift from production-based to consumption-based accounting because the producer and consumer regions are not necessarily directly connected to each other in global production networks. This problems call for a thorough analysis of carbon transfer from the perspective of spatial production fragmentation. Such a task is undertaken here by an analysis on the economic length of carbon transfer (ELCT).

This paper assumes that the economic distance between any two regions is one and uses the frequency of border-crossing of traded products [23] to define an average ELCT, which essentially accounts for the number of times a product is traded across regional borders. A smaller ELCT implies a more direct economic linkage between carbon emitters (i.e., producers of raw, intermediate or finished goods) and consumers; and a greater ELCT suggest that the emitter and the consumer are connected through multiple intermediate trading parties. For instance, the ELCT for the traditional "Ricardian" trade is one; whereas the intermediate products cross national borders multiple times. The magnitude of ELCT increases with the degree of spatial production fragmentation. Furthermore, the ELCT is directional and is related to but different from the geographical distance between regions. For example, the average ELCT from region A to region B (with A being the producer and B being the consumer) is not necessarily equal to the average ELCT from region B to region A (with B being the producer and A being the consumer).

Production-based and consumption-based accounting are two ways of handling carbon allocation along the supply chain [24]; the former allocates emissions occurring in the regional territory where production takes place while the latter allocates emissions to the region where consumption occurs. We believe a new insight into the nature and complexity of the gap between these two extremes from the perspective of spatial production fragmentation could also help in understanding the shared responsibility proposed by the literature [24,25]. Despite its importance, the shared responsibility is not the primary focus of this paper. In addition, the policy implications of this approach also lie in providing an important basis for trade-related climate regulations [26,27]. Considering the difficulty involved in the worldwide cooperation in carbon reduction, it is more feasible for the implication of the consumption-based accounting within a country's territory boundary. Therefore, this paper distinguishes between provincial and national borders and focuses mainly on sub-national ELCT. The major contribution of this paper lies in remapping carbon transfer among different provinces in China from both perspectives of magnitude and ELCT. The paper is organized into five sections. Section 2 reviews the relevant literature. Section 3 describes the methodology used to calculate the ELCT. Section 4 presents the simulation results. Conclusions and policy implications are presented in Section 5.

2. Literature review

Production-based and consumption-based accountings are the two most common carbon accounting methods. Peters [5] proposes two approaches to shift from the production-based accounting to the consumption-based accounting. The first approach considers bilateral trade (EEBT) and does not distinguish between final and intermediate product trade. As the EEBT approach focuses on carbon emissions embodied in bilateral direct traded flows, its ELCT is always one. The second approach uses multi-regional input-output analysis (MRIOA), and intermediate product trade is endogenously determined, as are the effects of spatial production fragmentation on the allocation of carbon responsibility. In order to reveal the effects of spatial production fragmentation on the allocation of carbon reduction responsibility, this study decomposes the trade flow of all (intermediate and finished) products and derives the ELCT based on the MRIO data.

The present paper is closely related to the literature that evaluates the environmental effects of production fragmentation [18,19,23,28–39]. Dean and Lovely [28] find that production fragmentation reduces the pollution intensity of China's exports while Meng et al. [36] have been able to trace carbon emissions along global value chains and thus to evaluate the environmental effects of cross-country production sharing. Lin et al. [33] evaluate the role of China' international exports in that country's air pollution, and their later works [34,39] analyze the impacts of global multi-lateral trade on climate forcing and public health and thus promote the idea of globalizing air pollution. Zhang et al. [19] test the pollution haven hypothesis from the perspective of global production fragmentation. The existing studies focus mainly on a country's incorporation into the global supply chain [40], but the scale of interregional trade within some large countries, such as China [41], may be significantly greater than that of international trade. In particular, China's rapid economic development in recent years has promoted the production fragmentation among different provinces [42,43].

The differences in regional carbon responsibility between a consumption-based and a production-based accounting can be explained from the perspective of carbon transfer. A growing literature exists on carbon transfer within China [4,9,35,44]. It is found that approximately half of China's emissions are induced by interprovincial trade and the net carbon transfer direction is from the central and western regions to the coastal region [4]. The central and western regions are China's important resource bases for raw materials that may be processed sequentially by several different regions. This means that the traded products may cross provincial borders multiple times, and thus the carbon transfer becomes much more complex. The existing studies focus mainly on the magnitude and direction of carbon transfer [6,7,14–17] and less on the inter-regional routes of carbon transfer. To the best of our knowledge, no studies have analyzed the carbon transfer within China from the perspective of the border-crossing frequency associated with traded products. Thus the present paper embraces the perspective of production fragmentation to provide new insight on carbon transfer within China.

The input-output model is also widely used to measure the production fragmentation by the number of production stages [45–50]. Dietzenbacher et al. [46] define the average production lengths (APL) to identify the production chains. Antràs et al. [45] propose the expression upstreamness to measure the position in production networks. The differences between APL and ELCT are summarized below. (1) The APL measures the economic distance between two sectors [46], and the ELCT measures the economic distance between the carbon emitting region and the final consuming region. (2) APL reflects the average number of production stages it takes a stimulus in one industry to affect another industry. ELCT is related to the number of regions that are involved in the interregional carbon transfer and focuses mainly on the transnational production stages. (3) APL could be adopted to analyze the production chains in a certain country (Dietzenbacher et al., 2005) based on single region input-output analysis framework. However, the calculation of ELCT is based on multi-regional input-output analysis framework.

Two approaches exist to calculate border-crossing frequencies associated with trade products. The first approach decomposes the intermediate input matrix [49,51]. Zhang et al. [23] propose a second approach that decomposes the Leontief inverse matrix. Zhang and Zhu [52] use this method to evaluate the effects of border-crossing frequencies on the effectiveness of trade-related climate regulations. This present paper extends Zhang et al.'s study [23] by highlighting another important policy implication of border-crossing frequencies associated with carbon footprints from the perspective of regional carbon accounting. From the methodological perspective, this present study extends Zhang et al.'s study [23] by introducing the Structural Path Analysis (SPA) [53–58] to map carbon emissions embodied in cross-border trade flows. The existing studies mainly analyze the transfer paths from the sectoral perspective; to the best of our knowledge, this present paper is the first study that uses SPA to analyze the transfer routes of embodied emissions from a spatial perspective.

3. Methodology and data

This paper defines the ELCT based on the border-crossing frequency associated with carbon footprints proposed by Zhang et al. [23]. Border-crossing frequency represents the number of borders a product crosses in a supply chain before it is absorbed by the consuming region. The literature has provided a detailed explanation on the calculation of border-crossing frequency associated with carbon footprint. Therefore, this section mainly presents how we extend Zhang et al.'s study (2017) from the perspective of methodology.

First, this paper distinguishes between provincial and national borders. The outputs of a province may be absorbed directly or exported to other provinces or foreign countries. This paper divides provincial emissions into four parts. The first part is induced by pure provincial economic activity that has no relation with interprovincial or international border crossing. The second part is induced by products that are directly exported to foreign countries and is only related to international border crossing. The third part is generated to support the production of interprovincial exported products, which will not cross China's national border. The fourth part represents emissions embodied in interprovincial traded products that would finally be exported to foreign countries.

Second, this paper focuses mainly on the allocation of carbon responsibility among provinces in China. International border crossing is not analyzed in this study. Based on the number of provincial borders that traded products cross, we quantitatively evaluate the economic length of carbon transfer path within China. This paper further divides carbon transfer between two certain provinces based on whether the exported products will be further exported to foreign countries or not. We defines the economic length of carbon transfer for domestic final demand ($ELCTd$) and exports ($ELCTf$), respectively. It is found that the average ELCT within China is arithmetical mean of $ELCTd$ and $ELCTf$ weighted by volumes of carbon transfer for domestic final demand and international export.

Third, this paper introduces SPA to map the carbon transfer path at spatial perspective. To satisfy domestic final demand, a province needs to buy final or intermediate products from other provinces and these provinces would generate carbon emissions. To produce these exported products, these provinces also need to import intermediate inputs and meanwhile carbon emissions are released. There would be an infinite number of carbon transfer paths between two certain provinces. However, the scale of carbon transfer would decrease with the increase of border-crossing frequency. SPA also allows us to find the most important path of carbon transfer between any two regions.

The mathematical model of this present paper is presented in Appendix A. We apply the proposed method to a multi-regional input-output table of China in 2010 [59]. The provincial carbon emissions are obtained from China emission accounts and datasets (CEADs) [60]. The multi-regional input-output table includes 30 sectors for 30 regions (please refer to Appendix B).[1] CEADs provide carbon emissions for 45 sectors in 30 regions. In order to bridge these two databases, we first aggregate the last four service sectors in the multi-regional input-output table into one sector. Second, the carbon emissions data from CEADs are also aggregated into the corresponding 27 sectors (please refer to Appendix C).

4. Results

4.1. Decomposition of provincial emissions

According to Eq. (4), this study calculates production-based and consumption-based provincial emissions and decomposes four types of economic activities for each perspective. This study only focuses on the allocation of carbon emissions within China. Under the production-based accounting, the embodied emissions are allocated to the sources of carbon transfer within China. Under the consumption-based accounting, the embodied emissions are attributed to the destinations of carbon transfer within China.

Fig. 1a and b present the production-based and consumption-based provincial emissions in 2010 respectively. The inland provinces are important suppliers of raw materials that are used to support the consumption of the coastal regions. In addition, export enterprises are mainly located in the coastal provinces, such as Guangdong, Zhejiang, and Jiangsu. The inland provinces provide raw materials to support the production of the international exported products. Therefore, the coastal provinces correspond to greater carbon emissions under the consumption-based accounting. The net carbon transfer within China is from the inland provinces to the coastal provinces. To reveal the difference between production-based and consumption-based provincial emissions, this study further decomposes provincial emissions into four parts.

The first part (blue bar) is induced by provincial domestic economic activities to support that province's final consumption, and it is not related to any border crossing. The second part (direct international exports, red bar) is generated to support production of products that are directly exported to foreign countries. The third part (interprovincial exports, green bar) is generated to support the interprovincial trade and the traded products do not cross the national border. The fourth part (indirect international exports, purple bar) is induced by interprovincial trade in that the traded products are finally exported to foreign countries. Fig. 1b presents the counterpart consumption-based emissions. The first two parts are the same as those in Fig. 1a. The third part represents other provinces' emissions generated to support a province's final consumption through interprovincial exports. The fourth part represents other provinces' emissions generated to support a province's international exports.

The first and third parts of the emissions are generated to support the domestic final demand, and together they account for a greater share than the other two parts (for international exports). The second and fourth parts of emissions are associated with production of goods exported to foreign countries. Su and Ang [9] found that 18.55% of China's carbon emissions in 2010 were induced by international exports, close to our value at 17.24% (10.33% for the second part and 6.91% for the fourth part). The difference between production-based and consumption-based regional emissions are mainly lie in the third and fourth parts of emissions, which are related to the carbon transfer within China. The third part is related to the carbon transfer for domestic final demand, and the fourth part is related to the carbon transfer for international exports. The close economic linkages between different provinces result in that a significant share of provincial emissions being induced by interprovincial cross-border trade flows. Thus a comprehensive knowledge on the carbon transfer is important for regional cooperation on carbon reduction. The following sections mainly discuss the ELCT for interprovincial trade from provincial, bilateral and bilateral-sector perspectives.

4.2. Provincial perspective

The production-based accounting allocates emissions embodied in

[1] Due to data limitation, Tibet and Taiwan are not analyzed in this paper. It should be pointed out that the ELCT would increase with the spatial disaggregation. However, this paper focuses on the effect of regional jurisdiction on the allocation of carbon responsibility. Smaller sub-regions tend to have lower autonomy. Therefore, we do not suggest further splitting China into smaller sub-regions.

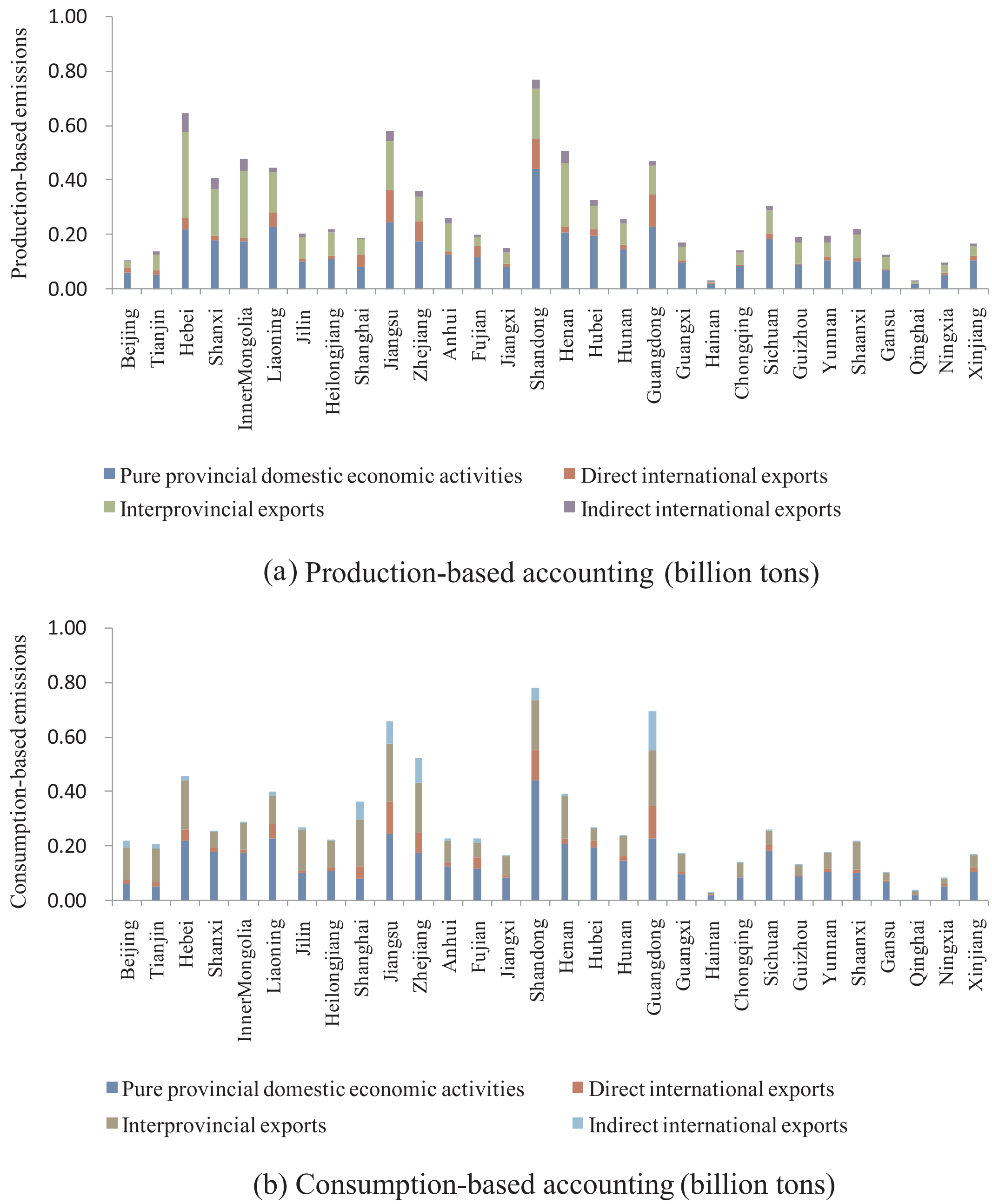


Fig. 1. Decomposition of production-based and consumption-based carbon emissions of China's 30 provinces in 2010.

interregional trade to the sources of carbon transfer (forward industrial linkage), while the consumption-based accounting allocates embodied emissions to the destinations of carbon transfer (backward industrial linkage). Under the production-based accounting, the average ELCT reflects the average number of borders that traded products produced by that province cross until the products are consumed by domestic consumers or exported to foreign countries. Under the consumption-based accounting, the average ELCT reflects the average number of borders that traded products cross until the products are finally consumed or exported by a certain province. The calculation results for the 30 provinces, which are classified into three regions, are presented in Table 1.

From a national average basis, the ELCT results are equal from the perspectives of forward and backward industrial linkages. The average ELCT for international exports (ELCT_f) is 1.28, and the average ELCT for domestic final demand (ELCT_d) is 1.35. ELCT_f is slightly shorter than ELCT_d, reflecting that for foreign consumption only some segments of global production chains are located in China. The average ELCT within China (ELCT = 1.34) is the arithmetical mean of ELCT_d and ELCT_f weighted by volumes of carbon transfer for domestic final demand and international export. ELCT is close to ELCT_d because of a much greater volume of interprovincial trade for domestic final demand than for international export. For any given province, the production-based ELCT (for forward linkage) is not necessarily equal to the consumption-based ELCT (for backward linkage). For instance, the average ELCT from Beijing to other regions is 1.17, while the average ELCT from other regions to Beijing is 1.30. This finding may be traced to the fact industrial products account for a greater share in interprovincial imports of Beijing than that of its interprovincial exports; further, the industrial products have a greater degree of production fragmentation. Li et al. [61] point out that Beijing tends to outsource black carbon emissions to industrial provinces, such as Hebei. Chen and Chen [62] find that the magnitude of carbon transfer from Hebei to Beijing was 65 million tons, and the scale of carbon flows in metal and non-metal

Table 1
Average ELCT within China in 2010 at the provincial level.

		Forward industrial linkage			Backward industrial linkage		
		ELCT_f	ELCT_d	ELCT	ELCT_f	ELCT_d	ELCT
Coastal region	Beijing (BJ)	1.31	1.16	1.17	1.31	1.30	1.30
	Tianjin (TJ)	1.29	1.35	1.34	1.28	1.33	1.32
	Hebei (HB)	1.24	1.38	1.35	1.24	1.31	1.30
	Liaoning (LN)	1.42	1.33	1.34	1.39	1.43	1.42
	Shanghai (SH)	1.31	1.20	1.21	1.29	1.33	1.32
	Jiangsu (JS)	1.27	1.33	1.32	1.28	1.33	1.32
	Zhejiang (ZJ)	1.20	1.31	1.29	1.27	1.27	1.27
	Fujian (FJ)	1.17	1.31	1.28	1.40	1.45	1.44
	Shandong (SD)	1.30	1.30	1.30	1.17	1.22	1.21
	Guangdong (GD)	1.36	1.31	1.32	1.29	1.33	1.31
	Guangxi (GX)	1.20	1.39	1.34	1.43	1.46	1.46
	Hainan (HA)	1.27	1.33	1.32	1.43	1.49	1.48
Middle region	Shanxi (SX)	1.35	1.47	1.45	1.44	1.55	1.54
	InnerMongolia (NM)	1.36	1.45	1.43	1.42	1.45	1.45
	Jilin (JL)	1.34	1.32	1.32	1.15	1.25	1.24
	Heilongjiang (HL)	1.39	1.37	1.37	1.38	1.43	1.42
	Anhui (AH)	1.23	1.27	1.26	1.38	1.38	1.38
	Jiangxi (JX)	1.19	1.37	1.32	1.20	1.19	1.19
	Henan (HE)	1.27	1.31	1.31	1.29	1.46	1.46
	Hubei (UB)	1.24	1.32	1.31	1.26	1.31	1.30
	Hunan (HU)	1.19	1.23	1.23	1.30	1.38	1.38
Western region	Chongqing (CQ)	1.24	1.26	1.25	1.30	1.32	1.32
	Sichuan (SC)	1.27	1.30	1.29	1.37	1.43	1.43
	Guizhou (GZ)	1.29	1.37	1.35	1.42	1.46	1.46
	Yunnan (YN)	1.19	1.43	1.35	1.40	1.49	1.49
	Shaanxi (SA)	1.29	1.34	1.33	1.31	1.38	1.38
	Gansu (GS)	1.34	1.46	1.44	1.26	1.31	1.31
	Qinghai (QH)	1.37	1.56	1.51	1.21	1.31	1.30
	Ningxia (NX)	1.42	1.42	1.42	1.29	1.38	1.37
	Xinjiang (XJ)	1.41	1.43	1.43	1.41	1.41	1.41
National		1.28	1.35	1.34	1.28	1.35	1.34

manufacture products reached as much as 19 million tons.

Fig. 2 further classifies the 30 provinces into four types according to their average ELCT relative to the national average length (1.34). For the first type of provinces, their average ELCT is greater than the national average level from the perspectives of both forward and backward industrial linkages. Many provinces in this group are China's energy bases, including Shanxi, Inner Mongolia, Xinjiang and Ningxia. These provinces provide raw materials and resources to support the industrial production of other provinces, from which they may purchase final products. Production fragmentation of the industrial products determines that these resource-providing provinces have a longer average ELCT from both forward and backward perspectives.

The second type of province has an ELCT above (below) the national average from a backward (forward) linkage. These provinces are often located in the middle region, such as Henan, Hunan, and Anhui. A significant amount of carbon emissions of these provinces is transferred to coastal provinces [35]. The intermediate products account for a greater share in the bilateral trade, leading to a relatively short forward ELCT. In contrast, products from inland provinces (middle and western) may be first processed in the coastal region and then exported to the middle region, leading to an above-national-average ELCT from the backward perspective. The third type of provinces has below-national-average ELCT for both forward and backward industrial linkages, such as Guangdong, Zhejiang, and Shandong. These provinces are all located in the coastal region. There exists large scale of carbon transfer among provinces located in the coastal region, and the corresponding ELCTs are relatively small (Section 4.3 provides a more detailed discussion). Sheng and Lu [63] point out that China's producer services industry tend to concentrate in the eastern coastal areas. Service industry generally requires fewer production stages. There exist some special cases. Fujian and Jiangxi are neighboring provinces. However, these two countries correspond to different carbon transfer path. The consumption of Jiangxi contributes most to the emissions generated in Hubei. Jiangxi and Hubei are geographically connected to each other. Therefore, Jiangxi corresponds to a low ELCT from the perspective of backward industrial linkage. By the contrast, Fujian has a greater ELCT than the national average level and is located in the second quadrant. This is because Fujian imports large scale of industrial products from other provinces. Hebei is the major source of carbon transfer to Fujian.

The fourth type of provinces have an ELCT above (below) the national average from a forward (backward) linkage, such as Hebei and Qinghai. The final demand and international exports of Hebei mainly promote the carbon emissions of the neighboring provinces, such as Shanxi, Inner Mongolia, and Liaoning. The traded products mainly comprise natural resources, which tend to be transferred to Hebei directly; hence, the average backward ELCT is short. In contrast,

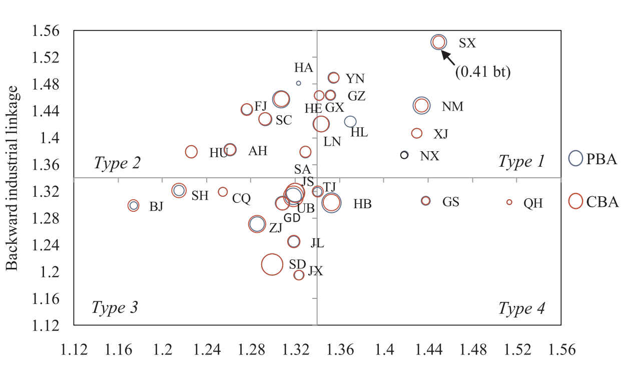


Fig. 2. Classifications of the 30 provinces by average ELCT. Notes: the abbreviated names of the 30 provinces are presented in Table 1. PBA means production-based accounting, and CBA means consumption-based accounting.

emissions embodied in interprovincial exports of Hebei are mainly transferred to the eastern coastal provinces with the traded products mainly comprising industrial products with longer production chains. Therefore, Hebei's forward ELCT is above the national average. Qinghai's backward ELCT is short because a large volume of electricity is transferred from Gansu and Xinjiang to Qinghai. Qinghai's forward ELCTis long, because it exports many raw materials to various provinces before these products are finally consumed by the coastal region.

A greater ELCT (for either a forward or a backward industrial linkage) means a greater practical difficulty to convert from production- to consumption-based accounting, because more regions are involved in this process. Fig. 2 shows that the net carbon exporters are mainly located in the first, second and fourth quadrants. This means that these provinces experience above-national-average complex supply chains, and it is practically harder for them to construct a consumption-based accounting, due to wider system boundary [5]. In addition, the coastal regions are mainly located in the third quadrant and correspond to a relatively lower ELCT. However, the coastal regions will bear more carbon reduction responsibility under a consumption-based accounting, and thus they will resist such an accounting.

4.3. Bilateral perspective

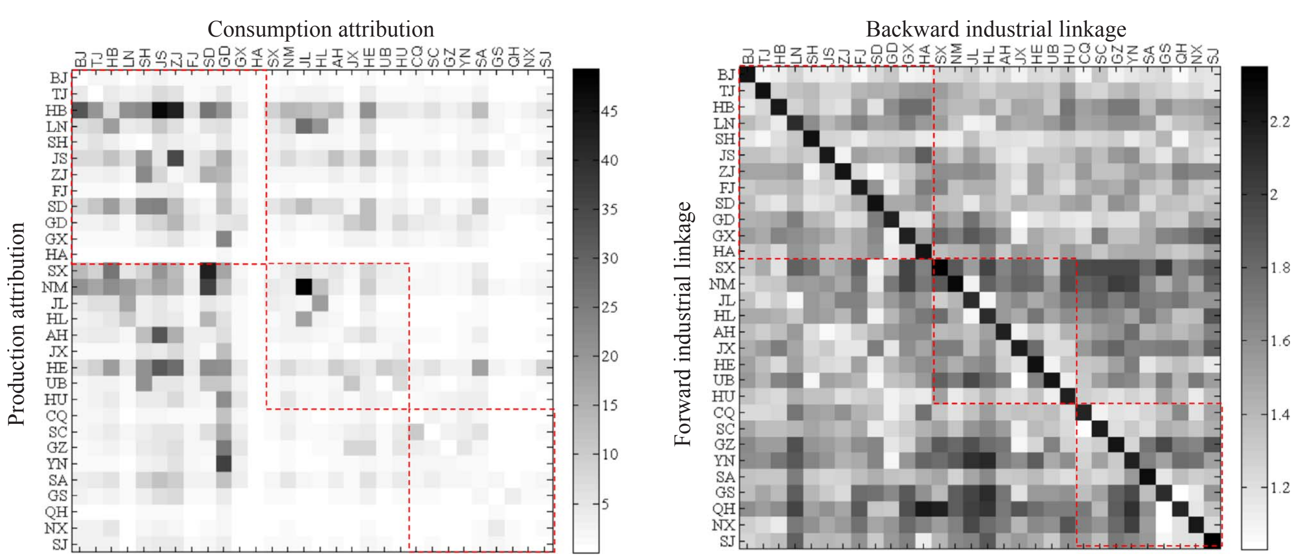
This section analyzes the carbon transfer between source province and destination province from a bilateral perspective. Fig. 3 presents the carbon transfer among the 30 provinces, which are divided into three regions—coastal, middle and western—according to Table 1. The carbon transfer shown here is induced both by final demand and by international exports.

Fig. 3a shows that the carbon transfer within China is mainly from the middle and western regions to the coastal region. For instance, the volume of carbon transfer from the middle to the coastal region reaches 879.15 million tons. The coastal region is China's most developed region, and its prominent interprovincial trade flows correspond to large scale carbon transfer. The middle and western regions are China's energy base with greater carbon intensities. Thus, the large scales of consumption demand and international exports of the coastal region obviously contribute to carbon emissions of the middle and western regions [61]. The scale of carbon transfer from the middle and western regions to the coastal region is greater than the scale of carbon transfer from the coastal region to the middle and western regions. The balance of embodied emissions from the middle and western regions to the coastal region is 460.89 million tons and 171.08 million tons, respectively. This means that the net carbon transfer direction within China is from the middle and western regions to the coastal region, consistent with Feng et al.'s study [4] and Zhao et al.'s study [43].

Fig. 3b presents the average ELCT for forward and backward linkages. For carbon transfer among provinces within the three regions, the average ELCTs of the middle (1.42) and western (1.32) regions are greater than that of the coastal (1.31) region. Production fragmentation within China is closely related to the regional resource endowments. The middle and western regions provide raw materials and resources to support the production in the coastal region, and the final products may return to and be finally consumed by the middle and western regions. Therefore, the carbon transfer within the middle and western regions corresponds to a greater average ELCT. In addition, the carbon transfer between the middle and western regions also corresponds to a greater ELCT. However, the middle and western provinces are less involved in the carbon transfer among provinces located in the coastal region; as a result, the carbon transfer within the coastal region is short.

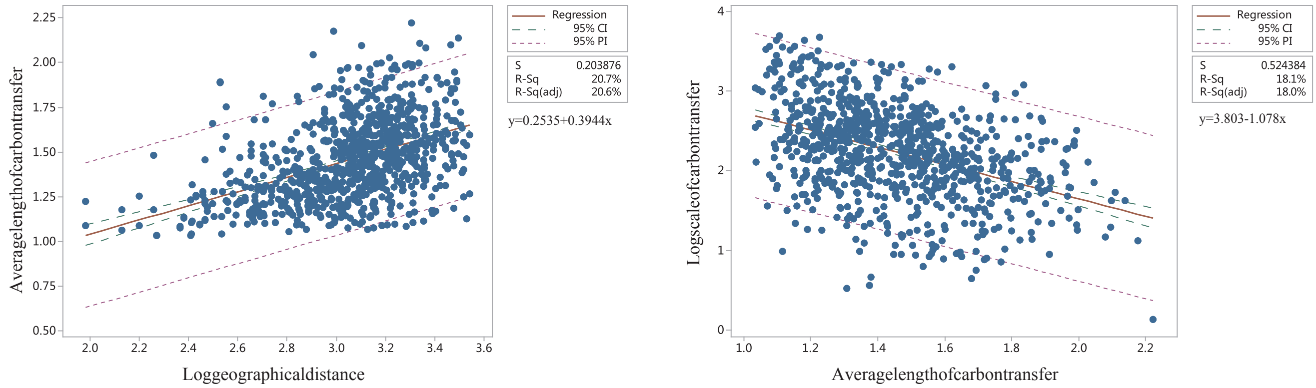
Fig. 3b shows that the average ELCT between any two provinces is greater than one because the interprovincial traded products cross provincial borders at least once. The traded products need to cross provincial borders at least twice to return to the exporting province; thus, the diagonal elements of Fig. 3 are greater than 2. However, the scale of carbon transfer that will return to the local province is small (Fig. 3a). In addition, the average ELCT between neighboring provinces tends to be shorter, such as the average ELCT from Anhui to Jiangsu that is only 1.06. This suggests a need to further analyze the relationship between the average ELCT and the geographical distance and the relationship between the average ELCT and the scale of carbon transfer. The regression results are presented in Fig. 4.

Fig. 4 shows that the ELCT is positively associated with geographical distance and is negatively related to the scale of carbon transfer. For instance, the scale of carbon transfer from the middle region to the coastal region is greater than the scale of carbon transfer from the western region to the coastal region, and the average ELCT from the middle region to the coastal region (1.31) is lower than the average ELCT from the western region to the coastal region (1.34). However, the average ELCT cannot be simply measured by the geographical distance. For instance, the average ELCT from the western region to the coastal region (1.38) is shorter than the average ELCT from the western region to the middle region (1.48), although the middle and western regions are closer geographically. This



(a) Volumeof carbon transfer (million tons) (b) Length of carbon transfer

Fig. 3. Mapping carbon transfer within China in 2010 at the bilateral level.



(a) The relation between the geographical distance and the average ELCT

(b) The relation between the average length and scale of carbon transfer

Fig. 4. The relationships among the geographical distance, the scale of carbon transfer, and the average ELCT.

demonstrates that the average ELCT could provide new insight for understanding carbon emissions embodied in interregional trade, especially from the perspective of spatial production fragmentation.

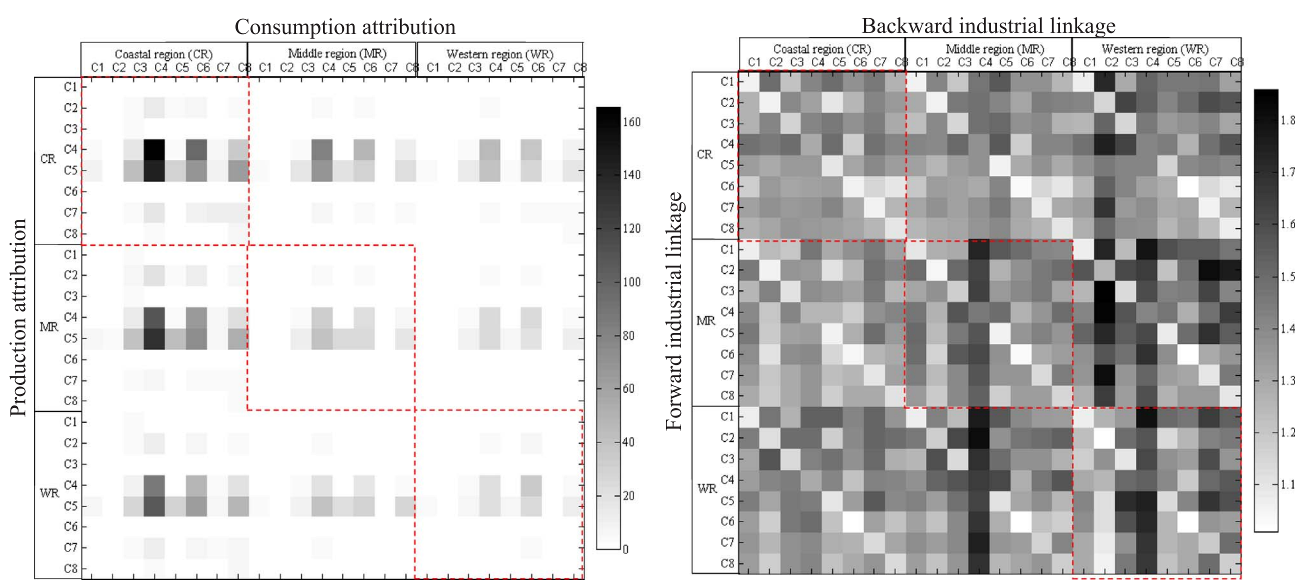
A greater volume of carbon transfer means a greater political resistance from the net carbon importing regions, while a greater ELCT means a greater practical resistance. Fig. 4 shows that the neighboring provinces tend to face a greater volume of carbon transfer (greater political resistance) which corresponds to shorter economic distance (lower practical resistance). The volume of carbon transfer between two regions that are far away from each other is small (lower political resistance), and the corresponding ELCT is long (greater practical resistance). This implies that it is difficult to satisfy lower political and practical resistance simultaneously, which is called a paradox of shifting from production- to the consumption-based accounting.

4.4. Bilateral-sector perspective

We further analyze the carbon transfer within China from a bilateral-sectoral perspective. To present the results clearly, we aggregate the 30 provinces into three regions and aggregated the 27 sectors into eight sectors (see Appendixes B and C). Fig. 5 maps the carbon transfer among China's three regions for eight sectors in 2010.

Fig. 5a presents the scale of carbon transfer within three regions for eight sectors in 2010. From the horizontal perspective, the interregional trade within China mainly promotes the carbon emissions of the heavy industry sector (C4), followed by the electricity, steam, gas and water production and supply sector (C5). These two sectors also generate most of the direct emissions of China and are the major focus of China's climate regulations, such as the forthcoming national emissions trading system. It is suggested that China's carbon trading system could adopt the technology-adjusted carbon accounting approach to credit the greener trade patterns within China [64], which will promote the carbon reduction of these two sectors. From the vertical perspective, the major destinations of carbon transfer are the heavy industry sector (C4), the construction sector (C6), and the other services sector (C8). The final goods of the construction sector and the service sector are mainly used to satisfy domestic final demand, while the products of the heavy industry sector are not only consumed by domestic consumers but also account for a significant share of China's gross exports. This suggests that cleaning up the supply chains of the exported products will play an important role in reducing China's terrestrial emissions.

Fig. 5b maps the average ELCT among the three regions in eight sectors. Fig. 5b comprises nine sub-matrixes, whose diagonal elements are all relatively small. This result arises because firms from the same



(a) Scale of carbon transfer (million tons)

(b) Length of carbon transfer

Fig. 5. Mapping carbon transfer within China in 2010 from the bilateral-sector perspective. Notes. The x dimension represents the sources of carbon transfer and the y dimension represents the destinations of carbon transfer. We provide the average length of two types of carbon transfer in Appendix E.

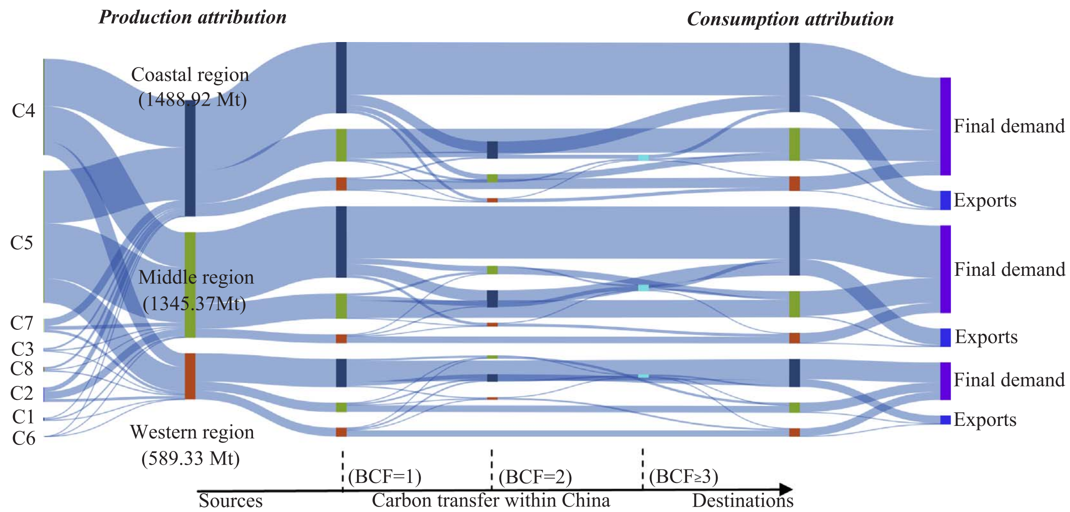


Fig. 6. Sankey diagram of carbon transfer within China. Notes, the widths of indicated flows represent the scale of carbon transfer. The coastal, middle and western regions are represented by three types of colors. We do not distinguish three regions any more for the carbon transfer that crosses provincial border more than twice (border crossing frequency (BCF) ≥ 3). The left-hand side of the map shows the magnitude of sectoral emissions induced by interregional trade. The right-hand sided of the map makes a distinction between carbon transfer for domestic final demand and exports. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

sectors have relatively closer economic linkages, and the average length of the corresponding carbon transfer tends to be small. Nonetheless, the heavy industry sector (C4) includes several different sub-sectors (see Appendix E) with greater ELCT among them, thus the average ELCT from sector C4 to C4 is relatively greater than the other diagonal elements (from C1 to C1, from C2 to C2, etc.). From the perspective of forward industrial linkage, the mining sector (C2) corresponds to the greatest average ELCT (1.39), followed by the electricity, steam, gas and water production and supply sector (C5, 1.36). The products of these two sectors are important raw materials and energy resources, and firms of these two sectors tend to be located in the upstream position of the production chains that may be distributed among different provinces. Therefore, these two sectors have a greater average ELCT. From the perspective of backward industrial linkage, the heavy industry sector (C4) corresponds to the greatest average ELCT (1.39). This means that the production of heavy industry has a greater degree of production fragmentation within China. Policy makers should focus mainly on the allocation of emissions generated in the mining and electricity generation sector to support the production of other sectors.

The Sankey diagram in Fig. 6 shows the carbon transfer within China, taking into account border-crossing frequency associated with traded products. From the perspective of the source of carbon transfer, interregional trade mainly promotes carbon emissions of the heavy industry sector (C4), the electricity generation sector (C5), and the mining sector (C2). About 90.42% of carbon emissions embodied in interregional trade are generated in these three sectors. The heavy industry corresponds to large trade scale and great carbon intensity; thus, a large volume of their emissions is induced by interregional trade. The interregional transfer of the electricity and mining products within China is common in China, and the electricity generation sector provides raw material to support the production of traded products. Therefore, these two sectors also generate large scale carbon transfers.

Fig. 6 classifies different types of carbon transfer by the length, as the traded products may be processed in different provinces. About 73.46% of interregional carbon transfer crosses provincial borders once, 20.79%of interregional carbon transfer crosses provincial borders twice, and 5.75% of the interregional carbon transfer crosses provincial borders three times or more. Fig. 6 shows that the scale of carbon transfer for domestic final demand is much greater than that of carbon transfer for exports. Moreover, the interregional carbon transfer is mainly induced by the final demands and exports of the coastal region. Consumption-based accounting would reduce the carbon reduction responsibility faced by the middle and western regions. However, the spatial production fragmentation would result in a greater uncertainty and hinders the shift of carbon accounting.

5. Conclusions

Given the fragmentation of production systems in recent decades [65], shifting from production-based accounting to consumption-based accounting becomes challenging because the carbon transfer through cross-border trade flows is increasingly complex. This study attempts to provide new insight for understanding the carbon transfer by revealing the frequencies of cross-border trade, i.e., the ELCT.

We find that about 73.46% of interregional carbon transfer crosses provincial borders once, 20.79%of interregional carbon transfer crosses provincial borders twice, and 5.75% of the interregional carbon transfer crosses provincial borders three times or more. The average ELCT within China in 2010 was 1.34. However, there exist obvious differences in the ELCT from the provincial, bilateral and sectoral perspectives. First, the ELCT for the nation's international exports (1.28) was shorter than the ELCT for domestic final demand (1.35). Secondly, the consumption-based accounting reduces the carbon reduction responsibility of the inland provinces. However, the inland provinces have greater ELCT than the coastal provinces and correspond to greater practical difficulty in moving from production-based to consumption-based accounting. Thirdly, from the perspective of forward industrial linkage, the carbon transfer that begins with the mining sector corresponds to the greatest ELCT (1.39). From the perspective of backward industrial linkage, the carbon transfer that end with the heavy industry sector corresponds to the greatest ELCT (1.39). Fourth, the average ELCT is negatively associated with the volume of carbon transfer and is positively related to the geographical distance. This means it is difficult to satisfy lower political and practical resistance simultaneously during the shifting from production-based to consumption-based accounting.

The study has some limitations. Carbon transfer within China is divided into two types, namely the carbon transfer for exports and the carbon transfer for domestic final demand. The export producers tend to have relatively lower carbon intensity than the national average level [17], particularly in the foreign-invested enterprises [29,66,67]. However, this paper does not distinguish between supply chains for exports and chains for domestic final demand because the input-output model assumes that the output of each sector is homogeneous. This limitation would result in an overestimation of the scale of carbon transfer for exports and influences the measure of the average ELCT. In addition, the calculation of carbon transfer within China is subject to uncertainty in the input-output table and emissions factors. It is suggested that the future studies could adopt other data sets for multi-regional input-output tables of China [68] and emissions factors [69] to discuss the uncertainty in ELCT. Finally, exports of intermediate products account for a significant share of China's gross exports, and such products may return to China and be consumed by its domestic consumers [70]. However, this paper focuses only on the supply chains within China and cannot account for such international trade. Future studies could apply the proposed method to an inter-country input-output table that also includes countries' interregional input-output table [71–73]. The proposed method could be used to evaluate other types of emissions or resources embodied in inter-regional trade. It could also be adopted to evaluate the degree of spatial production fragmentation [65].

Acknowledgements

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Appendix A. Mathematical model of this paper

Assume a country that is composed of G regions. Each region produces tradable products in N sectors. The economic outputs (in monetary units) are used to satisfy the intermediate demand, the domestic final demand and the international exports. The original input-output monetary flows are balanced as:

$$X = Z + Y + R, \tag{1}$$

where X denotes the $GN \times 1$ gross output vector of all regions, Z denotes the $GN \times GN$ intermediate input matrix, Y denotes the $GN \times G$ domestic final demand vector of all regions, R denotes the $GN \times 1$ international export vector of all regions. We assume $\hat{R} = \begin{bmatrix} \hat{R}_{11} & 0 & \cdots & 0 \\ 0 & \hat{R}_{22} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \hat{R}_{GG} \end{bmatrix}$, $\hat{Y} = \begin{bmatrix} \hat{Y}_{11} & \hat{Y}_{12} & \cdots & \hat{Y}_{1G} \\ \hat{Y}_{21} & \hat{Y}_{22} & \cdots & \hat{Y}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{Y}_{G1} & \hat{Y}_{G2} & \cdots & \hat{Y}_{GG} \end{bmatrix}$, $A = Z/X = \begin{bmatrix} A_{11} & A_{12} & \cdots & A_{1G} \\ A_{21} & A_{22} & \cdots & A_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ A_{G1} & A_{G2} & \cdots & A_{GG} \end{bmatrix}$, $B = \begin{bmatrix} I-A_{11} & -A_{12} & \cdots & -A_{1G} \\ -A_{21} & I-A_{22} & \cdots & -A_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ -A_{G1} & -A_{G2} & \cdots & I-A_{GG} \end{bmatrix}^{-1}$, where $\hat{R}_{ij}$ and $\hat{Y}_{ij}$ represents diagonal matrixes with the $N \times 1$ vectors R_{ij} and Y_{ij} in their diagonal, A_{ij} is a $N \times N$ matrix, and B is a $GN \times GN$ matrix. Thus Eq. (1) can be expressed as:

$$\hat{X} = B\hat{Y} + B\hat{R}, \tag{2}$$

where $\hat{X}$ represents the outputs induced by different economic activities. The methodology of this study uses $\hat{X}$ rather than X because it allows us to generate a more detailed discussion on consumption and exports at the sectoral perspective (see Section 4.4). F_i represents the $N \times 1$ carbon intensity matrix of region i, and $F = \begin{bmatrix} \hat{F}_1 & 0 & \cdots & 0 \\ 0 & \hat{F}_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \hat{F}_G \end{bmatrix}$ is a $GN \times GN$ matrix. Then, the matrix of carbon emissions for different regions is

$$E = F\hat{X} = FB\hat{Y} + FB\hat{R}. \tag{3}$$

where E denotes the $GN \times GN$ carbon emissions matrix. From the horizontal perspective (i.e., each row of the matrix), we could obtain the regional emissions under the production-based accounting. From the vertical perspective (i.e., each column of the matrix), we could obtain the regional emissions under the consumption-based accounting. We define the local Leontief inverse matrix of region s as $L_{ss} = (I-A_{ss})^{-1}$, and $L^D = \begin{bmatrix} L_{11} & 0 & \cdots & 0 \\ 0 & L_{22} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & L_{GG} \end{bmatrix}$. The relationship between B and L^D satisfies $B = L^D + L^D A^E B$ [58], where $A^E = \begin{bmatrix} 0 & A_{12} & \cdots & A_{1G} \\ A_{21} & 0 & \cdots & A_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ A_{G1} & A_{G2} & \cdots & 0 \end{bmatrix}$. Eq. (3) for carbon emissions becomes:

$$E = FL^D\hat{Y}^D + FL^D\hat{R} + FL^D Td + FL^D Tf, \tag{4}$$

where $Td = Y^E + A^E B\hat{Y}$ represents the interregional trade to satisfy domestic final demand ($\hat{Y}^E = \begin{bmatrix} 0 & \hat{Y}_{12} & \cdots & \hat{Y}_{1G} \\ \hat{Y}_{21} & 0 & \cdots & \hat{Y}_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{Y}_{G1} & \hat{Y}_{G2} & \cdots & 0 \end{bmatrix}$, $\hat{Y}^D = \hat{Y} - \hat{Y}^E = \begin{bmatrix} \hat{Y}_{11} & 0 & \cdots & 0 \\ 0 & \hat{Y}_{22} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \hat{Y}_{GG} \end{bmatrix}$), $Tf = A^E B\hat{R}$ represents the interregional trade to support the production of products exported to foreign countries, and the gross trade flow is $T = Td + Tf$. We define $M = \begin{bmatrix} 0 & M_{12} & \cdots & M_{1G} \\ M_{21} & 0 & \cdots & M_{2G} \\ \vdots & \vdots & \ddots & \vdots \\ M_{31} & M_{32} & \cdots & 0 \end{bmatrix} = \begin{bmatrix} 0 & A_{12}L_{22} & \cdots & A_{1G}L_{GG} \\ A_{21}L_{11} & 0 & \cdots & A_{2G}L_{GG} \\ \vdots & \vdots & \ddots & \vdots \\ A_{31}L_{11} & A_{32}L_{22} & \cdots & 0 \end{bmatrix}$ to reflect the effects of output change on the interregional imports of intermediate goods, and it satisfies $B = L^D(I-M)^{-1}$.[2] The emissions embodied in interregional trade flow (EEX) are

$$EEX = FL^DT= \underbrace{FL^DM\hat{Y}^D + FL^D\hat{Y}^E + FL^DM\hat{R}}_{BCF=1} + \underbrace{FL^DM^2\hat{Y}^D + FL^DM\hat{Y}^E + FL^DM^2\hat{R}}_{BCF=2} + \underbrace{FL^DM^3\hat{Y}^D + FL^DM^2\hat{Y}^E + FL^DM^3\hat{R}}_{BCF=3} + \cdots. \quad (5)$$

where $FL^D(M)^tY^D$ represents the carbon emissions embodied in intermediate product trade flows – the intermediate products cross borders t times before they are finally absorbed by domestic consumers. FL^DY^E represents the carbon emissions embodied in final product trade that cross borders once. $FL^D(M)^tY^E$ represents the carbon transfer related to both intermediate and final products trade – the intermediate product cross regional borders t times, and the final product cross regional borders once. $FL^D(M)^tR$ represents the carbon transfer for international exports, and the traded products cross regional borders t times before they are finally exported to other countries. This paper performs a SPA based on the matrix M. For instance, $\hat{F}_iL_{ii}M_{ij}M_{jk}\hat{Y}_{kl}$ denotes the carbon transfer routes from region i to region j to region k and finally to region l, where $i \neq j \neq k \neq l$. Four regions are involved in this carbon transfer, and the corresponding ELCT is three. It should be noted that the final products produced in region k may be absorbed by domestic consumers. In other words, $\hat{F}_iL_{ii}M_{ij}M_{jk}\hat{Y}_{kk}$ means three regions are involved in the carbon transfer and the corresponding ELCT is two. Similarly, we could perform SPA on carbon transfer for international exports. The average length of different types of carbon transfer will satisfy[3]:

$$\begin{cases} ELCT = \frac{FBT}{FL^DT} \\ ELCTd = \frac{FBT\,d}{FL^DT\,d}, \\ ELCTf = \frac{FBT\,f}{FL^DT\,f} \end{cases} \quad (6)$$

where "–" represents an element-wise matrix division operator. This means each element of the numerator matrix is divided by the corresponding element of the denominator matrix. The relationship among these three types of ELCT is $ELCT = \frac{FL^DT\,d}{FL^DT}ELCTd + \frac{FL^DT\_f}{FL^DT}ELCT\_f$. As such, the average ELCT within China is the weighted average of $ELCT\_d$ and $ELCT\_f$. The descriptions of notations used in this present paper are presented in Table A1.

[2] According to $B = L^D + L^DA^EB$, we obtain

$$\begin{aligned} B &= L^D + L^DA^EB \\ &= L^D + L^DA^E(L^D + L^DA^EB) \\ &= L^D + L^DA^EL^D + L^DA^EL^DA^EL^D + L^DA^EL^DA^EL^DA^EL^D + \ldots\ldots \\ &= L^D + L^DM + L^DM^2 + L^DM^3 + \ldots\ldots \\ &= L^D(I-M)^{-1}. \end{aligned}$$

[3]

$$\begin{aligned} ELCT &= \frac{FL^D(M+2M^2+\ldots)\hat{Y}^D + FL^D(I+2M+3M^2+\ldots)\hat{Y}^E + FL^D(1M+2M^2+\ldots)\hat{R}}{FL^DT} \\ &= \frac{FL^D((I-M)^{-1})^2\hat{Y} - FL^D(I-M)^{-1}\hat{Y}^D + FL^D((I-M)^{-1})^2\hat{R} - FL^D(I-M)^{-1}\hat{R}}{FL^DT} \\ &= \frac{FB((I-M)^{-1}\hat{Y} - \hat{Y}^D) + FB((I-M)^{-1}\hat{R} - \hat{R})}{FL^DT} \\ &= \frac{FB(\hat{Y}^E + (M+M^2+\ldots)\hat{Y} + (M+M^2+\ldots)\hat{R})}{FL^DT} \\ &= \frac{FB(\hat{Y}^E + A^EB\hat{Y} + A^EB\hat{R})}{FL^DT} \\ &= \frac{FBT}{FL^DT}. \end{aligned}$$

Similarly, we could prove $ELCTd = \frac{FBT\,d}{FL^DT\,d}$ and $ELCTf = \frac{FBT\,f}{FL^DT\,f}$.

Table A.1
Description of notations used in this present paper.

Matrices	Description
X	GN × G matrix of total output
Z	GN × GN matrix of intermediate input
$\hat{X}$	GN × GN matrix of total output
A	GN × GN matrix of input-output coefficient
A^E	GN × GN matrix of input-output coefficient for other provinces
B	GN × GN Leontief inverse matrix
Y	GN × G matrix of domestic final demand
$\hat{Y}^D$	GN × GN matrix of domestic final demand supplied by local province
$\hat{Y}^E$	GN × GN matrix of domestic final demand supplied by other provinces
$\hat{Y}$	GN × GN matrix of domestic final demand
R	GN × 1 column vector of domestic final demand
$\hat{R}$	GN × GN column vector of domestic final demand
F	GN × GN matrix of carbon intensity
E	GN × GN matrix of carbon emissions
L_{ss}	N × N local Leontief inverse matrix
L^D	GN × GN local Leontief inverse matrix
M	GN × GN matrix that is related to A^E and L^D
T	GN × GN matrix of interprovincial trade
Tf	GN × GN matrix of interprovincial trade to support the international exports
Td	GN × GN matrix of interprovincial trade to support the domestic final demands

Appendix B. Classifications of 30 provinces

See Fig. B1.

Fig. B.1. Map of China's provinces.

Appendix C. Abbreviations and classifications of sectors

See Table C1.

Table C.1
Abbreviations and classifications of sectors.

Abbreviation	8 Sectors	27 Sectors
C1	Agriculture	Farming, Forestry, Animal Husbandry and Fishery
C2	Mining	Coal Mining and Dressing
		Petroleum and Natural Gas Extraction
		Ferrous Metals Mining and Dressing
		Nonferrous Metals Mining and Dressing
C3	Light Industry	Food Production and Tobacco Processing
		Textile Industry
		Garment, Leather, Furs, Down and Related Products
		Timber Processing and Furniture Manufacturing
		Papermaking, Printing, Cultural Educational and Sports Articles
C4	Heavy Industry	Petroleum Processing, Coking and Nuclear Fuel Processing
		Chemical Products
		Nonmetal Mineral Products
		Smelting and Pressing of Ferrous Metals
		Metal Products
		Equipment for General and Special Purposes
		Transportation Equipment
		Electric Equipment and Machinery
		Electronic and Telecommunications Equipment
		Instruments, Meters, Cultural and Office Machinery
		Other Manufacturing Industry
C5	Electricity, Steam, Gas and Water Production and Supply	Production and Supply of Electric Power, Steam and Hot Water
		Production and Supply of Gas and Tap Water
C6	Construction	Construction
C7	Transport, Storage and Post	Transportation, Storage, Post and Telecommunication Services
		Wholesale, Retail Trade and Catering Services
C8	Other Services	Other Services

Appendix D. Average ELCT within China at bilateral level

See Table D1–D3.

Table D.1
Average ELCT for exports at bilateral level.

		Coastal region												Middle region									Western region								
		BJ	TJ	HB	LN	SH	JS	ZJ	FJ	SD	GD	GX	HA	SX	NM	JL	HL	AH	JX	HE	UB	HU	CQ	SC	GZ	YN	SA	GS	QH	NX	SJ
Coastal region	BJ	2.23	1.12	1.25	1.37	1.19	1.29	1.40	1.17	1.34	1.48	1.23	1.12	1.21	1.19	1.33	1.33	1.23	1.19	1.29	1.27	1.51	1.37	1.52	1.12	1.18	1.28	1.40	1.23	1.29	1.27
	TJ	1.21	2.24	1.18	1.31	1.34	1.21	1.23	1.44	1.44	1.37	1.52	1.47	1.40	1.36	1.28	1.18	1.36	1.32	1.33	1.32	1.49	1.21	1.17	1.31	1.35	1.21	1.26	1.22	1.18	1.12
	HB	1.16	1.15	2.22	1.18	1.28	1.16	1.17	1.41	1.16	1.53	1.55	1.63	1.30	1.24	1.33	1.34	1.24	1.46	1.18	1.22	1.53	1.40	1.36	1.52	1.50	1.26	1.66	1.44	1.35	1.47
	LN	1.39	1.26	1.10	2.12	1.63	1.36	1.53	1.63	1.52	1.57	1.55	1.64	1.57	1.35	1.09	1.13	1.52	1.43	1.43	1.46	1.61	1.56	1.50	1.45	1.45	1.49	1.17	1.22	1.45	1.61
	SH	1.16	1.12	1.31	1.37	2.26	1.33	1.28	1.19	1.34	1.35	1.33	1.19	1.21	1.15	1.51	1.24	1.24	1.22	1.26	1.35	1.39	1.39	1.32	1.27	1.20	1.27	1.60	1.20	1.34	1.32
	JS	1.32	1.30	1.18	1.31	1.23	2.21	1.10	1.42	1.41	1.40	1.60	1.87	1.47	1.37	1.55	1.38	1.21	1.12	1.18	1.22	1.35	1.47	1.38	1.72	1.50	1.22	1.13	1.31	1.31	1.17
	ZJ	1.44	1.36	1.45	1.50	1.09	1.25	2.22	1.19	1.05	1.20	1.34	1.38	1.48	1.44	1.48	1.46	1.24	1.17	1.37	1.26	1.31	1.55	1.40	1.42	1.44	1.46	1.39	1.45	1.61	1.53
	FJ	1.32	1.30	1.38	1.44	1.20	1.23	1.19	2.19	1.52	1.10	1.37	1.62	1.46	1.38	1.47	1.49	1.25	1.13	1.33	1.24	1.20	1.62	1.46	1.48	1.53	1.38	1.39	1.38	1.41	1.35
	SD	1.40	1.24	1.17	1.42	1.17	1.20	1.31	1.40	2.25	1.50	1.45	1.63	1.33	1.32	1.10	1.49	1.30	1.46	1.29	1.34	1.49	1.56	1.37	1.58	1.46	1.18	1.40	1.40	1.32	1.39
	GD	1.43	1.38	1.38	1.68	1.38	1.35	1.18	1.19	1.69	2.17	1.12	1.14	1.42	1.38	1.64	1.53	1.37	1.06	1.07	1.20	1.11	1.12	1.18	1.15	1.15	1.42	1.47	1.24	1.38	1.50
	GX	1.49	1.38	1.54	1.48	1.49	1.45	1.36	1.38	1.66	1.08	2.13	1.41	1.56	1.51	1.92	1.66	1.60	1.13	1.22	1.41	1.29	1.26	1.61	1.31	1.30	1.58	1.76	1.77	1.77	1.86
	HA	1.32	1.41	1.27	1.53	1.57	1.33	1.44	1.52	1.57	1.15	1.17	2.18	1.30	1.23	1.27	1.78	1.30	1.58	1.34	1.28	1.45	1.61	1.26	1.31	1.34	1.58	1.42	1.18	1.29	1.62
Middle region	SX	1.33	1.42	1.08	1.77	1.67	1.35	1.53	1.82	1.08	1.41	1.85	2.06	2.27	1.56	1.32	1.92	1.57	1.79	1.43	1.27	1.66	1.96	1.80	1.74	1.75	1.59	2.01	1.47	1.63	1.90
	NM	1.24	1.24	1.25	1.48	1.42	1.48	1.45	1.61	1.11	1.66	1.79	1.68	1.67	2.26	1.04	1.74	1.66	1.72	1.43	1.43	1.71	1.75	1.76	1.87	1.74	1.45	1.33	1.40	1.25	1.83
	JL	1.32	1.17	1.26	1.09	1.61	1.49	1.77	1.65	1.36	1.55	1.77	1.60	1.29	1.30	2.11	1.06	1.55	1.59	1.49	1.57	1.73	1.82	1.75	1.54	1.63	1.63	1.73	1.68	1.37	1.46
	HL	1.52	1.60	1.46	1.32	1.73	1.56	1.61	1.78	1.08	1.63	1.63	1.69	1.70	1.45	1.04	2.10	1.54	1.60	1.59	1.47	1.50	1.74	1.62	1.55	1.55	1.74	1.47	1.43	1.62	1.89
	AH	1.41	1.32	1.38	1.69	1.26	1.06	1.18	1.33	1.50	1.63	1.76	1.63	1.47	1.52	1.48	1.62	2.18	1.14	1.32	1.21	1.39	1.63	1.66	1.58	1.71	1.52	1.66	1.54	1.54	1.64
	JX	1.44	1.48	1.66	1.51	1.27	1.24	1.18	1.12	1.60	1.13	1.44	1.49	1.51	1.45	1.27	1.51	1.24	2.19	1.46	1.18	1.12	1.51	1.64	1.73	1.50	1.65	1.74	1.61	1.29	1.63
	HE	1.52	1.43	1.22	1.58	1.29	1.19	1.22	1.49	1.12	1.40	1.51	1.71	1.58	1.56	1.63	1.71	1.31	1.24	2.24	1.09	1.26	1.39	1.43	1.57	1.63	1.12	1.33	1.40	1.28	1.19
	UB	1.48	1.31	1.53	1.72	1.08	1.50	1.50	1.33	1.06	1.33	1.39	1.45	1.63	1.46	1.93	1.70	1.64	1.04	1.46	2.23	1.09	1.37	1.49	1.53	1.52	1.24	1.70	1.50	1.50	1.33
	HU	1.45	1.47	1.48	1.41	1.32	1.31	1.20	1.25	1.26	1.10	1.28	1.20	1.51	1.45	1.62	1.49	1.32	1.20	1.33	1.09	2.15	1.39	1.26	1.26	1.31	1.38	1.59	1.49	1.45	1.66
Western region	CQ	1.19	1.21	1.34	1.66	1.44	1.48	1.61	1.46	1.33	1.12	1.24	1.55	1.20	1.38	1.61	1.64	1.36	1.27	1.33	1.36	1.33	2.13	1.10	1.17	1.15	1.31	1.31	1.45	1.38	1.55
	SC	1.60	1.41	1.42	1.36	1.41	1.39	1.36	1.44	1.11	1.20	1.38	1.44	1.43	1.43	1.76	1.64	1.68	1.10	1.31	1.31	1.19	1.04	2.18	1.20	1.25	1.16	1.46	1.42	1.37	1.50
	GZ	1.68	1.45	1.57	1.89	1.56	1.52	1.50	1.60	1.66	1.17	1.23	1.52	1.69	1.72	1.99	1.90	1.77	1.08	1.11	1.65	1.18	1.18	1.19	2.21	1.16	1.70	2.06	1.83	1.63	2.01
	YN	1.61	1.54	1.65	1.78	1.62	1.51	1.44	1.38	1.63	1.06	1.51	1.75	1.67	1.65	1.99	2.08	1.68	1.63	1.60	1.61	1.54	1.25	1.39	1.25	2.13	1.65	1.43	1.90	1.39	1.28
	SA	1.33	1.31	1.39	1.70	1.22	1.19	1.26	1.37	1.44	1.37	1.43	1.33	1.29	1.32	1.59	1.76	1.32	1.25	1.29	1.20	1.22	1.25	1.15	1.33	1.39	2.26	1.14	1.28	1.26	1.44
	GS	1.33	1.39	1.27	1.85	1.31	1.25	1.21	1.77	1.74	1.57	1.73	1.76	1.14	1.62	1.77	2.14	1.69	1.14	1.26	1.45	1.37	1.30	1.37	1.69	1.73	1.26	2.07	1.01	1.04	1.50
	QH	1.60	1.36	1.44	1.86	1.39	1.50	1.47	1.76	1.25	1.23	2.01	2.18	1.88	1.98	2.06	2.01	1.71	1.77	1.45	1.60	1.68	1.51	1.23	1.91	1.87	1.40	1.02	2.09	1.27	1.62
	NX	1.27	1.18	1.11	1.68	1.57	1.41	1.57	1.69	1.46	1.49	1.72	1.60	1.36	1.54	1.85	1.72	1.67	1.44	1.44	1.57	1.80	1.71	1.52	1.63	1.76	1.39	1.04	1.20	2.11	1.19
	SJ	1.22	1.28	1.44	1.82	1.48	1.41	1.38	1.56	1.28	1.56	1.57	1.05	1.28	1.41	1.48	1.84	1.43	1.57	1.30	1.30	1.41	1.57	1.28	1.54	1.48	1.36	1.06	1.16	1.11	2.31

Table D.2
Average ELCT for domestic final demand at bilateral level.

		Coastal region												Middle region									Western region								
		BJ	TJ	HB	LN	SH	JS	ZJ	FJ	SD	GD	GX	HA	SX	NM	JL	HL	AH	JX	HE	UB	HU	CQ	SC	GZ	YN	SA	GS	QH	NX	SJ
Coastal region	BJ	2.23	1.09	1.13	1.25	1.12	1.11	1.16	1.08	1.22	1.27	1.10	1.12	1.22	1.23	1.29	1.17	1.21	1.09	1.22	1.20	1.30	1.07	1.31	1.10	1.17	1.21	1.23	1.07	1.19	1.17
	TJ	1.23	2.25	1.26	1.36	1.42	1.27	1.24	1.40	1.46	1.47	1.54	1.57	1.55	1.44	1.34	1.29	1.38	1.36	1.40	1.32	1.57	1.30	1.25	1.37	1.44	1.31	1.26	1.21	1.24	1.18
	HB	1.13	1.27	2.21	1.27	1.43	1.26	1.19	1.56	1.20	1.68	1.78	1.80	1.49	1.40	1.41	1.51	1.29	1.50	1.48	1.30	1.75	1.53	1.58	1.73	1.74	1.41	1.59	1.47	1.49	1.56
	LN	1.39	1.30	1.15	2.12	1.62	1.41	1.49	1.69	1.52	1.53	1.69	1.54	1.53	1.33	1.10	1.15	1.53	1.46	1.48	1.55	1.70	1.50	1.51	1.60	1.61	1.54	1.20	1.35	1.37	1.49
	SH	1.16	1.09	1.19	1.32	2.25	1.24	1.24	1.15	1.23	1.23	1.23	1.15	1.15	1.13	1.35	1.18	1.21	1.18	1.16	1.25	1.28	1.22	1.25	1.30	1.15	1.22	1.41	1.08	1.29	1.25
	JS	1.35	1.36	1.27	1.34	1.30	2.23	1.12	1.54	1.46	1.46	1.55	1.86	1.47	1.33	1.53	1.40	1.17	1.14	1.31	1.31	1.36	1.50	1.36	1.55	1.61	1.29	1.17	1.43	1.26	1.19
	ZJ	1.51	1.52	1.50	1.57	1.09	1.34	2.24	1.24	1.07	1.21	1.31	1.50	1.61	1.60	1.63	1.61	1.29	1.20	1.51	1.33	1.28	1.55	1.35	1.34	1.49	1.54	1.44	1.72	1.64	1.64
	FJ	1.30	1.38	1.38	1.42	1.23	1.27	1.19	2.19	1.58	1.14	1.38	1.70	1.66	1.34	1.45	1.45	1.28	1.15	1.52	1.28	1.21	1.45	1.49	1.45	1.59	1.34	1.29	1.51	1.33	1.26
	SD	1.37	1.23	1.17	1.36	1.17	1.22	1.30	1.46	2.25	1.47	1.48	1.60	1.37	1.34	1.17	1.38	1.28	1.41	1.34	1.35	1.50	1.54	1.28	1.60	1.52	1.22	1.38	1.34	1.29	1.36
	GD	1.45	1.46	1.51	1.70	1.43	1.39	1.18	1.24	1.71	2.19	1.21	1.18	1.59	1.47	1.77	1.51	1.41	1.05	1.17	1.23	1.16	1.14	1.27	1.21	1.20	1.45	1.30	1.28	1.56	1.47
	GX	1.53	1.49	1.66	1.63	1.57	1.52	1.37	1.50	1.62	1.13	2.18	1.52	1.82	1.68	1.89	1.79	1.60	1.12	1.48	1.37	1.36	1.23	1.67	1.35	1.34	1.48	1.66	1.69	1.80	1.95
	HA	1.31	1.37	1.21	1.58	1.50	1.34	1.30	1.46	1.60	1.11	1.29	2.25	1.36	1.43	1.46	1.65	1.31	1.55	1.51	1.35	1.57	1.46	1.34	1.45	1.48	1.47	1.38	1.31	1.38	1.53
Middle region	SX	1.33	1.49	1.19	1.87	1.79	1.48	1.52	1.86	1.10	1.42	1.99	1.67	2.35	1.90	1.54	2.00	1.67	1.80	1.77	1.38	1.92	1.95	1.98	1.97	1.97	1.82	2.05	1.63	1.77	1.89
	NM	1.23	1.32	1.33	1.57	1.58	1.62	1.50	1.77	1.16	1.77	1.99	1.74	1.89	2.29	1.11	1.84	1.71	1.82	1.83	1.55	1.94	1.84	1.90	2.03	1.99	1.66	1.44	1.63	1.48	1.82
	JL	1.34	1.20	1.29	1.09	1.53	1.50	1.64	1.68	1.33	1.57	1.70	1.56	1.28	1.41	2.12	1.08	1.55	1.64	1.48	1.57	1.76	1.74	1.85	1.71	1.84	1.70	1.68	1.75	1.58	1.57
	HL	1.46	1.46	1.43	1.30	1.51	1.50	1.35	1.62	1.12	1.36	1.60	1.73	1.80	1.47	1.09	2.12	1.56	1.47	1.76	1.51	1.63	1.57	1.66	1.62	1.49	1.74	1.55	1.34	1.36	1.90
	AH	1.35	1.28	1.37	1.54	1.20	1.06	1.12	1.28	1.40	1.52	1.62	1.65	1.38	1.42	1.34	1.52	2.17	1.09	1.31	1.21	1.44	1.45	1.53	1.60	1.79	1.41	1.47	1.39	1.48	1.68
	JX	1.45	1.54	1.71	1.50	1.25	1.34	1.16	1.18	1.71	1.20	1.62	1.50	1.71	1.70	1.39	1.60	1.27	2.20	1.80	1.24	1.24	1.56	1.74	1.82	1.66	1.67	1.71	1.72	1.56	1.87
	HE	1.52	1.36	1.23	1.51	1.29	1.23	1.19	1.52	1.15	1.42	1.51	1.61	1.59	1.46	1.59	1.66	1.29	1.18	2.26	1.11	1.33	1.33	1.34	1.51	1.70	1.16	1.28	1.38	1.29	1.15
	UB	1.56	1.43	1.67	1.75	1.10	1.51	1.45	1.43	1.10	1.34	1.40	1.57	1.86	1.70	1.96	1.78	1.66	1.03	1.69	2.24	1.13	1.31	1.51	1.68	1.64	1.43	1.70	1.42	1.72	1.55
	HU	1.33	1.24	1.22	1.46	1.36	1.37	1.20	1.27	1.32	1.11	1.16	1.15	1.53	1.14	1.26	1.41	1.23	1.21	1.34	1.12	2.18	1.28	1.24	1.18	1.27	1.21	1.52	1.36	1.15	1.40
Western region	CQ	1.23	1.22	1.24	1.75	1.55	1.51	1.60	1.43	1.38	1.10	1.22	1.78	1.33	1.18	1.34	1.53	1.29	1.35	1.33	1.38	1.20	2.16	1.11	1.18	1.17	1.25	1.34	1.64	1.19	1.49
	SC	1.47	1.35	1.36	1.43	1.52	1.47	1.37	1.48	1.15	1.24	1.30	1.43	1.52	1.32	1.57	1.66	1.53	1.13	1.40	1.32	1.23	1.04	2.20	1.21	1.31	1.20	1.45	1.41	1.33	1.45
	GZ	1.64	1.54	1.54	1.92	1.58	1.53	1.45	1.63	1.66	1.18	1.26	1.60	1.89	1.80	1.91	1.78	1.75	1.09	1.25	1.67	1.27	1.22	1.30	2.24	1.25	1.74	1.97	1.71	1.67	1.91
	YN	1.62	1.60	1.76	1.89	1.66	1.61	1.44	1.49	1.66	1.09	1.57	1.83	1.80	1.88	2.10	2.14	1.69	1.61	1.87	1.46	1.63	1.27	1.52	1.31	2.18	1.67	1.52	1.78	1.78	1.53
	SA	1.34	1.32	1.33	1.70	1.34	1.26	1.26	1.37	1.46	1.33	1.31	1.43	1.49	1.26	1.50	1.63	1.30	1.34	1.40	1.27	1.21	1.30	1.23	1.29	1.57	2.28	1.16	1.38	1.28	1.33
	GS	1.36	1.51	1.42	1.86	1.49	1.35	1.22	1.78	1.76	1.69	1.89	1.59	1.41	1.87	1.98	2.11	1.75	1.19	1.57	1.56	1.62	1.39	1.52	1.84	1.98	1.38	2.12	1.03	1.15	1.57
	QH	1.63	1.56	1.65	2.02	1.61	1.64	1.51	1.91	1.35	1.41	1.91	2.23	2.18	1.86	1.99	2.08	1.72	1.92	1.79	1.71	1.69	1.74	1.42	1.86	2.11	1.62	1.04	2.16	1.16	1.34
	NX	1.30	1.24	1.16	1.73	1.61	1.50	1.56	1.78	1.51	1.65	1.81	1.69	1.55	1.68	1.97	1.78	1.70	1.42	1.65	1.59	1.91	1.68	1.57	1.80	2.01	1.54	1.04	1.18	2.22	1.22
	SJ	1.26	1.30	1.37	1.86	1.38	1.43	1.39	1.60	1.32	1.55	1.68	1.14	1.41	1.65	1.68	1.89	1.49	1.56	1.47	1.31	1.62	1.53	1.38	1.74	1.66	1.56	1.10	1.18	1.22	2.33

Table D.3
Weight average ELCT for exports and domestic final demand at bilateral level.

		Coastal region												Middle region									Western region								
		BJ	TJ	HB	LN	SH	JS	ZJ	FJ	SD	GD	GX	HA	SX	NM	JL	HL	AH	JX	HE	UB	HU	CQ	SC	GZ	YN	SA	GS	QH	NX	SJ
Coastal region	BJ	2.23	1.09	1.13	1.26	1.14	1.13	1.19	1.09	1.23	1.32	1.11	1.12	1.22	1.23	1.29	1.17	1.22	1.10	1.22	1.21	1.31	1.08	1.32	1.10	1.17	1.21	1.23	1.07	1.19	1.17
	TJ	1.22	2.25	1.26	1.35	1.40	1.25	1.24	1.41	1.46	1.43	1.54	1.56	1.54	1.44	1.34	1.29	1.37	1.36	1.39	1.32	1.57	1.29	1.25	1.37	1.43	1.31	1.26	1.21	1.24	1.17
	HB	1.14	1.25	2.21	1.26	1.38	1.23	1.18	1.53	1.19	1.62	1.78	1.79	1.48	1.39	1.40	1.50	1.29	1.50	1.47	1.30	1.74	1.52	1.57	1.72	1.73	1.40	1.59	1.47	1.49	1.55
	LN	1.39	1.29	1.15	2.12	1.62	1.40	1.50	1.68	1.52	1.54	1.69	1.55	1.53	1.33	1.10	1.14	1.53	1.45	1.48	1.55	1.70	1.50	1.51	1.59	1.60	1.54	1.20	1.35	1.37	1.49
	SH	1.16	1.09	1.20	1.32	2.25	1.26	1.25	1.15	1.24	1.26	1.24	1.15	1.15	1.13	1.35	1.18	1.21	1.19	1.16	1.25	1.29	1.22	1.26	1.30	1.15	1.22	1.42	1.08	1.29	1.25
	JS	1.34	1.35	1.26	1.34	1.28	2.22	1.11	1.51	1.45	1.43	1.55	1.86	1.47	1.33	1.53	1.40	1.18	1.14	1.30	1.30	1.36	1.50	1.36	1.55	1.61	1.28	1.17	1.43	1.26	1.19
	ZJ	1.49	1.50	1.49	1.56	1.09	1.32	2.23	1.23	1.07	1.21	1.31	1.49	1.61	1.59	1.63	1.60	1.28	1.20	1.51	1.33	1.28	1.55	1.35	1.34	1.49	1.54	1.44	1.71	1.64	1.63
	FJ	1.31	1.37	1.38	1.42	1.22	1.26	1.19	2.19	1.57	1.12	1.38	1.69	1.66	1.34	1.45	1.46	1.28	1.15	1.52	1.28	1.21	1.46	1.49	1.45	1.59	1.34	1.29	1.51	1.33	1.27
	SD	1.38	1.23	1.17	1.37	1.17	1.21	1.30	1.45	2.25	1.48	1.48	1.60	1.37	1.34	1.17	1.39	1.28	1.41	1.34	1.35	1.50	1.54	1.29	1.60	1.51	1.22	1.38	1.34	1.29	1.36
	GD	1.44	1.45	1.50	1.69	1.42	1.38	1.18	1.23	1.71	2.18	1.21	1.18	1.58	1.47	1.77	1.52	1.41	1.05	1.17	1.22	1.16	1.14	1.26	1.21	1.20	1.45	1.31	1.28	1.56	1.47
	GX	1.53	1.48	1.65	1.61	1.55	1.50	1.37	1.47	1.63	1.10	2.18	1.52	1.81	1.68	1.89	1.78	1.60	1.12	1.47	1.37	1.35	1.23	1.67	1.35	1.34	1.48	1.66	1.69	1.80	1.95
	HA	1.31	1.38	1.22	1.57	1.51	1.34	1.34	1.47	1.59	1.13	1.28	2.24	1.36	1.43	1.45	1.65	1.31	1.55	1.50	1.35	1.56	1.47	1.33	1.45	1.47	1.47	1.38	1.31	1.37	1.54
Middle region	SX	1.33	1.48	1.18	1.85	1.75	1.44	1.52	1.85	1.10	1.42	1.99	1.68	2.35	1.89	1.53	1.99	1.66	1.80	1.75	1.37	1.90	1.95	1.97	1.96	1.96	1.81	2.05	1.63	1.77	1.89
	NM	1.23	1.31	1.33	1.55	1.53	1.58	1.48	1.74	1.15	1.72	1.99	1.73	1.89	2.29	1.11	1.84	1.70	1.82	1.81	1.54	1.93	1.84	1.89	2.03	1.98	1.65	1.43	1.63	1.47	1.82
	JL	1.34	1.19	1.29	1.09	1.55	1.49	1.67	1.68	1.33	1.56	1.70	1.56	1.28	1.41	2.12	1.08	1.55	1.64	1.48	1.57	1.75	1.75	1.85	1.71	1.83	1.70	1.68	1.75	1.58	1.57
	HL	1.47	1.47	1.43	1.30	1.55	1.51	1.41	1.65	1.11	1.42	1.60	1.72	1.79	1.47	1.09	2.12	1.56	1.47	1.75	1.50	1.62	1.58	1.66	1.62	1.49	1.74	1.55	1.34	1.36	1.90
	AH	1.36	1.28	1.37	1.56	1.21	1.06	1.14	1.29	1.41	1.56	1.63	1.64	1.39	1.42	1.35	1.52	2.17	1.10	1.31	1.21	1.44	1.45	1.54	1.60	1.79	1.41	1.47	1.39	1.48	1.68
	JX	1.45	1.54	1.71	1.50	1.25	1.31	1.17	1.16	1.69	1.16	1.61	1.50	1.71	1.69	1.38	1.60	1.27	2.20	1.78	1.23	1.23	1.56	1.73	1.82	1.65	1.67	1.71	1.72	1.55	1.85
	HE	1.52	1.37	1.23	1.52	1.29	1.22	1.20	1.52	1.15	1.41	1.51	1.62	1.59	1.46	1.59	1.66	1.29	1.18	2.26	1.11	1.32	1.33	1.35	1.51	1.70	1.16	1.28	1.38	1.29	1.15
	UB	1.55	1.41	1.66	1.75	1.09	1.51	1.47	1.41	1.09	1.34	1.40	1.56	1.85	1.70	1.96	1.78	1.66	1.03	1.68	2.24	1.12	1.31	1.51	1.68	1.64	1.42	1.70	1.42	1.72	1.53
	HU	1.35	1.26	1.23	1.45	1.35	1.35	1.20	1.26	1.31	1.11	1.17	1.15	1.52	1.15	1.27	1.41	1.24	1.21	1.34	1.12	2.18	1.29	1.24	1.18	1.27	1.21	1.52	1.36	1.15	1.40
Western region	CQ	1.22	1.22	1.25	1.74	1.52	1.50	1.60	1.44	1.37	1.11	1.22	1.77	1.32	1.19	1.35	1.54	1.30	1.34	1.33	1.38	1.21	2.16	1.11	1.18	1.17	1.25	1.34	1.63	1.19	1.49
	SC	1.49	1.36	1.36	1.42	1.49	1.44	1.36	1.47	1.14	1.22	1.31	1.43	1.52	1.32	1.58	1.66	1.54	1.13	1.40	1.32	1.23	1.04	2.20	1.21	1.31	1.20	1.45	1.41	1.33	1.45
	GZ	1.64	1.53	1.54	1.92	1.58	1.53	1.47	1.62	1.66	1.17	1.25	1.60	1.89	1.80	1.92	1.79	1.75	1.09	1.24	1.67	1.26	1.22	1.29	2.24	1.25	1.74	1.97	1.71	1.66	1.91
	YN	1.62	1.59	1.75	1.88	1.65	1.58	1.44	1.47	1.65	1.08	1.57	1.82	1.79	1.88	2.10	2.14	1.69	1.61	1.86	1.47	1.62	1.27	1.51	1.31	2.18	1.67	1.52	1.78	1.76	1.51
	SA	1.34	1.32	1.33	1.70	1.30	1.24	1.26	1.37	1.46	1.34	1.32	1.43	1.49	1.26	1.50	1.63	1.31	1.33	1.39	1.27	1.21	1.30	1.22	1.29	1.56	2.27	1.16	1.38	1.28	1.33
	GS	1.36	1.49	1.40	1.86	1.42	1.31	1.22	1.78	1.76	1.64	1.89	1.60	1.40	1.87	1.98	2.11	1.74	1.19	1.56	1.55	1.60	1.38	1.51	1.84	1.97	1.37	2.11	1.03	1.14	1.57
	QH	1.62	1.53	1.62	1.99	1.52	1.59	1.50	1.88	1.33	1.31	1.92	2.22	2.18	1.86	2.00	2.08	1.72	1.91	1.78	1.70	1.69	1.72	1.40	1.86	2.10	1.61	1.04	2.16	1.16	1.35
	NX	1.29	1.23	1.15	1.73	1.60	1.47	1.56	1.76	1.50	1.58	1.80	1.68	1.54	1.68	1.97	1.78	1.70	1.42	1.64	1.59	1.90	1.68	1.57	1.80	2.00	1.53	1.04	1.18	2.22	1.22
	SJ	1.25	1.30	1.38	1.85	1.40	1.42	1.39	1.59	1.31	1.55	1.68	1.13	1.41	1.64	1.67	1.89	1.48	1.56	1.47	1.31	1.60	1.53	1.37	1.73	1.65	1.55	1.09	1.18	1.21	2.33

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Appendix E. Average ELCT within China at bilateral-sector level

See Table E1–E3.

Table E.1
Average ELCT for exports at bilateral-sector level.

		Eastern Region								Middle Region								Western Region							
		C1	C2	C3	C4	C5	C6	C7	C8	C1	C2	C3	C4	C5	C6	C7	C8	C1	C2	C3	C4	C5	C6	C7	C8
ER	C1	1.14	1.39	1.20	1.36	1.64	1.35	1.33	1.21	1.14	1.34	1.15	1.31	1.54	1.34	1.29	1.19	1.21	1.36	1.18	1.39	1.43	1.42	1.34	1.25
	C2	1.29	1.16	1.31	1.25	1.06	1.21	1.24	1.24	1.36	1.28	1.39	1.30	1.16	1.27	1.31	1.36	1.59	1.37	1.53	1.48	1.61	1.43	1.39	1.51
	C3	1.24	1.39	1.16	1.34	1.59	1.33	1.33	1.20	1.19	1.30	1.16	1.32	1.44	1.34	1.32	1.17	1.25	1.27	1.14	1.29	1.25	1.31	1.27	1.17
	C4	1.40	1.30	1.40	1.23	1.51	1.14	1.36	1.34	1.36	1.27	1.40	1.20	1.43	1.14	1.33	1.37	1.44	1.28	1.46	1.27	1.48	1.22	1.35	1.42
	C5	1.30	1.28	1.29	1.30	1.42	1.30	1.32	1.28	1.27	1.22	1.27	1.24	1.10	1.25	1.30	1.25	1.37	1.31	1.34	1.35	1.44	1.34	1.36	1.35
	C6	1.23	1.28	1.28	1.30	1.44	1.29	1.22	1.18	1.23	1.26	1.26	1.28	1.42	1.25	1.18	1.18	1.28	1.17	1.29	1.30	1.23	1.27	1.17	1.16
	C7	1.31	1.24	1.32	1.32	1.57	1.27	1.18	1.22	1.32	1.21	1.30	1.29	1.52	1.27	1.23	1.27	1.29	1.20	1.28	1.30	1.22	1.25	1.21	1.23
	C8	1.30	1.29	1.32	1.29	1.47	1.27	1.24	1.18	1.27	1.27	1.25	1.24	1.37	1.25	1.22	1.20	1.22	1.18	1.22	1.26	1.19	1.25	1.18	1.17
MR	C1	1.11	1.29	1.21	1.40	1.20	1.39	1.34	1.23	1.18	1.48	1.19	1.42	1.46	1.47	1.33	1.29	1.14	1.57	1.18	1.49	1.53	1.55	1.44	1.29
	C2	1.32	1.19	1.30	1.26	1.05	1.25	1.32	1.35	1.50	1.28	1.40	1.32	1.10	1.34	1.33	1.39	1.65	1.46	1.72	1.56	1.71	1.52	1.58	1.59
	C3	1.12	1.33	1.16	1.32	1.45	1.31	1.29	1.17	1.23	1.37	1.23	1.38	1.36	1.37	1.36	1.21	1.17	1.41	1.25	1.44	1.50	1.45	1.43	1.21
	C4	1.33	1.21	1.35	1.22	1.14	1.17	1.24	1.36	1.45	1.36	1.46	1.31	1.35	1.22	1.24	1.41	1.46	1.34	1.54	1.35	1.58	1.28	1.28	1.46
	C5	1.22	1.17	1.30	1.28	1.20	1.27	1.35	1.30	1.46	1.21	1.31	1.31	1.06	1.33	1.33	1.28	1.57	1.32	1.60	1.48	1.80	1.54	1.52	1.43
	C6	1.30	1.17	1.34	1.34	1.08	1.37	1.27	1.27	1.39	1.47	1.48	1.40	1.51	1.39	1.28	1.31	1.46	1.32	1.52	1.57	1.59	1.53	1.32	1.26
	C7	1.27	1.20	1.29	1.29	1.18	1.28	1.19	1.24	1.44	1.27	1.38	1.37	1.29	1.34	1.30	1.36	1.36	1.27	1.39	1.41	1.33	1.34	1.30	1.31
	C8	1.25	1.22	1.28	1.28	1.18	1.32	1.24	1.20	1.35	1.33	1.29	1.29	1.29	1.30	1.27	1.26	1.27	1.26	1.29	1.37	1.29	1.37	1.25	1.21
WR	C1	1.13	1.38	1.23	1.43	1.50	1.43	1.36	1.24	1.11	1.36	1.15	1.36	1.43	1.40	1.27	1.21	1.16	1.58	1.25	1.42	1.40	1.49	1.48	1.30
	C2	1.38	1.26	1.41	1.38	1.10	1.45	1.35	1.42	1.52	1.42	1.48	1.45	1.18	1.47	1.38	1.45	1.24	1.40	1.31	1.20	1.09	1.20	1.32	1.31
	C3	1.18	1.39	1.18	1.32	1.37	1.40	1.32	1.20	1.17	1.34	1.23	1.37	1.59	1.41	1.29	1.16	1.13	1.33	1.22	1.34	1.31	1.32	1.34	1.13
	C4	1.35	1.28	1.37	1.20	1.26	1.22	1.30	1.35	1.39	1.48	1.55	1.39	1.53	1.34	1.36	1.49	1.32	1.36	1.44	1.27	1.46	1.17	1.33	1.39
	C5	1.33	1.25	1.38	1.32	1.06	1.35	1.42	1.35	1.35	1.11	1.28	1.30	1.02	1.30	1.30	1.18	1.48	1.51	1.57	1.39	1.42	1.38	1.54	1.46
	C6	1.20	1.21	1.40	1.37	1.21	1.27	1.24	1.15	1.17	1.24	1.31	1.33	1.08	1.22	1.12	1.12	1.36	1.21	1.43	1.36	1.30	1.30	1.19	1.15
	C7	1.28	1.21	1.35	1.29	1.24	1.28	1.18	1.23	1.38	1.25	1.38	1.38	1.18	1.37	1.27	1.31	1.31	1.30	1.40	1.32	1.23	1.28	1.32	1.32
	C8	1.28	1.22	1.34	1.29	1.19	1.31	1.24	1.19	1.31	1.28	1.28	1.31	1.11	1.33	1.27	1.22	1.28	1.29	1.35	1.30	1.18	1.29	1.30	1.23

Table E.2
Average ELCT for domestic final demand at bilateral-sector level.

		Eastern Region								Middle Region								Western Region							
		C1	C2	C3	C4	C5	C6	C7	C8	C1	C2	C3	C4	C5	C6	C7	C8	C1	C2	C3	C4	C5	C6	C7	C8
ER	C1	1.05	1.53	1.22	1.49	1.50	1.38	1.48	1.28	1.06	1.46	1.21	1.49	1.56	1.37	1.39	1.27	1.07	1.82	1.29	1.53	1.46	1.46	1.49	1.32
	C2	1.27	1.05	1.51	1.40	1.10	1.25	1.46	1.37	1.30	1.05	1.46	1.49	1.42	1.31	1.47	1.43	1.42	1.14	1.64	1.53	1.42	1.49	1.63	1.59
	C3	1.27	1.43	1.16	1.49	1.46	1.37	1.47	1.30	1.23	1.47	1.15	1.50	1.51	1.38	1.41	1.27	1.26	1.57	1.15	1.47	1.35	1.38	1.43	1.31
	C4	1.49	1.51	1.57	1.34	1.50	1.19	1.52	1.43	1.42	1.48	1.53	1.38	1.56	1.18	1.43	1.42	1.48	1.94	1.64	1.42	1.44	1.27	1.50	1.58
	C5	1.34	1.30	1.40	1.39	1.09	1.31	1.42	1.34	1.32	1.25	1.34	1.40	1.06	1.29	1.38	1.30	1.38	1.48	1.42	1.42	1.16	1.40	1.44	1.40
	C6	1.17	1.37	1.32	1.33	1.33	1.06	1.14	1.10	1.20	1.37	1.33	1.29	1.41	1.03	1.15	1.10	1.25	1.64	1.42	1.32	1.28	1.02	1.13	1.08
	C7	1.32	1.41	1.37	1.40	1.41	1.29	1.06	1.26	1.31	1.47	1.32	1.38	1.45	1.31	1.07	1.29	1.33	1.84	1.36	1.40	1.30	1.31	1.06	1.26
	C8	1.27	1.31	1.39	1.40	1.34	1.31	1.26	1.09	1.26	1.29	1.32	1.37	1.40	1.29	1.25	1.10	1.28	1.59	1.41	1.39	1.26	1.32	1.24	1.06
MR	C1	1.07	1.23	1.20	1.55	1.30	1.38	1.48	1.33	1.10	1.25	1.29	1.77	1.56	1.50	1.43	1.41	1.07	1.77	1.25	1.82	1.59	1.55	1.56	1.48
	C2	1.46	1.04	1.42	1.45	1.11	1.25	1.55	1.42	1.49	1.04	1.52	1.66	1.27	1.37	1.49	1.49	1.58	1.23	1.61	1.66	1.21	1.48	1.87	1.76
	C3	1.27	1.47	1.10	1.46	1.36	1.32	1.51	1.28	1.31	1.37	1.18	1.66	1.35	1.40	1.49	1.32	1.25	2.00	1.14	1.61	1.43	1.44	1.66	1.43
	C4	1.41	1.20	1.47	1.27	1.25	1.18	1.43	1.41	1.47	1.25	1.58	1.47	1.49	1.27	1.39	1.49	1.42	2.03	1.58	1.43	1.46	1.28	1.53	1.66
	C5	1.46	1.20	1.33	1.37	1.06	1.28	1.53	1.36	1.51	1.25	1.48	1.60	1.06	1.36	1.45	1.36	1.52	1.84	1.55	1.63	1.08	1.49	1.73	1.56
	C6	1.39	1.10	1.43	1.46	1.15	1.04	1.24	1.30	1.51	1.13	1.57	1.64	1.38	1.03	1.30	1.34	1.38	1.63	1.48	1.69	1.39	1.01	1.28	1.36
	C7	1.35	1.20	1.30	1.41	1.23	1.26	1.08	1.32	1.44	1.24	1.40	1.58	1.36	1.36	1.12	1.44	1.36	2.00	1.36	1.53	1.34	1.31	1.10	1.46
	C8	1.30	1.19	1.30	1.44	1.17	1.30	1.32	1.11	1.35	1.17	1.41	1.56	1.18	1.33	1.36	1.15	1.28	1.76	1.33	1.61	1.27	1.35	1.36	1.09
WR	C1	1.07	1.50	1.28	1.68	1.54	1.41	1.57	1.38	1.07	1.47	1.24	1.83	1.56	1.40	1.36	1.34	1.07	1.26	1.35	1.86	1.51	1.47	1.69	1.56
	C2	1.45	1.10	1.58	1.61	1.18	1.40	1.59	1.51	1.46	1.14	1.62	1.85	1.37	1.47	1.52	1.54	1.23	1.02	1.50	1.64	1.13	1.25	1.46	1.46
	C3	1.32	1.64	1.12	1.59	1.48	1.38	1.57	1.29	1.26	1.90	1.14	1.74	1.49	1.38	1.39	1.28	1.18	1.37	1.10	1.64	1.38	1.34	1.65	1.37
	C4	1.34	1.47	1.52	1.40	1.43	1.20	1.48	1.42	1.37	1.54	1.58	1.68	1.62	1.28	1.49	1.58	1.30	1.25	1.51	1.55	1.40	1.19	1.54	1.57
	C5	1.45	1.32	1.52	1.57	1.10	1.33	1.62	1.40	1.43	1.54	1.51	1.67	1.11	1.31	1.41	1.26	1.41	1.11	1.72	1.79	1.13	1.41	1.71	1.59
	C6	1.34	1.18	1.47	1.63	1.21	1.01	1.34	1.22	1.33	1.20	1.41	1.73	1.28	1.01	1.24	1.19	1.39	1.11	1.60	1.77	1.26	1.01	1.39	1.34
	C7	1.37	1.26	1.40	1.54	1.28	1.27	1.12	1.32	1.39	1.40	1.40	1.79	1.36	1.33	1.15	1.41	1.30	1.08	1.38	1.72	1.26	1.29	1.19	1.50
	C8	1.34	1.17	1.39	1.55	1.21	1.30	1.39	1.13	1.34	1.21	1.37	1.75	1.26	1.31	1.38	1.17	1.30	1.06	1.46	1.72	1.22	1.30	1.52	1.18

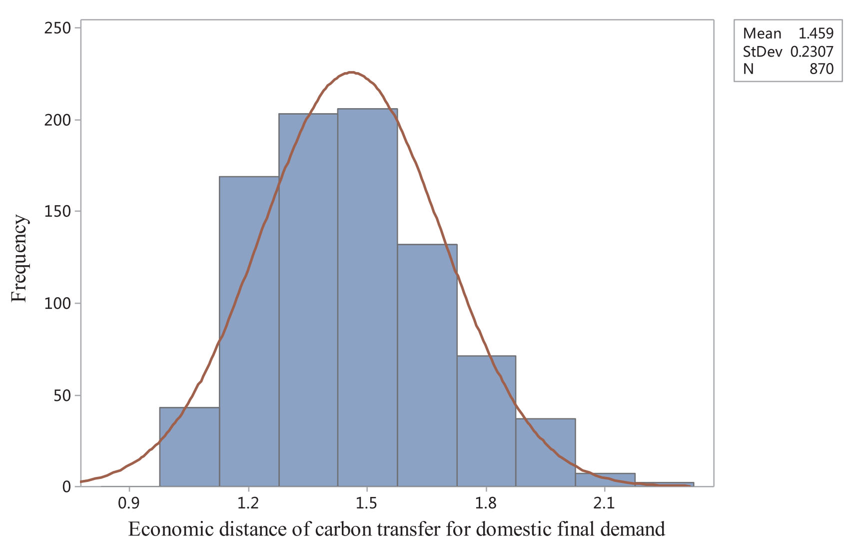
Table E.3
Average ELCT within China at bilateral-sector level.

		Eastern Region								Middle Region								Western Region							
		C1	C2	C3	C4	C5	C6	C7	C8	C1	C2	C3	C4	C5	C6	C7	C8	C1	C2	C3	C4	C5	C6	C7	C8
ER	C1	1.05	1.49	1.21	1.42	1.50	1.38	1.45	1.27	1.06	1.42	1.20	1.47	1.56	1.37	1.37	1.26	1.07	1.72	1.29	1.52	1.46	1.45	1.47	1.32
	C2	1.27	1.05	1.40	1.32	1.10	1.25	1.41	1.35	1.30	1.06	1.45	1.48	1.42	1.31	1.44	1.43	1.42	1.15	1.63	1.53	1.42	1.49	1.60	1.58
	C3	1.27	1.42	1.16	1.41	1.46	1.37	1.44	1.29	1.23	1.40	1.15	1.48	1.51	1.38	1.40	1.27	1.26	1.52	1.15	1.45	1.35	1.38	1.41	1.31
	C4	1.48	1.45	1.49	1.30	1.50	1.18	1.48	1.42	1.41	1.40	1.51	1.37	1.56	1.18	1.41	1.42	1.48	1.75	1.63	1.41	1.44	1.27	1.48	1.57
	C5	1.34	1.29	1.35	1.35	1.09	1.31	1.40	1.33	1.32	1.25	1.34	1.38	1.06	1.29	1.37	1.30	1.38	1.45	1.42	1.42	1.16	1.40	1.43	1.40
	C6	1.17	1.35	1.31	1.32	1.33	1.06	1.15	1.10	1.20	1.33	1.32	1.29	1.41	1.03	1.15	1.10	1.25	1.54	1.41	1.32	1.28	1.02	1.13	1.08
	C7	1.32	1.37	1.35	1.36	1.42	1.29	1.06	1.26	1.31	1.37	1.32	1.38	1.45	1.31	1.08	1.29	1.33	1.68	1.35	1.39	1.30	1.31	1.06	1.26
	C8	1.27	1.31	1.36	1.35	1.34	1.31	1.26	1.10	1.26	1.29	1.31	1.36	1.40	1.29	1.25	1.10	1.28	1.51	1.39	1.38	1.26	1.32	1.23	1.07
MR	C1	1.07	1.24	1.20	1.47	1.30	1.38	1.45	1.32	1.10	1.28	1.29	1.73	1.56	1.50	1.41	1.40	1.07	1.74	1.24	1.79	1.59	1.55	1.55	1.47
	C2	1.46	1.05	1.36	1.35	1.11	1.25	1.48	1.41	1.49	1.04	1.51	1.63	1.27	1.37	1.45	1.49	1.58	1.25	1.61	1.66	1.21	1.48	1.82	1.76
	C3	1.26	1.43	1.11	1.39	1.36	1.32	1.45	1.26	1.31	1.37	1.18	1.64	1.35	1.40	1.46	1.31	1.25	1.86	1.14	1.60	1.43	1.44	1.63	1.42
	C4	1.40	1.20	1.41	1.25	1.25	1.18	1.38	1.41	1.47	1.27	1.57	1.46	1.49	1.27	1.36	1.49	1.42	1.84	1.58	1.42	1.47	1.28	1.48	1.65
	C5	1.45	1.19	1.32	1.34	1.06	1.28	1.49	1.35	1.51	1.24	1.46	1.57	1.06	1.36	1.43	1.36	1.52	1.72	1.55	1.62	1.08	1.49	1.70	1.55
	C6	1.39	1.11	1.39	1.40	1.15	1.04	1.25	1.30	1.50	1.16	1.56	1.62	1.38	1.03	1.30	1.34	1.38	1.58	1.48	1.69	1.39	1.01	1.29	1.36
	C7	1.35	1.20	1.30	1.36	1.23	1.26	1.09	1.32	1.44	1.24	1.40	1.57	1.36	1.36	1.13	1.44	1.36	1.81	1.36	1.52	1.34	1.31	1.10	1.46
	C8	1.30	1.19	1.29	1.36	1.17	1.30	1.30	1.11	1.35	1.19	1.40	1.54	1.18	1.33	1.34	1.15	1.28	1.65	1.33	1.59	1.27	1.35	1.35	1.09
WR	C1	1.07	1.47	1.27	1.54	1.54	1.41	1.52	1.36	1.07	1.43	1.24	1.76	1.56	1.40	1.35	1.33	1.07	1.27	1.35	1.80	1.51	1.47	1.66	1.54
	C2	1.44	1.12	1.49	1.49	1.18	1.40	1.52	1.50	1.46	1.17	1.61	1.81	1.37	1.47	1.49	1.54	1.23	1.02	1.49	1.57	1.13	1.25	1.43	1.45
	C3	1.31	1.57	1.13	1.43	1.48	1.38	1.51	1.28	1.25	1.59	1.14	1.70	1.49	1.38	1.37	1.27	1.18	1.37	1.10	1.61	1.38	1.34	1.60	1.36
	C4	1.34	1.41	1.44	1.29	1.42	1.21	1.43	1.41	1.37	1.52	1.58	1.66	1.62	1.28	1.47	1.58	1.30	1.26	1.51	1.53	1.40	1.19	1.51	1.56
	C5	1.44	1.31	1.46	1.44	1.10	1.33	1.56	1.40	1.43	1.34	1.48	1.63	1.11	1.31	1.39	1.25	1.41	1.12	1.71	1.75	1.13	1.41	1.68	1.59
	C6	1.33	1.18	1.45	1.49	1.21	1.01	1.32	1.22	1.32	1.21	1.40	1.68	1.28	1.01	1.21	1.18	1.39	1.12	1.59	1.72	1.26	1.01	1.36	1.34
	C7	1.36	1.25	1.38	1.40	1.28	1.27	1.13	1.31	1.39	1.34	1.40	1.75	1.36	1.33	1.16	1.41	1.30	1.08	1.38	1.68	1.26	1.29	1.19	1.50
	C8	1.33	1.17	1.37	1.41	1.21	1.30	1.36	1.13	1.33	1.22	1.36	1.70	1.26	1.31	1.36	1.17	1.30	1.06	1.45	1.67	1.22	1.30	1.49	1.18

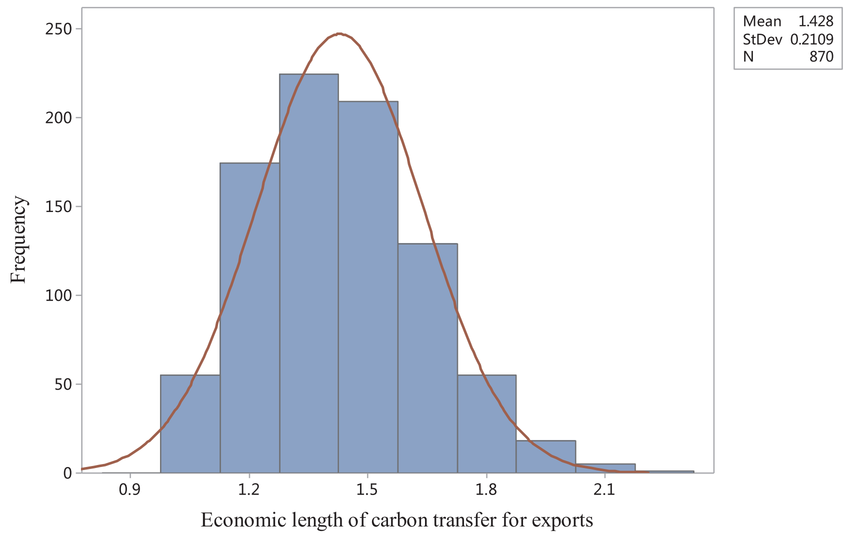
Appendix F. Average ELCT within China from sectoral perspective

	C1	C2	C3	C4	C5	C6	C7	C8	Sum
C1	1.07	1.37	1.24	1.54	1.45	1.42	1.46	1.34	1.26
C2	1.38	1.05	1.45	1.46	1.17	1.32	1.49	1.46	1.39
C3	1.26	1.46	1.14	1.46	1.43	1.37	1.45	1.29	1.25
C4	1.41	1.35	1.49	1.34	1.41	1.21	1.44	1.45	1.32
C5	1.41	1.26	1.40	1.43	1.08	1.33	1.47	1.36	1.36
C6	1.28	1.19	1.38	1.41	1.24	1.02	1.20	1.15	1.07
C7	1.34	1.26	1.35	1.42	1.32	1.29	1.09	1.31	1.31
C8	1.30	1.18	1.36	1.43	1.24	1.31	1.31	1.11	1.25
Sum	1.35	1.22	1.39	1.39	1.12	1.27	1.35	1.37	

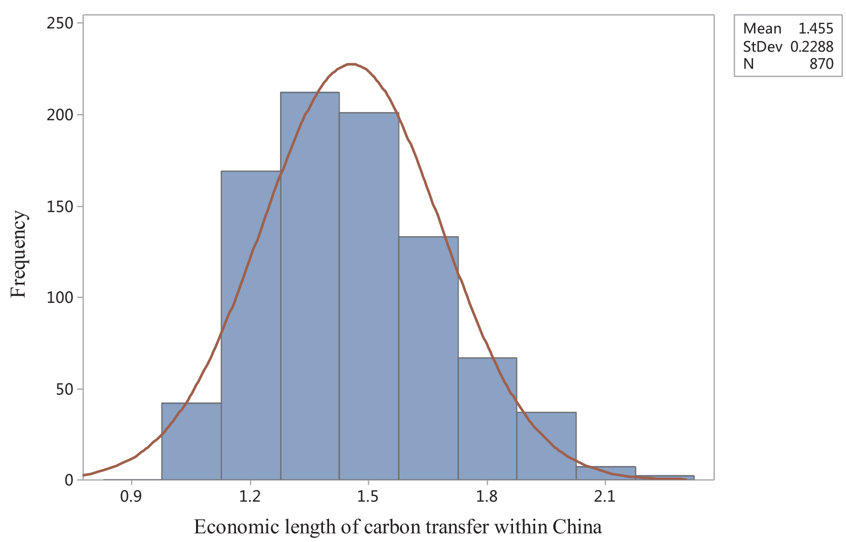
Appendix G. The histograms of all ($870 = 30 \times (30 - 1)$) the bilateral ELCT



(a) Bilateral ELCT for domestic final demand



(b) Bilateral ELCT for exports



(c) Bilateral ELCT within China

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