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Tracking embodied carbon flows in the Belt and Road regions

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Abstract: In the past few decades, economic globalization has driven rapid growth of cross-border trade and a new international division of labor, leading to increasing inter-country embodied carbon flows. Multi-region input-output (MRIO) analysis is used to identify embodied carbon flows between major world regions, including seven regions along the Belt and Road (BR), and the spatial distribution of production- and consumption-based carbon intensities. The results show that current embodied carbon flows are virtually all from BR regions to developed countries, with more than 95% of world net embodied carbon exports coming from BR regions. Consumption in the United States and European Union countries induce about 30% of the carbon emissions in most BR regions, indicating that the former bear a high proportion of consumers' responsibility for the carbon emitted in the latter. For this reason, measuring environmental responsibilities from consumption rather than a production-based perspective is more equitable, while developing countries should be given a louder voice in the construction through dialogue and cooperation, in part in the context of the Belt and Road Initiative, of an inclusive global climate governance system.

Keywords: MRIO; embodied carbon transfers; consumption-based carbon emission; Belt and Road Initiative; inclusive globalization

1 Introduction

Climate change is often considered a global challenge and as posing a long-term threat to human survival and the ecosystem. The Fifth Assessment of the United Nations Intergovernmental Panel on Climate Change (IPCC) indicated that the human impact on the climate system is clear and continues to increase (Mastrandrea *et al*., 2010). As early as the 1990s, researchers began to pay attention to the environmental impacts of global production networks, and in particular of cross-border trade and the international division of labor (Cope-

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land and Taylor, 1994, 2004; Grossman and Krueger, 1991; Chichilnisky, 1994; Antweiler *et al*., 1998). After the Kyoto Protocol in 1997, attempts to identify carbon emission responsibilities have resulted in considerable controversies. Some studies show that current assessments of national carbon responsibilities ignore trade-induced geographies of production and consumption (Peters and Hertwich, 2008). Others draw on analyses of the consequences of economic globalization and international trade to identify consumer responsibilities for embodied carbon emissions and the implications for effective climate policies and international climate cooperation (Lenzen *et al*., 2007).

Previous studies of carbon emissions and carbon leakages rarely used multi-regional input-output (MRIO) analysis due to the lack of availability of data and the complexity of inter-regional relationships. More recently the deepening of globalization and the increasing acuteness of related natural resource and environmental issues have seen the publication of articles using these methods in prestigious journals like *Nature*, *Science*, and *Proceedings of the National Academy of Sciences* (*PNAS*) (Lenzen *et al*., 2012b; Liu *et al*., 2015b; Zhang *et al*., 2017). This research has sought to identify the resource and environmental impacts of geographies of production and consumption (Li *et al*., 2013; Han *et al*., 2017; Han and Chen, 2018; Li and Han, 2018). A number of these studies have revealed environmental linkages caused by the spatial shift of industrial capacity from developed to developing countries and the consequent rapid increase in international trade, showing in some cases that carbon leakages are mainly from emerging to developed economies, such as the United States, Japan, and some EU countries (Ahmad and Wyckoff, 2003; Davis and Caldeira, 2010). These developed countries that therefore take substantial responsibility as consumers for carbon emissions have the greatest capacity technologically to reduce them. And yet it is emerging countries specialized in low-end manufacturing and unable to easily afford advanced environmental protection technologies that are placed under the strongest pressure to reduce carbon emissions (Wyckoff and Roop, 1994; Peters and Hertwich, 2008; Liu *et al*., 2014).

The rise of emerging economies, including China, has challenged the dominance of developed countries in the global governance system (Kowalski and Shepherd, 2006; Hudson, 2016), and these economies are playing an ever more important role in handling international issues. At the same time it is absolutely clear that addressing climate change must involve measures that deal not just with production but also with exchange and with consumption. In this situation it is increasingly important to identify the consumption-related drivers of carbon emissions.

Existing studies have identified embodied carbon emission flows between developed and developing countries by examining the impacts of domestic consumption on the latter. A systematic analysis of consumption-related flows has however yet to be conducted. Given the existence of dramatic changes in the geographies of global development, cooperation among countries in the Global South is at least as important as North-South cooperation and serves to increase the role of these countries in global governance (Marco and David, 2006). As noted by the United Nations (2013), linkages between developing countries in the fields of trade, investment and finance are rapidly growing, and are expected to continue to grow relatively quickly, expanding their domestic markets and international economic relationships. In turn these linkages enable them to share experiences and design institutional and policy reforms capable of contributing to sustainable and equitable economic growth. The rise of the Global South is thus helping reshape the global governance system, traditionally dominated by the Global North. In this context, China's Belt and Road Initiative (BRI) represents a new type of South-South cooperation (Dunford and Liu, 2016; Liu and Dunford, 2016).

The Belt and Road regions (BR regions hereafter) are richly endowed with mineral resources, including oil, natural gas, coal, iron and copper. For example, the oil reserves of the Middle East account for about 60% of the world total, while the natural gas reserves of Russia, Iran, and Qatar account for approximately 58% of the world total (Zou *et al*., 2015). However, in BR regions there are significant mismatches in the geographies of the production and consumption of these and other resources. This situation requires further consideration (Hao *et al*., 2017), not least as the BRI will promote trade and investment that will alter the regional allocation of resources with inevitable environmental impacts on both receiving and providing countries. As the BRI prioritizes infrastructure development, it is also likely to increase the demand for energy (Schwerhoff and Sy, 2017), may stimulate the growth of energy-intensive industries and may engender more extensive supply chains (Wang and Wang, 2017).

These potential but uncertain impacts of the BRI on global carbon emissions will make it a focus of global climate change studies. Nonetheless, at this early stage it is already clear that the development of a comprehensive energy cooperation model and carbon reduction mechanisms are crucial for both BRI implementation and coping with global warming (Zhu *et al*., 2016; Zhang *et al*., 2017). Although impacts will depend on the outcome of these steps, the research that does so far exist suggests that the BRI implementation may increase global carbon emissions to a certain extent. Any potential increase requires however further examination and discussion in the context of global carbon emission linkages.

To contribute to this end, this research examined embodied carbon emission transfers of BR regions with production- and consumption-based intensities to identify production- and consumption-related responsibilities. The remainder of the paper is structured as follows: Section 2 articulates the method employed in this study, Section 3 analyzes the results, Section 4 discusses the policy implications, and Section 5 draws some conclusions.

2 Method and materials

2.1 Method

To identify quantifiably and analyze the embodiment of resources in different economic activities, input-output tables have been widely used. In particular MRIO tables have been employed in many studies to explore the economic interdependence of different economies and to assess the resource and environmental impacts of human activity (Wyckoff and Roop, 1994; Ahmad and Wyckoff, 2003; Wiedmann *et al*., 2007; Peters and Hertwich, 2008; Davis and Caldeira, 2010; Lin and Sun, 2010; Liu *et al*., 2015a). In this research, the MRIO technique and more specifically an existing MRIO model for global resources and emissions (Wiedmann *et al*., 2007; Chen and Han, 2015; Han *et al*., 2018) was developed to compute embodied regional carbon emission flows. The model integrates economic networks and ecological endowments by examining the physical balance of resource use and environmental emissions for a regional system comprising m regions each involving n sectors.

The physical balance of carbon emissions for Sector i in Region r is defined as:

$$p_i^r + \sum_{s=1}^{m}\sum_{j=1}^{n}\varepsilon_j^s z_{ji}^{sr} = \varepsilon_i^r x_i^r \tag{1}$$

where p_i^r represents the direct environmental emissions of economic Sector i in Region r, ε_j^s represents the embodied carbon intensity of Sector j in Region s, z_{ji}^{sr} represents the output from Sector j in Region s for intermediate input to Sector i in Region r, and x_i^r represents the gross output of Sector i in Region r. x_i^r is defined as

$$x_i^r = \sum_{s=1}^{m}\sum_{j=1}^{n} z_{ij}^{rs} + \sum_{s=1}^{m} f_{ii}^{rs} \tag{2}$$

where f_{ii}^{rs} represents the output from Sector i in Region r satisfying the final demand of Sector i in Region s.

Defining $P=[p_i^r]_{1\times mn}$, $E=[\varepsilon_j^s]_{1\times mn}$, $Z=[z_{ji}^{sr}]_{mn\times mn}$, the diagonal matrix $\hat{X}=[x_{ij}^{rs}]_{mn\times mn}$, where $r,s\in(1,2,\ldots,m)$, $i,j\in(1,2,\ldots,n)$, $x_{ij}^{rs}=x_i^r$ when $(i=j)\cap(r=s)$ and $x_{ij}^{rs}=0$ when $(i\neq j)\cup(r\neq s)$, and the diagonal matrix $\hat{F}=[f_{ij}^{rs}]_{mn\times mn}$, where $r,s\in(1,2,\ldots,m)$, $i,j\in(1,2,\ldots,n)$, $f_{ij}^{rs}=f_i^r$ when $(i=j)\cap(r=s)$ and $f_{ij}^{rs}=0$, when $(i\neq j)\cup(r\neq s)$, Equations 1 and 2 can be expressed in matrix form as:

$$P + EZ = E\hat{X} \tag{3}$$

and

$$\hat{X} = Z + \hat{F} \tag{4}$$

Therefore, given the direct inputs matrix P, intermediate inputs matrix Z and gross outputs matrix $\hat{X}$, the embodied carbon intensity matrix can be obtained as:

$$E = P(\hat{X} - Z)^{-1} \tag{5}$$

Emissions embodied in imports and exports for intermediate use ($TEIM$ and $TEEX$), respectively defined as production-driven inflows and outflows, can be obtained as:

$$TEIM^r = \sum_{i=1}^{n} TEIM_i^r = \sum_{i=1}^{n}\sum_{s=1(s\neq r)}^{m}\sum_{j=1}^{n}(\varepsilon_j^s z_{ji}^{sr}) \tag{6}$$

$$TEEX^r = \sum_{i=1}^{n} TEEX_i^r = \sum_{i=1}^{n}\sum_{s=1(s\neq r)}^{m}\sum_{j=1}^{n}(\varepsilon_i^r z_{ij}^{rs}) \tag{7}$$

Emissions embodied in imports and exports for final demand ($FEIM$ and $FEEX$), respectively defined as consumption-driven inflows and outflows, can be obtained as:

$$FEIM^r = \sum_{i=1}^{n} FEIM_i^r = \sum_{i=1}^{n}\sum_{s=1(s\neq r)}^{m}(\varepsilon_i^s f_{ii}^{sr}) \tag{8}$$

$$FEEX^r = \sum_{i=1}^{n} FEEX_i^r = \sum_{i=1}^{n}\sum_{s=1(s\neq r)}^{m}(\varepsilon_i^r f_{ii}^{rs}) \tag{9}$$

In matrix form, direct production-based emissions, TEF, can be obtained as:

$$TEF^r = P^r = \sum_{i=1}^{n} p_i^r \tag{10}$$

while consumption-based emissions, *FEF*, defined as the total emissions associated with domestic demand, can be obtained as:

$$FEF^r = P^r + (TEIM^r - TEEX^r) + (FEIM^r - TEEX^r) \tag{11}$$

2.2 Data sources

Many organizations have built MRIO tables. These databases include the GTAP (Global Trade Analysis Project) database, Economic Co-operation and Development (OECD) database, the World Input-Output Database (WIOD) and the Eora database. In this study the simplified Eora 2012 MRIO table was used (Lenzen *et al.*, 2012a, 2013). This table corresponds with the newly published 2012 input-output table from the Chinese National Bureau of Statistics. At present, the Eora database is the most detailed global scale multi-regional input-output database, covering more countries and longer periods of time than any other. The model covers 189 individual economies and features a 26-sector harmonized industrial classification. This database provides satellite accounts for energy use, carbon emissions and environmental pollution, which can be used to analyze embodied global carbon transfers and the emissions impacts of countries along the Belt and Road. All per capita and GDP data came from the World Bank database (World Bank, 2012). Table A.1 lists the names of and abbreviations for the 65 regions (including China) along the Belt and Road for reference.

3 Results

3.1 Embodied carbon transfers

To study embodied carbon transfers of BR countries, the 189 economies were grouped into 15 regions, and the 65 economies along the Belt and Road were divided into 7 regions (as shown in Table 1): China, Central Asia, Mongolia & Russia, Southeast Asia, South Asia, Central & East Europe and West Asia & Middle East. The detailed embodied production- and consumption-induced carbon transfers, as estimated by the MRIO model, are reported in Table A.2 for reference.

Overall, the total gross embodied carbon exports of the 15 regions was estimated to equal 2925.51 Mt, with net carbon exports amounting to 915.46 Mt. Apart from Central Asia and West Asia & Middle East, all countries/regions along the Belt and Road were net embodied carbon exporters (of in all 893.12 Mt) to other countries/regions. 95% of the world's net carbon exports originated in regions along the Belt and Road. Of these net carbon exporters, China was the largest, exporting 717.89 Mt (78.42% of the world's total). China was closely followed by South Asia and Southeast Asia, with net exports of 94.03 and 76.88 Mt, respectively. Most countries outside of the BRI area were net carbon importers, with the United States accounting for 403.01 Mt of net carbon imports (44.02% of the world total). East Asia, West Asia & Middle East, South America and West Europe were also net importers, accounting for 14.01% (128.27 Mt), 11.46% (104.93 Mt), 10.41% (95.31 Mt) and 8.56% (78.34 Mt) of the total, respectively.

The embodied carbon transfers of BR regions are plotted in Figure 1. As Figure 1 shows, China, South Asia and Southeast Asia were major net embodied carbon exporters, with all regions outside of the BRI area importing embodied carbon from these regions. The main transfer flows included those from China to other BRI regions, from South Asia and Southeast Asia to West Asia & Middle East, from Central & East Europe to Mongolia & Russia and to West Asia & Middle East, and from Mongolia & Russia to Central Asia and to West Asia & Middle East. Of these BR regions, China was the largest carbon exporter, while West Asia & Middle East was the largest carbon importer, with especially large embodied carbon emission imports for Iran, Saudi Arabia, Turkey and the UAE.

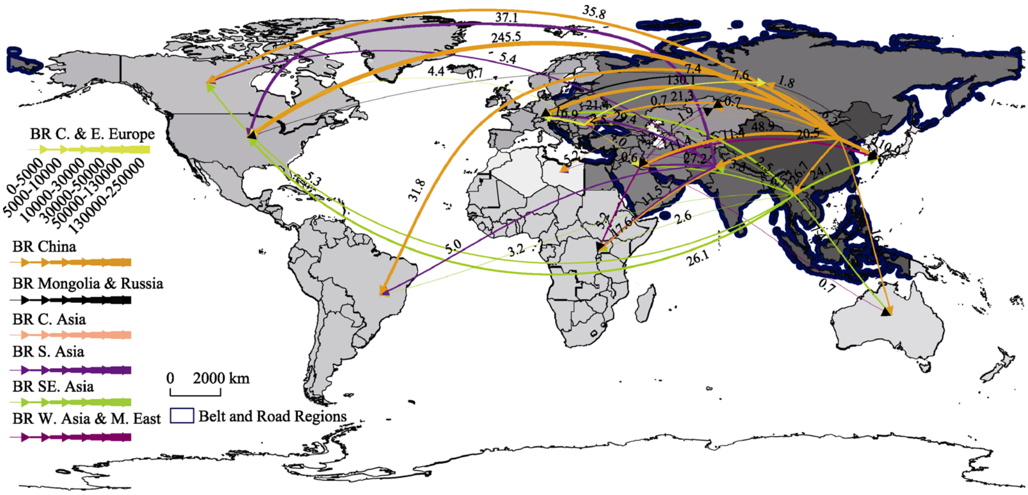

Figure 1 Embodied carbon transfers of the Belt and Road regions

Table 1 Regional classification of 65 regions

Category	Region
China (BRI)	China (12)
Central Asia (BRI)	Kazakhstan (26), Kyrgyzstan (28), Tajikistan (56), Turkmenistan (60), Uzbekistan (63)
Mongolia & Russia (BRI)	Mongolia (37), Russia (48)
Southeast Asia (BRI)	Brunei (9), Cambodia (11), Indonesia (21), Laos (29), Malaysia (34), Myanmar (39), Philippines (44), Singapore (51), Thailand (57), Viet Nam (64)
South Asia (BRI)	Afghanistan (1), Bangladesh (6), India (20), Maldives (35), Nepal (40), Pakistan (42), Sri Lanka (54), Bhutan (58)
Central & East Europe (BRI)	Albania (2), Belarus (7), Bosnia and Herzegovina (8), Bulgaria (10), Croatia (13), Cyprus (14), Czech Republic (15), Estonia (17), Hungary (19), Latvia (30), Lithuania (32), Macedonia (33), Moldova (36), Montenegro (38), Poland (45), Romania (47), Serbia (50), Slovakia (52), Slovenia (53), Ukraine (61)
West Asia & Middle East (BRI)	Armenia (3), Azerbaijan (4), Bahrain (5), Egypt (16), Georgia (18), Iran (22), Iraq (23), Israel (24), Jordan (25), Kuwait (27), Lebanon (31), Oman (41), Palestine (43), Qatar (46), Saudi Arabia (49), Syria (55), Turkey (59), UAE (62), Yemen (65)

3.2 Production- and consumption-based intensities

MRIO analysis also permits the identification of production- and consumption-induced carbon intensities for different countries/regions. Production-based carbon intensity refers to the direct carbon emission within a given country/region per unit of output, and consumption-based carbon intensity refers to the total embodied carbon emissions per unit of final demand. The detailed results are reported in Table A.3.

The geographies of production- and consumption-based carbon intensities were significantly different, especially when comparing BRI and non-BRI regions. As Figure 2 shows, the production- (averaging 0.67 kg/USD) and consumption-based (averaging 0.62 kg/USD) carbon intensities of most regions along the Belt and Road were significantly higher than the global average (0.45 kg/USD). For regions along the Belt and Road, regional production-based carbon intensities in order of magnitude were Mongolia & Russia (1.49 kg/USD), Central Asia (1.43 kg/USD), China (1.17 kg/USD), Central & East Europe (0.65 kg/USD), West Asia & Middle East (0.60 kg/USD), South Asia (0.54 kg/USD), and Southeast Asia (0.48 kg/USD). The consumption-based carbon intensities were respectively: Central Asia (1.10 kg/USD), China (0.88 kg/USD), Mongolia & Russia (0.69 kg/USD), Central & East Europe (0.66 kg/USD), West Asia & Middle East (0.54 kg/USD), South Asia (0.51 kg/USD) and Southeast Asia (0.49 kg/USD).

A comparison of production- and consumption-based carbon intensities (shown in Figure 3) shows that for most BRI regions production-based carbon intensities were significantly higher than those that were consumption-based. More specifically, the differences were: Mongolia & Russia (0.80 kg/USD), Central Asia (0.33 kg/USD), China (0.30 kg/USD), West Asia & Middle East (0.06 kg/USD), and South Asia (0.03 kg/USD).

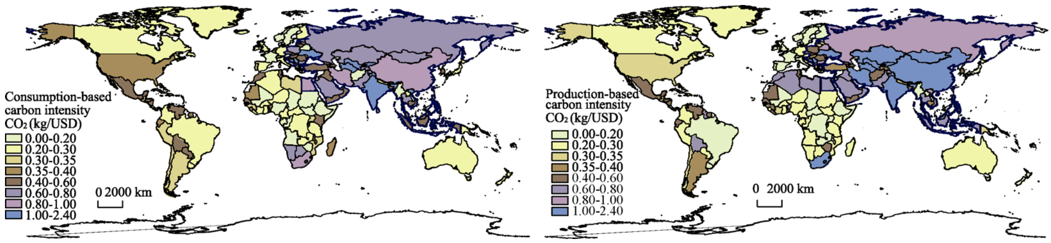

Figure 2 Production- and consumption-based carbon intensities (kg/USD)

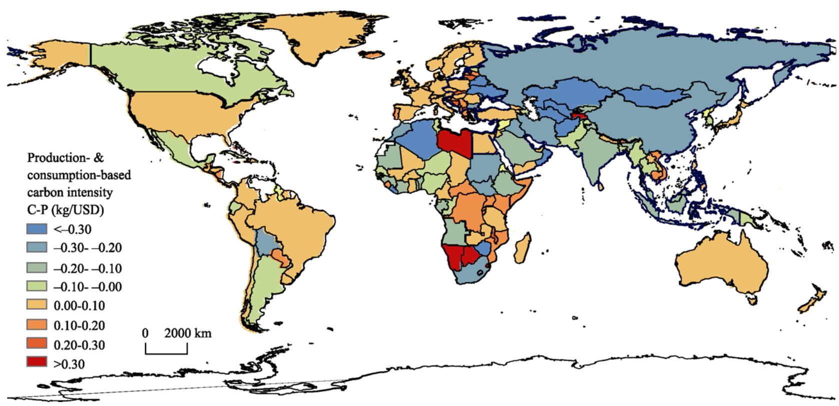

Figure 3 The gap between production- and consumption-based carbon intensities (kg/USD)

Outside the BRI the production-based carbon intensities of most outside regions were lower than their consumption-based intensities, although the differences were no more than 0.10 kg/USD. Generally speaking, for any pair of countries/regions, embodied carbon transfers flow from countries/regions with relatively lower to those with relatively higher carbon intensity. If the directions of flows were the opposite, the carbon emissions of countries/regions with relatively higher carbon intensities would increase, raising global total carbon emissions to a certain degree.

3.3 Sources and sinks of embodied carbon emissions

The identification of embodied consumption-based carbon emissions permits identification and assessment of their sources and sinks for BR regions. A source in this case is the total emissions embodied in goods produced in a particular area. A sink refers to the place in which the products that produce these emissions are consumed.

Nearly 83.06% of all embodied carbon emissions along the Belt and Road were associated with consumption within the area, while 7.20% were associated with the production of goods exported to West Europe, 3.73% and 3.72% with those exported to the rest of East Asia and the United States, respectively, and about 1.36% with goods produced for export to the rest of North America and South America, respectively (Figure 4a). For regions along the Belt and Road, economies including the United States, West Europe and the rest of East Asia usually accounted for about 30% of embodied carbon sources.

The percentages of embodied carbon emissions consumed within China, South Asia and West Asia & Middle East (from 77.63% to 78.73%) were relatively larger than for the other regions. The embodied carbon exports of these areas that were associated with production for non-BRI regions were mainly associated with consumption in West Europe, the United States, and non-BRI East Asia. In contrast, the percentages of embodied emissions associated with self-consumption in Southeast Asia, Central Asia, Mongolia & Russia, and Central & East Europe were somewhat lower, lying between 65.86% and 69.11%.

Of China's embodied carbon emissions, West Europe, the United States and the rest of East Asia accounted for 5.51%, 4.90% and 4.20%, respectively. Paying attention to specific countries, most of the carbon emissions embodied in the imports of the United States, Japan, Korea, Germany, the UK, Canada, Singapore and India are from China (Figure 4b).

The consumption structure of South Asia's carbon emissions was similar to that of China, with 5.58% and 3.56% of its embodied carbon emissions associated with goods produced for export to West Europe and the United States, respectively, and 3.54% and 2.20% for goods exported to West Asia & Middle East and China, respectively (Figure 4c). The United States, China, Germany, the UAE, the UK, Japan, Italy and Singapore were identified as its major carbon importers.

In the case of the carbon emission structure of West Asia & Middle East, West Europe and the rest of East Asia took the largest responsibility for import-generated emissions, accounting for 5.98% and 5.43% of these areas' national totals, respectively. These zones were followed by the United States, China, South Asia and Southeast Asia, with 2.07%, 1.88%, 1.85% and 1.57%, respectively (Figure 4d). The largest contributors to the emissions generated by the production of goods for export from West Asia & Middle East were Japan, Korea, the United States, India, China, Germany and Italy.

In the case of Southeast Asia, 7.74% of carbon emissions were a result of goods they produced for consumption in China, while the rest of East Asia, West Europe and the United States were responsible for 6.67%, 5.86% and 4.87%, respectively. China, the United States, Japan, Korea, Germany, India, the UK and Australia were all major contributors, through their imports, to carbon generated in Southeast Asia (Figure 4e).

Of the carbon emissions of Central Asia, 10.14% and 7.86% were a result of production for export to Mongolia & Russia and West Europe, respectively, while 4.17% and 4.08% were due to exports produced for Central & East Europe and China, respectively. Russia, China, Germany, Ukraine, Iran, Italy, Romania, and the United States were the countries whose imports made the largest contributions to Central Asian emissions (Figure 4f).

Some 11.15% of the embodied carbon emissions of Mongolia & Russia were generated by the production of goods for export to West Europe. 6.97% derived from exports to Central & East Europe, and 3.48%, 2.54% and 2.04% from exports to China, the rest of East Asia and West Asia & Middle East, respectively. The major generators of emissions through imports were China, Germany, Japan, Ukraine, Kazakhstan, France, Turkey and Slovakia (Figure 4g).

Some 19.34% of the embodied carbon emissions of Central & East Europe were associated with exports to West Europe, and 8.32% with those to Mongolia & Russia. Overall, Germany, Russia, Italy, the United States, Austria, France, Turkey, the Netherlands and the UK were the largest causes of emissions from the production of exports in this area (Figure 4h).

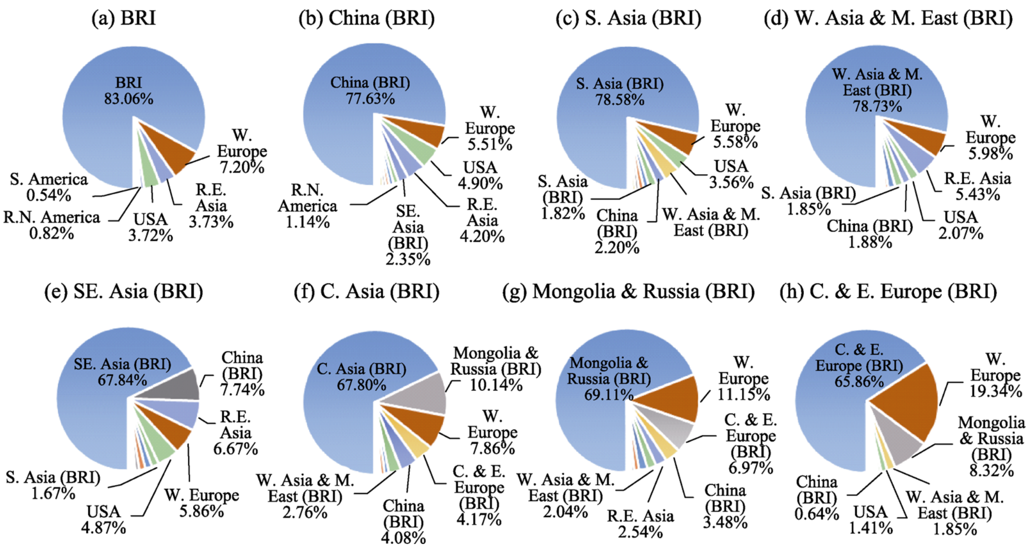

Figure 4 Embodied carbon sources of Belt and Road regions

4 Discussion and conclusions

Manufacturing activities, in particular low-end manufacturing, are a major source of global carbon emissions. In the past, as they industrialized, developed countries produced huge carbon emissions. Only in recent decades, and as a result of the shifting of low-end manufacturing to developing countries from which they then imported finished goods for final consumption, did they witness a decrease in carbon emissions. A reality of globalization was in other words the transfer of high carbon emitting industries producing goods for developed country consumption to emerging economies.

Existing research has revealed that trade-embodied carbon emissions account for about one-third of global carbon emissions. An assessment of national or regional carbon emissions from a production based perspective alone cannot therefore identify national responsibilities. This fact is particularly true in the case of BR regions as these regions have become the world's factory, starting with China and extending subsequently to other BR countries.

The analysis in this paper indicates that the global transfer of embodied carbon overwhelmingly involves transfers from BR regions to other parts of the world. China, South Asia and Southeast Asia are the main exporters of embodied carbon, while the United States, Western Europe, Japan, and Korea are the major importers. Astonishingly, at the time of this study, more than 95% of the world's net embodied carbon export came from BR regions, and the consumption of imported goods accounted for about 30% of the carbon emissions in most of the BR regions. Therefore, although some authors argue that BRI implementation may increase global carbon emissions (e.g., Zhang *et al*., 2017), an outcome of this kind must be understood in the context of global production and consumption linkages and the global carbon emission linkages associated directly with them. In other words, what drives increased carbon emissions in BR regions is not the implementation of the BRI but increased global consumption and in particular increased consumption in developed countries.

By tracing the geographies of embodied carbon flows and comparing production- and consumption-based carbon intensities in BRI regions, this paper has identified their carbon emission sources and sinks. In China, South Asia and West Asia & Middle East an average of about 78% of their total carbon emissions was due to domestic consumption, while the carbon emissions associated with the production of goods to meet import demand from other countries was largely due to exports to West Europe, the United States and the rest of East Asia. In Southeast Asia, Central Asia, Mongolia & Russia, and Central & East Europe, 65% to 70% of their total carbon emissions were induced by domestic consumption.

There was, moreover, a clear spatial difference between global production- and consumption-based embodied carbon intensities. In BR regions, particularly Mongolia, Russia, Central Asia and China, production-based carbon intensities were significantly higher than those that were consumption-based, further indicating that the contribution of developing countries to world economic growth occurred at the expense of increased domestic resource and environmental costs.

This research showed that carbon leakages were more obvious in BR regions than in developed countries like the United States or in poor countries with few manufacturing activities. Since BR regions are and will probably continue to function as the world factory, one cannot expect carbon intensities in these regions to be significantly lower than in other regions. These considerations must play an important role in global economic governance, although global institutions are at present dominated by developed countries that do not want to assume responsibility for the consequences of their own consumption.

In the face of these difficulties, the BRI actually brings new opportunities for BR countries to cope with global climate change. The fact that it is difficult in the short term to persuade developed countries to assume responsibility for their own consumption shows that a clarification of the responsibility of each country or region for carbon emissions is not a scientific issue but a political one, involving bargaining and negotiation. For that reason, the development within the context of the BRI of a comprehensive energy cooperation model and carbon reduction mechanisms will play a crucial role in global climate change governance. Indeed, the joint communiqué of the Belt and Road Forum for International Cooperation called for 'urgent action on climate change and encouraging all parties which have ratified it to fully implement the Paris Agreement' (NDRC, 2015).

Since the BRI embraces most developing countries as well as most net carbon exporters, it is crucial that BR regions enhance cooperation on carbon issues and through that cooperation acquire a louder voice in global climate change governance. The measurement in this article of the responsibility of different countries for consumption-related carbon emissions can help ensure that the principle of fairness is better reflected in international affairs. A consideration of both production and consumption responsibilities and the enhancement of cooperation between embodied carbon importers and exporters will help develop more inclusive global climate governance mechanisms and help find better and more efficient solutions to global climate change.

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