# Consumption-based emission accounting for Chinese cities

Zhifu Mi[1], Yunkun Zhang[1], Dabo Guan[1,*], Yuli Shan[1], Zhu Liu[2], Ronggang Cong[3], Xiao-Chen Yuan[4,5], Yi-Ming Wei[4,5]

[1] Tyndall Centre for Climate Change Research, School of International Development, University of East Anglia, Norwich NR4 7TJ, UK

[2] Applied Physics and Materials Science, California Institute of Technology Resnick Sustainability Institute, Pasadena CA 91125, USA

[3] Department of Environmental Science, Aarhus University, Roskilde 4000, Denmark

[4] Center for Energy and Environmental Policy Research, Beijing Institute of Technology, Beijing 100081, China

[5] School of Management and Economics, Beijing Institute of Technology, Beijing 100081, China

**Abstract**: Most of China's $CO_2$ emissions are related to energy consumption in its cities. Thus, cities are critical for implementing China's carbon emissions mitigation policies. In this study, we employ an input-output model to calculate consumption-based $CO_2$ emissions for thirteen Chinese cities and find substantial differences between production- and consumption-based accounting in terms of both overall and per capita carbon emissions. Urban consumption not only leads to carbon emissions within a city's own boundaries but also induces emissions in other regions via interregional trade. In megacities such as Shanghai, Beijing and Tianjin, approximately 70% of consumption-based emissions are imported from other regions. Annual per capita consumption-based emissions in the three megacities are 14, 12 and 10 tonnes of $CO_2$ per person, respectively. Some medium-sized cities, such as Shenyang, Dalian and Ningbo, exhibit per capita emissions that resemble those in Tianjin. From the perspective of final use, capital formation is the largest contributor to consumption-based emissions at 32–65%. All thirteen cities are categorized by their trading patterns: five are production-based cities in which production-based emissions exceed consumption-based emissions, whereas eight are consumption-based cities, with the opposite emissions pattern. Moreover, production-based cities tend to become consumption-based as they undergo socioeconomic development.

**Keywords**: Consumption-based accounting; Production-based emissions; Embodied emissions; Input-output analysis; Carbon footprint; City

## 1. Introduction

China has been the world's largest producer of $CO_2$ emissions since 2007. In 2013, its $CO_2$ emissions from fuel combustion totalled 8.5 billion tonnes, which accounted for a quarter of global $CO_2$

* **Corresponding author at**: School of International Development, University of East Anglia, Norwich NR4 7TJ, UK
**E-mail address**: dabo.guan@uea.ac.uk (D. Guan).

emissions [1, 2]. China has prioritized climate change mitigation in the past decade, announcing in the 2014 “U.S.–China Joint Announcement on Climate Change” that its $CO_2$ emissions will peak by 2030. In addition, in its 2015 Intended Nationally Determined Contributions, China promised to decrease its $CO_2$ emissions per unit of GDP by 60-65% (based on 2005 levels) by 2030 [3].

Accompanying its rapid economic growth, China’s urban population has increased dramatically during recent decades. The urban population grew to 750 million in 2014, increasing from approximately 300 million in 1990. Today, more than half of China’s population lives in cities [4]. This rapid urbanization and industrialization have led to increased demands for energy and materials, which result in substantial emissions of greenhouse gases (GHG), including $CO_2$ [5, 6]. Approximately 85% of China’s $CO_2$ emissions are related to urban energy consumption, a rate that is much higher than that experienced in Europe (69%) or in the U.S. (80%) [7, 8]. Therefore, cities are critical for implementing China’s carbon emissions mitigation policies. There is an urgent need to understand China’s urban $CO_2$ emissions, as such understanding is fundamental to proposing mitigation actions.

There are two approaches to measuring GHG emissions: production-based and consumption-based accounting [9-11]. Production-based $CO_2$ emissions are emissions caused by domestic production, including exports [12]. This approach accounts for $CO_2$ emissions at the point of production, without consideration of where goods are used or who ultimately uses them [13, 14]. This approach is widely used in global climate change agreements, including the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Conversely, under consumption-based accounting, all emissions occurring along the chains of production and distribution are allocated to the final consumers of products [15]. Pursuant to this approach, areas that import products are allocated the emissions related to their production. Therefore, consumption-based emissions include imports and emissions embodied in trade but exclude exports, whereas production-based emissions include exports and exclude imports [12]. Recent studies have compared the two approaches and demonstrated the advantages of consumption-based accounting [16-19]. For example, Steininger et al. [13] argued that a consumption-based climate policy approach can improve both cost-effectiveness and justice, while Guan et al. [20] indicated that consumption-based accounting helps mitigate global air pollution. Moreover, Larsen and Hertwich [21] argued that consumption-based accounting provides a more useful and less misleading indicator for assessing the performance of local climate actions. Finally, Peters and Hertwich [22] have noted that consumption-based accounting has many advantages over production-based accounting, such as addressing carbon leakage, promoting environmental comparative advantages, increasing options for mitigation, and encouraging technology diffusion.

There are numerous studies on consumption-based carbon emissions at the global and national levels [23]. Peters and Hertwich [22] calculated $CO_2$ emissions embodied in international trade among 87 countries. They found that 53 billion tonnes of $CO_2$ emissions in 2001 were embodied in international trade and that developed countries were net importers of emissions. Hertwich and Peters [24] quantified consumption-based greenhouse gas emissions for 73 nations and 14 aggregated world regions. At the global level in 2001, 72% of greenhouse gas emissions were related to household consumption, 18% to investment and 10% to government consumption. Davis and Caldeira [25] used a fully coupled multi-region input-output (MRIO) model to construct a consumption-based $CO_2$ emissions inventory of 113 countries and regions. The results showed that

62 billion tonnes of $CO_2$ were traded internationally, which accounted for 23% of global emissions. These $CO_2$ emissions were mainly exported from China and other emerging markets to developed countries. Peters et al. [26] developed a global database for consumption-based $CO_2$ emissions for 113 countries. In most developed countries, consumption-based emissions increased faster than territorial production-based emissions. Under consumption-based accounting, net $CO_2$ emissions transferred from developing countries to developed countries grew from 4 billion tonnes in 1990 to 16 billion tonnes in 2008.

At the national level, Wood and Dey [27] applied a consumption-based approach to calculating Australia's carbon footprint and found that emissions embodied in exports were much higher than those embodied in imports and that Australia's total carbon footprint was 522 million tonnes (Mt) in 2005. Nansai et al. [28] applied a global link input-output model to analyse Japan's carbon footprint. Wiedmann et al. [29] and Barrett et al. [30] both calculated the UK's consumption-based greenhouse gas emissions and found that consumption-based carbon emissions were rapidly increasing and that there was a widening gap between production- and consumption-based emissions. Feng et al. [31] tracked carbon emissions embodied in products in the Chinese provinces; these authors found that 57% of total emissions were related to goods and services that were used outside of the province in which they were produced. For example, 80% of the emissions embodied in goods used in the highly developed coastal provinces were imported from less developed areas.

Studies of emission inventories for cities are limited, and most are focused on production-based accounting. Dhakal [8] compiled energy usage and emissions inventories for 35 provincial capital cities in China. The results showed that these 35 cities accounted for 40% of China's energy consumption and $CO_2$ emissions and that the carbon intensity for these cities decreased throughout the 1990s. Hoornweg et al. [32] analysed per capita GHG emissions for several large cities and reviewed emissions for 100 cities. They showed that annual per capita emissions for cities varied from more than 15 tonnes of $CO_2$ equivalent to less than half a tonne. Sugar et al. [33] provided detailed GHG emission inventories for Beijing, Shanghai and Tianjin and found that Chinese cities are among the world's highest per capita emitters when compared with ten other global cities. Liu et al. [34] analysed features, trajectories and driving forces of GHG emissions in four Chinese megacities (Beijing, Tianjin, Shanghai and Chongqing) from 1995 to 2009. The emission inventories compiled in this paper include both direct emissions and emissions from imported electricity. Creutzig [35] used data from 274 cities to explore the potential for urban mitigation of global climate change. The results showed that urban energy use will grow threefold between 2005 and 2050, if current trends in urban expansion continue.

Few studies have researched consumption-based emissions for cities [36, 37]. Hasegawa et al. [38] constructed a multi-region input-output table among 47 prefectures in Japan and estimated their consumption-based carbon emissions. They found that production-based emissions differed great from consumption-based emissions. Moreover, the ratio of carbon leakage to carbon footprint was more than 50% on average at the regional level. Almost all previous studies of consumption-based emissions in Chinese cities focus on the same four megacities, i.e., Beijing, Shanghai, Tianjin and Chongqing. Dhakal [39] used a consumption-based approach to analyse the carbon footprints of four Asian megacities, including Beijing and Shanghai. Feng et al. [40] also analysed consumption-based carbon emissions in the four Chinese megacities and found that urban consumption imposed high emissions on surrounding regions via interregional trade. In this study, we use an input-output model to construct consumption-based $CO_2$ emissions for thirteen Chinese cities.

## 2. Method and data

### 2.1 Input-output model for consumption-based accounting of carbon emissions

The input-output model is one of the most widely used methods of analysing consumption-based carbon emissions [41]. The method is divided into single-region input-output and multi-region input-output (MRIO). In this study, we use the single-region input-output model. Some studies have summarized the input-output model and its applications [42, 43]. Dietzenbacher et al. [44] compiled eight experts' views on the future of input-output. As mentioned above, the method has been widely used in environmental research [45] on energy consumption [46-48], greenhouse gas emissions [49-52], air pollution [53, 54], water use [55-58], land use [59, 60], biodiversity loss [61, 62] and materials use [63, 64]. In this study, the input-output model is used to calculate the production-based carbon emissions from production based emission inventories for Chinese cities. The relationship between production- and consumption-based emissions is 'consumption-based emissions = production-based emissions – emissions embodied in exports + emissions embodied in imports'.

The analytical framework of the input-output model was developed by Wassily Leontief in the late 1930s [65]. The basic linear equation of the input-output model is

$$X = (I - A)^{-1} Y \tag{1}$$

where $X$ is the total output vector whose element $x_i$ is the output of sector $i$, $Y$ is the final demand vector whose element $y_i$ is the final demand of sector $i$, $I$ is the identity matrix, and $(I - A)^{-1}$ is the Leontief inverse matrix.

To calculate consumption-based $CO_2$ emissions, we require the carbon intensity (i.e., $CO_2$ emissions per unit of economic output) for all economic sectors. Suppose $k_i$ is the carbon intensity of sector $i$, then the consumption-based $CO_2$ emissions can be calculated as follows:

$$C = K(I - A)^{-1} Y^d \tag{2}$$

where $C$ is a vector of total $CO_2$ emissions embodied in goods and services used for final demand, $K = [k_1\ k_2\ ...\ k_n]$ is a vector of carbon intensity for all economic sectors, and $Y^d = diag(Y)$ means that the vector of $Y$ is diagonalized [12, 66].

Eq. (2) calculates the total emissions associated with the final demand, but it may not able to distinguish $CO_2$ emissions from local production and imports. It is difficult to obtain details related to imports, so we use national data to calculate the emissions embodied in imports:

$$\overline{C} = \overline{K}(I - \overline{A})^{-1} \overline{Y}^d \tag{3}$$

where $\overline{C}$ is the total embodied emissions in the import, $\overline{K}$ is the vector of national carbon intensity, $\overline{A}$ is the direct requirement matrix for the import, $\overline{Y}$ is the import, and $\overline{Y}^d = diag(\overline{Y})$ means that the vector of $\overline{Y}$ is diagonalized.

Notably, emissions from residential energy consumption are not included in our calculations.

### 2.2 Data sources

In this study, we use the input-output model to calculate consumption-based $CO_2$ emissions for thirteen cities in China. The input-output tables for the cities are derived from regional statistics bureaus. Population data are obtained from the database of the National Bureau of Statistics of China [4]. China does not officially release carbon emissions data, and data quality is relatively poor at the city level—with the exception of a few megacities. Therefore, we developed a method for constructing a production-based $CO_2$ emissions inventory for Chinese cities using the definition provided by the IPCC territorial emission accounting approach [67-69]. Each inventory covers 47 socioeconomic sectors, 20 energy types and 9 primary industry products.

## 3. Results

### 3.1 Consumption-based carbon emissions for thirteen cities in China

Table 1 shows the socio-economic information of the thirteen cities in 2007. It can be seen that Shanghai has the highest GDP per capita and the highest population density. On the contrary, Hengshui has the lowest GDP per capita with only 12724 Chinese Yuan (CNY) per capita. Capital formation occupies the highest percentage in the final demand. For example, Xian's capital formation occupies more than 70% in the total final demand.

Table 1 Socio-economic information of the thirteen cities in 2007.

| | Population (Million) | Area ($km^2$) | GDP per capita (¥ per person) | Household consumption (Million ¥) | Government consumption (Million ¥) | Fixed capital formation (Million ¥) | Inventory increase (Million ¥) | Export (Million ¥) | Import (Million ¥) |
|---|---|---|---|---|---|---|---|---|---|
| Beijing | 12.2 | 16411 | 78762 | 284654 | 221379 | 408256 | 47571 | 1179544 | 1183462 |
| Shanghai | 13.8 | 6340 | 88398 | 445552 | 156079 | 504140 | 52709 | 2165237 | 2104832 |
| Tianjin | 9.6 | 11920 | 52382 | 130924 | 75515 | 268135 | 24111 | 851749 | 845395 |
| Chongqing | 32.4 | 82400 | 12918 | 181557 | 59575 | 221678 | 9046 | 245238 | 299169 |
| Dalian | 5.8 | 13237 | 54146 | 76832 | 39215 | 170614 | 16101 | 385848 | 375542 |
| Harbin | 9.9 | 53840 | 24680 | 69486 | 41707 | 105799 | 19634 | 111420 | 104367 |
| Hengshui | 4.3 | 8815 | 12724 | 18367 | 5798 | 20927 | 7686 | 561432 | 559760 |
| Ningbo | 5.6 | 9816 | 60844 | 66565 | 40943 | 166523 | 27301 | 710087 | 667917 |
| Qingdao | 7.6 | 11282 | 49955 | 100176 | 41389 | 172300 | 19382 | 571674 | 526269 |
| Shenyang | 7.1 | 12948 | 45383 | 79783 | 50200 | 181827 | 2287 | 169577 | 161559 |
| Shijiazhuang | 9.6 | 15848 | 24841 | 67565 | 26044 | 128040 | 113 | 527903 | 512420 |
| Tangshan | 7.2 | 13472 | 38355 | 71417 | 25075 | 69382 | 33204 | 337393 | 258530 |
| Xian | 7.6 | 10108 | 23065 | 70717 | 27502 | 126904 | 16928 | 102712 | 168490 |

Note: ¥ means Chinese Yuan (CNY).

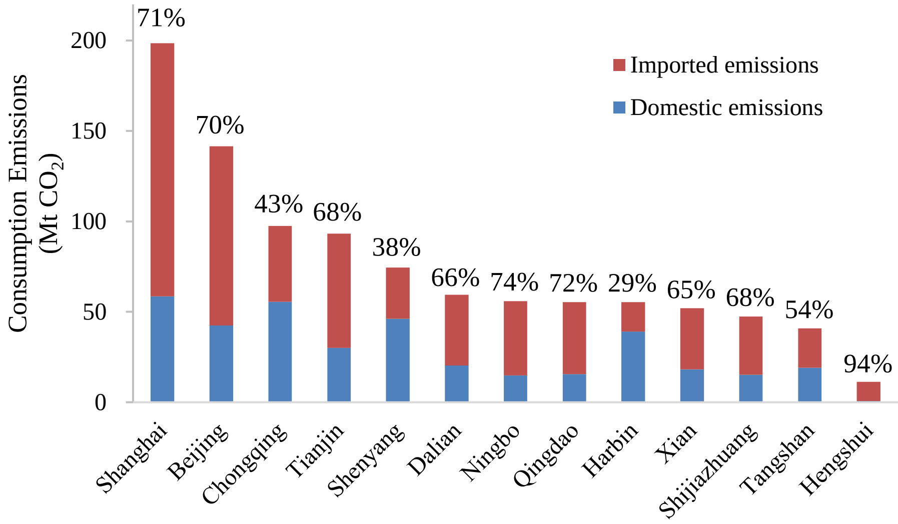


Fig. 1. Imported and domestic emissions in the total consumption-based $CO_2$ emissions. The percentages of imported emissions are shown above the bars.

Consumption-based emissions include imported emissions (emissions embodied in imports) and domestic emissions (from the consumption of domestic products). Fig. 1 shows that imported emissions were much higher than domestic emissions in 2007 in most cities. In megacities such as Shanghai, Beijing and Tianjin, approximately 70% of consumption-based emissions are imported from other regions. Hengshui has the highest percentage of imported emissions in its total consumption-based emissions because its imports are approximately 11 times greater than its final consumption. Overall, this reveals that urban consumers rely largely on goods and services produced elsewhere in China. This result is consistent with studies on cities in other countries. For example, Hasegawa et al. [38] found that imported $CO_2$ emissions accounted for about 40-80% in total emissions for Japanese prefectures.

In several cities, including Chongqing, Shenyang and Harbin, more than half of the consumption-based $CO_2$ emissions occur within city boundaries. Approximately 29% of Harbin's emissions are imported from other regions for two reasons. First, Harbin has lower imports than other cities. For example, Shijiazhuang's imports are 4 times those of Harbin, although the two cities have similar GDPs. Second, the carbon intensity of Harbin's exports is much higher than that of its imports. Specifically, the carbon intensity of its exports is 215 g $CO_2$ per CNY, which is 37% higher than that of its imports.

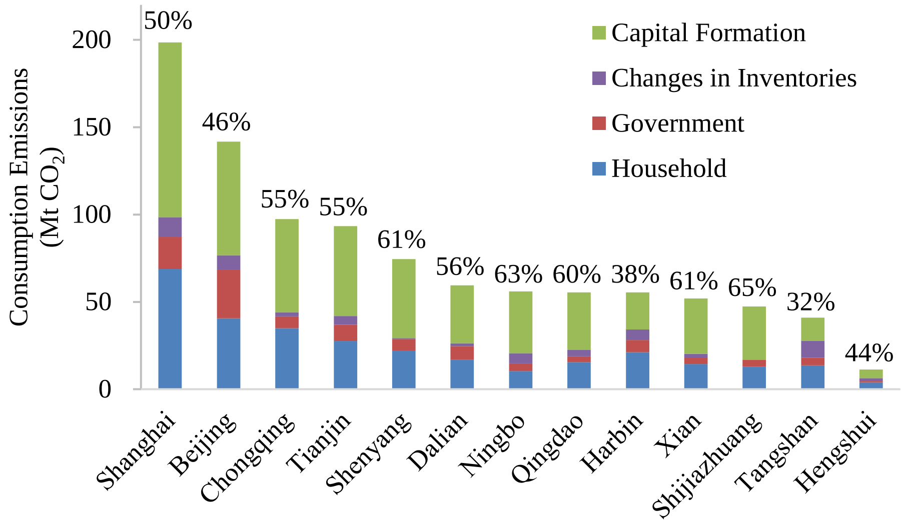


Fig. 2. Embodied $CO_2$ emissions in major final demand categories. The percentages of emissions induced by capital formation are shown above the bars.

From the perspective of final consumption, $CO_2$ emissions are produced by four final demand categories, including household consumption, government, changes in inventories, and capital formation. Fig. 2 shows that capital formation is the largest contributor to consumption-based emissions, which corroborates previous research on $CO_2$ emissions in China [70-72]. The high contribution of capital investments to consumption-based emissions is driven by rapid urbanization, large-scale economic growth, and government policies [40, 73]. Capital formation contributes more than 60% of emissions in four cities, including Shijiazhuang (65%), Ningbo (63%), Xian (61%) and Shenyang (61%). Shijiazhuang has the highest percentage of emissions derived from capital formation, which is determined by its consumption structure. Its capital formation accounted for 58% in its total final demands in 2007. After capital formation, household consumption is the second largest driver of emissions. The percentages of emissions produced by household consumption range between 19% (Ningbo) and 38% (Harbin). Harbin exhibits the highest percentage of emissions attributed to household consumption. In this city, capital formation and household consumption make similar contributions to final, with each contributing 38% of total $CO_2$ emissions.

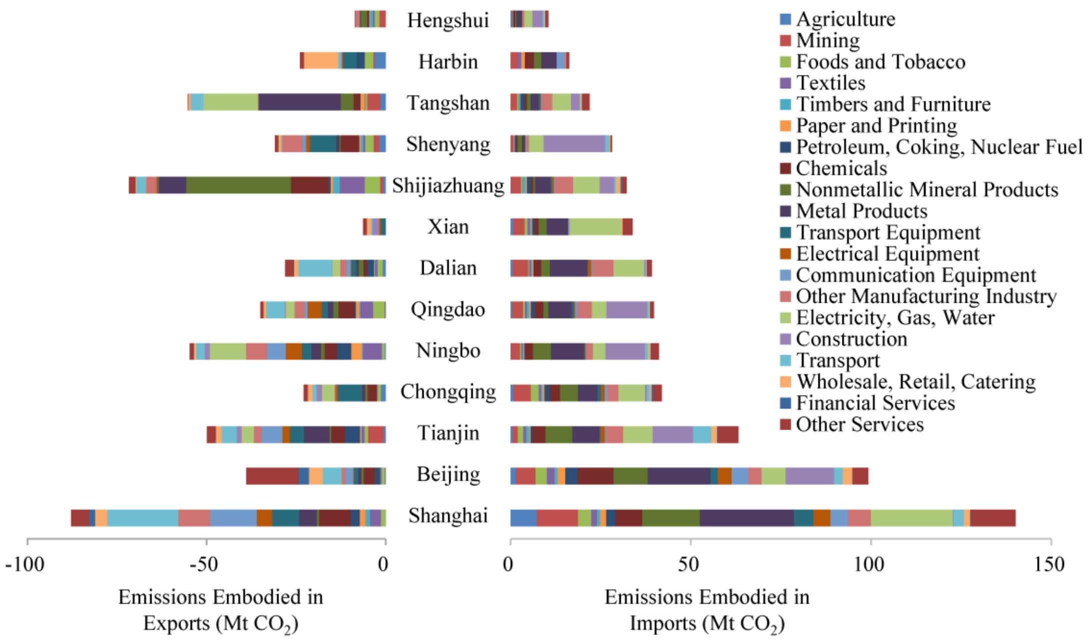


Fig. 3. $CO_2$ emissions embodied in imports and exports for thirteen cities.

Carbon emissions embodied in imports and exports vary greatly in the thirteen Chinese cities included in this study (see Fig. 3). Emissions embodied in imports for the four megacities are much larger than in other medium-sized cities. For example, emissions embodied in imports in Shanghai are 140 Mt $CO_2$, which is 13 times greater than in Hengshui. The sector of metal products is the largest contributor to the embodied emissions of imports. In the city of Dalian, the imports of metal products produce 10 Mt $CO_2$, which account for 26% of the total emissions embodied in imports. In addition, the sector of construction also cause substantial carbon emissions in Chinese cities. For example, Qingdao's imports in Construction generate 11 Mt $CO_2$ or approximately 28% of total emissions embodied in imports.

For most cities, the emissions embodied in their imports are greater than the emissions embodied in their exports. For instance, the embodied emissions of Xian's imports are 34 Gt $CO_2$, whereas the embodied emissions of its exports are only 6 Gt $CO_2$. In fact, Xian's imports were approximately 1.6 times greater than its exports in 2007. In addition, the carbon intensity of Xian's production is lower than that of its exports. The carbon intensity of Xian's imports was 201 g $CO_2$ per CNY in 2007, which was much higher than that of its exports (61 g $CO_2$ per CNY). Therefore, one unit of import embodies more $CO_2$ emissions than an equivalent unit of export. However, the embodied emissions in imports are smaller than the embodied emissions in exports for five cities, including Tangshan, Shijiazhuang, Harbin, Ningbo and Shenyang. Therefore, the producer responsibility is greater than the consumer responsibility in these regions. For example, emissions embodied in Tangshan's imports equal 22 Gt $CO_2$, which is less than half the emissions embodied in its exports (55 Gt $CO_2$) mainly because the carbon intensity of its imports is much lower than that of its exports. The carbon intensities of Tangshan's imports and exports were 85 and 164 g $CO_2$ per CNY in 2007, respectively.

### 3.2 Comparisons between production- and consumption-based emissions

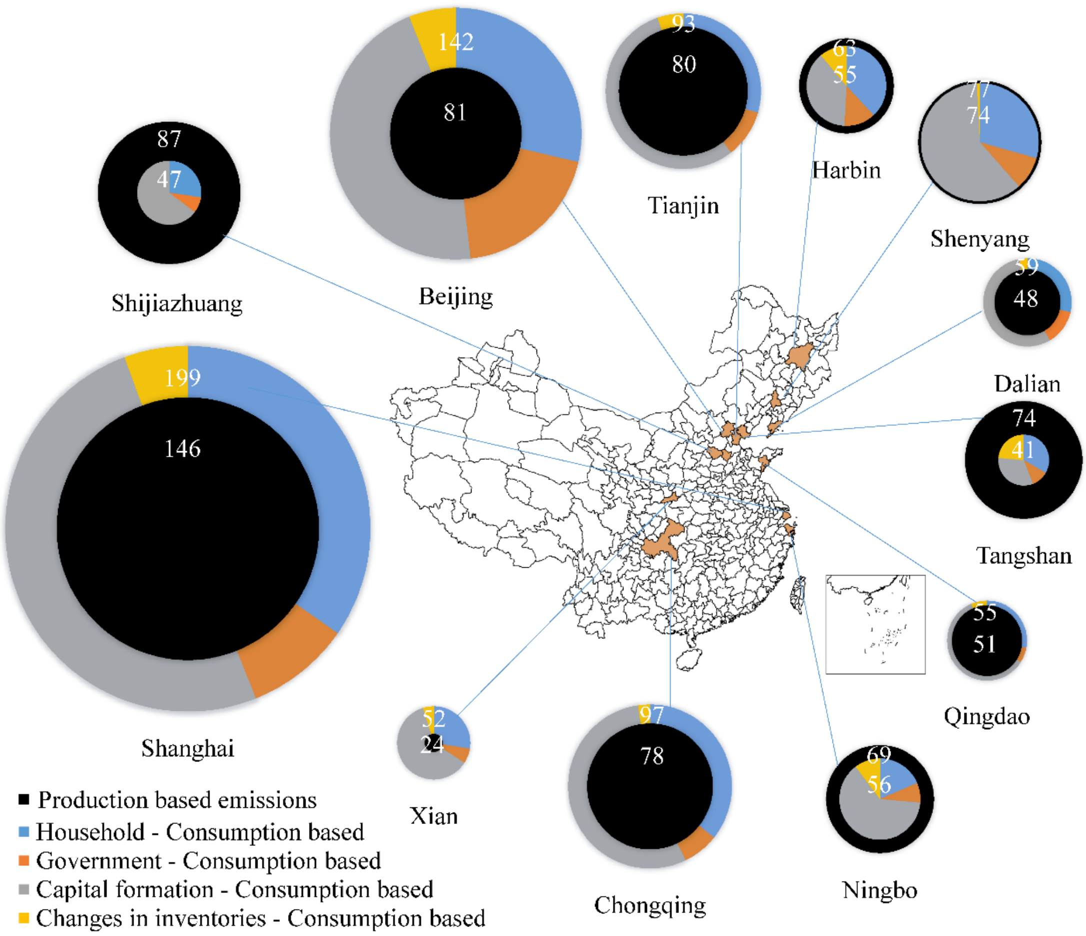


Fig. 4. Production- and consumption-based $CO_2$ emissions at the city level. The black circles represent production-based emissions, whereas the other circles represent consumption-based emissions, with the four colours representing emissions produced by household consumption, government, capital formation and changes in inventory, respectively. Total production- and consumption-based $CO_2$ emissions are shown in the pie charts (in Mt $CO_2$).

Fig. 4 compares production- and consumption-based carbon emissions in a selection of Chinese cities. It can be seen that there are great differences between production- and consumption-based emissions for all cities. It is mainly caused by two factors: trade deficit and different carbon intensity [74, 75]. All thirteen cities are categorized by their trading patterns. Fig. 4 shows that five are production-based cities in which production-based emissions are higher than consumption-based emissions. Shijiazhuang is a typical production-based city with production- and consumption-based $CO_2$ emissions at 87 and 47 Mt, respectively. Its annual per capita production-based emissions total 9 tonnes, which is 83% higher than its annual per capita consumption-based emissions (5 tonnes). Notably, Shijiazhuang's imports and exports are almost equal, although there is a substantial difference between the $CO_2$ emissions embodied in its imports and exports, which is mainly due to its high-carbon-intensity domestic production. The average carbon intensity of its exports is 136 g $CO_2$ per CNY, which is much higher than that of its imports (63 g $CO_2$ per CNY). Therefore, improving technology and reducing carbon intensity are critical for these cities to control production-based emissions. Because of the large gap between the two approaches to emission accounting, the production-based cities prefer that consumption-based accounting be used to allocate responsibilities for climate change mitigation.

Consumption-based emissions are larger than production-based emissions in eight cities. For example, Xian's consumption-based $CO_2$ emissions are 52 Mt, which is more than twice its production-based emissions (24 Mt). In fact, Xian's imports are approximately 1.6 times more than its exports. In addition, the carbon intensity of Xian's domestic production is lower than other cities.

The carbon intensity of its exports is 61 g $CO_2$ per CNY, which is similar to Tianjin. However, the carbon intensity of Xian's imports is 201 g $CO_2$ per CNY—much higher than its exports. Production-based accounting benefits these consumption-based cities in allocating responsibilities. Clearly, the most developed cities in China, such as Beijing, Shanghai and Tianjin, tend to be consumption-based cities On the contrary, most medium-sized cities are production-based cities. Production-based cities tend to become consumption-based cities as they undergo further socioeconomic development.

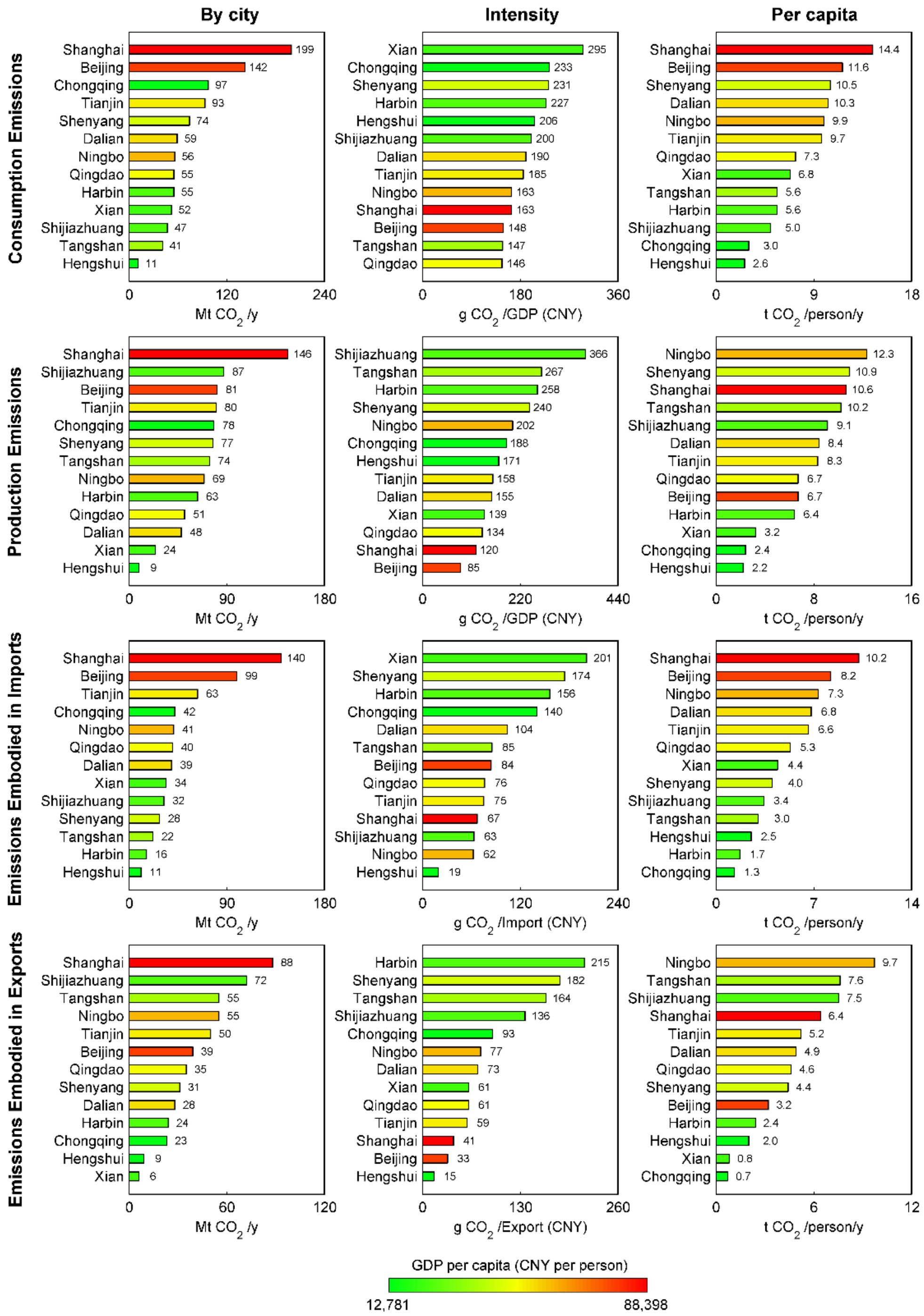


Fig. 5 Thirteen cities' consumption-based emissions (row 1), production-based emissions (row 2), emissions embodied in imports (row 3), and emissions embodied in exports (row 4). This figure shows regional emissions totals (left column), emissions intensity (centre column), and per capita emissions (right column). The colour of the bars corresponds to the city's GDP per capita, from the most affluent cities in red to the least developed cities in green (see scale).

Fig. 5, row 1, *Left*, shows the consumption-based emissions for thirteen cities in China. Overall consumption-based emissions are greatest in the four megacities, i.e., Shanghai (199 Mt $CO_2$), Beijing (142 Mt $CO_2$), Chongqing (97 Mt $CO_2$) and Tianjin (93 Mt $CO_2$). Consumption-based emissions in Shanghai are approximately 18 times those of Hengshui (11 Mt $CO_2$). Annual per capita consumption-based emissions in Shanghai, Beijing and Tianjin are 14, 12 and 10 tonnes of $CO_2$ per person, respectively (Fig. 5, row 1, *Right*). Some medium-sized cities, such as Shenyang, Dalian and Ningbo, have per capita emissions that are similar to Tianjin's. In Chongqing, per capita consumption-based emissions are very low (3 tonnes $CO_2$ per person), although this city's total consumption-based emissions are high.

With regard to production-based emissions, Shanghai is the largest emitter with 146 Mt $CO_2$ (Fig. 5, row 2, *Left*). Shijiazhuang has rather high production-based emissions (87 Mt $CO_2$), which are even higher than Beijing (81 Mt $CO_2$) and Tianjin (80 Mt $CO_2$). Domestic production-based emissions per unit of GDP reflect the technological level of a city's production (Fig. 5, row 2, *Centre*). Shijiazhuang has the highest carbon intensity of the thirteen Chinese cities, with 366 g $CO_2$ per CNY, which is one of the main reasons for its high production-based emissions. By contrast, Beijing and Shanghai have the highest levels of technology, and their carbon intensities are 85 and 120 g $CO_2$ per CNY, respectively. The highest annual per capita production-based emissions are found in Ningbo, Shenyang, Shanghai and Tangshan (10-12 tonnes $CO_2$ per person; Fig. 5, row 2, *Right*). In Chongqing, per capita production-based emissions are low, as are its per capita consumption-based emissions. We find a substantial difference between production- and consumption-based accounting in terms of overall carbon emissions as well as per capita levels. As a result, the choice of an emission accounting approach has a major impact on allocating responsibilities for climate change mitigation. Thus, the two different accounting approaches must be considered comprehensively in identifying fair mitigation policies.

Overall emissions embodied in imports are shown in Fig. 5, row 3, *Left*. We find that more developed cities tend to import more $CO_2$ emissions. As the two most developed cities in China, Shanghai and Beijing have the largest amounts of emissions embodied in imports. By contrast, Harbin and Hengshui, two less developed cities, have the lowest amounts of emissions embodied in imports, which further confirms that production-based cities tend to become consumption-based cities as they undergo further socioeconomic development. In the case of exports (Fig. 5, row 4, *Left*), emissions embodied in exports are greatest in Shanghai (88 Mt $CO_2$) and Shijiazhuang (72 Mt $CO_2$), which is a primary reason for Shijiazhuang's high production-based $CO_2$ emissions.

## 4. Conclusions

Consumption-based $CO_2$ emissions have been accepted by an increasing number of researchers and policy makers. In this study, we calculate consumption-based $CO_2$ emissions for thirteen Chinese cities and find that consumption in these cities not only leads to carbon emissions within their own boundaries but also induces emissions in other regions via interregional trade. For instance, more than 70% of consumption-based emissions in Beijing and Shanghai are imported from other regions, which shows that urban consumers rely largely on goods and services imported from elsewhere in China. Therefore, cooperation between consuming and producing regions is critical to mitigate climate change. China currently has pilot carbon trading systems in seven cities and plans to establish a national emissions trading scheme by 2017, which will help improve regional cooperation on mitigation in China. In addition, a clean development mechanism (CDM) within China may encourage cooperation between cities and their neighbours. Under such a mechanism, cities may invest in their surrounding areas and obtain carbon emission permits.

Capital formation is the largest contributor to consumption-based emissions in the thirteen cities. For example, more than 60% of consumption-based emissions were caused by capital formation in Shenyang and Ningbo in 2007. The high contribution of capital investment to consumption-based emissions is driven by rapid urbanization, large-scale economic growth, and government policies. Household consumption is the second largest driver of emissions, but the percentage of emissions induced by household consumption remains much smaller in China than in other countries. In the future, more residents will transition from rural to urban lifestyles as China continues its rapid urbanization, leading to increased $CO_2$ emissions related to household consumption.

All thirteen cities are categorized in terms of their trading patterns. In five production-based cities, production-based emissions are higher than consumption-based emissions. Shijiazhuang is a typical production-based city, whose production- and consumption-based $CO_2$ emissions are 87 and 47 Mt, respectively. Improving technology and reducing carbon intensity are critical if these cities are to control production-based emissions. Conversely, eight of the cities are consumption-based cities in which consumption-based emissions exceed production-based emissions. For example, Xian's consumption-based $CO_2$ emissions are 52 Mt, more than twice its production-based emissions (24 Mt). Clearly, the most developed cities in China tend to be consumption-based cities, such as Beijing, Shanghai and Tianjin. Similarly, most medium-sized cities are production-based cities, and production-based cities tend to become consumption-based cities as they undergo further socioeconomic development. Based on this trend, more Chinese cities will transition from production-based to consumption-based cities as a result of rapid social development. Consequently, more production-based $CO_2$ emissions will be transferred to rural areas or abroad. Therefore, rural and urban areas must cooperate to tackle the challenge of climate change within China.

At present, few governments choose consumption-based accounting in determining their mitigation policies, and most global climate change agreements are based on production-based accounting, including the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Consumption-based accounting's advantages have been shown in many studies; this approach elucidates the drivers of emissions growth, improves cost-effectiveness and justice, addresses carbon leakage, promotes environmental comparative advantages, and encourages technology diffusion [13, 22, 26, 40]. There are substantial differences between production- and consumption-based accounting in terms of calculating both overall and per capita carbon emissions levels. As a result, the selection of an emission accounting approach has a major influence on the allocation of responsibilities for climate change mitigation. The two different accounting approaches must thus be considered comprehensively to identify fair mitigation policies. At the city level, consumption-based accounting can help cities to reduce emissions both within city boundaries and along their entire supply chains at minimum cost. Interregional cooperation on climate change mitigation should employ consumption-based accounting to allocate mitigation responsibilities more fairly and efficiently. Therefore, consumption-based carbon emission accounting is a complementary tool for promoting climate action at the city level.

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## Support information

In this study, the production-based $CO_2$ emissions inventories are compiled according to Intergovernmental Panel on Climate Change (IPCC) guidance and include two parts: $CO_2$ emissions from fossil fuel consumption and from industrial processes. **Error! Reference source not found.** presents the methodology framework of the inventory compilation.

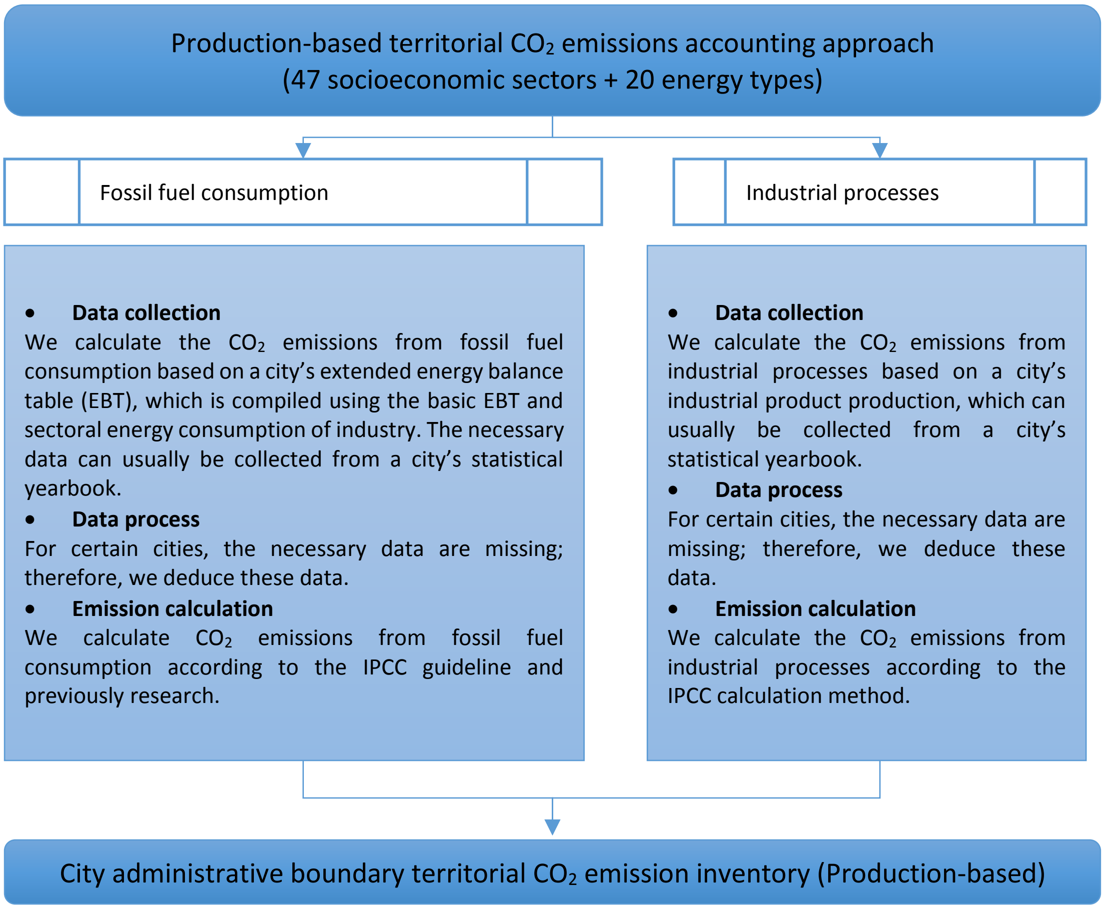


Figure S1 Production-based $CO_2$ emission inventory accounting approach

## 1. Scopes definition

In accordance with the guidelines from the IPCC regarding the allocation of GHG emissions, we defined the scope of city's production-based $CO_2$ emissions accounts in **Error! Reference source not found.**. The $CO_2$ emissions include all that occurs within administered territories and offshore areas over which one region has jurisdiction, including emissions produced by socioeconomic sectors and residence activities directly within the region boundary. The $CO_2$ emissions inventory compiled by this method consists of two parts (see **Error! Reference source not found.**). The first part is emissions from fossil fuel consumption, and the second part is emissions from industrial processes.

Table S1 Scope definition for city's production-based $CO_2$ emissions accounts

| Spatial boundaries | Components |
|---|---|
| In-boundary fossil fuel related $CO_2$ emissions | Primary-industry fossil fuel combustion (farming, forestry, animal husbandry, fishery and water conservancy)<br>Industrial fossil fuel combustion (40 sectors)<br>Construction fossil fuel combustion<br>Tertiary-industry fossil fuel combustion (2 sectors)<br>Residential fossil fuel combustion (Urban and Rural)<br>Other |
| $CO_2$ emissions from industrial process | $CO_2$ emissions from 9 industrial production process |

Note: Due to the city administrative boundary spans both urban and rural geographies in China, we divide the residential energy use into 2 parts: urban and rural.

The fossil fuel related $CO_2$ emissions are calculated for 20 energy types and 47 socioeconomic sectors. The 47 socioeconomic sectors are defined according to the Chinese National Administration for Quality Supervision and Inspection and Quarantine (NAQSIQ), which include all possible socioeconomic activities conducted in a Chinese city's administrative boundary (see **Error! Reference source not found.**).

Table S2 Sectors defined in city's $CO_2$ emission inventory

| No. (***i***) | Socioeconomic sectors | Category |
|---|---|---|
| 1 | Farming, Forestry, Animal Husbandry, Fishery and Water Conservancy | Primary industry |
| 2 | Coal Mining and Dressing | Mining |
| 3 | Petroleum and Natural Gas Extraction | |
| 4 | Ferrous Metals Mining and Dressing | |
| 5 | Nonferrous Metals Mining and Dressing | |
| 6 | Non-metal Minerals Mining and Dressing | |
| 7 | Other Minerals Mining and Dressing | |
| 8 | Logging and Transport of Wood and Bamboo | Manufacturing |
| 9 | Food Processing | |
| 10 | Food Production | |
| 11 | Beverage Production | |
| 12 | Tobacco Processing | |
| 13 | Textile Industry | |
| 14 | Garments and Other Fibre Products | |
| 15 | Leather, Furs, Down and Related Products | |
| 16 | Timber Processing, Bamboo, Cane, Palm Fibre & Straw Products | |
| 17 | Furniture Manufacturing | |
| 18 | Papermaking and Paper Products | |
| 19 | Printing and Record Medium Reproduction | |
| 20 | Cultural, Educational and Sports Articles | |
| 21 | Petroleum Processing and Coking | |
| 22 | Raw Chemical Materials and Chemical Products | |
| 23 | Medical and Pharmaceutical Products | |
| 24 | Chemical Fibre | |
| 25 | Rubber Products | |
| 26 | Plastic Products | |
| 27 | Non-metal Mineral Products | |
| 28 | Smelting and Pressing of Ferrous Metals | |
| 29 | Smelting and Pressing of Nonferrous Metals | |
| 30 | Metal Products | |
| 31 | Ordinary Machinery | |
| 32 | Equipment for Special Purposes | |
| 33 | Transportation Equipment manufacturing | |
| 34 | Electric Equipment and Machinery | |
| 35 | Electronic and Telecommunications Equipment | |
| 36 | Instruments, Meters, Cultural and Office Machinery | |
| 37 | Other Manufacturing Industry | |
| 38 | Scrap and waste | |
| 39 | Production and Supply of Electric Power, Steam and Hot Water (Electricity generation) | Electric power, gas and water production and supply |
| 40 | Production and Supply of Gas | |
| 41 | Production and Supply of Tap Water | |
| 42 | Construction | Construction |
| 43 | Transportation, Storage, Post and Telecommunication Services (Transportation services) | Services sectors / Tertiary industry |
| 44 | Wholesale, Retail Trade and Catering Services (Wholesale services) | |
| 45 | Urban | Residential usage |
| 46 | Rural | |
| 47 | Other | Other |

We include 20 energy types in this paper that are widely used in the Chinese energy system (see **Error! Reference source not found.**). We exclude emissions from imported electricity and heat consumption from outside the city boundary owing to the lack of data on the energy mix in the generation of imported electricity.

Table S3 Energy types involved in city's $CO_2$ emission inventory and emission factors

| No. ($j$) | Energy types | $NCV_j$ (PJ / $10^4\,t, 10^8\,m^3$, etc.) | $EF_j$ (Mt $CO_2$ / PJ) | $O_{ij}$ (%) |
|---|---|---|---|---|
| 1 | Raw coal | 0.20908 | 0.087464 | 88.535 |
| 2 | Cleaned coal | 0.26344 | 0.087464 | 88.535 |
| 3 | Other washed coal | 0.15393 | 0.087464 | 88.535 |
| 4 | Briquettes | 0.17796 | 0.087464 | 88.535 |
| 5 | Coke | 0.28435 | 0.104292 | 97.000 |
| 6 | Coke oven gas | 1.63080 | 0.071414 | 99.000 |
| 7 | Other gas | 0.84290 | 0.071414 | 99.000 |
| 8 | Other coking products | 0.28435 | 0.091212 | 97.000 |
| 9 | Crude oil | 0.41816 | 0.073284 | 98.000 |
| 10 | Gasoline | 0.43124 | 0.069253 | 98.000 |
| 11 | Kerosene | 0.43124 | 0.071818 | 98.000 |
| 12 | Diesel oil | 0.42652 | 0.074017 | 98.000 |
| 13 | Fuel oil | 0.41816 | 0.077314 | 98.000 |
| 14 | Liquefied petroleum gas (LPG) | 0.50179 | 0.063024 | 99.000 |
| 15 | Refinery gas | 0.46055 | 0.073284 | 99.000 |
| 16 | Other petroleum products | 0.41816 | 0.074017 | 98.000 |
| 17 | Nature gas | 3.89310 | 0.056062 | 99.000 |
| 18 | Non-fossil Heat | 0.01000 | 0.000000 | 0.0000 |
| 19 | Non-fossil Electricity | 0.36000 | 0.000000 | 0.0000 |
| 20 | Other energy | 0.29308 | 0.000000 | 0.0000 |

In the second part of the emissions inventory, we calculate $CO_2$ emissions from 9 industrial production processes (see **Error! Reference source not found.**). The industrial process emissions are $CO_2$ emitted as a result of chemical reactions in the production process, not as a result of the energy used by industry. Emissions from industrial processes are factored into the corresponding industrial sectors in the final emissions inventory.

Table S4 Industrial products involved in city's $CO_2$ emission inventory and emission factors

| No.($t$) | Industrial Products | $EF_t$ (t/t) | No.($t$) | Industrial Products | $EF_t$ (t/t) |
|---|---|---|---|---|---|
| 1 | Ammonia | 1.5000 | 6 | Silicon metal | 4.3000 |
| 2 | Soda Ash | 0.4150 | 7 | Ferro-unclassified | 4.0000 |
| 3 | Cement | 0.4985 | 8 | Coke as reducing agent (Ferrous Metals) | 3.1000 |
| 4 | Lime | 0.6830 | 9 | Coke as a reducing agent (Nonferrous Metals) | 3.1000 |
| 5 | Ferrochromium | 1.3000 | | | |

## 2. Calculation method

We adopt the IPCC approach to calculate the $CO_2$ emissions from fossil fuel combustion and industrial process, which are widely applied by scholars.

$$CE_{ij} = AD_{ij} \times NCV_j \times EF_j \times O_{ij}, i \in [1,47], j \in [1,20] \quad \textit{Equation S1}$$

$CE_{ij}$ represents the fossil fuel related $CO_2$ emissions by sectors and energy types; $AD_{ij}$ represents fossil fuel consumption; $NCV_j$ represents the net calorific value of different energy types; $EF_j$ refers to the emission factors; and $O_{ij}$ refers to the oxygenation efficiency of different sectors and energy types. The subscript $i \in [2,41]$ represents 40 industry sectors (see **Error! Reference source not found.**), $j \in [1,20]$ represents 20 energy types (see **Error! Reference source not found.**).

$$CE_t = AD_t \times EF_t, t \in [1,9] \quad \textit{Equation S2}$$

$CE_t$ represents the process related $CO_2$ emissions, and $EF_t$ represents the emission factors for each industrial product. $CO_2$ emissions from different industrial process will be allocated into the relevant manufacturing sectors in the final emission inventory. $t \in [1,9]$ represents 9 main industry products (see **Error! Reference source not found.**)

## 3. Data collection

### 3.1 Activity data

We need energy balance table, sectoral energy consumption for industry enterprises by energy types, and Industrial products' production to calculate the city's $CO_2$ emission inventory. The data are collected from cities' statistical yearbooks. However, due to the data limitation at city-level, some necessary data is missing (see **Error! Reference source not found.**). We deduce the missing data in the following ways.

Table S5 Data availability of 13 case cities

| City | Energy balance table | Sectoral energy consumption for ADS industry enterprises by energy types | Industry products' production |
|---|---|---|---|
| Shanghai | Yes | Yes | For the whole industry enterprises |
| Beijing | Yes | Yes | For the whole industry enterprises |
| Chongqing | Yes | Yes | For the whole industry enterprises |
| Tianjin | Yes | Yes | For the whole industry enterprises |
| Shenyang | N/A | Yes | For the whole industry enterprises |
| Dalian | N/A | Yes | For the whole industry enterprises |
| Ningbo | N/A | Yes | For ADS industry enterprises |
| Qingdao | N/A | Yes | For ADS industry enterprises |
| Harbin | N/A | Yes | For the whole industry enterprises |
| Xi'an | N/A | Yes | For ADS industry enterprises |
| Shijiazhuang | N/A | Yes | For the whole industry enterprises |
| Tangshan | Yes | Yes | For ADS industry enterprises |
| Hengshui | N/A | Yes | For ADS industry enterprises |

Note: The abbreviation "ADS" is short for "above-designated-size" in this paper.

*1.1.1 Energy balance table*

For most city in China, there is no energy balance table in the city's statistical yearbook, such as Shenyang, Dalian, Ningbo, Harbin, Xi'an, Shijiazhuang, and Hengshui in our case. We deduce the city's basic energy balance table from the corresponding provincial energy balance table. We divide the provincial energy balance table by the corresponding percentage of one city takes in its province to get the city's energy balance table.

*1.1.2 Energy consumption for industry sectors*

Almost every city statistics the sectoral energy consumption for ADS (above-designated-size) industry enterprises by energy types in the city's statistical yearbook, such as all the 13 case cities in this paper. We expand the sectoral energy consumption for ADS enterprises by whole industry energy consumption to get the sectoral energy consumption for the whole industry.

*1.1.3 Industry products' production*

The city's statistical yearbook statistics industry products' production as well. If the production is for ADS industry enterprises (such as Ningbo, Harbin, Xi'an, Tangshan, and Hengshui), we expand the production to the whole industry enterprises by the city's whole industry output to ADS industry output ratio.

### 3.2 Emission factors

To calculate the $CO_2$ emissions from energy consumption, we collect $NCV_j$, $EF_j$, and $O_{ij}$ from our latest research, which are measured based on 602 coal sample from the 100 largest coal-mining areas in China. The measured emission factors are assumed to be more accurate compare with IPCC and default value (see **Error! Reference source not found.**). The emissions factors for 9 industrial products are collected from IPCC and National Development and Reform Commission (NDRC) in China, shown in **Error! Reference source not found.**.

## 4. Production-based CO2 emission inventory

Based on the methodology provided above, we get the production-based $CO_2$ emission inventory for the thirteen cities in China (see **Error! Reference source not found.**). The carbon emissions from urban and rural residents' energy consumption are shown in the table, although they are not included in this study.

Table S6 Production-based CO2 emission inventory for 13 cities

| | Beijing | Shanghai | Tianjin | Chongqing | Dalian | Harbin | Ningbo | Qingdao | Shenyang | Shijiazhuang | Tangshan | Xian | Hengshui |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Farming, Forestry, Animal Husbandry, Fishery and Water Conservancy | 1.24 | 1.19 | 0.92 | 5.17 | 1.07 | 2.20 | 0.97 | 1.06 | 0.73 | 0.21 | 0.61 | 0.19 | 0.07 |
| Coal Mining and Dressing | 0.02 | 0.00 | 0.00 | 7.56 | 0.00 | 0.08 | 0.00 | 0.00 | 13.15 | 0.11 | 11.09 | 0.00 | 0.00 |
| Petroleum and Natural Gas Extraction | 0.31 | 0.00 | 0.84 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.49 | 0.00 | 0.00 |
| Ferrous Metals Mining and Dressing | 0.04 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.30 | 0.00 | 0.00 |
| Nonferrous Metals Mining and Dressing | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.02 | 0.00 | 0.03 | 0.00 | 0.04 | 0.00 | 0.04 | 0.00 |
| Non-metal Minerals Mining and Dressing | 0.04 | 0.00 | 0.11 | 0.30 | 0.08 | 0.00 | 0.00 | 0.15 | 0.06 | 2.90 | 0.06 | 0.00 | 0.00 |
| Other Minerals Mining and Dressing | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 | 0.00 |
| Logging and Transport of Wood and Bamboo | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Food Processing | 0.13 | 0.09 | 0.05 | 0.10 | 0.39 | 0.32 | 0.09 | 0.62 | 0.54 | 3.31 | 0.03 | 0.46 | 0.06 |
| Food Production | 0.11 | 0.22 | 0.07 | 0.11 | 0.07 | 0.37 | 0.10 | 0.34 | 0.19 | 1.34 | 0.04 | 0.14 | 0.02 |
| Beverage Production | 0.25 | 0.09 | 0.16 | 0.11 | 0.23 | 0.37 | 0.09 | 0.25 | 0.30 | 0.25 | 0.04 | 0.28 | 0.06 |
| Tobacco Processing | 0.00 | 0.00 | 0.01 | 0.02 | 0.00 | 0.12 | 0.00 | 0.00 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 |
| Textile Industry | 0.06 | 0.25 | 0.09 | 0.21 | 0.06 | 0.13 | 1.10 | 0.68 | 0.06 | 2.29 | 0.01 | 0.06 | 0.06 |
| Garments and Other Fibre Products | 0.08 | 0.13 | 0.04 | 0.01 | 0.16 | 0.00 | 0.34 | 0.38 | 0.08 | 0.90 | 0.00 | 0.00 | 0.01 |
| Leather, Furs, Down and Related Products | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.02 | 0.32 | 0.15 | 2.36 | 0.00 | 0.00 | 0.02 |
| Timber Processing, Bamboo, Cane, Palm Fibre & Straw Products | 0.01 | 0.03 | 0.03 | 0.01 | 0.02 | 0.11 | 0.03 | 0.09 | 0.12 | 1.14 | 0.00 | 0.01 | 0.06 |
| Furniture Manufacturing | 0.03 | 0.03 | 0.02 | 0.00 | 0.10 | 0.02 | 0.03 | 0.13 | 0.13 | 1.87 | 0.00 | 0.00 | 0.00 |
| Papermaking and Paper Products | 0.09 | 0.24 | 0.07 | 0.34 | 0.13 | 0.17 | 2.04 | 0.57 | 0.10 | 2.28 | 0.48 | 0.93 | 0.02 |
| Printing and Record Medium Reproduction | 0.06 | 0.06 | 0.01 | 0.01 | 0.01 | 0.05 | 0.07 | 0.07 | 0.04 | 0.09 | 0.01 | 0.01 | 0.00 |
| Cultural, Educational and Sports Articles | 0.01 | 0.05 | 0.01 | 0.00 | 0.00 | 0.01 | 0.10 | 0.11 | 0.01 | 0.11 | 0.00 | 0.00 | 0.01 |
| Petroleum Processing and Coking | 2.88 | 6.78 | 3.37 | 0.63 | 2.64 | 17.16 | 5.78 | 2.39 | 1.87 | 2.89 | 1.60 | 2.15 | 0.01 |
| Raw Chemical Materials and Chemical Products | 4.74 | 2.67 | 1.82 | 5.78 | 2.15 | 0.14 | 0.69 | 4.07 | 2.45 | 9.13 | 2.18 | 1.22 | 1.15 |
| Medical and Pharmaceutical Products | 0.08 | 0.11 | 0.09 | 0.21 | 0.10 | 1.21 | 0.03 | 0.09 | 1.20 | 0.17 | 0.01 | 0.09 | 0.04 |
| Chemical Fibre | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.18 | 0.56 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 |
| Rubber Products | 0.02 | 0.12 | 0.12 | 0.05 | 0.06 | 0.00 | 0.08 | 0.96 | 0.23 | 0.17 | 0.02 | 0.01 | 0.06 |
| Plastic Products | 0.04 | 0.19 | 0.06 | 0.03 | 0.06 | 0.02 | 0.31 | 0.18 | 0.16 | 2.02 | 0.04 | 0.02 | 0.01 |
| Non-metal Mineral Products | 1.69 | 1.22 | 0.98 | 4.58 | 3.20 | 2.50 | 0.82 | 1.62 | 2.42 | 32.97 | 2.22 | 0.57 | 0.10 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Smelting and Pressing of Ferrous Metals | 1.68 | 5.25 | 4.51 | 1.76 | 1.83 | 0.13 | 0.59 | 1.29 | 0.37 | 6.41 | 6.75 | 0.13 | 0.12 |
| Smelting and Pressing of Nonferrous Metals | 0.02 | 0.27 | 0.06 | 0.54 | 0.01 | 0.09 | 0.46 | 0.08 | 1.06 | 0.71 | 0.01 | 0.02 | 0.00 |
| Metal Products | 0.08 | 0.31 | 0.19 | 0.08 | 0.08 | 0.16 | 0.46 | 0.31 | 0.50 | 3.65 | 0.14 | 0.02 | 0.11 |
| Ordinary Machinery | 0.17 | 0.61 | 0.24 | 0.40 | 0.84 | 0.22 | 0.95 | 0.98 | 1.07 | 2.22 | 0.20 | 0.16 | 0.05 |
| Equipment for Special Purposes | 0.18 | 0.15 | 0.07 | 0.10 | 0.12 | 0.10 | 0.21 | 0.31 | 0.56 | 0.49 | 0.04 | 0.25 | 0.02 |
| Transportation Equipment manufacturing | 0.33 | 0.56 | 0.28 | 1.03 | 0.38 | 1.25 | 0.41 | 0.39 | 0.81 | 0.10 | 0.07 | 0.81 | 0.02 |
| Electric Equipment and Machinery | 0.05 | 0.19 | 0.08 | 0.07 | 0.07 | 0.22 | 0.42 | 0.61 | 0.61 | 0.00 | 0.01 | 0.07 | 0.03 |
| Electronic and Telecommunications Equipment | 0.05 | 0.12 | 0.08 | 0.01 | 0.08 | 0.00 | 0.12 | 0.11 | 0.04 | 0.15 | 0.00 | 0.10 | 0.00 |
| Instruments, Meters, Cultural and Office Machinery | 0.02 | 0.02 | 0.01 | 0.03 | 0.01 | 0.07 | 0.07 | 0.03 | 0.02 | 0.01 | 0.00 | 0.03 | 0.00 |
| Other Manufacturing Industry | 0.15 | 0.03 | 0.03 | 0.02 | 0.02 | 0.00 | 0.06 | 0.20 | 0.16 | 0.01 | 0.00 | 0.05 | 0.01 |
| Scrap and waste | 0.01 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 2.25 | 0.00 | 0.00 | 0.00 |
| Production and Supply of Electric Power, Steam and Hot Water (Electricity generation) | 38.41 | 74.23 | 51.58 | 38.01 | 18.55 | 22.81 | 47.43 | 17.81 | 38.87 | 0.02 | 43.04 | 9.79 | 6.40 |
| Production and Supply of Gas | 0.04 | 1.57 | 0.01 | 0.01 | 0.10 | 3.91 | 0.00 | 0.52 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| Production and Supply of Tap Water | 0.01 | 0.00 | 0.00 | 0.00 | 0.02 | 0.03 | 0.01 | 0.00 | 0.04 | 0.00 | 0.00 | 0.01 | 0.00 |
| Construction | 1.19 | 2.20 | 1.09 | 0.89 | 0.58 | 0.05 | 0.54 | 0.37 | 0.47 | 0.20 | 0.10 | 0.27 | 0.03 |
| Transportation, Storage, Post and Telecommunication Services | 13.99 | 37.36 | 6.69 | 8.71 | 14.09 | 5.12 | 3.83 | 11.58 | 7.05 | 2.72 | 3.19 | 3.75 | 0.54 |
| Wholesale, Retail Trade and Catering Services | 4.18 | 4.37 | 4.59 | 1.04 | 0.32 | 3.04 | 0.37 | 0.86 | 0.47 | 0.27 | 0.62 | 2.52 | 0.05 |
| Others | 8.82 | 5.56 | 1.63 | 0.23 | 0.78 | 0.61 | 0.30 | 1.00 | 1.01 | 0.86 | 0.80 | 0.26 | 0.18 |
| Urban | 8.05 | 5.16 | 2.47 | 1.92 | 1.07 | 1.82 | 0.82 | 1.47 | 1.46 | 1.05 | 0.28 | 1.59 | 0.27 |
| Rural | 3.58 | 1.98 | 0.94 | 2.33 | 0.37 | 0.32 | 0.48 | 0.29 | 0.39 | 1.40 | 2.71 | 0.30 | 0.83 |
| Total Consumption | 92.95 | 153.47 | 83.44 | 82.68 | 49.85 | 65.13 | 70.78 | 52.35 | 79.00 | 89.28 | 77.22 | 26.34 | 10.44 |