



# Carbon footprint of laptops for export from China: empirical results and policy implications



Jingru Liu<sup>\*</sup>, Dong Yang, Bin Lu, Jieqiong Zhang

State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, 18 Shuangqing Road, Beijing, 100085, PR China

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## ABSTRACT

China's laptop exports account for more than 70% of global laptop shipments by volume. Laptop is a typical import-and-assembly processing trade product in the machinery and electrical equipment-manufacturing sector and comprises nearly 60% of China's total export value. The laptop sector is also carbon emissions intensive and contributes heavily to China's carbon emissions problem. To study the laptop sector's impact on carbon emissions, we first developed a carbon footprint map for the product across its supply chain, which allowed us to identify the emission contributions of each component and the production process as a whole. Then, using Simapro software and life cycle inventory data derived from the bottom-up life cycle-analysis method, we calculated the carbon footprint of laptop production. The results show that 33.3% of the carbon emissions from the production of export laptops originate from components produced abroad, while 66.7% is derived mainly from components produced domestically. Finally, we discuss the uncertainties in our approach and the trade policy implications of our research results.

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## 1. Background

China is the largest carbon emitter in the world (Gregg et al., 2008), with goods and service exports yielding 20–40% of China's domestic carbon emissions, depending on the data sources and research methods used (Shui et al., 2006; Pan et al., 2008; Wang et al., 2008; Weber et al., 2008; Atkinson et al., 2011; Feng et al., 2013). As a fundamentally export-driven sector and an important global supplier, the machinery and electrical equipment manufacturing (MEM) sector constitutes nearly 60% of China's total export value. It is also a carbon-sensitive sector that produces 0.25% more carbon emissions for every 1% increase in output (Liu and Lu, 2010). Within this sector, computer exports account for approximately 15–30% of the emissions resulting from China's exports (Xu et al., 2010, 2011; Cui et al., 2015). As the world's factory, China produced more than 90% of the world's personal computer products in 2012; laptops were the largest component of this sector, accounting for approximately 51.5% of total production.

Carbon footprint is a measure of the total amount of carbon dioxide emissions directly and indirectly caused by an activity or accumulated over the life cycle of a product (Wiedmann and Minx, 2008). The term “carbon footprint” has recently come into wide use among academics and practitioners as a way to discuss production-based or consumption-based emission responsibilities (Peters et al., 2006, 2011; Weber et al., 2009; Davis and Caldeira, 2010). The calculation of a product's carbon footprint is based on the life cycle assessment (LCA) method, which can be implemented as a bottom-up process-sum LCA or a top-down input–output LCA (IO-LCA). The most common methodology used to estimate the emissions associated with international trade is the top-down IO-LCA. The MIOT and GTWP databases have been widely used to calculate carbon emissions embedded in international trade at the national and supra-national levels (Peters et al., 2008; Xu et al., 2010; Skelton et al., 2011; Su et al., 2011; Lindner et al., 2012). However, this method has certain shortcomings, including its inability to account for the differences in technological level and industrial structure between importing and exporting countries.

Although the calculation of a process-sum LCA is time- and labour-intensive, it does provide a good framework for developing a detailed carbon process map of a product across its supply chain (Lee, 2011). Additionally, it helps clarify the geographical separation

<sup>\*</sup> Corresponding author. State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, 18 Shuangqing Road, Haidian, 100085, PR China.

E-mail address: [liujingru@rcees.ac.cn](mailto:liujingru@rcees.ac.cn) (J. Liu).

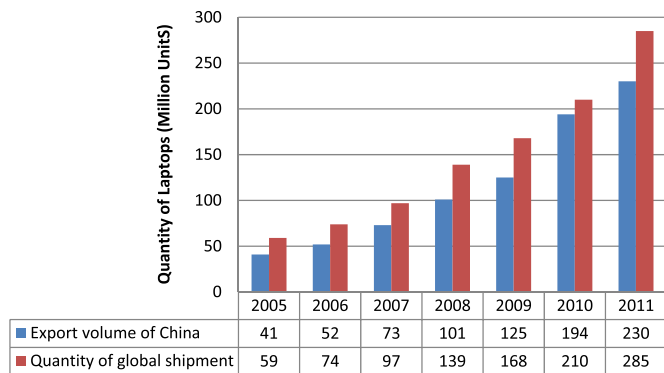


Fig. 1. China's laptop export volume and global laptop sales from 2005 to 2011.

of production and consumption activities, answering the fundamental question of who is responsible for what emissions (Caney, 2009).

The purposes of this study are to calculate the “cradle-to-freight” carbon footprint generated by China's export of laptops using the bottom-up process-sum LCA approach and to define the geographical distribution of laptop emissions (inside and outside China). We developed a product carbon footprint map across the laptop supply chain, which allowed us to identify the contributions of each component and process to laptop-related emissions (Kim et al., 2001). Identifying the greenhouse gas (GHG) emission patterns and key processes with the greatest carbon footprint contributions was emphasized to provide scientific support for decision makers developing low-carbon export policies. The carbon emissions generated by the production or processing of components and parts within China were calculated using our research centre's Life Cycle Inventory (LCI) databases. On-site data combined with information from a series of industrial reports were used to map out the laptop supply chain. The databases in Simapro 7.3 were used to calculate carbon emissions generated by the production of components outside of China.

## 2. Overview of laptop exports from China

In recent years, laptops have been the fastest growing export sector by volume in China. Fig. 1 illustrates the consistent increase

in export volume from 2005 to 2011 (General Administration of Customs, 2013).

Comparisons between China's laptop export volume and the quantity of global laptop shipments (Fig. 1) reveal that more than 70% of global laptop sales originated from China between 2005 and 2011. A laptop is a typical import-and-assembly processing trade product. This refers to the business of importing materials, parts and components from abroad and the processing or assembly of those parts by enterprises within the exporting country, followed by the export of the finished products. More than 95% of China's export laptops are processing-trade products. The United States and the EU countries are the primary importers of these products, receiving approximately 60% of laptop exports from China.

By synthesizing recent industrial reports on laptop exports, field surveys and expert interviews, we were able to summarize the laptop export supply chain, as shown in Fig. 2. Almost all of the high-tech core electronic components or parts, such as hard drives, chipsets, and optical drivers, were produced abroad in countries such as the USA, Japan and Korea (Eugster et al., 2007; Liu, 2011). Non-core components and miscellaneous accessories were typically manufactured or assembled in China. The core components and intermediate materials produced outside China were transported to Chinese manufacturers for assembly into finished products. After final assembly, the finished products were then exported.

China has become a major importer of hard drives because of this process. The quantities of hard drives imported to China increased from 207.54 million set in 2008 to 319.96 unit set in 2011. In 2011, the number of imported hard drives exceeded the number of laptops exported by threefold. This difference suggests that almost all laptop hard drives used in the laptop-manufacturing process are imported.

## 3. Methods and data

### 3.1. Goal, scope and system boundaries

#### 3.1.1. Functional unit

A 14-inch Hewlett–Packard (HP) laptop was chosen as the functional unit for this study. According to a survey by PC ONLINE (<http://www.pconline.com.cn>), the 14-inch HP laptop is the most popular laptop worldwide and is a typical high-volume, mainstream business laptop. Therefore, it can reliably represent a range of similar laptop products. A complete export laptop consists of a

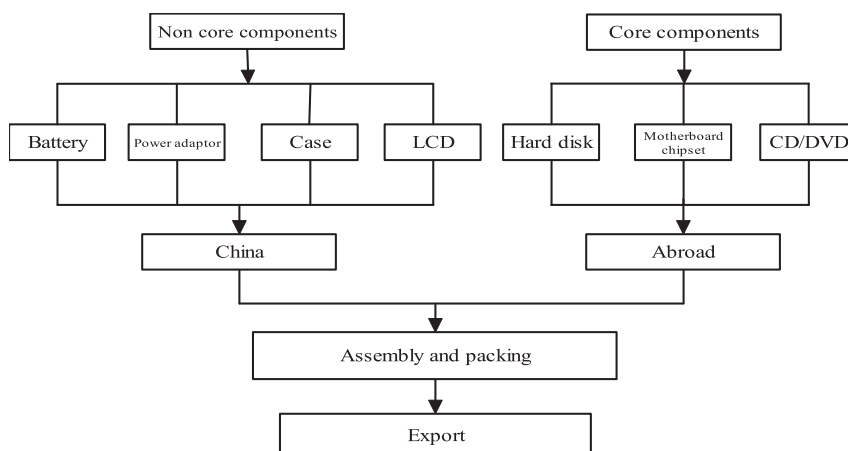


Fig. 2. Industry network diagram of laptop exports from China.

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