



# Material flows and resource productivity in China, South Korea and Japan from 1970 to 2008: A transitional perspective



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## ABSTRACT

China, Japan and South Korea are the important East Asian countries and being paid intensive attentions to their economic miracle, while their environmental performance is less discussed together. These three countries are in different level of developmental stages from emerging economy to matured developed economy. We hereby provide a laboratory idea to investigate the socio-economic metabolism under typical development stages, so that enlightenment on global resource management policy making can be made. This study is based on a long-time series data on the material flow analysis on China, South Korea and Japan, applied with up-to date standardized methodologies of material flow accounting. Material flows, resource productivity data, indicators as well as Environmental Kuznets Curve are presented and compared from 1970 to 2008. Driving forces for the material flow change were further investigated with IPAT approach. Obvious differences of resource efficiency, productivity and consumption patterns were verified. Japan presented the trend of dematerialization and technology effects made significant contribution; China was highlighted with surging resource consumption stage, mainly driven by the economic and population factors, even though the resource efficiency was significantly enhanced in the past three decades. South Korea presented the combined features of China and Japan in different stages. Based on the analytical results, information and insights behind results, like the industrial structure, value chain position in the global supply-demand chain and how they had impacts on the resource efficiency and productivity were discussed in-depth. The research results provide critical insights to future effective and efficient global resource management policy making.

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## 1. Introduction

With the surging population growth and economic expansion since the industrial revolution, global material flows has been in rapid growth, especially for emerging economies like China (Krausmann et al., 2011; Wang et al., 2012; Xu and Zhang, 2007). It was reported that the material extraction and consumption nearly had doubled from 1980 to 2009 (increased by 94%) (Giljum et al.,

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2014). Natural resources play the role as the basis for human being's life on Earth. Meanwhile, material extraction has brought environmental burden. Therefore, the pursuit of sustainable resource management is critical to the sustainable development. An in-depth investigation on the material flows provide basis to a better decision making (Fischer-Kowalski et al., 2011; Garmendia and Gamboa, 2012; Schandl and West, 2012).

One critical debate on the global environmental issues are the disparities of domestic situations (e.g. resource condition, industrial structure and the position in the global supply chain) and economic development stages in different countries (Mancheri, 2015). With various industrial and economic patterns, the difficulties of sustainable transition will be different. As a result, focuses on certain groups of countries, as well as in-depth analysis and comparison on the material flows features and patterns is beneficial to further resource management policies implications (Calvo et al., 2016; Mancini et al., 2015). Among countries, Asia-Pacific region has already become the fastest economic growth region, as well as the key driver to global resource consumption (Giljum et al., 2014; Schandl and West, 2012). As three key industrialized countries in East Asia, China, South Korea and Japan has interacted closely and presents three typical economic development stages: developing country (China), primary developed country (South Korea) and mature industrialized and developed country (Japan). An investigation on their material flows trends and socioeconomic drivers is significant to enlighten the countries in different stages and provides valuable experiences from developed countries to developing countries.

As a brief literature review, a number of MFA researches had been conducted in various spatial scales (Brunner and Rechberger, 2004), such as national scale (Hashimoto and Moriguchi, 2004; Hoffrén et al., 2000), regional and local level (Brunner et al., 1994), urban systems (Barles, 2009; Broto et al., 2012) and industrial areas (Sendra et al., 2007). On the whole, Economy-wide MFA (EW-MFA) was mostly widely applied and already become mature approach for national accounting on the socio-economic metabolism (Eurostat, 2001, 2007, 2009). To date, many countries had finished the MFA studies, including but not limited to EU members (e.g. Finland (Hoffrén et al., 2000), MFA guidelines published by Eurostat (Eurostat, 2001, 2007, 2009), Asia-Pacific countries like Japan (Krausmann et al., 2011; Moriguchi, 2001), China (Wang et al., 2012; Xu and Zhang, 2007) and Australia (Wood et al., 2009), as well as regions and countries group (Calvo et al., 2016; Giljum et al., 2014; Russi et al., 2008) were reported. However, material flows trends and typical patterns analysis and comparisons among different economies had been rather few. Particularly, results and experiences from developed countries were able to provide critical policies insights on sustainable resource management.

With this circumstance, this paper aims to answer the following major questions: (1) As basis, how are the material flows trends in three typical economy named China, South Korea and Japan? (2) Which factors drive the rapid increase in resource consumption in the three countries within various period? (3), is there any periodical regular pattern of the material flows trends in the three countries and what critical policies insights can we summarize? And (4), how the regional features, inter relationship and international trade features of the three countries will affect their resource management policies?

To address these, long time series comparison analysis on the material flows and resource productivity, in China, South Korea and Japan is conducted. We further applied an IPAT (Impact = Population × Affluence × Technology) framework to investigate the key drivers to the main change of material flows over time. Critical policies insights for emerging economy like China are provided, through analyzing and summarizing the

periodical regular pattern of developed economies.

The remainder of this paper is organized as: after this introduction section, section 2 overviews the general condition of China, South Korea and Japan and analyzes the regional features; section 3 describes the methods and data; section 4 presents the analytical results, discussions, as well as policies implications. Finally, section 5 draws the conclusions and future concerns.

## 2. General condition of China, South Korea and Japan

Asia-Pacific region has become the hot spot region of economic growth, as well as the key driver to global resource consumption and environmental impacts. Among the countries, China, South Korea and Japan are the three most important industrialized countries.

China is famous for its “world factory”. Industries bring huge resource consumption and carbon dioxide (CO<sub>2</sub>) emissions (Fig. 1). In addition, China presents another feature as typical developing countries: the challenge of urbanization (Chen et al., 2013; NBS, 2011; UN, 2012). Industrialization and urbanization is key drivers to China's booming economy, meanwhile, also the key driver to resource consumption. From supply side, process industries themselves are resource and energy intensive. They push the increase of material extraction and consumption. From demand side, surging urbanization requires large scale of infrastructure constructions, in return pull the industrial activities (e.g. iron and steel, cement industry) and material consumption. What is more, compared with developed countries, China suffers from both lower resource efficiency and recycling and reuse ratio. It was reported that in 2006, China consumed 15% worldwide primary energy, 30% crude steel and 50% cement, while the GDP only took 5.5% of global one (Dong, 2011). In 2008, the industrial waste discharge was as high as 1.9 billion tons, while the overall recycling and reuse ratio for resource was only 35%, 20% lower than the international advanced level. With this circumstance, diagnosis on the material flows and corresponding resource management policies is important.

Similar to China, industrialization is also one of the key drivers to South Korea's booming economy. Driven by industrialization, and big push by a series of open reform policies and stimulation policies, South Korea enjoyed the economic boost since 1970s. From 1960s to 1995, South Korea's GDP per capita had increased from less than 100 USD to more than 100000 USD (Holcombe, 2013; OECD, 2012; Park et al., 2016). After the Asian financial crisis, and to fight to the environmental challenges, South Korean government had begun to promote the strategy of “Green Growth”, which aimed harmonious development between economy and

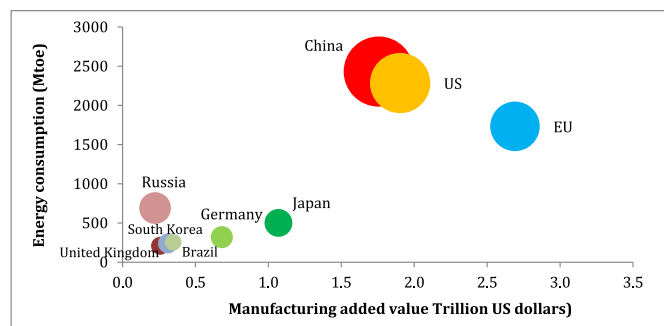


Fig. 1. Energy consumption, CO<sub>2</sub> emission and manufacturing added value in selected countries in 2010. Note: GDP applied the exchange value based national GDP (constant 2005 prices).

Data source: BP energy statistics, 2011; UN 2012.

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