Comparison of Material Flow Cost Accounting Research in Japan and China

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This paper compares native-language publications of studies in environmental accounting (EA), environmental management accounting (EMA), and material flow cost accounting (MFCA) in Japan and China. It documents the number of published studies spanning approximately from 1970 to 2018, explains the principles and computational characteristics of MFCA, and compares the content of MFCA studies in both countries. Comparison shows that China has published more studies of EA and EMA than Japan, whereas Japan has published more studies related to MFCA. However, the number of MFCA studies declined in Japan but increased in China during the period studied. We conclude that MFCA research has a sustainable space in China. We are concerned about MFCA’s research trends in Japan and China because MFCA is a key tool of EMA, and research from Japan indicates that MFCA promotes environmental and economic benefits. This study provides a reference for Chinese businesses hoping to use MFCA to protect the environment and cut costs.

Keywords: Environmental Accounting (EA), Environmental Management Accounting (EMA), Material Flow Cost Accounting (MFCA), positive product cost, negative product cost, research literature, research content, Government

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China’s economic growth is creating astonishing environmental challenges while depleting raw materials, energy, and other resources. To address those problems, the Chinese government in 2014 revised the Environmental Protection Act to tighten environmental regulations on business. Before its actions, research into environmental accounting (EA) had begun in the 1990s, and the Accounting Society of China had established an Environmental and Resource Accounting Expert Committee.

Accounting studies in Japan have been examining environmental management accounting (EMA) methods since 2000 under an initiative by the Ministry of Economy, Trade, and Industry (METI). Cost studies of Japanese firms have been incorporated as material flow cost accounting (MFCA) in the EMA Methodology Workbook. METI developed measures to promote MFCA specifications from 2004 to 2010. MFCA is spreading among Japanese companies.

MFCA emerged after EA and EMA as the result of the subdivision of EA discipline, and it is an important calculation method developed under the discipline of EMA.

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This paper compares native-language publications of studies in environmental accounting (EA), environmental management accounting (EMA), and material flow cost accounting (MFCA) in Japan and China until 2018. It documents the number of published studies, explains the principles and computational characteristics of MFCA, and compares the content of MFCA studies in both countries.

**Review of EA and EMA Studies in Japan and China**

**EA Studies in Japan and China**

Seeking to establish a common framework to support EA efforts, Japan’s Ministry of the Environment published *Guidelines for Understanding and Publication of Environmental Conservation Costs (Interim Summary)* in 1999. Thereafter, it published *Guidelines for the Introduction of EA Systems* in 2000 and revised them in 2002. The ministry published its *Environmental Conservation Cost Classification Guide and Guidelines for Environmental Performance Indicators for Business Operators* in 2003 and the *Environmental Report Guidelines* in 2004.

Industrial development will erode China’s environment, deplete its resources, and eventually limit economic growth. China now regards energy conservation and emission reduction as necessary for human survival and is expected to seek a model for sustainable economic development. Securing stable energy and resources is an important policy goal in China, and it has enacted policies concerning energy conservation and emission reduction (Table 1).

**Table 1**

*Policies for Energy Conservation and Emission Reduction (Partial)*

| Year  | Policy Description                                                                 |
|-------|-----------------------------------------------------------------------------------|
| 2005  | 11th Five-Year Plan (2006-2010) (targeted energy consumption per unit of GDP by about 20% compared to the end of 2000) |
| 2006  | China Festival Can Technology Policy                                               |
| 2007  | Measures for monitoring the reduction of total major pollutants (2007)            |
| 2008  | China People’s Republic Energy Conservation Law (revised in 2008)                 |
| 2010  | Guidance on further strengthening energy conservation and emission reduction for small- and medium-sized enterprises |
| 2015  | Environmental Protection Law of the People’s Republic of China (revised in 2014)  |
| 2016  | Water Law of the People’s Republic of China (revised in 2016)                     |
|       | China People’s Republic Energy Conservation Law (2016)                             |
|       | China People’s Republic of Solid Waste Pollution Environmental Prevention and Control Law (2016) |
|       | Environmental Impact Assessment Law of the People’s Republic of China (revised in 2018) |
| 2018  | People’s Republic of China Air Pollution Prevention and Control Law (revised in 2018) |
|       | Energy Conservation Law of the People’s Republic of China (2018 Revision)          |

Source: Website of the Ministry of Ecology and Environment of the People’s Republic of China (October 22, 2019).

Table 1 shows that the Chinese government has initiated numerous legal efforts to protect the environment. Although official awareness of environmental conservation is increasing, few existing environmental laws were surveyed. Transmission of EA information by Chinese companies was delayed, and there were no EA standards or related regulations. Standards for environmental disclosures by Chinese companies are confined to guidelines from the China Securities Regulatory Commission.

China has issued firms no specific guidance or instructions for introducing EA systems. Materials that do exist cite only three broad purposes: promoting EA through education and supervision, strengthening EA theory, and establishing and improving EA laws and regulations. It is difficult to find EA information in corporate materials and to discern the effects of their environmental activities.
We reviewed trends in EA research in China using the China National Knowledge Infrastructure (CNKI), China’s largest academic data service. Figure 1 shows that 3,512 academic papers appeared from 1992 to 2018. China’s first EA study (Sun, 1992), was a questionnaire survey of corporate EA activities. It turned out to be Wang, Liu, and Li (1998).

We examined Japanese trends in EA research using the National Institute of Informatics (CiNII) database. Japan’s first paper—The Concept of EA—was published by Tokutani (1972). Figure 1 shows that Japanese studies of EA increased throughout the 1990s and peaked at 159 in 2000. A total of 1,048 EA studies were published from 1972 to 2018.

![Figure 1. Number of environmental accounting studies in Japan and China 1972-2018. Source: CNKI, authors’ extracted information from CiNii.](image)

Although a smattering of EA studies appeared in Japan during the 1970s, none appeared between 1980 and 1991 (Figure 1). EA studies in Japan and China began to appear consistently at almost the same time but more significantly appeared in China up to 2018. Its research foundation suggests China to give full play to the role of EA in the sustainable development and to apply EA in Chinese businesses.

**EMA Studies in Japan and China**

Figure 2 shows that 301 EMA studies were published from 2000 to 2018 in China.

Figure 2 indicates that Japan began to publish EMA studies in 1993, but its 119 studies are fewer than China’s. Chinese interest in EMA research is strong, and its base of extant research is encouraging for the application of EMA in Chinese firms.
Comparing MFCA Studies in Japan and China

Introducing MFCA

MFCA focuses on the waste of resources and energy in manufacturing and associated material costs, processing costs, depreciation, and similar issues. It refers to these collectively as negative product costs. Using MFCA to visualize resource wastage helps business managers conserve costs, resources, energy, and the environment (Kokubu & Nakajima, 2018, p. 4).

Basis for MFCA

The basis for MFCA is mass balance, a physical law governing the relation between chemical changes and mass (also known as the law of mass preservation). According to Wagner, MFCA has stimulated managerial interest in material flows (Kokubu & Nakajima, 2018, p. 5).

MFCA calculations

MFCA collects and views data from traditional production management and cost accounting to address material flows in production. It is a method of calculating the quantity of raw materials for each input according to actual flows (flow and stock) and calculating the cost by multiplying the unit price by MFCA (Kokubu & Nakajima, 2018, p. 6).

METI (2009) calls this calculation positive product cost and denotes it as the expense of producing a positive product. Its opposite—negative product cost—denotes the expense of waste and emissions (a negative product). According to METI (2009), negative products are “waste in various stages in manufacturing, but loss of raw materials occurs, it is waste in processing.” (p. 5)

As shown in Table 2, MFCA distributes MC, SC, and EC among positive and negative products in the weight ratio of the material. Its approach differs from traditional cost accounting.

Table 2
Negative Products in MFCA

|   | Material loss during processing (end material, chips, etc.), defective products, impurities, and residues remaining in the device at the time of switching |
|---|---------------------------------------------------------------------------------------------------------------|
| (1) | Materials (solvents, detergents, catalysts)                                                                       |
| (2) | Raw material inventory, intermediate stock, and product inventory that can no longer be used due to defects |
Outline of MFCA Research in Japan and China

A prototype of MFCA emerged in Germany during the 1990s and has been developed in Japan since the 2000s under the leadership of METI. Under a proposal from Japan, the International Standards Organization (ISO) established international standards for MFCA in 2011 (ISO14051), standards concerning introduction of MFCA into the supply chain in 2017 (ISO14052), and MFCA standards for small and medium-sized enterprises in 2018 (ISO14053) (Kokubu & Nakajima, 2018, p. 3).

The first MFCA study in Japan (Matsumoto, Left, & Iwao, 2002) chronicled material flows in a city food system from production through disposal. It systematized relations between packaging and energy inputs and compared food waste counter measures in several cities (regions). China’s first MFCA study (Feng, 2008) was theoretical and useful for corporate management and environmental conservation.

Figure 3 compares numbers of MFCA studies published in Japan and China from 2002 to 2018. It shows that 312 MFCA research documents were published in Japan during that time. CNKI data revealed that 132 MFCA studies were published in China from 2008 to 2018, including one book. ISO 14051, an international standard for MFCA, was published in 2011 coincident with a large number of studies in Japan and China. The number of Japanese studies declined sharply after 2012. China published the most MFCA papers in 2015, and MFCA research there is expected to escalate.

Figures 1-3 show the number of studies by category for Japan and China. China’s EA and EMA research is richer than Japan’s, but its MFCA-related studies are fewer. The number of MFCA studies published in Japan has dropped sharply since 2011, but the number of Chinese MFCA studies has increased yearly since 2008 (Figure 3). This finding suggests promising possibilities for Chinese firms to incorporate MFCA in their environmental protection and cost-cutting activities.

Table 3 shows when the first EA, EMA, and MFCA studies appeared. As it suggests, MFCA emerged as a discipline after branching off from EA and EMA. MFCA is an important calculation tool developed under the discipline of EMA.

Comparison of MFCA Studies in Japan and China
Many studies of MFCA in Japan are normative research or case studies of major manufacturers. They largely address international and domestic trends and MFCA techniques. Table 4 gives a breakdown of their content.

Table 3

| Initial Publication of Studies Concerning EA, EMA, and MFCA |
|------------------------------------------------------------|
| Japan (year) | China (year) |
| Environmental accounting (EA) | 1972 | 1992 |
| Environmental management accounting (EMA) | 1993 | 2000 |
| Material flow accounting (MECA) | 2002 | 2008 |

Table 4

| Subjects of MFCA Studies in Japan and China (Partial) |
|-------------------------------------------------------|
| Research content | Previous research in Japan | Previous studies in China |
| International standardization of MFCA | Kokubu, 2008 | Kiei, XiaoYi, 2009 |
| | Furukawa-Tachikawa, 2011 | Kieyi, XiaoYi, 2012 |
| | Nakajima/Kimura, 2012 | Feng jiantao, 2013 |
| Introduction to MFCA research in other countries | China (Ga, Kabe, 2013) | Japan (Mr. Liu Ming, Liu Ying, Huang Zheng, 2009) |
| | South Korea (Zhang, 2009; Kim & Zhengbe, 2013) | Hot Water Ryoichi, Zhao Zheng, 2009 |
| | Vietnam (Nakajima, Kimura, 2012) | Huang, 2011, Hongoe, 2014 |
| | Malaysia (Tachikawa, 2012a) | Indonesia (FERDINAND EFFEND, Lee Jun, 2017) |
| | Nakajima/Kimura, 2012) | Latin America (Kei-An, Liu Zhizhi, 2014) |
| Introduction of MFCA research by international conferences | Kokubu, 2012 |
| Government-led MFCA adoption | Ministry of Economy, Trade and Industry’s MFCA Promotion Project (METI, 2007) |
| MFCA spread by region | Shiga Prefecture (Maekawa, 2006) | |
| | Tohoku Region (Imada, 2008) | |
| | Osaka & Kyoto (Nakajima, 2008; Okada & Kitada, 2009) | |
| | Nagano Prefecture (Seki, 2012) | |
| Study of MFCA’s explanation, consideration, and problem arrangement | Nakajima-Kashibe, 2003; Buttocks, 2005, 2007, 2009; Ito, 2009; Nakajima, 2012; Shimogaki, 2013b; Buttocks, 2014 |
| | Sakune Tsuji, 2008; Xiao Jian, 2009 | |
| MFCA’s functionality | Buttocks, 2003; Nakajima, 2003; Kashiwabe, Nakajima, 2003; Shimogaki, 2005; Shimogaki/Anjo, 2011; Anjo, 2012 |
| | Zhao Ming-kun, 2009; Cheng Zheng, 2010 | |
| A study considering the cooperation between MFCA and other management systems | MFCA and traditional costing collaboration (Nakanaka, Sakai, 2008), TPM (Total Productive Maintenance) (AsahiKawa, 2007), TRIZ (Theory of Inventive Problem Solving) (Nakajima, Yamada, 2009), cooperation with budget management (Nakajima & Thu Mura, 2012), Collaboration with Theory of Constraints (Tobita et al., 2013) LIME (Lifecycle Impact Assessment) as an integration with Lifecycle Assessment (LCA) Method based on Endpoint Modeling (Kono, 2007; Shimogaki, 2007a; Shimogaki, 2007b) and environmental impact integrated metrics |
| | Collaboration between MFCA and Traditional Costing (Kei, 2014, 2017). Collaboration with PDCA: Kim Yu-ryo, Wang Zheng, 2017), |
| Collaboration in terms of production control and on-site improvement | Cooperation with Theory of Constraints (Tobita et al., 2013) LIME (Lifecycle Impact Assessment) as an integration with Lifecycle Assessment (LCA) Method based on Endpoint Modeling (Kono, 2007; Shimogaki, 2007a; Shimogaki, 2007b) and environmental impact integrated metrics |
| Collaboration from the viewpoint of reducing environmental impact | LifeCycle Impact Assessment (LIME) as an integration with Lifecycle Assessment (LCA) Based on Endpoint Modeling (Zhao, 2010) |
Table 4 shows that studies of international trends in China are concentrated in Japan, where MFCA research is progressing. Also, Japan has hosted seminal international conferences, whereas China has not.

The Japanese lead in domestic studies, largely through the efforts of METI and the launch of MFCA guidance and services. No related studies have emerged in China, suggesting that the Chinese government has not promoted MFCA.

Studies of technical and functional aspects of MFCA are comprehensive and mature in both Japan and China. Japanese studies emphasize the business application of MFCA, but no Chinese studies did so during the period studied. Again, it seems that MFCA has not been popularized among Chinese businesses.

Japanese studies dominate in reporting the environmental and operating effects of applying MFCA. China evidenced no such studies during the period—likely for reasons already mentioned.

To sum up, the subject matter of MFCA studies differed between Japan and China during the period studied. Japan has assembled a rich literature of theoretical and applied studies, thanks to ISO specifications and governmental involvement, to include publishing data about MFCA’s positive effects for business and the environment. China has contributed numerous theoretical studies of MFCA but few about its practical applications. Given the environmental effects of MFCA practices, it would benefit scholarship and practice to promote and apply MFCA among China’s businesses.

**Conclusions**

This study has compared and classified research papers concerning EA, EMA, and MFCA published in...
Japan and China and itemized the research content of MFCA studies there until 2018. Comparison shows that more Chinese studies concern EA and EMA. China has published far fewer MFCA studies than Japan, but the number in Japan declined and the number in China increased yearly during the period studied. MFCA has established a sustainable scholarly and professional space in China. This suggests that Chinese businesses can aid the environment and reduce costs via MFCA.

Results for MFCA-related publications reveal that Japan has published more basic research and business treatments of MFCA. Those efforts have been encouraged by METI and by local governments promoting the application of MFCA in Japanese businesses. China’s basic research into MFCA is more successful, but it features few business applications.

Comparing Japan and China indicates that China it can be speculated that the application and research of MFCA will be developed in China in the future. As the Chinese government accelerates its environmental initiatives, it seems likely that further EMA studies will appear there and with them more studies of the business applications of MFCA. Therefore, we suggest that China’s Ministries of the Environment and of Economic Relations take the lead in promoting the application of EMA and MFCA. Those efforts would advance environmental protection and business efficiency in China.

Finally, it has been suggested that MFCA research in Japan has waned since 2012 because of the discipline’s limitations. That claim remains for future research.

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