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RESEARCH ARTICLE

Green Growth, Eco Innovation and Sustainable Transitions

Trends in corporate environmental management studies and databases

Hidemichi Fujii[1] · **Shunsuke Managi**[2,3]

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Abstract To explain why and how corporate environmental management is beneficial, it is important to provide incentives to private companies to encourage such environmental activities. This study proposes a new corporate financial and environmental dataset called the world resource table (WRT), which uses open data sources published by the Japanese government. Environmental data include Greenhouse gas emissions and toxic chemical release data. With more than 1000 annual samples, the WRT will allow empirical analyses that use productivity measures and econometric approaches. WRT will also include corporate patent data, with linkages to analytical software packages such as GAMS and R.

Keywords Corporate environmental management · Financial data · CO_2 emissions · Toxic chemical substances · Open data · World resource table

1 Introduction

Corporate environmental management (CEM) is necessary for manufacturing companies to achieve sustainable development. Although firms engage in production to achieve their key objective of economic development, the production processes of

✉ Hidemichi Fujii
hidemichifujii@nagasaki-u.ac.jp

Shunsuke Managi
managi.s@gmail.com

[1] Graduate School of Fisheries and Environmental Sciences, Nagasaki University, 1-14 Bunkyo-machi, Nagasaki 852-8521, Japan

[2] Department of Urban and Environmental Engineering, School of Engineering, Kyushu University, 744 Motooka, Nishiku, Fukuoka 819-0395, Japan

[3] QUT Business School, Queensland University of Technology, Level 8, Z Block, Gardens Point, 2 George St, Brisbane, QLD 4000, Australia

manufacturing companies generate a significant amount of environmental pollution (Fujii and Managi 2012). In the production process, a firm can realize economic benefits by recycling and saving intermediate materials. However, these savings are usually smaller than the costs of pollution abatement (Jasch 2006). Additionally, consumer preferences are still not significantly related to the environmental burden created through the production process but instead primarily concern product performance (Hibiki and Managi 2010). Therefore, an environmentally friendly corporate image has a weak influence on the market competitiveness of products, and improving environmental performance does not always generate higher profits.

Based on these situations, a clear explanation about the merits and demerits of CEM, as observed through empirical studies, is needed to provide an incentive for private firms and thereby encourage their CEM activities. If we can explain why and how firms can obtain market competitiveness and profit through CEM, a firm may be willing to promote CEM activities as long as they can receive such benefits. In this sense, an objective analysis using real firm data will play an important role in encouraging CEM.

Figure 1 shows the trend in the academic literature addressing CEM. From the figure, the number of publications has increased yearly, especially since 2004. Journal publications including "chemical" have been observed since the 1980s,

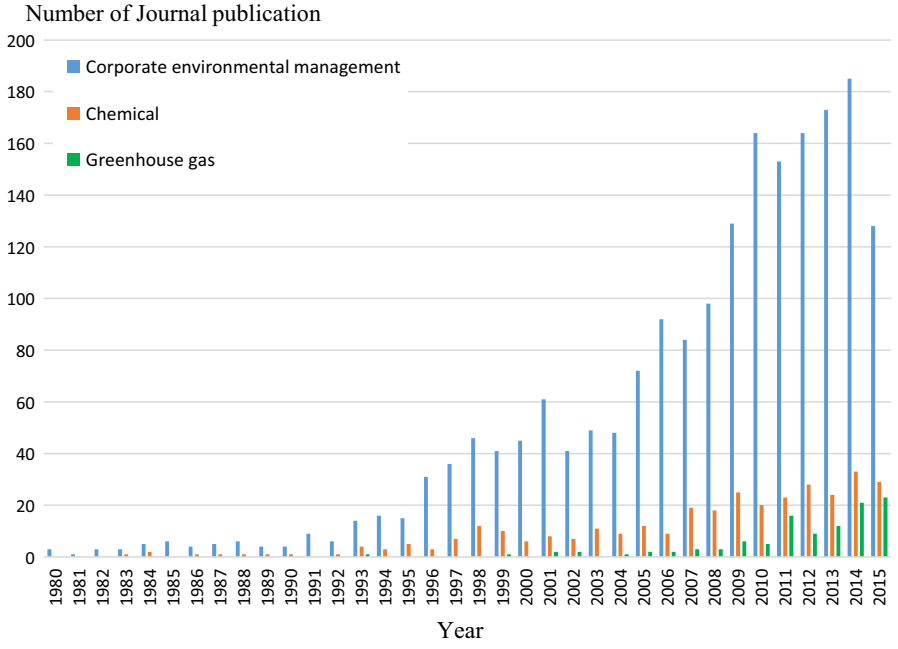

Fig. 1 Trend of academic literature on corporate environmental management. Source: Author produced using results from SCOPUS on August 31, 2015 (http://www.scopus.com/), using search words "Corporate Environmental Management" across journal title, keywords, and abstract. Note: (1) The scores of "chemical" and "greenhouse gas" represent the search results using the two search words "chemical" and "corporate environmental management," and "greenhouse gas" and "corporate environmental management" in the journal title, keywords, and abstract, separately. Note (2) Year 2015 data covers January 2015 to August 2015. The other years cover from January to December

whereas journal publications including "greenhouse gases" are primarily seen since the late 2000s. These results can be understood as environmental policy, information technology development, and available databases.

First, environmental policy on chemical substances was enforced in the 1960s and 1970s in the United States, Japan, and many other countries (Fujii et al. 2011). Because several toxic chemical present a high toxic risk for human health and ecosystems, governments have tried to control this risk through environmental policy. Additionally, an open database of toxic chemical substances was built in 1986 in the US, called the toxic release inventory (TRI), and they started to provide toxic chemical release data through the original homepage in 1999. Using this page, researchers can consult a huge amount of data over the internet. Today, many countries provide such information on chemical substances online.[1]

Second, greenhouse gas emissions policies started to be enforced mainly in developed countries in the 1990s and 2000s. Additionally, a corporate GHG emissions database was opened in Japan through the Mandatory Greenhouse Gas Accounting and Reporting System (covering 2006 onwards) and in the United States via the TRI (covering 2010 onwards). The Carbon Disclosure Project was started in 2000 (https://www.cdp.net/en-US/Pages/HomePage.aspx) and is another open data source of corporate GHG emissions. These open data, which were published in the 2000s, came later than that for chemicals.

To compare these search results, the availability of quantitative data is an important factor to encourage empirical studies on CEM. Further, corporate data published by non-English language are difficult to use for foreign researchers who cannot read the given language. Another point is that corporate data are generally sold by private companies at high costs. Therefore, we believe that a free corporate financial and environmental database in English would allow to use corporate data and undertake empirical studies on CEM by researchers who do not have a sufficient research budget to buy such a database.

The objective of this study is to create the world resource table (WRT), an open Japanese corporate financial and environmental database published by the Japanese government. The rest of the paper is organized as follows. We next review the literature on CEM and compare existing databases. Section 3 describes the database constructing approach, and Sect. 4 concludes.

2 Literature review and database comparison

In this section, we clarify the key variables that are used to analyze Japanese firms' CEM and thus construct the WRT to satisfy user demand. Table 1 presents the CEM literature using Japanese firm's financial and environmental data.[2] From the list of

[1] Pollution Inventory in the United Kingdom (https://www.gov.uk/government/collections/pollution-inventory-reporting), the National Pollutant Release Inventory in Canada (https://www.ec.gc.ca/inrp-npri/), the National Pollution Inventory in Australia (http://www.npi.gov.au/), and the Pollutant Release and Transfer Register system in Japan (http://www2.env.go.jp/chemi/prtr/prtrinfo/e-index.html).

[2] Arimura et al. (2008) and Arimura et al. (2011) applied firm-level survey data to analyze econometric approaches focusing on the environmental management system and ISO14001 certification.

Table 1 Literature review of corporate environmental management using Japanese firm data

Author	Data sample	Database	Methods	Key data variables
Fujii et al. (2011)	466 Japanese firms (2001–2008) and 386 US firms (1999–2007)	NEEDS, PRTR Mergent online, TRI	Nonparametric production function	Sales, number of employees, fixed assets, toxic chemical releases
Nishitani et al. (2012)	500 Japanese firms from 2002 to 2008	NEEDS, PRTR	Parametric production function	Sales, age, shareholder ratio, research and development expenditures, ISO14001, debt, toxic chemical releases
Fujii et al. (2013)	758 Samples from 2006 to 2008 (CO_2 emissions) 2498 Samples from 2001 to 2008 (toxic chemicals)	NEEDS, PRTR, the GHG emissions accounting, reporting and disclosure system	Econometrics (generalized least squares)	ROA, sales, number of employees, research and development expenditures, CO_2 emissions, toxic chemical releases
Ishinabe et al. (2013)	1024 Companies in 37 countries from 2002 to 2009	Factset, Truecost	Nonparametric production function	Sales, total assets, cost of goods sold, GHG emissions
Nishitani et al. (2014)	423 Japanese firms from 2007 to 2008	NEEDS, the GHG emissions accounting, reporting and disclosure system	Parametric production function	Value added, wages, material costs, fixed assets, CO_2 emissions
Yagi et al. (2015)	1735 Firms in 10 countries from 2007 to 2013	Bloomberg ESG	Nonparametric production function	Profit, capital stock, wages, energy use, GHG emissions (Scope 1, 2, 3), SOx, NOx, VOC, water use, paper consumption, corporate policy

key variables in Table 1, many previous studies apply sales and profit quantity data as financial performance indicators. Other financial performance data are return on asset (ROA) and return on sales (ROS). These variables are used primarily to understand the profit ratio and efficiency of asset use, which represent financial performance in a ratio measure.

Additionally, the number of employees and total wage data were applied as labor input data or company-scale data. Total fixed assets and capital stock were applied as capital input data in the productivity analysis of Fujii et al. (2011), Nishitani et al. (2014), and Yagi et al. (2015). Meanwhile, Nishitani et al. (2012) and Fujii et al. (2013), who focused on the porter hypothesis, applied research and development expenditure data to capture the effect of environmental policy on environmental technology development. Therefore, financial performance, when used as both a quantity and a ratio measure, labor and capital input, and research and development expenditure data are important variables that are needed to build a dataset for CEM studies.

Here, we discuss the database characteristics. From Table 1, four previous literatures apply the Nikkei economic electronic database system (NEEDS) database. Table 2 shows the information on each corporate database, including WRT. From Table 2, the Bloomberg, TRUECOST, Factset, and Mergent Online databases cover corporate data in multiple countries. All of these corporate databases except WRT provide data to users for purchase because much of the

Table 2 Comparison of databases for environmental management study

Database	Data coverage	Country	Data variables	Cost
Bloomberg[a]	More than 11,000 companies	More than 65 countries	Financial, environmental, social, and governance data	Pay
TRUECOST[b]	Over 93 % of global markets		Environmental data	Pay
Factset[c]	76,271 firms	116 Countries	Financial, social, environmental, and governance data	Pay
Mergent Online[d]	25,000 US companies and over 95 % of the non-US global market capitalization	United States and more than 200 countries	Financial data and corporate profile	Pay
NEEDS[e]	Approximately 20,000 Japanese firms	Japan	Financial data and corporate profiles	Pay
WRT	Approximately 1000 Japanese firms	Japan	Financial and environmental data	Free

[a] Bloomberg ESG Data (http://www.bloomberg.com/bcause/customers-using-esg-data-increased-76-in-2014)

[b] Truecost industry leading data (http://www.trucost.com/thoughtleaders)

[c] Factset fundamentals (http://www.factset.com/data/company_data/fundamentals)

[d] Mergent online (http://www.mergentonline.com/login.php)

[e] NEEDS corporate financial data (http://www.nikkeieu.com/needs/pdf/needs_data/corporate_financial.pdf)

information is difficult to collect from private companies. For example, the corporate governance data from Bloomberg and Factset are generally confidential to maintain market competitiveness. Database service companies try to collect these corporate strategy and corporate policy variables through surveys and interviews, which have a high labor cost.

The first priority of the WRT database is to provide free user access via the internet. Therefore, in this study, we focus on the financial data and environmental data that are available from open data sources from the Japanese government. In other words, the WRT does not cover data that have associated collection costs, such as corporate governance and policy.

3 World resource table (WRT)

Table 3 shows the open data sources that form the WRT (see also Managi 2015; Kanie and Managi 2014; Yang et al. 2015 for global coverage and a different take on the WRT). Financial performance data are obtained from electronic disclosures from the investors' NETwork (EDINET), which was published by the Financial Service Agency of Japan. Financial statements reports on Japanese companies started to be submitted using extensive business reporting language from 2008, which increase the accessibility of financial information. The main variables from EDINET are sales, profits, ROA, ROS, total assets, and number of employees. Research and development expenditure data are also available for a limited number of firms. The total number of firms sampled is approximately 3500 per year from 2008 to 2014.

Next, corporate GHG emissions data are obtained from a mandatory greenhouse gas accounting and reporting system published by the Ministry of the Environment,

Table 3 Description of the world resource table

Variable	Open data source name (Source of data) (URL of open database)	Time period	Number of samples per year
Financial data	Electronic disclosure for investors' NETwork (Financial Services Agency, Japan) (http://disclosure.edinet-fsa.go.jp/EKW0EZ1001.html)	2008–2014	3500
Greenhouse gas (GHG) emissions	Mandatory greenhouse gas accounting and reporting system (Ministry of the Environment, Japan) (http://ghg-santeikohyo.env.go.jp/result) in Japanese	2006–2012	10,000
Toxic chemical release	Pollutant Release and Transfer Register system (Ministry of the Environment, Japan) (http://www2.env.go.jp/chemi/prtr/prtrinfo/e-index.html)	2001–2013	7000

Table 4 Number of sample firms in the world resource table

Available data variable	Time period	Number of firms per year
Financial data and GHG emissions	2009–2012	1544
Financial data and toxic chemical releases	2009–2013	1065
Financial data, GHG emissions, and toxic chemical releases	2009–2012	835

Financial data in 2008 is now being collected

Japan. The dataset includes annual CO_2, CH_4, N_2O, HFC, PFC, SF_6 emissions of each company. Under this system, firms with more than 21 employees and either GHG emissions greater than 3000 tons of CO_2 or energy consumption of all facilities larger than 1500 kl of oil equivalent must provide annual reports to the central government on the quantities emitted (Fujii et al. 2013). The dataset presents reports from approximately 10,000 sources, including public buildings such as universities, city offices, and government agencies, from 2006 to 2012.

Finally, corporate toxic chemical release data are obtained from the pollution release and transfer register (PRTR) system, published by the Ministry of the Environment and Ministry of Economy, Trade and Industry, Japan. Under this system, facilities with more than 21 employees and that produce or use chemicals on a list of 462 legally specified substances must annually report the quantities they use to central government (Fujii et al. 2013).

Using the above three open data sources, we conduct the name-based aggregation. The results are shown in Table 4. The WRT database contains panel data across both year and firm. The available sample number is different among years due to missing and new samples during the data period. The number of available samples for both financial and GHG emissions data is approximately 1544 per year from 2009 to 2012. Additionally, the number of samples that are available for both financial and toxic chemical release data is approximately 1000 samples from 2009 to 2013. We believe that a dataset that contains more than 1000 samples is sufficient to conduct productivity and econometric analyses.

The number of samples in which all three data variables are available is approximately 835 firms from 2009 to 2012. Therefore, comparative analysis between GHG and chemistry is restricted due to sample size limitations. The WRT adopts the standard industrial classification to understand the industrial characteristics, thus allowing for industrial comparison studies.

4 Conclusion

To explain why and how corporate environmental management provides benefits, it is important to incentivize private firms to promote environmentally friendly activities. Empirical analyses using real-world data provide the information required to create logical and persuasive explanations. However, there is currently no free database of corporate financial and environmental data. Therefore, empirical studies

on corporate environmental management are limited due to the restrictions of limited research budgets.

This study proposes a new corporate financial and environmental dataset called the world resource table (WRT) using an open data source published by the Japanese government. The WRT database will be available and free to download (https://sites.google.com/site/hidemichifujii/Home/world-resource-table). The number of samples in the WRT is more than 1000 per year, which is sufficient to allow empirical analyses using productivity measures and econometric approaches.

The next steps are as follows. First, we will incorporate corporate patent data into the WRT database. Second, we will promote the linkage between the WRT database and analytical software such as GAMS for productivity analysis and R for econometric approaches. The development of user-friendly software will encourage more proactive learning among students who are able to use real-world data.

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