Circular Economy: Exploratory Study of Steel Industry in Thailand

Vichathorn Piyathanavong
School of Manufacturing Systems and Mechanical Engineering (MSME)
Sirindhorn International Institute of Technology (SIIT)
Thammasat University
99 Moo 18, Paholyothin, Khlong Luang, Pathum Thani 12120, Thailand

School of Knowledge Science
Japan Advanced Institute of Science and Technology, Japan
1-1 Asahidai, Nomi, Ishikawa, 923-1292, Japan
Vichathorn.Piy@dome.tu.ac.th

Jose Arturo Garza-Reyes
Centre for Supply Chain Improvement
The University of Derby
Kedleston Road Campus, Derby, DE22 1GB, UK
J.Reyes@derby.ac.uk

Van-Nam Huynh
School of Knowledge Science
Japan Advanced Institute of Science and Technology, Japan
Asahidai, Nomi, Ishikawa, 923-1292, Japan
Huynh@jaist.ac.jp

Sun Olapiriyakul
School of Manufacturing Systems and Mechanical Engineering (MSME)
Sirindhorn International Institute of Technology (SIIT)
Thammasat University
99 Moo 18, Paholyothin, Khlong Luang, Pathum Thani 12120, Thailand
Suno@siit.tu.ac.th

Jessada Karnjana
National Electronics and Computer Technology Center (NECTEC)
National Science and Technology Development Agency (NSTDA)
111 Thailand Science Park (TSP), Phahonyothin,
Khlong Luang, Pathum Thani 12120, Thailand
Jessada.Karnjana@nectec.or.th

Abstract

The Circular Economy (CE) is widely known as a possible solution to address sustainable development in the manufacturing sector. This paper investigates the adoption status of CE in the steel industry of Thailand. A survey questionnaire was designed, validated, and distributed among Thai steel manufacturing companies. The result of the study indicates that some of the participants' organization had already implemented the CE. The implementation success of CE is moderate-high. The CE is found to be implemented mainly at the departmental level, rather than across the entire organization. The main drivers of CE implementation are internal motivations, including environmental awareness, long-term sustainable development, and cost savings from material circularity. Furthermore, reducing the environmental impact on external stakeholders is the main CE external driver. A lack of proper training and knowledge, too much effort required, and a lack of support from top management are the main barriers to implementing the CE. This study offers direct benefits for academics, researchers, and steel manufacturing companies who are interested in CE implementation. It also shows the initial evidence of CE adoption in the Thai steel manufacturing industry.

Keywords
Circular Economy, Implementation, Steel Industry, Thailand, Environmental Sustainability

1. Introduction

The Circular Economy (CE) is an economic model to enhance resource utilization through waste elimination and long-term value retention of materials, leading to the reduction of required primary resources (Morseletto, 2020). Moreover, the CE concept prioritizes the creation of circular loops of materials, products, energy, and waste flows (Masi *et al.*, 2018). Thus, it has the potential to promote sustainable development and economic growth from the reduction of resource depletion and environmental protection. In addition, CE models keep resources within the economy when the products reach the End-of-Life (EoL) stage so that the materials can be recovered or reused again, hence recapturing more value (Di *et al.*, 2017).

There has been a growing concern for global climate change arising from the rapid increase of CO_2 emissions that represent an environmental threat and challenge for modern society (Lou *et al.*, 2017). Furthermore, resource consumption and economic growth are cointegrated. Both of them are long-term causes of CO_2 emissions (Wang *et al.*, 2011). The linkages among energy consumption, pollution emissions, and economic growth have received substantial attention over the last decade by both researchers and policymakers since accomplishing sustainable economic growth has become a major global priority (Antonakakis *et al.*, 2017). The manufacturing sector has been one of the main elements driving the economic growth of developing countries. However, promoting environmental performance could bring negative economic performance due to the higher costs of more environmental-friendly materials and investment in green technologies (Zhu *et al.*, 2016). Nonetheless, the CE is an operational approach that advances economic development by promoting material circularity, without neglecting environmental well-being and social benefits (Ngan *et al.*, 2019). It answers the concern 'Does it pay to be green?' from previous researchers (Ghisetti and Rennings, 2014).

Researchers have noticed that even though the steel industry has made an active contribution to the rapid rate of economic growth in developing countries, it is a resource and energy-intensive industry that produces high pollution and emissions (Ma *et al.*, 2014). Furthermore, Alam *et al.* (2016) highlight that energy consumption is responsible for CO_2 emissions, which is the major cause of creating Green House Gases (GHGs) in the atmosphere, leading to global warming and climate change. Since most steel manufacturing companies in developing countries suffer from poor environmental performance, CE and its practices bring new opportunities and business models for firms to solve this concern (Olmez *et al.*, 2016; Chiappetta Jabbour *et al.*, 2020; Conejo *et al.*, 2020). Moreover, Mura *et al.* (2020) highlight that CE brings about new business opportunities through the development of new value networks from the usage of secondary raw materials in the steel industry. Therefore, to promote the steel industry's environmental sustainability, CE can enhance economic performance and environmental performance, resulting in better companies' competitive advantages.

Jabbour *et al.* (2020) state that in the manufacturing industry, which uses metallic natural resources, CE has not been fully investigated. There are knowledge gaps regarding drivers, challenges, and opportunities related to the CE and the sharing economy. This study investigates the implementation of CE, particularly in the Thai steel industry. This includes an exploration of the benefits experienced and barriers faced by manufacturing companies in this industry when implementing the CE and its practices, their reasons for commencing or ignoring such adoption, etc. Thailand faces challenges in enhancing green outputs from Thai industries to enhance the economy. There are many unsatisfactory impacts on the environment from the improper usage of natural resources for industrial development, resulting in inefficient manufacturing operations and unfavorable impacts on the Thai economy (Pilouk and Koottatep, 2017). The CE may offer Thai manufacturing companies opportunities to enhance their environmental sustainability performance by promoting material circularity, resulting in short- and long-term economic and environmental benefits.

2. Literature review

The Circular Economy (CE) is an operational approach to promote environmental sustainability, especially in the manufacturing sector. It is underpinned by ten practices, namely, pollution prevention, product stewardship, reducing the use of resources, 3Rs, life cycle analysis, eco-design, internal environmental management, green purchasing, cooperation with customers (including environmental requirements), and investment recovery (Masi *et al.*, 2018; Piyathanavong *et al.*, 2019). A traditional linear economy follows the 'raw material-product-EoL-dispose' model (Bocken *et al.*, 2016). This means that raw materials are transformed into products that are used until they reach the End-of-Life (EoL) stage and finally discarded as waste. However, the CE overcomes the linear economic model by transforming the model into 'raw material-product-EoL-renewable resource'. The values of post-used products at their end-of-life (EoL) stage are recovered (Alamerew and Brissaud, 2020). Hence, material circularity reduces risks from material price volatility and shortage of material supply, thereby reducing natural resource degradation.

In the field of 'Circular Economy', some researchers have investigated the CE in specific manufacturing industries such as food, automotive, plastic, textile, and electronics industries (Principato *et al.*, 2019; Bonsu, 2020; Yadav *et al.*, 2020). Other researchers have focused on the CE implementation on a macro level, such as the study in the EU region (Hartley *et al.*, 2020). Furthermore, some scholars have concentrated on the frameworks contributing to the CE concept (Pomponi and Moncaster, 2016; Blomsma, 2018), which highlight the need to prioritize environmental research on both the micro and macro levels. Masi *et al.* (2018) investigate the CE implementation from a focal firm perspective (micro level). They highlight that the nature and the state of CE transition are important for creating effective policies and building comprehensive business strategies in manufacturing companies.

Various authors have studied the potential of CE in developed regions. Geerken *et al.* (2019) focus on the CE potential in Belgium. They notice that CE activities could positively impact several aspects: resource efficiency, reduction of dependency on materials, competitiveness, and reduction of Green House Gas (GHG) emissions. Paletta *et al.* (2019) study the barriers and challenges of CE in the Italian plastic industry. They show four main barriers to material circularity, including technological barriers, legislative barriers, economic barriers, and socio-cultural barriers. Therefore, an understanding of CE barriers has been found to help manufacturing companies successfully adopt CE and its practices to promote long-term sustainable development (Kirchherr *et al.*, 2018).

Some researchers have highlighted the motivations and barriers to CE implementation. Lieder and Rashid (2016) and Zhang *et al.* (2019) highlight some barriers or missing initiatives to support CE implementation in the manufacturing sector. They include the lack of support from the government, lack of environmental regulations and laws, lack of resources, and lack of environmental awareness. Furthermore, Ritzén and Sandström (2017) notice that financial barriers, top management attitudes, and the lack of adequate technical training and knowledge are the main barriers to a transition to CE. In contrast, behaviors such as environmental awareness, risk mitigation, consumer pressure for environmentally friendly products, and economic and competitive benefits are found to be the motivations for CE adoption (Geissdoerfer *et al.*, 2018; Prieto-Sandoval *et al.*, 2018).

From the literature previously discussed, it can be concluded that most of the works on the CE have been concentrated at various levels, including the macro and micro levels. However, apart from the study of Piyathanavong *et al.* (2019) and Pisitsankkhakarn and Vassanadumrongdee (2020), the investigation of the implementation status of CE in Thailand is almost non-existent. More specifically, none of the previous works focuses specifically on the Thai

manufacturing sector, especially the steel industry, which is energy and resource intensive. These gaps in the literature motivate the author to pursue the study illustrated in this paper.

3. Research methodology

3.1 Data collection – survey questionnaire

To investigate the CE implementation status in the steel industry of Thailand, a survey questionnaire was used for empirical data collection. This allows the generalization of the findings from large-scale data collection in the Thai steel industry. An Excel spreadsheet was used to consolidate the data collected from the questionnaires. The data was then analyzed using descriptive statistical tools, in which the outcome is presented in the charts, e.g. bar charts and pie charts. Similar to this research, Masi *et al.* (2018) use a survey questionnaire to explore the awareness of CE implementation from a focal firm perspective. The questionnaire consists of three main sections. The first section collects a general profile of the participants and their organizations, while the second section identifies CE implementation success and motivations for CE implementation. The last section assesses the barriers and challenges regarding CE adoption. The details of the survey data analysis are illustrated in Section 4.

3.2 Survey questionnaire validity and reliability

Before distributing the survey questionnaire, it is necessary to identify both the validity and reliability of the questionnaire. This ensures that the questions are ready for the actual round of data collection (Roopa and Rani, 2012). In this case, a small-scale pretest (pilot study) was conducted to ensure that the questions conform to the concepts that are being measured, eliminating both the subject and observer errors. The survey questionnaire was sent to six subject experts, including three industry experts/ management level of the steel manufacturing company and three academics. Their feedback was then used to amend and improve the survey questions, removing any bias or errors in the questions. Furthermore, based on the feedback from the academics, it is clear that the questions are comprehensive and in line with the objectives of this research. Moreover, feedback from the three industrialists was considered to promote a practical understanding of the questions in the questionnaire. This resulted in refining or eliminating any ambiguities and irrelevant questions.

3.3 Survey questionnaire distribution

Focusing on the implementation of CE in the Thai steel industry, the questionnaire was mainly distributed to steel manufacturing companies in Thailand. The research background and objectives were addressed by the cover letter. This study targets people who know or are involved in the company's operations in relevant departments such as production, operations, planning, etc. In total, 50 usable responses were obtained. Fifty responses are beyond the suggestion on minimal sample size (Johanson and Brooks, 2010). According to a similar exploratory study, e.g. Masi *et al.* (2018), 50 responses are adequate to generalize the findings and draw initial conclusions regarding the CE implementation in the Thai steel industry.

4. Results, analysis, and discussion

4.1 Respondents and companies' profiles

Figures 1 and 2 illustrate the profiles of companies and respondents, i.e. company size, the position of respondents, and respondents' experience in sustainable operations. The majority of the companies that participated in this study are large companies (76%), followed by medium (14%) and small (10%) (see Figure 1). Furthermore, the data is collected from respondents that cover many different positions in steel manufacturing companies ranging from team member to CEO (see Figure 2(a)). Additionally, most of the respondents who took part in this research already have had substantial experience in sustainable operations (see Figure 2(b)).

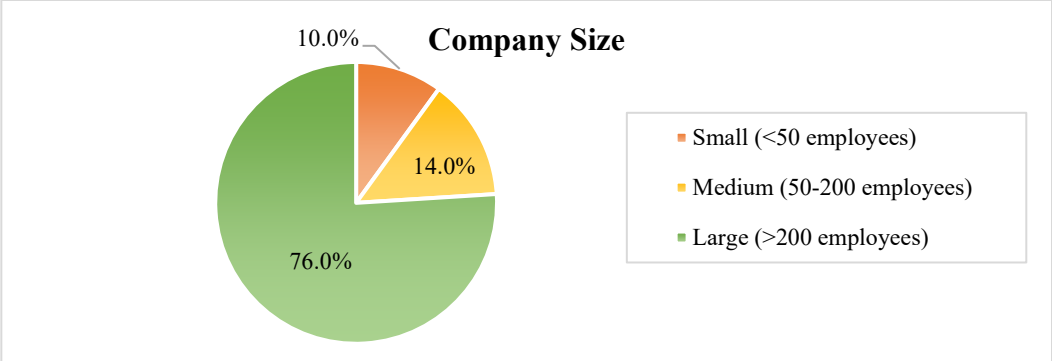
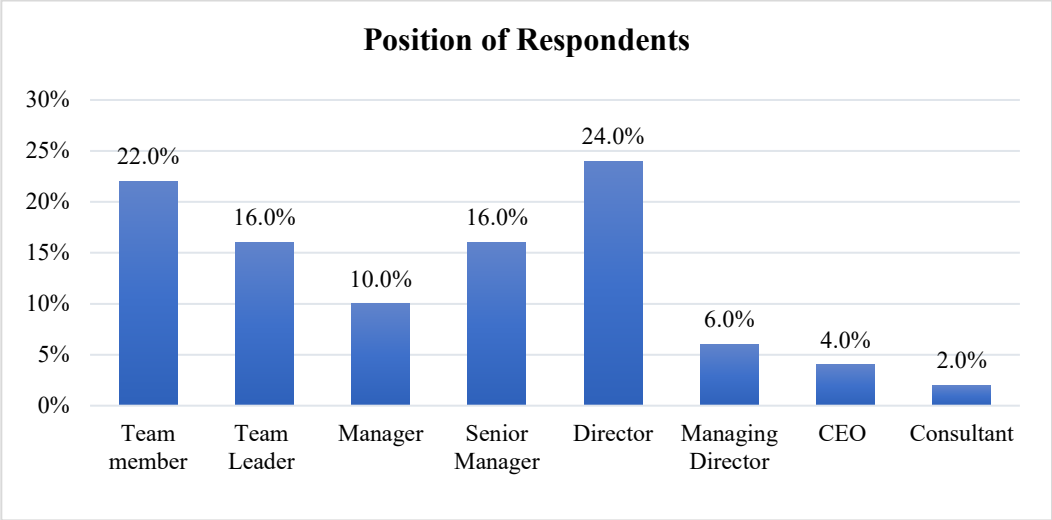
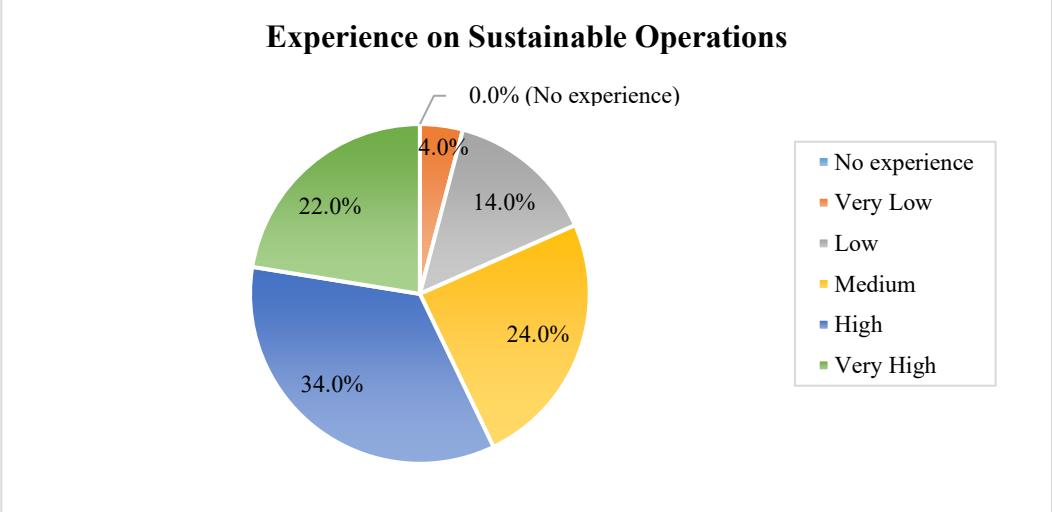


Figure 1. Respondents' Company Size



(a)

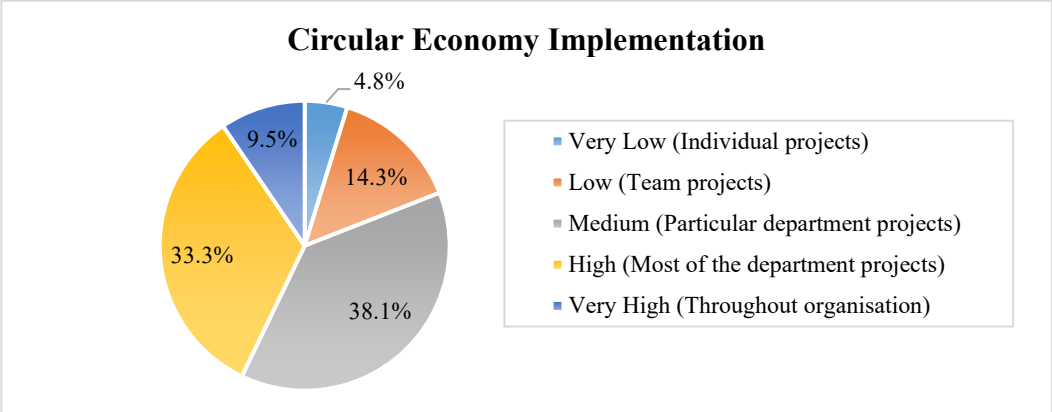


(b)

Figure 2. Respondents' profile: (a) Position of Respondents, (b) Respondents' Experience on Sustainable Operations

4.2 Circular Economy implementation

Respondents who participated in this study were asked whether their companies had implemented CE. Our results reveal that 42% of the respondent's companies had implemented CE, while 58% had not. Thailand is positioning itself in the rapidly emerging market economy of the ASEAN region, where Thailand is one of the main manufacturing hubs that export products globally (Pisitsankkhakarn and Vassanadumrongdee, 2020). However, manufacturing companies in Thailand are balancing the need for competitive advantages and environmental considerations, in which the CE could offer a solution to these concerns. This study investigates both aspects (internal and external) of the drivers for CE implementation in the steel industry since the studies in this area are limited to the EU, China, BRIC countries, etc. but not Thailand (Chiappetta Jabbour *et al.*, 2020; Kirchherr *et al.*, 2018; Mura *et al.*, 2020). For this reason, this study fills the literature gap and enhances the understanding of CE adoption in the steel manufacturing industry in Thailand.



(a)

Circular Economy Implementation, Internal Drivers

Percentage	Circular Economy Internal Drivers
61.9%	Improve environmental awareness
57.1%	Promote long-term sustainability, to be less dependent on non-renewable resources
52.4%	Improve cost savings from less resources consumption, material circularity and tax benefit
47.6%	Increase operational efficiency of the production processes
42.9%	Promote company's reputation, public image, and public trust
42.9%	Improve competitiveness by offering Eco-friendly products

(b)

Circular Economy Implementation, External Drivers

Percentage	Circular Economy External Drivers
52.4%	Reduction of the environmental impact on external stakeholders
38.1%	Compliance with environmental regulations and laws set by the government
28.6%	Customer's pressure for products and services that are more environmentally friendly
4.8%	Availability of financial support from government and/or private sources

(c)

Figure 3. (a) Implementation of CE, (b) CE Internal Drivers, (c) CE External Drivers

Respondents that their companies had implemented CE in their production-related operations were asked about different aspects related to the CE implementation. Figure 3 demonstrates three aspects regarding the CE adoption, including (a) the CE implementation success, (b) CE implementation internal drivers, and (c) CE implementation external drivers. From Figure 2(a), it is clear that the CE implementation success in the Thai steel industry is medium-high with success in particular department projects (38.1%) and most department projects (33.3%). However, some of the companies only succeed in implementing the CE in team projects (14.3%) and individual projects (4.8%), while only 9.5% of the companies can successfully implement CE throughout the entire organization. This suggests that although CE has been adopted by a relatively large number of Thai steel manufacturing companies, its implementation has been considered as only a part of the strategic priorities of these companies. Thus, this may result in the implementation of CE declining in the medium or long term. Further and more extensive research is required to promote an understanding of how to properly embed CE in the strategic priority of these companies, for achieving long-term sustainable benefits. This section provides initial information regarding the motivations of CE adoption to promote an understanding of why steel manufacturing companies implement CE; hence, respondents were asked to specify the drivers which support the internal and external adoption of CE (see Figure 3(b) and (c)).

Figure 3(b) presents the internal drivers for CE implementation. It indicates that most of the Thai steel manufacturing companies are already aware of the environmental impacts caused by their operations (61.9%). These companies are self-motivated in adopting the CE. In line with the study of Nußholz (2018), these companies adopt CE to create value from closed material loops, leading to long-term sustainability development (57.1%) and cost-savings (52.4%). Moreover, the CE improves the operational efficiency of the production process of these companies (47.6%), which is aligned with the findings of Ma *et al.* (2014) that CE and its practices have improved the output efficiency of resources in the Chinese steel industry. The results of their study indicate that promoting a company's image (42.9%) and improving competitive advantages (42.9%) were also CE internal drivers. For example, Park *et al.* (2010) state that CE reduces operational costs and enhances the public image of companies. Similarly, Pisitsankkhakarn and Vassanadumrongdee (2020) highlight that CE enhances customer purchase intentions, which leads to the improvement of the company's competitive advantages. Therefore, it can be concluded that steel manufacturing companies in Thailand have internal drivers as the motivation to adopt CE, especially in terms of self-environmental awareness and long-term sustainable development.

Respondents were also asked if external drivers support CE implementation, which the results are shown in Figure 3(c). The study results indicate that reducing the environmental impacts on external stakeholders (52.4%) and complying with environmental regulations and laws set by the government (38.1%) were the main external drivers for CE implementation. Customers' pressure for green products and services account for 28.6%, and only 4.8% comes from the availability of financial support from the government and private sector. This implies that the majority of Thai steel manufacturing companies have limited access to external financial support for CE adoption. Furthermore, stronger pressure from environmental regulations and customers should be enhanced, as they are considered to be challenging factors in the Thai manufacturing sector. For instance, Pilouk and Koottatep (2017) notice that Thailand faces challenges in assuring green outputs from Thai industries to boost the economy of the country. To effectively overcome these challenges, Thai manufacturing firms (not limited to the steel manufacturing industry) would need to consider adopting CE as an approach to reduce natural resource consumption and promote economic growth, leading to better (overall) environmental performance.

4.3 Non-implementation of Circular Economy

Respondents that their companies have not implemented CE were asked about CE implementation barriers (see Figure 4). These barriers were categorized into (a) CE internal barriers, and (b) CE external barriers. The study outcomes presented in this section clarify why Thai steel manufacturing companies do not consider implementing CE.

Regarding the CE implementation internal barriers illustrated in Figure 4(a), the main contributors include a lack of training and knowledge (51.7%), too much effort required (44.8%), lack of support from the management level (41.4%), lack of benefits from environmental sustainability (34.5%), lack of available resources such as Green technology (24.1%), and lack of environmental awareness (3.4%). This result is in line with the study of Geerken *et al.* (2019) that a lack of knowledge hampers the local economic implementation of new secondary material production activities, hence, limiting the success in implementing CE. Furthermore, Ritzén and Sandström (2017) observe that top management involvement in initiating a change toward CE is necessary for the transition. This agrees with the findings of this study.

Circular Economy Implementation, Internal Barriers

Percentage	Circular Economy Internal Barriers
51.7%	Lack of training and knowledge
44.8%	Too much effort required
41.4%	Lack of support from management level
34.5%	Lack of benefits from environmental sustainability
24.1%	Lack of avilable resources, such as Green technology
3.4%	Lack of environmental awareness

(a)

Circular Economy Implementation, External Barriers

Percentage	Circular Economy External Barriers
27.6%	Lack of environmental regulations and laws set by the government
13.8%	Lack of support from government such as tax credits and other business incentives
6.9%	Lack of financial support from government and/or private sources

(b)

Figure 4. (a) CE Internal Barriers, (b) CE External Barriers

CE external barriers were also investigated (see Figure 4(b)). The result indicates that external barriers consist of a lack of environmental regulations and laws set by the government (27.6%), lack of support from the government in terms of tax credits and other incentives (13.8%), and lack of financial support from the government and/or private sources (6.9%). Hence, in line with the finding of this study, Kirchherr *et al.* (2018) investigate the CE barriers in the EU and notice that governmental legislation/rulings and limited funding for circular business models are the main barriers of CE implementation.

Overall, in terms of internal barriers, it can be seen that steel manufacturing companies in Thailand still lack of resources for proper knowledge and training and top management support. However, these companies might prioritize more on investments in other aspects that are not related to the environment but directly promote short-term competitiveness. Ghisetti and Rennings (2014) raise the question of 'how does it pay to be green?'. In the context of the Thai manufacturing industry with limited resources and a highly-competitive environment, these steel manufacturing companies may consider short-term benefits rather than green investment for long-term benefits, leading to not adopting CE. Furthermore, external support for CE implementation in Thailand needs to be enhanced, including green regulations set by the government and other business incentives to motivate these firms to adopt material circularity operations.

5. Conclusions

CE, an approach to achieve environmental sustainability in the manufacturing sector, has been known to offer benefits to a wide range of manufacturing industries. This is due to its potential contributions to sustainable development by extracting the maximum value from the resources and keeping them in use for as long as possible. However, in Thailand, the investigation of CE is still limited, and the implementation status in the Thai steel industry is still relatively unknown. Hence, this study explores the implementation status of CE in the Thai steel industry, including motivations and barriers (both internally and externally). This study is one of the first of its kind; hence, it will provide direct benefits to academics, researchers, and steel manufacturing companies who are interested in CE implementation in rapidly developing countries like Thailand. The results of this study indicate that some of the participants' organization had already implemented CE. However, the implementation success is still limited to moderate-high, and most of the implementation success is limited to the departmental level. The main drivers for CE adoption include environmental awareness, long-term sustainable development, cost savings from material circularity, and reducing the

environmental impacts on external stakeholders. The barriers include a lack of proper training and knowledge, too much effort required, and a lack of support from top management.

Even though this study shows some interesting evidence regarding the CE implementation in the Thai steel manufacturing industry, it has some limitations. The results need to be interpreted with caution. The limitations of this study include the small sample size used in the survey study and the limited study's scope due to the limited budget and time constraints. Thus, in future study, more robust research with a higher number of respondents can be conducted to validate and extend the result of this study, and qualitative data collection, e.g. interview, can also be conducted to promote a better understanding of the CE implementation. This can expand the factors involved in the study. Furthermore, a future research can also be performed in the different manufacturing industry or in other countries where the manufacturing industries face different experiences and environments.

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Biographies

Vichathorn Piyathanavong is a PhD student at both the School of Manufacturing Systems and Mechanical Engineering (MSME), Sirindhorn International Institute of Technology (SIIT), Thammasat University, Thailand and the School of Knowledge Science, Japan Advanced Institute of Science and Technology (JAIST), Japan. Mr. Piyathanavong holds a Bachelor of Engineering degree in Industrial Engineering with First-Class honors from Sirindhorn International Institute of Technology (SIIT), Thammasat University, Thailand, and a Master of Science in Engineering Business Management with Distinction from Warwick Manufacturing Group (WMG), the University of Warwick, the United Kingdom. Mr. Piyathanavong has expertise in sustainable operations and Circular Economy, and has a Circular Economy related publication in the Journal of Cleaner Production.

Jose Arturo Garza-Reyes is a professor of Operations Management and Head of the Centre for Supply Chain Improvement at the University of Derby, UK. He is actively involved in industrial projects where he combines his knowledge, expertise and industrial experience in operations management to help organizations achieve excellence in their internal functions and supply chains. He has also led and managed international research projects funded by the British Academy, British Council, European Commission and Mexico's National Council of Science and Technology (CONACYT). As a leading academic, he has published over 150 articles in leading scientific journals, international conferences and six books. Prof. Garza-Reyes is Associate Editor of the Int. J. of Operations and Production Management, Associate Editor of the Journal of Manufacturing Technology Management, Editor of the Int. J. of Supply Chain and Operations Resilience and Editor-in-Chief of the Int. J. of Industrial Engineering and Operations Management. Areas of expertise and interest for Professor Garza-Reyes include general aspects of operations and manufacturing management, business excellence, quality improvement, and performance measurement.

Van-Nam Huynh is a professor of the School of Knowledge Science, Japan Advanced Institute of Science and Technology (JAIST). He also served as an Adjunct Professor at Chiang Mai University, Thailand during 2015-2017, and Part-time Lecturer at Tsukuba University, Japan during 2011-2015. His current research interests include decision analysis and management science, data mining and machine learning, modelling and reasoning with uncertain knowledge, multi-agent systems, kansei information processing and applications. He has published more than 150 refereed scientific papers, and (co-)edited over fifteen Springer volumes and seven special issues for International Journal of Approximate Reasoning, Annals of Operations Research, and Data and Knowledge Engineering. Dr. Huynh currently serves as an Area Editor of International Journal of Approximate Reasoning (Elsevier), Editor-in-Chief of International Journal of Knowledge and Systems Science (IGI Global), and an Editorial Board Member of the journal ARRAY (Elsevier).

Sun Olapiriyakul is an assistant professor of the Industrial Engineering program at Sirindhorn International Institute of Technology (SIIT) of Thammasat University, Thailand. After earning a BEng in mechanical engineering from SIIT, Thailand, and an MSc in industrial engineering from San Jose State University, US, he received a doctoral scholarship from Royal Thai Government in 2005 to study in industrial engineering and conduct research related to nanotechnology. He completed his Ph.D. in industrial engineering at New Jersey Institute of Technology, US, in 2010, with his dissertation titled: End-of-life Management of Nanotechnology Products. Dr. Olapiriyakul current research focuses on sustainable supply chain network design, urban freight transport, and workforce scheduling. His approach to research revolves around the use of industrial engineering principles in conjunction with sustainability concepts and environmental impact assessment methodologies.

Jessada Karnjana received his B.Eng. (electronics engineering), M.Eng. (microelectronics), Ph.D. (information science), and Ph.D. (engineering and technology) from King Mongkut's Institute of Technology Ladkrabang, from Asian Institute of Technology, Thailand, from Japan Advanced Institute of Science and Technology, Japan, and from Sirindhorn International Institute of Technology, Thammasat University, Thailand, in 1999, 2006, 2016, and 2017, respectively. His research interests focus on mathematical modeling, data analysis, and signal processing. He has worked at National Electronics and Computer Technology Center, Thailand, since 1999.