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Barriers and coping strategies when implementing circular business models — A multiple case study of Taiwanese companies

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Abstract

The circular economy has gained momentum in the academic discourse for five years. However, there are merely a few empirical and cross-industry studies on how circular business models are implemented in the Asia context, particularly in Taiwan. Furthermore, most studies focused on the successful implementation of circular business models while ignoring how the companies conquer the internal and external barriers. This research fills the gap by studying the barriers that five Taiwanese companies encountered when implementing or adopting circular business models. Additionally, one research institute in the textile industry was also interviewed to provide insights into what barriers may surface for textile companies. Lastly, the coping strategies that these five companies adopt are presented.

This research uses multiple case studies and applies a purposing sampling strategy to pinpoint the barriers that emerge in companies. Additionally, this research applies thematic analysis to transcribe and group the internal and external barriers that companies encountered. The findings were analyzed in comparison with the barriers previously identified by scholars.

This research discovers that barriers do not vary between the two types of circular business models (CBMs) that interviewed companies adopted. Barriers mostly emerge under the supply chain category because of lacking shared values, low transparency of information and data, and limited spaces for dialogues leading to an incomplete supply chain for CE. Additionally, the barriers interlink with each other, such as lacking financial incentives and lagged regulatory reactions. Coping strategies to tackle barriers were mostly related to building resiliency through diversifying business and collaborating with industry networks and governments. Overall, implications for companies include collaborating with governments through dialogues or consultations and seeking supports from other stakeholders such as research institute or academic institutions for innovations.

Future research can focus on the following areas. Firstly, enlarging the sample collections and industry types and consider other factors such as companies' sizes. Secondly, expanding the research on more industries. Thirdly, assessing the effectiveness of the coping strategies in association with specific barriers. Fourthly, conducting an analysis of the extent of barriers interlinking with each other. And lastly, exploring service-oriented CBMs to understand the similarities and differences of barriers as these types of CBMs had no presence in this research.

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LIST OF ABBREVIATIONS

CE: circular economy
BMs: business models
CBMs: circular business models

1. Introduction

1.1 The linear economy and its associated problems

The "take-make-dispose" model has been dominating the human economy after the Industrial Revolution. Humans have more energy surplus with the use of coal, oil, and gas, and this serves as a prerequisite for economic growth. Moreover, the emergence of advanced technology realized the potentials of unlimited productions (Martin et al., 2016). With the contributions of machines and sophisticated techniques, more basic commodities such as medication, food supply, and clothing contributed to the growth of the population and wealth accumulation. After World War II, the population has nearly tripled while the commodities are mostly consumed by the endless demands of people inhabiting developed economies (Korhonen et al., 2018). Mass production and overconsumption mean that more natural resources are depleted to maintain our lifestyles. This unsustainable pattern is impossible to sustain considering the finite resources on the planet (Korhonen et al., 2018).

In the early twentieth century, "Planned Obsolescence" was coined by Bernard London in his paper 'Ending the depression through planned obsolescence' published in 1932 in confrontation with the downturn at the Great Depression (Andrews, 2015). The intent of planned obsolescence is intentionally designing a limited lifespan for products. Therefore, products will be obsolete and make it hard to repair or become more fragile. By doing so, goods with a limited lifespan can propel the increase of demands (Rivera and Lallmahomed, 2016). For instance, "if one breaks the display of Apple MacBook Pro retina, then the only way to repair it is by sending back to Apple since the battery is glued in with industrial-strength glue, and the screen is bonded" (Aladeojebi, 2013, p.1505).

Linear economy implies that companies can utilize sophisticated technologies to extract virgin materials manufacture not durable products and throw away right after products' end of life. After 1960, the linear model was commonly adopted when drastic changes in the global market, with the decline in the fossil fuel costs coupled with lower prices of labors and capitals (Pfister, 2010). Moreover, products were not designed for recollections,

“salvaging metals, paper, glass, and textiles became less economically attractive than buying new ones” (Andrews, 2015, p.307). Due to the upward trends of demands, the use of global resources “has already tripled since 1970” (UNEP, 2020).

The linear model certainly has boosted the economy for the past century but at the expense of the environment. Environmental repercussions include erosions of ecosystem services, climate-related risks, and ecological stress (Ellen Macarthur Foundation, 2015). According to the Global Footprint Network by 2019, humanity is currently using natural resources 1.75 times faster than our planet’s ecosystems can regenerate, which means that we need 1.75 earth to sustain all of humanity's current lifestyle. Additionally, the linear economy expedites climate change through overconsumption of food, water, as well as natural resources, overexploitation of arable lands, and destabilization of ecosystems (Williamson et al., 2018). For example, agriculture accounts for around a third of global anthropogenic greenhouse gas (GHG) emissions, and land-use change alone contributes 10% of anthropogenic CO2 emissions (Alexander et al., 2016; Quéré et al., 2015).

However, the linear model faces limitations, such as volatile resource prices. In the first decade of the twenty-first century, energy prices have increased by 260 percent, due primarily to rising costs of supply and surging demands from non-OECD nations. Additionally, food prices have risen by 120 percent, resulting from policy changes, a declining pace of yield increases, and supply-side shocks. Lastly, material prices have increased by 135 percent, of which prices for gold increase the most significantly (Dobbs et al., 2013).

The population growth, resource scarcity, volatile resource prices, environmental degradations, and unsustainable consumption and production all indicate that the unlimited growth of the economy is not going to sustain over a long period of time (Daly, 1990).

1.2 Circular economy and business models innovations

Currently, there is a framework that gains momentum: the circular economy (CE). The CE concept takes into account the consumption of natural resources and waste generation on the environment. This formulates a closed-loop system that keeps waste within the loop as much as possible, makes optimal use of virgin resources, and reduces pollutants within the production system (Sauvé et al., 2016).

The CE does not originate from one single source, many scholars indicate that CE was primarily introduced by Pearce and Turner (1990), who derived their concept of a circular economic system based on previous studies of ecological economists (Boulding, 1966; Ghisellini et al., 2016). A host of schools of thought include regenerative design, performance economy, cradle to cradle, industrial ecology, and biomimicry (Ellen Macarthur Foundation, 2015).

The advantages of CE encompass environmental, social, and economic win. For environmental gains, reduced virgin materials and energy input, reduced wastes, and emissions. For social gains, new employment opportunities through new uses of the value embedded in resources and a heightened sense of community. As for the economic win, there are reduced raw materials and energy costs, the use of costly scarce resources being minimized, and reduced costs from future environmental regulations and taxes (Korhonen et al., 2018).

As companies seek ways to orient their products and strategies into sustainability, they have to concurrently find the appropriate business models to transform the way to reap the benefits of CE. Without radical change from the incumbent business models, products, and technology innovations cannot realize their potentials and do not guarantee business success. (Bocken et al., 2016).

Enhanced explorations within sustainability and CE are still nascent and most knowledge is "still on the conceptualization stage" (Pieroni et al., 2019, p.199). Practitioners adopt

circularity into their business models resulting from changing regulatory landscapes, and thus "gray literature by companies, consultancies, and NGOs have proposed circular business models (CBMs) innovation approaches" (Pieroni et al., 2019, p.199).

1.3 Circular economy in Asian contexts

The circular economy has entered into the legislative phase in the EU, and many national initiatives also showcase keen interests in the transition towards the CE-oriented economy (Bonviu et al., 2014). Asian countries are driving the surging development of the global economy, while scholars seldom shed highlights in Asia (Wang and Kuah, 2018). And a large amount of wastes is generated through rising consumption levels, but Asian consumers are rarely aware of the significance of the CE and remanufactured products are less acceptable for them because of quality and reliability concerns towards the products according to a survey conducted by Wang and Kuah (2018). This aforementioned lack of awareness is one of the barriers for Asian companies to successfully implement CBMs. However, there are only a few CE-related studies conducted in Asia, and mostly focused on literature reviews (McDowall et al., 2017; Geng et al., 2012). Though the implementation case studies have been explored, many studies are in China and Japan contexts (Yap, 2005, Geng et al., 2012, Mathews and Tan, 2011, Su et al., 2013., Ghisellini et al. 2016; Ogunmakinde, 2019).

Few academic discussions focus on the Taiwan context (Hsieh et al., 2017; Ibitz, 2020). To align with international trends moving towards a CE-based economy model, the CE has become part of future nationally industrial policies, which is called the "Five Plus Two Innovative Industries Plan" (National Development Committee, 2015). With Taiwan's achievement in having a highly efficient recycling system, the Taiwanese government had a good foundation to initiate the CE policies (Department of Information Services, Executive Yuan, 2019).

Taiwan Circular Economy Network explained the industrial policy in detail on their website, "Five Plus Two" refers to the five major industries—Asia Silicon Valley, green energy, biomedicine, intelligent machinery, national defense and aerospace, and two transformation strategies—the CE and new agriculture." Furthermore, The Ministry of Economic Affairs of the Executive Yuan (the executive branch of the government of Taiwan) proposed the "Circular Economy Promotion Plan" on 20 December 2018 to encourage industries embedding CE concepts into industrial processes and integrating sustainability in the national economic activities (Department of Information Services, Executive Yuan, 2019).

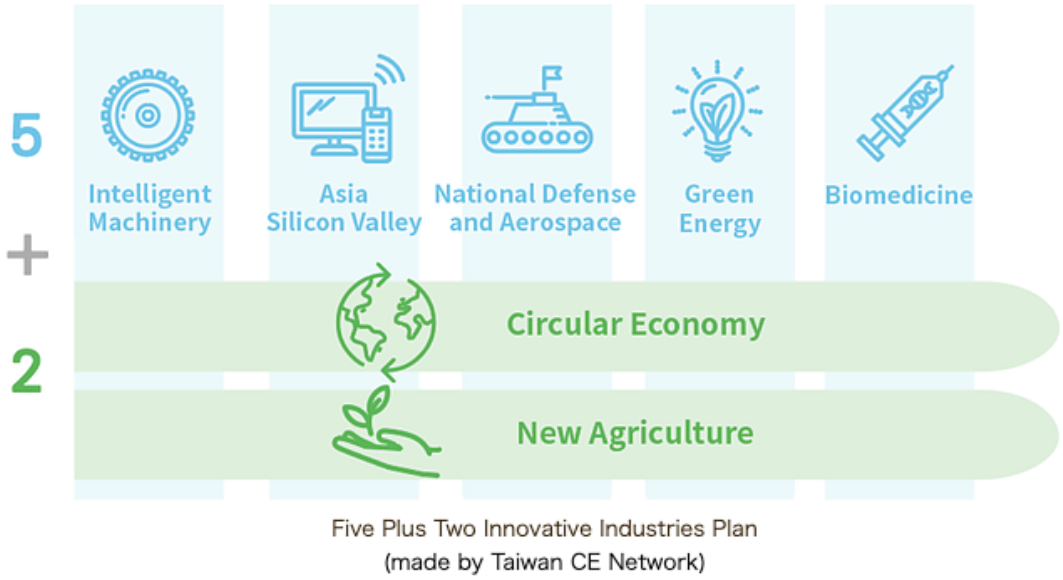

Figure 1: Five Plus Two Innovative Industries Plan, Taiwan Circular Economy Network

1.4 Research gap

This research aims at addressing four research gaps in current academic discussions.

Firstly, case studies on how practices are adopted by companies are crucial contributions to the CE field. However, relatively few case studies explore how businesses embed circularity in their business models. Hence, more case studies on how to implement CE business models will be valuable for practitioners (Bocken et al., 2014).

Secondly, some case studies are focusing on individual case studies (Riisgaard et al., 2016; Leväne et al., 2018) or specific industries (Stål et al., 2018; Guldmann et al., 2019), but fewer studies focus on cross-industries analysis, with some exceptions (Ranta et al., 2018; Bocken et al., 2018; Vermunt et al., 2019).

Thirdly, most of the case studies still concentrate on European contexts (Guldmann et al., 2019). And in Asia, rare case studies are exploring how Chinese, Japanese (Yap, 2005, Geng et al., 2012, Mathews and Tan, 2011, Su et al., 2013., Ghisellini et al. 2016; Ogunmakinde, 2019), and Taiwanese companies (Hsieh et al., 2017; Ibitz, 2020) implement circular business models (CBMs).

Lastly, there is a lack of revelations of barriers when adopting CBMs behind arrays of "stories of successfully implementing CBMs" (Taiwan Circular Economy Network, 2019). As indicated by Kirchherr et al. (2018, p.271) "...future work may attempt to expand our sample size and/or explore CE barriers in specific sectors or business models.", further work on this topic may provide insights for policymakers to make informed interventions policies to expedite the transition towards CE.

1.5 Research objective & research questions

The objective of this research is to uncover how the CBMs are applied in the real context, solely focused on Taiwanese companies. In this research, the main aim is to explore what internal and external barriers lie in front of the case companies when they decide to adopt certain CBMs, and how they manage to overcome the barriers.

- Research question: What internal and external barriers may Taiwanese companies encounter when transitioning to circular business models or adopting circular business models in the first place, and how do they overcome them?

2. Literature Review

To understand what barriers arising from implementing CBMs, a comprehensive study of how CBMs developed from conventional business models should be examined.

2.1 The concept of a business model

Companies needed business models to tell narratives, and business models described how each part of companies' strategies creates values and fits together (Magretta, 2002). In the past, the definitions for "business models" were not unified, one can see "revenue model", "business concept", "business idea", and "economic model" being utilized interchangeably (Magretta, 2002; Wirtz 2016).

According to a systematic literature review conducted by Wirtz et al. (2016), the evolution of business model definitions could be categorized into "three basic perspectives of technology, organization, and strategy in the course of time." Before 2002, most of the scientific research still focused on the technology field, but after this time, more strategy-oriented discussions appeared (including Magretta's article).

In addition to this, scholars interpreted business models in two disparate ways according to Slavik and Bednár (2014). Some regarded business models as a system to produce money. Chesbrough (2006), for instance, defined business models "The business model is a useful framework to link ideas and technologies to economic outcomes ". Conversely, others contended that business models should incorporate not only the production of revenues and costs but the creation of values. The creators of the Business Model Canvas defined business models: "A business model describes the logic of how an organization creates, delivers and controls value and how money is earned in a company. "(Osterwalder & Pigneur, 2009).

Teece (2010) also synthesized the money and value creation in defining the business models. One of the most cited papers, written by Teece (2010), explored the connections between business models, business strategy, innovation management, and economic theory. Teece defined essential meanings for business models "... the organizational and financial 'architecture' of a business". Additionally, businesses needed to reconstruct their business models to ensure commercially sustainable operations (Teece, 2010). Other than this, a viable business model should ensure the competitive advantages of companies. In other words, businesses should develop a business model that at the same time differentiates from competitors while avoiding competitors from emulating similar models or strategies accordingly within the short term.

Teece also stressed the importance of innovation of business models if enterprises wanted to capture value from technological innovations. Companies could choose to expand their market shares through incremental improvements in their manufacturing processes. If companies would like to advance their models more radically (e.g. CBMs), then the more comprehensively they have to revise current business models (Teece, 2010, p.186).

While Teece focused on the strategy-oriented aspect of business models, Osterwalder and Pigneur (2009) created a Business Model Canvas, concentrating on detailed examinations of business model compositions. The Business Model Canvas presented practical implications for enterprises to utilize and provided a holistic view on how to weave from visions, strategies, down to operational activities. The advantages of implementing the Business Model Canvas was widely studied in the academic discourse. According to Ladd (2018), "teams that used the elements of customer segment, value proposition, key activities or key partnerships performed significantly better in the competition".

The Business Model Canvas consisted of nine basic elements: customer segments, customer relationships, distribution channels, value proposition, key resources, key activities, partners, cost structure, and revenue streams. (Osterwalder and Pigneur, 2009).

The origin of The Business Model Canvas can be traced back to the paper published by Osterwalder & Pigneur in 2005. In Wirtz et al. (2016)'s literature review, the compositions of the business models developed by Osterwalder & Pigneur in 2005 were quite similar to the one they created in 2009. They modified the name for two elements: from "core competency" in the paper of 2005 to "key resources" in the book of 2009, and "value configuration" to "key activities". The limitations also surfaced through citations of this book are highly referred to in the academic discussion. The Business Model Canvas implied that the risks and rewards of all businesses are measured in financial terms. But nowadays there were other types of capitals (natural, human, social, intellectual) that played equal or more important roles in deciding whether a company can grow or even survive (Spinelli and Heather, 2014).

2.2 Sustainable business models (SBMs)

As conventional business models focused primarily on creating values for organizations, many companies downplayed the importance of community engagements and roles of ecosystems (Freeman and Gilbert Jr., 1992). And the dominant business models were built on neoclassical theory according to Stubbs and Cocklin (2008), the primary goal for an enterprise was to maximize the shareholder values (Stubbs and Cocklin, 2008). As Schaltegger et al. (2002) indicated in their research that many companies did not consider or prioritized environmental performance before reaching their economic goals (Schaltegger et al., 2002). Some corporations may adopt reactive measures until stakeholders become vocal or regulatory risks are realized (Bansal et al., 2000). Sustainability served as a cost-reduction strategy through eco-efficiency as indicated by Brady et al. (1999). Nowadays, sustainability

has become a competitive advantage for firms, especially those who survive the financial crisis in 2008 (Nidumolu, 2009).

Some definitions related to sustainable business models are presented below:

Sustainable business models were about integrating sustainability into their value proposition, value creation, and delivery activities, and/ or value capture mechanisms. For instance, Lüdeke-Freund (2010) defined sustainable business models as models to sustain companies' economic operations while not exacerbating the negative impacts on the environment (Geissdoerfer et al., 2018).

Bocken et al. (2014) built sustainable archetypes through exploring a wide range of mechanisms and examples to construct the business models for sustainability, namely sustainable business models. They utilized Boons and Lüdeke-Freund (2013)'s framework (Technological innovation, Organisational innovation, Social innovation) in defining descriptive groupings. In a most recent case studies research, Ritala et al. (2018) revised Bocken's archetypes by adding one more archetype "inclusive value creation" due to the "growing need for collaboration and sharing models" (Ritala et al., 2018), and relatively unaddressed topic such as the Bottom of the Pyramid (Ritala et al., 2018, p.6). On top of this, the main groupings were no more "Technological innovation, Organisational innovation, Social innovation" formulated by Boons and Lüdeke-Freund (2013). Instead, they utilized the major innovation types: environmental, social, and economic as the updated groupings.

2.3 Circular economy business models

The concept of the CE can be traced back to the concept of industrial ecology (Ludeke-Freund et al., 2019). The industrial ecology paved the foundations for the CE, which has popularized recently. CE principles illustrated that CE is "...a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing,

and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling." (Geissdoerfer et al., 2018).

Additionally, achieving a regenerative economy required collaborations within the value chain to deliver CE value through business models (Lüdeke-Freund et al., 2019). The whole value chain may include the "macro-level" (cities, provinces, regions, and nations), "meso-level" (networks, eco-industrial parks), and "micro-level" (individual companies, consumers) (Lüdeke-Freund et al., 2019; Ghisellini et al. 2016).

Business models came into play when companies aimed at delivering values from products and services combined and through the reconstruction of supply chains (Lüdeke-Freund et al., 2019). The CBMs were subsets of sustainable business models because they share some commonalities. They both considered multiple stakeholders and incorporated long-term perspectives (Geissdoerfer et al., 2018). Specifically, CBMs proactively sought solutions for a CE to be implemented through a circular value chain and stakeholder incentive alignment systems (Geissdoerfer et al., 2018).

Transitions from linear business models to CBMs encompassed arrays of challenges illustrated by Guldmann and Huulgaard (2019), an overhaul of companies' beliefs and strategies, lack of aligned frameworks, and knowledge for companies deterred the uptakes of CE business models (Guldmann and Huulgaard, 2019). Currently, companies still widely applied a linear production system instead of considering processes, materials, and products designed for take-back, refurbishing, remanufacturing, recycling, or upcycling (Lüdeke-Freund et al., 2019). As Accenture (2014) put it, "...companies today are simply not built to capitalize on the opportunities the CE presents. Their strategies, structures, and operations were deeply rooted in the linear approach to growth . . .," and thus companies "need to develop business models that are free of the constraints of linear thinking" (Accenture 2014;

Lüdeke-Freund et al., 2019).

As aforementioned, the transition from linear thinking to circular modes cannot be achieved instantly, aligned definitions of CBMs and elements included in the model were critical for companies to capture the core essences of the CE concept and develop the roadmap accordingly (Nußholz, 2018). Salvador et al. (2020) conducted systematic literature reviews and defined CBM as "...seek maintaining resource value at its maximum for as long as feasible, and eliminating or reducing resource leakage, by closing, slowing, or narrowing resource flows."

In the following section, I will explore two classifications of CBMs and dive deeper into how CBMs were categorized.

2.3.1 CBMs classifications

CBMs encompassed wide ranges of classifications. "The ReSOLVE framework" was proposed by Ellen MacArthur Foundation (2015), the framework was helpful for businesses and governments to promote CE transition. And according to Manninen et al. (2018), the ReSOLVE framework was widely applied to most BMs. The ReSOLVE included six elements, namely "Regenerate, Share, Optimize, Loop, Virtualize and Exchange":

1) "Regenerate": Shifting towards renewable energy system and the regeneration of ecosystems

2) "Share": Sharing, reusing, and extending product lifetimes. Ownership is not necessary in order to enjoy a product's value (Jabbour, 2019).

3) "Optimize": Improving efficiency of products and materials. Big data is applied to reduce wastes without changing the product or technology.

4) “Loop”: Striving to keep components and materials within loops and encourage remanufacturing, recycling, reuse and composting to maximize the values (Jabbour, 2019).

5) “Virtualize”: Delivering values without the need to materialize it into physical products.

6) “Exchange”: Replacing old materials with advanced non-renewable materials and apply new technologies (Manninen et al., 2018).

In addition, scholars also classified CBMs based on how natural resources and materials flowed within the economic system (Hofmann, 2019).

There were two main aspects that influence the implementation of CBM. Bocken et al. (2016) developed a framework that encompasses product design and business model strategies based on other scholars’ work to facilitate the transition from a linear economy towards a circular one. In their paper, slowing, closing, and narrowing loops are introduced. Slowing loops meant that extending the utilization period of products, and thus slowing down the flow of resources while closing loops connected the after-use and production phase by recycling, then the resources flowed circularly. Another distinct strategy was narrowing resource flowed aiming at pouring fewer resources per product. However, the narrowing loops strategy also fit in the linear economy while slowing and closing loops typify a CE (Lüdeke-Freund et al., 2019).

As for the BMs that incorporate slowing resource flows focused on extending product life, the closing flows focused on capturing values from wastes. And BMs allowed narrowing resource flows focused on maximizing material and energy efficiency (Salvador et al., 2020).

Business models strategies for slowing loops:

- Access and performance model: providing the capabilities or alternative services that satisfy users' needs without providing physical products
- Extending product value: exploiting residual value of products
- Classic long-life model: delivering products that can last for a long-term with supports of repair services or durable designs
- Encourage sufficiency actively seeks ways to address post-use consumption through enhancing durability, upgradability, and repairability

Business models strategies for closing loops:

- Extending resource value: exploiting residual value of resources
- Industrial symbiosis: Using the residual values of outputs from previous stage as the inputs for another (Salvador et al., 2020)

But as Bocken et al. (2016) indicated at the end of the paper, there was a possibility that companies infuse various forms of BMs, namely, hybrid models. For instance, large firms may procure renewable materials for one product while utilizing the waste stream for another (Vermunt et al., 2019).

Another prestigious classification was developed by Accenture (2014). Five CBMs from 120 case studies were identified and visualized where the BMs function from upstream to downstream. The CBMs that Accenture (2014) defined:

1. Circular supplies: companies adopt this model to replace non-recyclable and scarce resources with biodegradable and recyclable inputs. This further supported circular systems for producers and consumers while benefiting companies coping with scarce

resources.

2. Resources recovery: This model was about recovery of residual values at the end of product's lifecycle to recircle to another with supportive upcycling services. This model prevented resources from leaving the resource flow and was a good fit for companies that generate considerate by-products.

3. Product life extension: This model retained the values from wasted products and materials through remanufacturing, repairing, and upgrading. This model was suitable for most capital-intensive B2B companies and B2C companies whose newly released products provided marginal performance benefits compared to the older version.

4. Sharing platforms: This model provided a platform that encourages collaboration among other individuals or business entities. Through this model, overcapacity and underutilization can be addressed. This model was beneficial for companies' products "with low utilization or ownership rates" (Accenture, 2014).

5. Product as a service: This model revolutionized the conventional mindset "buy-and-own", products circulate among many customers through a lease or pay-for-use arrangement. This model was appealing for businesses whose "products' costs of operation share is high" (Accenture, 2014) and that had better maintenance capabilities than their customers.

Moreno et al. (2016) developed a circular framework that incorporates their archetypes for practitioners to understand how to design a circular process with simultaneous considerations of CBMs. And their frameworks were built on the previous work accomplished by the

ReSOLVE framework (Ellen MacArthur Foundation, 2015), Bocken et al. (2016), and Accenture (2014).

Table 1. Comparisons of CBMs from Moreno et al. (2016), p.9

CBMs by Accenture (2015)	CBMs by Bocken et al. (2016)
Sharing platforms	Access and performance model
Product-as-a-service	Extending product value
Product life extension	Classic long-life model Encourage sufficiency
Resource recovery	Extending resource values
Circular supplies	Industrial symbiosis

In sum, the five CBMs based on Accenture (2014) and Bocken et al. (2016) are summarized and presented here as the thesis' framework. These five CBMs are:

1. Product-as-a-service model: this model took several forms according to Lacy and Rutqvist (2015), including "pay-for-use, leasing, rental, performance agreement". Products should be designed for optimal use, maintenance, reuse, remanufacture, and recycling to ensure some challenges were avoided, such as rapid quality degradation, short longevity of products, low utilization rate, and low recycling rate. These difficulties will undermine businesses' financial performance. But advantages of this model encompassed "increased customer loyalty resulting from continuous interactions between business and customers and strong feedback loop to further improve products' performance" (Lacy and Rutqvist, 2015).

2. Product life extension model: According to Lacy and Rutqvist (2015), this model aimed at extending products' useful life to generate additional values. The authors identified six major initiatives that company adopt: these included products/parts are a) built-to-last, b) refurbish, c) take-back-logistics, d) upgrade, e) refill ("replacing a function that's depleted more quickly than the product itself, such as refillable packaging"), f) repair, and g) remanufacture.

3. Recycling & recovery model: this model combined the concept of recycling and recovery according to Potting et al. (2017). Recycling meant that processing materials but gaining at most equal quality from post-consumer products or post-producers waste stream and can be applied anywhere throughout the use life cycle (Potting et al., 2017; Reike et al., 2018). Recovery meant that capturing energy embodied in wastes from incineration to produce energy (Potting et al., 2017; Reike et al., 2018). This model presented some clear benefits, including "reduced costs of compliance and waste management", decreased environmental footprints "with lower demands for virgin resources and energy", and "convenient options for customers to tackle their unwanted products" (Lacy and Rutqvist, 2015).

4. Circular supplies: this model offered renewable and biodegradable alternatives for linear inputs. Businesses can produce for their own use or for other counterparts. The beneficial parts of adopting this model involve operating in future-proof mode and be more competitive in this regard. Changes in regulatory landscapes would spur the supply of circular supplies (Lacy and Rutqvist, 2015).

5. Sharing platform: This model linked the product owners and interested individuals/corporations on a platform to circulate the idle products. As Lacy and

Rutqvist (2015) put it, "...the platform boosts their productivity by allowing co-access and co-ownership." Sharing platform was distinct in terms of addressing the environmental footprints related to production and consumption as well as underutilization of products/services (Lacy and Rutqvist, 2015). Several advantages include competitive prices compared with owning them, tailored products/services, and increasing conveniences because of widening choices of products (Lacy and Rutqvist, 2015).

2.3.2 Business model innovation towards circular economy

As linear business models were incompatible with applying CE strategies and hence require adaptations of current BMs or innovation to incorporate CE (Urbinati et al., 2017). The fundamental differences of BMs incorporating CE concepts from incumbent BMs were (1) managing 'reverse supply chain', (2) adopting a new value proposition, namely "product-service-systems", and (3) changing the interaction ways with customers because of leasing and rental contracts (Urbinati et al., 2017).

Transforming from incumbent BMs to sustainable business models or CBMs required innovation on business logic and the ways that business acquires and delivers values to their customers (Pieroni et al., 2019). And innovations rooted in a company's reaction to internal and external motivations (Pieroni et al., 2019).

As Pieroni et al. (2019) suggested that there was little alignment between different scholars regarding "Sustainable business models innovation" and "CBMs innovation", the sustainability-oriented BMs innovation and CE-oriented BMs innovation will be utilized here (Geissdoerfer et al., 2018).

The literature suggested that CBMs are subsets of sustainable business models, the innovation differences between these two BMs will be discussed below (Geissdoerfer et al., 2018). Sustainability-oriented BMs innovation meant that companies deliver superior customer values while influencing positively the environment and society (Pieroni et al., 2019). While CE-oriented BMs innovation concentrated more on 'resource-efficient and longevity and economic growth'. While both innovations valued 'delivering superior customer values' to ensure the business operation, sustainability-oriented BMs innovation prioritizes social relevance over resource efficiency and superior customer value (Pieroni et al., 2019).

Additionally, innovating business models itself can generate impactful outcomes, but these outcomes were also contingent on the implementation levels of sustainability by executives and the strategies generated accordingly (Geissdoerfer et al., 2018; Pieroni et al., 2019). (Pieroni et al., 2019). As Schaltegger et al. (2012) mentioned three kinds of strategies for companies to embed sustainability into their business models: "defensive" (often reactive to possible or upcoming legislative and reputational risks), "accommodative" (consider environmental and social objectives in most of the internal processes without influencing core business strategies), and "proactive" (core business models and business processes operate in a way that is sustainability-compatible and refine the definitions of costs and benefits with consideration of externalities).

2.4 Internal and external barriers when implementing circular business models

Barriers that companies may encounter when implementing CBMs are summarized in various literatures. These barriers will be summarized and categorized into two groups, namely "internal" and "external" as Mont (2002) suggested in her article. Later in the finding section, the summarized table will be served as a theoretical reference for interviewed companies.

2.4.1 Internal barriers

Internal barriers included governance, financial, technological, knowledge, and cultural barriers (Govindan and Hasanagic, 2018). They utilized stakeholder views to structure the barriers. Internal barriers include: No formal and standard indicators to track CE performances in the supply chain, high upfront costs to implement CE, high recycling costs for recycled materials than virgin ones, surging production costs, technological incapability to track recycled materials, ensuring the quality of recycled products and materials, design challenges to reuse and recovered materials, insufficient skills and knowledge for employees to integrate CE, poor leadership and management, prioritizing other issues, lack of enthusiasms, organizational structure being incompatible with implementing the CE, challenges of taking back products from other companies.

Another literature review by Kirchherr et al. (2018) focused on building a comprehensive framework for CE barriers from other studies that adopt semi-structured interviews. They synthesized previous work into four concise categories: cultural, regulatory, market, and technological. After examination cultural and technological factors were appropriate to put under internal barriers. Regulatory and market factors will be discussed in the next section "external barriers".

Table 2. Summary of internal barriers from Kirchherr et al. (2018)

Aspect	**Category**
Cultural	Low awareness or willingness to implement CE
Technological	Lacking sufficient technologies (track impacts, circular design, or produce high-quality remanufactured products)

The third study regarding internal barriers was from Rizos et al. (2015). They introduced similar viewpoints to the previous scholars but concentrate on the small- and medium-enterprises contexts.

The internal barriers they discovered and summarized from the extant literature include:

Table 3. Summary of internal barriers from Rizos et al. (2015)

Aspect	**Category**
Environmental culture	Lack of positive attitudes towards implementing CE
Financial	High upfront costs and long payback periods Hidden costs: time and human resources
Informational	Lack of understandings on CE benefits
Technical	Insufficient capabilities to advance current system

Environmental culture is about internal attitudes towards implementing pro-environmental measures, and the factors that influence this include what sectors a company operates in. As for financial barriers, many small- and medium-enterprises may encounter a lack of access to financial funding compared to large companies (Rizos et al., 2015). Apart from the visible costs, hidden costs include insufficient human resources dedicated to the implementation of the CE, this may hamper the green innovations (Rizos et al., 2015).

Rizos et al. (2015) indicated that information regarding the benefits of integrating CE such as the saving costs from resource efficiency. Most companies expect short-term financial gains and focus on return on investment (ROI) figures because the prevailing accounting principles are still favorable for linear economy systems (Pheifer et al., 2017). As for the technical barriers referred to the necessary technical options to advance the system and realize the cost savings resulting from adopting CE measures (Rizos et al., 2015).

They also mentioned the administrative burdens raised from coping with EU legislation and frameworks. Considering that the main study context for this research is in Taiwan, I ruled out this category from the literature review.

As most of the categories overlapped with each other, I will mainly extract information that does not overlap with another category. For the internal functions, Ritzén et al. (2017) identified from two companies that internal silos hamper the communication channels. And the allocations of responsibility remained unclear in that middle managers may be expected to experiment while employees in operational positions required clear guidelines and support to execute CE-related measures.

Pheifer et al. (2017) also mentioned that divergent understandings on CE may result in misplaced resources. For instance, many executives still interpret CE is mostly about recycling. However, recycling remains the lowest value compared to service loops which serve the benefits of both companies and customers. This means that many executives are willing to dedicate themselves to the CE realm but place resources in the wrong place, undermining the benefits they can realize from implementing the CE.

2.4.2 External barriers

Govindan and Hasanagic (2018) also summarized external barriers into governmental, societal, and consumers' perspectives. For the governmental barriers, the laws may not fit in with the CE concept and do not support the waste management system that is necessary for accelerating the adoption of CBMs. Additionally, incentives to propel companies to shift from a linear economy to a circular one was also crucial.

When it comes to societal barriers, the general public may not feel urgent to move towards a circular economy and stakeholders do not have enthusiasms or support to make the transition. Lastly, speaking of the consumers' perspective, consumers may have health and quality

concerns on refurbished or remanufactured products. And consumers may not have sufficient understandings to distinguish the quality of new products and refurbished ones (Govindan and Hasanagic, 2018).

Table 4. Summary of external barriers from Govindan and Hasanagic (2018)

Aspect	**Category**
Governmental	• CE laws are implemented incompletely • Existing laws regarding waste management is not supportive for CE • Weak economic incentives • The whole supply chain needs are not considered • Other favorable solutions existed than implementing CE
Societal	• Lack of reliable information for stakeholders to recycle and remanufactured products • Lack of awareness
Consumers'	• Lack of knowledge • Consumers' perceptions towards recycled products are not favorable

Kirchherr et al. (2018) summarized two external barriers (Table 5). Regulatory barriers appeared to be not significant in their study, but companies still named numerous relevant points, including the unfavorable laws for importing recycled materials from other countries. As for the market barriers, Kirchherr et al. (2018) mentioned that low prices of raw materials, high upfront investment costs, and lack of financial subsidies were included under this

category.

Table 5. Summary of external barriers from Kirchherr et al. (2018)

Aspect	**Category**
Regulatory	Unfavorable laws and regulations, lack of consensus among different nations
Market	low economic viability of CE (low virgin material prices, high upfront investment costs, limited funding channels)

Rizos et al. (2015) included two external barriers as summarized below in table 6.

Table 6. Summary of external barriers from Rizos et al. (2015)

Aspect	**Category**
Governmental supports and effective legislations	Absent governmental supports either from legislations or economic incentives
Supply and demand networks	Suppliers' and customers' low awareness regarding sustainability

Regarding the lack of governmental support and effective legislation in place, Rizos et al. (2015) mentioned that the significance of government support is because small companies rely more on regulators to enforce environmental measures. Without effective incentives such as taxation policy, training, and provisions of funding opportunities, environmental improvement measures of small companies may depend on managers' instructions and attitudes (Rizos et al., 2015).

As for the supply and demand network, consumers may not prioritize sustainability when purchasing. Lack of uptakes of environmental measures by suppliers may further discourage

companies to implement CE throughout the supply chain because of their relatively small bargaining powers (Rizos et al., 2015).

Pheifer et al. (2017) mentioned that the externalities costs of ecology and societal damages are not taken into accounts. The price was still mainly contingent on the price of materials and marketing costs coupled with supply and demand (Pheifer et al., 2017).

While Mont et al. (2017) included more external barriers regarding value chains. For instance:

- Existing supply chain dependencies
- Hard to collaborate with other industry peers
- Risks on relying mostly on operations-uncertain suppliers compared with stable-market suppliers that offer virgin materials
- OEM may have relationship destruction with dealers or retailers resulting from offering repair or refurbishment
- Position in the supply chain may hamper component producers to adopt the CE

2.4.3 Summary of internal and external barriers

As many scholars indicated that there are a plethora internal and external barriers in implementing CBMs, I categorized the aforementioned barriers into "internal'' and "external". I also utilized barriers categorized identified by Vermunt et al. (2019) and a framework developed by Tura et al. (2019) to inform the following categorizations.

Under internal barriers, these include the following four categories: organizational, financial, knowledge, and technology. As for external barriers, categories include regulatory, supply chain, and market barriers. The details under each category can be seen in the table below (Table 7).

Table 7. Summary of internal and external barriers

Internal barriers	
Organizational	• Siloed thinking • Unclear responsibilities for managers and executives • Conflicts with current business model • Insufficient cross-departmental communication and channels collaborations • Fixed organizational hierarchy structure • Lack of managements' supports
Financial	• Upfront costs and lengthy payback periods • Heightening production and recycling costs compared with those for virgin materials • Hidden costs (time invested, increased needs for labors devoted to applying CBMs) • Uncertain financial business cases
Knowledge	• Insufficient knowledge of CE • Insufficient technology know-how regarding the CE process
Technology	• Lack of sufficient technologies (track impacts, circular design, or produce high-quality remanufactured products) • Design challenges for durable parts/goods
External barriers	

Regulatory	• Unfavorable laws and regulations regarding recycling, incineration or disposal • Current accounting frameworks are incompatible with CE concept • No/insufficient economic incentives
Supply Chain	• Trust and collaboration with industry peers • Stability of materials/returned goods supply • High reliance on external partners • Insufficient information flowing between value chain partners • Risks of destroying existing relationships with industry partners/suppliers/value chain actors
Market	• Less competitive prices of recycled materials • Unclear market demands • Low consumers' awareness towards CE • Lack of suppliers for recycled materials

3. Methodology

In this research, the qualitative method is applied. As Creswell and Poth (2016) pointed out that qualitative research is an approach ascribed to the study of a social or human problem. In the study, I plan to conduct research on what internal and external barriers will Taiwanese companies encounter when transitioning to certain circular business models or adopting certain circular business models in the first place. And how do they overcome them,

ultimately resulting in decreasing the externalities to both the ecosystem and the adjacent communities.

3.1 Research Design

For the design of this research, I choose the multiple-case study design because of the lack of empirical studies on CBMI barriers according to Guldmann (2019). Furthermore, more studies focused on single case studies and hence may limit to specific industries (Riisgaard et al., 2016; Linder et al., 2017; Guldmann and Huulgaard, 2019).

A case study was consistently described as an approach that is suitable for in-depth investigations of complex issues with many variables involved and the boundary was vague (Harrison et al., 2017). As Kirchherr et al. (2018) mentioned in their study, "Future work may attempt to explore CE barriers in specific sectors or business models". Without empirical studies on barriers lying behind different types of CBMs, companies may find it difficult to select appropriate models and hence undermine the development of CBMs (Vermunt, 2019).

Multiple case studies can generate strong and reliable evidence and can help researchers analyze different situations (Baxter and Jack, 2008). Furthermore, this approach may increase external validity but creates insufficient depth for the study (Voss et al., 2002). Due to the dearth of empirical studies on barriers among different CBMs, more comprehensive studies were necessary to be conducted for future research and to offer solid proofs for practitioners. A single case study had limitations such as the generalizability of the conclusions (Voss et al., 2002), this is why I adopt multiple case studies in this research.

As for the sampling method, I apply the purposing sampling strategy in this research. According to Cresswell and Plano Clark (2011), the process involved identifying and selecting individuals or groups of individuals that were especially knowledgeable about or experienced a phenomenon of interest. Moreover, selections of companies are based on a

report called *"Towards a Circular Taiwan"* published by Taiwan Circular Economy Network in 2019. With information-oriented selection companies in the report, large variations allow me to examine "the significance of various circumstances for case process and outcome (e.g., company sizes, different CBMs)" (Flyvbjerg, 2006). Moreover, selections will be differentiated based on categorized industries in the report, such as Textiles and Plastics, Construction and Transportation, and Technology and Chemistry.

As for selecting the informants within the company, I held the interviews with one professional in the company rather than many of them within the company (Tongco, 2007). Tongco (2007) also suggested list certain qualities to choose from or at least inform the contact person of the company to find the most suitable interviewees. Hence, I found the interviewees according to at least one of the following characteristics: (1) participating in and managing circular economy initiatives of the company or (2) being responsible for the sustainability communication or initiatives.

The interview process constantly proceeded until data saturation points of each CBM types, but the situation is contingent on the numbers and types of companies that are willing to be interviewed (Fusch and Ness, 2015). This meant that the interviews cannot be determined beforehand in that the exact numbers of companies to reach data saturation is hard to quantify. The process of having interviews stopped at the point that collected data demonstrates a coherent manner and no additional dimensions can be found (Allen, 2017). One thing should be noted was that the core questions should be consistent across different interviews with different companies and industries. If the questions were inconsistent, then one may find the data saturation point boundless and hamper the reliability (Fusch and Ness, 2015; Cresswell, 2017).

All the case companies are headquartered in Taiwan. I interviewed with management levels within the case companies in that the main purpose of this research focuses more on strategic viewpoints. Additionally, I interviewed with one director from a research institute that works

closely with textile industries and is familiar with the challenges most textile companies may face. The director holds regular workshops with both public sectors and private industries to promote circular economy, contributing a host of insights for the barriers and transition process that this research primarily concentrates.

All the interviews were conducted in Chinese, and I grouped the emerging themes and the following analysis in English.

Table 8. Lists of case companies and their background information

Name	**CBMs Type**	**Industry**	**Interviewee Position**	**Duration**	**Interview Dates**
Daai Technology	• Circular supplies • Recycle & recovery	Textile	President and CEO	1 hour	30 June, 2020
UWin Nanotech. Co., Ltd.	Recycle & recovery	Chemistry	Deputy Manager	50 minutes	14 July, 2020
Taiwan Textile Research Institute (TTRI)	• Circular supplies • Recycle & recovery	Research institute	Director of Sustainability and Certification Section	40 minutes	16 July, 2020
ChiaoFu	• Circular supplies • Recycle & recovery	Plastics	Vice President	50 minutes	7 July, 2020
Grabio	Recycle & recovery	Biotechnology	Vice President	1 hour	21 July, 2020
E&E Recycling	Recycle & recovery	Others	Executive Specialist	30 minutes	14 August, 2020

Daai Technology: The company starts their reduce-waste journey from reusing plastic bottles as inputs from their recycling stations located all around Taiwan. The product sets range from blankets, furniture, clothing, to wood plastic composite (WPC), which is laid on the floor.

Besides tackling the plastic bottles from the technical aspect, the B corporation also aims at disseminating the circular economy concepts through environmental education and speeches.

UWin Nanotech. Co., Ltd.: Conventionally, the process of tackling e-wastes through thermal and strong acid causes detrimental effects to both the environment and the people's health involved in the process. UWin Nanotech adopts green chemistry to counteract traditional ways of addressing e-wastes through highly selective metal eco-strippers for precious metals.

Taiwan Textile Research Institute (TTRI): TTRI has incorporated the aspect of circular economy in addition to upgrading technologies and innovating products and systems with Taiwan textile industry. The institute is crucial in transforming the structure of the domestic textile industry towards more circular economy models through its solid ground on research, industry networks, and active roles in between private and public sectors.

Chiao-Fu: In collaboration with the council of agriculture executive yuan to resolve the shortage of labors and environmental problems arising from PE mulch films. Traditionally, PE mulch films require people to recycle PE mulch films and undergo laborious recycling processes. Chiao-Fu hence strives to address the issues with compostable mulch films made with brewery spent grain. Farmers can bury the milch films directly in the soils. By providing this product, it is not compulsory for farmers to hire people to tackle the mulch films and solve the recycling puzzles of the PE mulch films for the farmers.

Grabio: As the awareness of environmental pollution and energy problems become more prominent, Grabio utilizes renewable resource material to develop bio-based and biodegradable products in an effort to reduce the usage of petroleum.

E & E Recycling: E&E Recycling was established in August 1998 by 12 major home appliance manufacturers and is the first licensed recycling plant in Taiwan. The company tackle electronic and electrical wastes after the usage to re-dedicate these recycled resources

as inputs for upstream manufacturers and complete the physical processing safely.

3.2 Data Collection

I conducted semi-structured interviews with chosen Taiwanese companies through video interviews, and the interview questions will derive from a critical literature review. Furthermore, I resorted to public resources of companies such as their annual and corporate social responsibility reports, press releases, and reports that compile their CBMs implementations.

A semi-structured interview was suitable for studying people's perceptions and opinions or complex (Kallio et al., 2016). And the leading questions were not encouraged according to Kallio et al. (2016). I want to elicit their perceptions towards the difficulties they may encounter when transitioning/adopting CBMs, and this topic was seldom mentioned to outsiders (Kallio et al., 2016).

I used my phone or software in-built functions to record the interview and conducted the interview in Chinese as some professionals may feel easier to express their opinions in-depth in their native languages. After the interview, I examined the key insights and translated them into English as a reference.

The interview questions mainly consisted of three categories: (1) describe their company's CBMs types (2) elaborates barriers they encounter when implementing CBMs (3) explain how they manage to overcome or how they plan to overcome. And the interview questions are as followed:

- CBMs

1. What kind of CBMs is your company according to these predefined categories?
2. What's the story of your company to transition from a linear economy to CBMs?
3. What are your core activities for the CBMs?
4. Who is involved in these activities? How long have you been implementing the activities?
5. What initiatives have you done related to the core activities?

- Barriers

6. What barriers do you encounter when implementing predefined CBMs? (internal and external)
7. In which ways the barriers you mentioned come into play?

- Overcome

8. How did you manage to overcome these barriers?
9. How do you define "overcome"? Do you have any metrics or processes to track the following performance?
10. If you are still trying to overcome it, then what have you done to tackle the issues? Or what do you plan to put in place to tackle the barriers?

After the interviews, I also asked the interviewee if they had additional materials for me to triangulate and the finished draft was also confirmed by the interviewees to ensure the accuracy of the information.

3.3 Data Analysis

I utilized the Framework Method developed mentioned in the book of Gale et al. (2013). This method was suitable for the thematic analysis of semi-structured interview transcripts and accommodated homogenous data i.e. data cover similar topics (Gale et al., 2013).

Gale et al. (2013) summarize the framework as followed:

Stage 1: Transcription
Stage 2: Familiarization with the interview
Stage 3: Coding
Stage 4: Developing a working analytical framework
Stage 5: Applying the analytical framework
Stage 6: Charting data into the framework matrix
Stage 7: Interpreting the data

For the reliability of this research, I transcribed the insights from interviewees from Chinese to English and I started to capture the sentences that were related to barriers. Subsequently, I derived a common theme for each barrier and lastly grouped the themes under the types of barriers based on the summarized categories in the literature review (Cresswell, 2017).

Since the barriers were summarized and discussed by scholars, I conducted a deductive analysis when congregating the themes for each keyword I identified from the interview transcripts. The predetermined themes are summarized in 2.4.3 Summary of internal and external barriers. However, detailed categories were not provided during the interviews to avoid leading questions or framing the interviewees under certain categories (Vaismoradi et al., 2013).

Additionally, I clarified the biases that may occur associated with data collections and numbers of interviews to increase the validity in the limitation section.

The method to increase the validity of this research was by asking participants about the accuracy of the information collected from them (Cresswell, 2017). Cresswell (2017) suggested that researchers can present the polished product for the participants to confirm the accuracy rather than taking the raw data back.

4. Findings and Discussions

The insights gathering from five interviewed companies and one research institute provided foundations for answering the research question. The finding section unfold as followed, firstly the barriers collected from the companies interviews and results were presented. Subsequently, how the interview companies managed to overcome or how they envision to overcome were discussed. Additionally, the barriers and overcome process were grouped according to the barriers' types, namely external and internal barriers.

4.1 External Barriers

4.1.1 Regulatory

Regulatory constraints when transitioning to CE emerged in both the recycling and recovery and the circular supplies model (See table 10 in the Appendix 1). Although there was only one regulatory barrier written in the table 10, the barriers manifested in two aspects: the first one was regarding the accessibility of circular materials and the second one was about obstructing laws in supporting CE development domestically.

Firstly, the regulations for waste recovery were not supportive for CE transitions. The research institute mentioned that textile companies were uncertain about whether sourcing wastes being legal or not *"It is hard for apparel industries to recycle the wastes as the definition of wastes is still ambiguous in regulations. When we want to procure waste materials, they are unsure whether the process is legal or not"* (TTRI Interview, 2020). Another firm indicated that current recycling policies was ineffective *"Since China banned the plastic wastes from flowing into their country in 2018, all other plastics wastes swamp into Taiwan and other Southeast Asia countries. However, there are no efficient policies in controlling which wastes can be imported, so all unsorted wastes enter Taiwan. And our company has no choices but procuring all plastic wastes for further recycling. Around thirty*

to forty percent of plastic wastes go back to the waste treatment process, causing additional environmental burdens and water pollutions" (Chiao Fu Interview, 2020).

Secondly, the regulatory barrier arose from conflicting interests between incumbent companies and those who adopt CBMs in the same industry. A company adopting both CBMs specifically mentioned that *"Although the plastic phase-out laws in the EU has been litigated, current legislations are still not in favor of more sustainable plastics materials because of vested interests of traditional plastic industry peers"* (Chiao Fu Interview, 2020). The other company in the same industry but only adopt recycling and recovery model raised a point that *"Regulations regarding phasing out plastic uses are still instructional rather than mandatory. Hence, some suppliers are hesitant to join the supply chain for producing sustainable plastics"* (Grabio Interview, 2020).

4.1.2 Market

There are four types of market barriers reported by the interviewed companies, and the barriers manifest in both types of CBMs (See table 10 in the Appendix 1).

The most prominent barrier mentioned by most of the interviewed companies was market demands for CE materials being generally low or volatile. This barrier appeared both in the circular supplies and recycling and recovery models. Companies adopting both the circular supplies and recycling and recovery models mentioned that this may due to the higher costs of circular materials compared to the virgin ones and low consciousness of CE (Chiao Fu Interview, 2020).

As for companies adopting only the recycling and recovery model, unpredictable and volatile demands for circular materials posed challenges for their financial stability. One company mentioned that *"Though expanding the market areas internationally increases the competitiveness with local suppliers, this also applies to foreign companies who would like*

to enter Taiwan's market. Therefore, the most crucial thing for us is to secure domestic markets, then we can be confident in developing foreign markets. Now the domestic demands for biodegradable and compostable plastics are still unstable" (Grabio Interview, 2020). Another company implementing also the recycling and recovery model discussed the seasonal changes, prices of crude oils affecting the downstream demands, and the competition for the same market with other industry peers. *"There are around 14 other companies doing the similar business. Hence, the seasonal changes, volatile prices of crude oils, and the pandemic all influence the downstream demands for plastics or irons"* (E & E Recycling Interview, 2020).

Another market barrier mentioned by most of the interviewed companies was the volatile costs of circular materials. This barrier manifested both in the circular supplies and recycling and recovery models. A company only adopting the circular supplies said in the interview that some customers prefer virgin materials because of the more affordable prices (Chaio Fu Interview, 2020). Another company adopting only the recycling and recovery model mentioned that *"Most manufacturers merely consider price competitiveness when there exist no other incentives. Compostable plastics are still three time more costly than the virgin ones"* (Grabio Interview, 2020). Lastly, the research institute noted that textile companies implementing both the circular supplies and recycling and recovery models sourced most of the materials from abroad. Hence, the manufacturing and transportation costs also enhanced the price for circular materials (TTRI Interview, 2020).

The third barrier was low consumers' understandings on CE products. Consumers may think that CE products primarily consist of recycled materials were inferior to the ones made from virgin materials (Chiao Fu Interview, 2020). The company noted in the interview that *"Consumers regard the recycled materials as an economical way to save costs, hence the price of our product should be more affordable"* (Chiao Fu Interview, 2020). Clients also chose cheaper products over the circular ones because of financial priorities. The company noted in the interview that *"Some clients concentrate mostly on which suppliers offer a*

product that could maximize economic values. Hence, if the green product cannot offer the same levels of economic benefits, then clients still prefer the one with highest economic values" (UWin Nanotech Interview, 2020).

Lastly, competing with industry peers who utilized virgin materials to produce products inflicted a tense relationship between companies adopting CBMs and the incumbent ones (UWin Nanotech Interview, 2020).

4.1.3 Supply Chain

There are seven types of supply chain barriers reported by the interviewed companies, and the barriers manifest in both the recycling and recovery and the circular supplies models. This renders the supply chain barriers being the most prominent category among other types of barriers in this research (See table 10 in the Appendix 1).

Most companies encountered challenges such as lack of suppliers for certain process and high upfront costs on acquiring internationally recognized certifications. The two challenges unfolded in both the circular supplies and recycling and recovery models. A company adopting both CBMs mentioned that the suppliers may not enter the CE loop because of low demands and high costs of processing circular materials for merely few companies (Chiao Fu Interview, 2020). And the whole CE loop were not able to be formulated when there existed only few actors in each stage along the whole supply chain (Grabio Interview, 2020).

As for the costs of certified by international recognized organizations, a company mentioned that some industry peers found it hard to financially support their transitions towards CE. Furthermore, obtaining enough certifications to enter developed markets required time and high upfront costs (Chiao Fu Interview, 2020). As the research institute noted in the interview *"Most Taiwanese textile companies comply with the supplier code of conducts of their brand customers. The requirements cover environmental management, occupational safety*

standards, and health and hygiene management. These all amplify the financial burdens to certain manufacturers if they don't possess similar certifications" (TTRI Interview, 2020).

The next challenge, suppliers' reluctance in accepting CE appeared in both the circular supplies and recycling and recovery models. This challenge may arise from conflicted strategic priorities between a company and its suppliers (Daai Technology Interview; Grabio Interview, 2020). One company specifically mentioned that bureaucracy may be one of the reasons that transformation in a client's company was time-consuming: *"The whole company culture may be bureaucratic, and employees or workers have limited powers to deliver CE concepts or proposals to their management levels. Furthermore, those who proposed have to shoulder the responsibilities and disseminate CE concepts to the whole company"* (Grabio Interview, 2020).

Another supply chain barrier was the instability to obtain key recycled/circular materials. This barrier displayed in the companies implementing the recycling and recovery model. One company noted that the uncertain time in gaining recycled materials due to varied obsolescence time of electronic products. The quote from the company was *"Electronic products may re-enter secondhand markets, and the rest of the products become our source of recycled materials. This volatile time of obtaining recycled materials render the estimations hugely difficult"* (UWin Nanotech Interview, 2020). Moreover, suppliers demonstrating low interest to be parts of the CE loops also lessened the predictability of gaining recycled materials (Grabio Interview, 2020).

Another challenge was low traceability of materials flowing in the supply chain. This challenge occurred on a company implementing both the circular supplies and recycling and recovery models. The company mentioned the reason that contributed to the low traceability may be *"When it comes to traceability, one issue is that lacking required certifications. This*

certification is necessary to be part of the CE supply chain, but it imposes an extra financial burden for suppliers. Therefore, certain amounts of suppliers are reluctant to participate resulting in an incomplete supply chain" (Chaio Fu Interview, 2020).

Additionally, suppliers possessed limited knowledge on CE may indirectly cause the insufficient amounts of materials to recycle (E & E Recycling Interview, 2020). The company illustrated that *"if the suppliers don't know where the materials can be recycled, they may otherwise discard them"* (E & E Recycling Interview, 2020).

4.2 Internal Barriers

Interviewed companies reported that they encounter barriers related to knowledge, organizations, and finance. But no companies mentioned about barriers associated with technology.

4.2.1 Knowledge

When it comes to knowledge in CE, two companies mentioned this barrier. Only one case company implementing the recycling and recovery model and one company adopting circular supplies encountered this barrier (See table 10 in the Appendix 1). A firm adopting both the circular supplies and the recycling recovery models mentioned that *"Initially, our employees are not from the relevant backgrounds with CE, so we had to learn the concepts from scratch"* (Daai Technology Interview, 2020). Another firm adopting the recycling recovery model specifically mentioned the difficulties in promoting CE concepts to the whole supply chain *"Most of the workers in the factory participating in the processing phase for plastic flakes don't know what the CE means to them, hence not realizing the values they contribute to"* (Grabio Interview, 2020).

4.2.2 Organizational

Two companies mentioned this type of barrier. One adopted the recycling and recovery model and the other company adopted the circular supplies models (See table 10 in the Appendix 1). The firm mentioned that the challenges arose from leadership hesitant and other employees' reluctance. In the interview, the interviewee from the firm noticed that *"firstly, I have to persuade our management levels in financial terms, proving that the investment in CE products is financially viable and with long-term benefits*" (Chiao Fu Interview, 2020). Additionally, the firm also stressed that *"Because the stable business model and employees' mindsets, it's difficult to engage everyone in integrating a foreign concept into current BMs. Developing a new market and promoting a new product requires constant efforts and certain level of knowledge in CE."* (Chiao Fu Interview, 2020).

4.2.3 Financial

Two companies mentioned the financial issue. One company adopted both the recycling and recovery and circular supplies model while the other one only adopted the circular supplies model (See table 10 in the Appendix 1). The management levels considered the short-term financial bottom lines for their company and were uncertain about the positive financial implications of fully adopting the CBMs (E & E Recycling Interview, 2020). The company said that *"The metrics to measure the performance for their main business area primarily focus on efficiency rather than quality, hence this may sacrifice values of recycled materials"* (E & E Recycling Interview, 2020). And the uncertainty and lengthy payback periods also hampered the CE innovation unless a company had another business focus to support their financial security (Chiao Fu Interview, 2020)

4.3 Coping strategies

In this section, the coping strategies to overcome the barriers sorted in the previous section are going to be discussed. All coping strategies mainly address the market and supply chain barriers. Table 9 summarizes the barriers to be overcome and the coping strategies accordingly.

4.3.1 Addressing market barriers

Four companies adopt the same strategy to tackle the volatile market demands, they collaborated with government to receive the financial supports, techniques sharing, and networking opportunities with other interested peers and accumulated customer bases through projects. For instance, a company reported that they collaborated with governments to obtain CE expertise and network with research institutes to share techniques (Daai Technology Interview, 2020). By doing this, companies involved in the collaboration nurtured a knowledge-sharing atmosphere and built trusts simultaneously.

Another company shared the details when collaborating with government through projects: *"When involving in the project initiated by the government, we also have the chance to express our opinions towards the set-up of the project. For instance, we tell the government that there should be an iconic client for us to participate. By doing this, we have the incentive to dedicate abundant resources and we can ensure that the result is viable enough for us to expand the market base"* (Chiao Fu Interview, 2020). Additionally, the supports from research institute also played a crucial role in obtaining supports. As some financial resources from the public sectors required completing bureaucratic and multiple procedures, companies may not notice the existence of resources or do not have sufficient time on the procedures. Therefore, the research institute assisted some textile companies in applying governmental supports through series of consultations (TTRI Interview, 2020).

Furthermore, acquiring internationally renowned certifications also solidified the opportunity to enter developed markets. This coping strategy was adopted in both circular supplies and recycling and recovery models. But one company took proactive actions in obtaining the certification, while the other mentioned that most of the textile companies reacted to the requirements from the international clients (Chiao Fu Interview; TTRI Interview, 2020). As one company noted in the interview that *"To be part of the circular supply chain, some*

multinational companies require their suppliers to be certified. By gaining the certifications, we can demonstrate to them that we are capable of being their partners in achieving transparent sourcing" (Chiao Fu Interview, 2020).

Another coping strategy reacting to volatile market demands was having another business focus while developing CE project/products. There was only one company stressing this point. The company sustained their financial stability through developing other products that stably contribute to the business, then they considered initiating CE-related projects. In the interview, they said that *"Fortunately we have another business focus to secure our business while developing CE-related products. We have been dedicating ourselves in CE area for a decade and other partners transitioning towards CE cannot find a way to stabilize their business"* (Chiao Fu Interview, 2020). Another company also diversified their market focus internationally such as the EU market because the existing suppliers did not have sufficient awareness on CE in Taiwan as they noted in the interview (UWin Nanotech Interview, 2020). In addition to this, the company also strived to align incentives with important stakeholders in client's company with long-term benefits such as brand enhancing values and cost-benefit analysis (UWin Nanotech Interview, 2020).

4.3.2 Addressing supply chain barriers

The first supply chain barrier was supplier's reluctance in accepting CE. And one company adopt the recycling and recovery model and the other company applying both the circular supplies and the recycling recovery models possessed the same coping strategy. To address the suppliers' reluctance, building trust and raising awareness were regarded as crucial elements. One company illustrated the importance of building consensus with suppliers (Daai Technology Interview, 2020), while the other company explained that they demonstrated the values of a green product through completing a successful project with signature clients, then suppliers were more willing to buy in the CE concept (Grabio Interview, 2020).

Another supply chain barrier was instability in obtaining circular materials, and only one company with the recycling and recovery model had a reacting strategy to tackle the barrier. The company strived to engage key stakeholders in the value chain and diversified their sourcing of recycled materials in reacting to more service-oriented market. In the interview, the company described that *"We cooperate with government to discuss the recycling systems and research institutes about the incentives to nudge suppliers' and customers' recycling behaviors. Moreover, as the more service-oriented CBMs become prominent, we diversify our sourcing channels and negotiate with governments about the materials that are not mandatory to enter recycling systems"* (E & E Recycling Interview, 2020).

Table 9. Summary of coping strategies

Barriers to overcome	Coping strategies
Market barrier: Market demands and interests are low or volatile	• Collaborated with government to receive the financial supports, techniques sharing, and networking opportunities • Accumulated customer bases through projects • Acquired internationally renowned certifications • Aligned incentives with important stakeholders in client's company with long-term benefits • Had another business focus while developing CE project/products to secure financial stability • Expanded market areas

Supply chain barrier: Instability in obtaining circular materials	• Engaged key stakeholders in the value chain and diversified their sourcing of recycled materials
Supply chain barrier: Supplier's reluctance in accepting CE	• Built trust and raised awareness

4.4 Discussion

4.4.1 Barriers

In this research, one of the aims is to uncover the internal and external barriers in five CBMs. Though in the end, the companies agreed to be interviewed only encompassed two CBMs, the limitations regarding this aspect will be discussed in the last section. As indicated from the findings, internal and external barriers varied between two CBMs, more discussions were presented below.

Concerning the internal barriers, there were two points to illustrate. Firstly, most of the internal barriers were found in the circular supplies model, including the knowledge and organizational ones. The recycling and recovery model, there was only one internal barrier mentioned by interviewed companies, namely the financial barrier. Additionally, among the internal barriers, financial ones were discussed the most by the interviewed companies. This finding was in line with the studies conducted by De Jesus and Mendonça (2018) that financial barriers may undermine SMEs' ability to transition to CE, especially the high upfront investment costs and costs of developing innovation. Additionally, the finding of financial barriers being prominent corresponded to what Rizos et al. (2016) presented in their research. Rizos et al. (2016) summarized that the most challenging internal barrier for small and medium enterprises (SMEs) was regarding the direct and indirect costs associated with

transition to CE. And all interviewed companies listed the internal barriers all belong to SMEs according to the categorization from Ministry of Economics (2020).

Secondly, there were no companies mentioning technical barriers in the interviews though the literatures suggested otherwise. De Jesus and Mendonça (2018) said that technical barriers were among the most prominent factors for transition to CE. Scholars discussed about several crucial elements containing in the technical barriers, including availability of technical solutions, lag between product invention and production, and lack of personnel possessing expertise (De Jesus and Mendonça, 2018). However, most interviewed companies illustrated that they have already adopt CE for several years, built a team with CE expertise, and received the supports from other stakeholders to overcome the technical barriers. These factors were resonated with the points raised by Kirchherr et al. (2018): overcoming technical barriers was time-consuming, but not many companies ranked technical barriers at the top of the list as other factors such as cultural ones were regarded as more challenging for most companies that aim at transitioning to CE.

Regarding the external barriers, regulatory barriers were merely found in companies adopting the circular supplies model. This finding was in line with the results indicated by Rizos et al. (2016). They concluded that obstructing laws regarding materials may undermine the transition pace. This statement also corresponded to what Kirchherr et al. (2018) discovered from their survey that some companies emphasized the difficulties in purchasing waste from other countries because of violations of current regulations. But their findings were only applicable in the EU regions and the EU has stipulated favorable regulations for transitioning to CE (Kirchherr et al., 2018). Whereas the Taiwanese government was currently working on regulations that favor CE transitions, this was why regulatory barriers were still mentioned by all Taiwanese companies adopting the circular supplies model (Chiao Fu Interview; Grabio Interview, 2020). Furthermore, lagged incentive mechanisms for replacing virgin materials and inconsistent regulations and dialogues between the government and companies caused uncertainties (Rizos et al., 2016).

Most of the market barriers were discovered in the recycling and recovery model. Notably the volatile market demands of circular materials appeared to be the major challenge for both CBMs. This finding corresponded to what previous scholar displayed in their research (e.g. De Jesus and Mendonça, 2018; Kirchherr et al., 2018; Vermunt et al. 2019). For the passive consumers' attitudes towards CE, this was the least mentioned barrier under the "market" barriers. The result was in contrast with most of the scholars' findings, for example, Kirchherr et al. (2018) said that this barrier was mentioned the most among other barriers such as 'hesitant company culture' and 'operating in a linear system'.

Furthermore, as most of the interviewed companies explained that the reasons of low demands for circular materials, including less competitive prices of circular materials, unfavorable regulations and incentives and the production phase of circular materials is not economical compared to producing virgin materials. These explanations were all in line with authors exploring this area (e.g. Ranta et al. 2018; Kirchherr et al., 2018). The incentive was also explained by some scholars that subsidies may in turn render circular materials more affordable and spur consumer's interests when the economic factor being less crucial in their purchasing decisions (Kirchherr et al., 2018).

Lastly, supply chain barriers appeared in both types of CBMs. There were no distinguished distributions of supply chain barriers during the interviews, aligning with the results presented by other scholars (Vermunt et al., 2019). The most prominent supply chain barrier for both CBM was the time and costs dedicating to acquiring certifications to be part of the international circular-oriented supply chain. As, for example, the research institute indicated that most textile companies were embedded into global supply chain and the orders from international corporations were financially important (TTRI Interview, 2020). Additionally, other interviewed companies expanded their market focus to the areas that value CE concepts and integrated the CE into current legislations, the certifications were crucial for them to stay relevant within the CE-oriented supply chain (Tura et al., 2019; TTRI, UWin Nanotech,

Chiao Fu, Grabio Interview, 2020) and were primary to generate business case for the global brand customers (Rizos et al., 2016).

Reasons for most of the barriers located under the supply chain category may arise from the essences of CBMs adopted by these interviewed companies. Both the recycling and the recovery and circular supplies models required the activities of the reverse supply chain, such as the logistics, information and data flow of products and materials, and process involved remanufacturing, recycling, and refurbishment. Therefore, more collaborations between supply chain partners and focal firms enhanced (Urbinati et al., 2017).

Another marked finding from the interviews may be the business conflicts between traditional industry actors and the ones that possess CE-oriented products. This barrier was only found in the recycling and recovery model. And only few scholars mentioned this barrier in their studies (e.g. Tura et al., 2019). Tura et al. (2019) mentioned that conflicting interests between partners in the value chain hinder the transitions towards CE and hence the information related to monetary factors is hidden, reducing the transparency and trust. To tackle these challenges, Vermunt et al. (2019) recommended that incentives alignments, equal division of benefits and costs, open dialogues, and increased information availability could be helpful in alleviating this challenge.

The barriers found in the interviews also interlinked with each other. For instance, the unfavorable regulations for nurturing CE may lead to incomplete supply chain for CE because of lacking economic incentives (Grabio Interview, 2020). Additionally, consumers didn't possess relevant knowledge and enough awareness towards CE contribute to the volatile demands. And lacking leadership buy-in may result from no immediate financial paybacks (UWin Nanotech and Chiao Fu Interview, 2020).

4.4.2 Coping strategies

This research also summarized the coping strategies that companies implemented when encountering certain types of barriers. One thing to be noted was that all coping strategies were associated with supply chain and market barriers.

Though vested interests of current industry peers dominated the market directions and demands for circular products were generally unstable, some companies strived to seek the opportunities for securing financial viability of circular products. They strived to enlarge their market bases either internationally or domestically through certain strategies. For instance, they acquired internationally recognized certifications to expand their market bases into the EU and other markets with high CE-awareness. Simultaneously, these companies based theirs core operations domestically, hence they were motivated to actively engage with governments, research institutes, and other interested industry partners to assimilate latest findings for the CE and solidify trust. Consequently, they initiated projects with the government to approach incumbent companies that were willing to shift to more CE-oriented business to establish partnerships.

Some companies also engaged with key stakeholders within client's companies to demonstrate the long-term business case in terms of enhancing brand images, cost-benefit analysis, and talent retentions and attractions. Lastly, they also overhauled internally such as diversifying their business in accordance with the international trends and regulatory landscapes. For example, those companies that initially adopted linear BM possessed stable financial flows from the products made of virgin materials, then they could utilize those capitals to fund CE-oriented products as the regulations became more supportive for CE transitions.

Some companies also gained supports from the CE-oriented networks to build a collaborative network within the industry, as the information transparency and feedback were helpful in achieving a CE system (Bianchini et al, 2019). However, Taiwan enforcement laws regarding CE were modified gradually but not comprehensive enough to overhaul the incentive

mechanisms for the whole industry. Furthermore, the effectiveness of dialogues and supports may be undermined by the bureaucratic process and mindsets of the government officials.

Lastly, the coping strategies showcased that interviewed companies strived to integrate resiliency into their business operations. Resiliency was defined as ability to recover from the ramifications of volatile virgin material prices, resource scarcity, and geopolitical tensions (Hofmann, 2019). Most of the interviewed companies mentioned that as scarce resource is the major issue, Taiwanese businesses were susceptible to the turmoil of international commodity markets. Therefore, Taiwanese governments and private sectors that were enthusiastic on CE transitions could jointly construct a CE ecosystem and thus became less vulnerable to geopolitical pressures (Hofmann, 2019; Ibitz, 2020).

4.4.3 Implications

Three implications derived from the findings are presented below.

Firstly, the CE transition may be further expedited after conquering the technical barriers as claimed by Kirchherr et al. (2018). The scholars obtained different results from other existing literature that the most challenging aspect to conquer may be the cultural barriers such as consumers' and suppliers' awareness of CE rather than technical challenges. As cultural change required tremendous amounts of time, technological innovations may be faster than the cultural shifts (Kirchherr et al., 2018). One way to shorten the pace of cultural shift towards a CE-oriented system was through educating consumers (Bianchini et al, 2019). This finding resonated with the endeavor of one of the interviewed companies. Their strategies included organizing environmental protection activities for volunteers as well as their families and collaborating with academic institutions to disseminate the CE knowledge (Daai Interview, 2020).

Additionally, the CE transition encompassed profound changes in current production and consumption systems. As emphasized by the interviewed companies, integrating closed-loop thinking from strategic levels down to operational layers posed a huge burden to enter the CE supply chain as early adopters (Hofmann, 2019). However, Kirchherr et al. (2018) concluded that bursts of enthusiasms may eventually assist companies in breaking the bottlenecks and experimenting with multiple CBMs with experience sharing from other industry peers. The enthusiasm to partake in circular-oriented supply chains should also be placed under the supportive environments for CE and this leads to the second point.

Secondly, governmental interventions seemed to direct the economic incentives and industry, influence the whole value chain, connect the supportive industry networks for companies that keen on participating in CE transitions and enforce the regulations that change the consumers' behaviors. Kirchherr et al. (2018) suggested that most of the companies they surveyed on reported that market barriers such as virgin material prices and high upfront investment costs were the most pressing to address. The market barriers categorized by Kirchherr et al. (2018) corresponded to the market and supply chain barriers in this research, the economic reasons further enhance the reluctance of suppliers' entering into the CE-oriented supply chain.

The government could remove the roadblocks for the companies adopting CBMs in that a single company cannot influence the whole value chain as well as the production and consumption patterns. De Jesus and Mendonça (2018) mentioned that 'Fiscal and regulatory policies can reconstruct the processes of industrial ecosystems', this endeavor could be seen in the electronics sector in Taiwan (Ibitz, 2020). The Taiwanese government dedicated huge investments into large state-owned companies for them to pivot Taiwanese industries in CE transitions. However, SMEs were the backbone of Taiwan's economy as 97% of the companies belong to this category (Ibitz, 2020). Without the comprehensive regulatory frameworks and innovation funds, SMEs showcased low interest to facilitate the CE transitions altogether with large companies. In this research, all the interviewed companies are SMEs and they emphasized that early adopters need to rapidly build the market niche and

exhibit the business cases to their clients, receive financial supports from the government to be financially sound throughout the transition. Nevertheless, receiving government financial aids did not necessarily guarantee the shift of production and consumption patterns, but the chances of transition towards CE increased dramatically as Kirchherr et al. (2018) concluded.

Furthermore, governments could also nurture a reciprocal network for circular-oriented networks to engage those traditional industry peers. One of the barriers was related to the business conflicts between the linear and circular companies. Incumbent and circular companies may not coordinate with each other because the incumbent ones may sense the competition and refuse to initiate any dialogues. Without the promotions of collective values and third-party intervention, the volumes of circular materials may be volatile, and the CE value cycle was difficult to form (Hofmann, 2019).

Lastly, the interviewed companies encountered different barriers that may result from the extent to which companies implementing CBMs. Guldmann and Huulgaard (2019) noted that the degree of implementation of CBMs may affect the amounts of and complexity of the barriers emerged alongside the CE transition.

5. Conclusions

5.1 Summary of Findings and Theoretical Contributions

In this research, the main aim is to answer the research question: *What internal and external barriers may Taiwanese companies encounter when transitioning to circular business models or adopting circular business models in the first place, and how do they overcome them?*

And this research also strived to address four gaps within the current scholarly discussions. Firstly, more case explorations on how CBMs were implemented would be valuable. This research presented five Taiwanese companies and one research institute on what CBMs they

adopted and the barriers emerged along the way. Secondly, few studies examined cross-industry cases, especially for the CBMs barriers types, hence this research alleviated the gap through collecting insights from apparel, chemistry, plastics, and biotechnology industries to diversify the case selections. Thirdly, only few case studies concentrated on Taiwan while China, Japan, and other geographical areas received most of the attention. Therefore, this study interviewed five Taiwanese companies and one research institute to bridge the geographical gaps within the current CBMs barriers studies. Lastly, this research also presented barriers and the conquering process of barriers behind arrays of "stories of successfully implementing CBMs".

This research revealed four points to answer the research question. Firstly, the comparison of barriers in two different types of CBMs (circular supplies and the recycling and recovery models) showed that there may exist varied barriers when companies adopting or implementing CBMs. Most of the barriers corresponded to what appeared in previous scholarly discussions, except for the conflicting business interest among incumbent and circular companies. This exception could provide one addition to the list of barriers from the previous literature. Secondly, this research brought Taiwanese regulatory landscapes into the CE discussions. Many Taiwanese companies struggled with the incomplete Taiwanese regulations for nurturing CE while most of the previous research focused more on the landscapes in the EU region. The latter area possessed a more solid regulation environment and incentive mechanisms for businesses to revolutionize their current BMs. Hence, this research contributed to the discussions of CE transitions in Asian contexts by broadening the geographical focus to Taiwan.

Furthermore, supply chain barriers appeared to be the most prominent category in this research, aligning with what scholars discovered in their studies. Specifically, there were no shared values, transparency of information and data, and spaces for dialogues leading to an incomplete supply chain for CE. Before the trend of CE-innovations, collaborating with governments was one of the feasible ways when facing bottom-line predicaments. This

finding was also in line with other scholars' thoughts that governmental interventions were of prominence in the early stage of CE-innovations.

Lastly, the barriers also interlinked with each other, especially the supply chain and regulatory aspects may be the most influential ones in the Taiwan context according to the findings. Furthermore, this research also presented the coping strategies of how companies managed to overcome or what they intended to implement and their associations with the identified barriers. These associations demonstrated that market barriers were one of the main motivations for companies to tackle. Companies were required to secure the financial stability firstly to innovate towards CE.

Overall, this research discovered that barriers varied among two CBMs across four different industries based on the collected insights. Additionally, this research provided reacting strategies for companies that are keen on transitioning to CE and discern what barriers companies prioritized and tackled.

5.2 Managerial Implications

For SMEs that showed interests in integrating CE into current BMs, it is crucial to collaborate with potential or existing partners within the current CE supply chains to share the knowledge and formulate networks, communicate with key stakeholders (e.g. research institutes) to seek support, and negotiate with governments regarding current regulations as an industry may be influenced by the supply chain shocks and international market directions.

Companies should aware that the barriers were intertwined together and hence seeking supports from preceding companies that managed to find strategies to survive is important. The barriers associated with each other such as technical barriers may relate to supply chain barriers because current suppliers don't possess capacities or willingness for utilizing circular

inputs or produce CE-products. Additionally, SMEs may find it difficult to secure funding from investors or large financial institutions as the regulations were not supportive enough.

5.3 Areas for Future Research

This study managed to collect insights from five case companies and one research institute, but future research can expand the sample sizes to validate if the barriers differ among CBMs. This research was initially be designed to collect five CBMs. However, as the time constraints and interview willingness of the companies, the companies that were consented to participate adopt two types of CBMs, namely the circular supplies and the recycling and the recovery model. Hence, there is more work for future scholars to compare other three types of CBMs, as they had no presence in this research. This may render the studies of barriers on CBMs incomplete and less informative for scholars and practitioners. Therefore, future studies can strive to enlarge the sample collections and industry types and consider other factors such as companies' sizes as well as if they have existing sustainability strategies.

Furthermore, focusing on multiple sectors would help in identifying the difference between barriers and coping strategies. Since the sample sizes and time length did now allow a thorough study on multiple sectors such as food, agriculture, and machinery, the future area can concentrate on how the implementation and coping strategies intertwined together and to discern the differences between these sectors. Another future area to explore may be assessing the effectiveness of the coping strategies in association with specific barriers, this can help practitioners identify and share similar experiences among industries as most of the companies share identical barriers.

Additionally, one area to dive deeper into is the connections of barriers. Guldmann and Huulgaard (2019) categorized the barriers for implementing CBMs into four levels, namely employee, organizational, value chains, and market and institutional. Future research can

identify the relationships of barriers discerned between/among each level for scholars and practitioners to generate feasible policies and possible solutions for CE transitions.

Lastly, there are fewer (12 out of 66 case studies) service-oriented CBMs that appeared in the report *"Towards a Circular Taiwan"* published by Taiwan Circular Economy Network in 2019. These CBMs include product-as-a-service and sharing platform. Therefore, future research can expand their focus on the two aforementioned types of CBMs to mitigate the research gaps and explore if there underline regulatory, systemic, and socio-economic reasons for developing these two CBMs.

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7. Appendices

7.1 Appendix 1

Table 10. Summary of internal and external barriers for different CBMs

Types of CBMs		**Circular Supplies**			**Recycling & Recovery**					
Barrier categories	**Barriers**									
		Daai Tech	Chiao Fu	TTRI	Daai Tech	Chiao Fu	UWin Nanotech	TTRI	Grabio	E & E Recycling
Internal										
Knowledge	Limited expertise on CE	v							v	
Organizational	Lack of leadership buy-in, especially on cost-benefit analysis		v							
Financial	Short-term financial		v			v				v

	pressures for managements									
External										
Regulatory	Unfavorable regulations for nurturing CE	v	v	v		v			v	
Market	Market demands and interests are low or volatile		v	v		v		v	v	v
	Volatile costs of circular materials		v	v				v	v	
	Low consumers' and clients' attitudes and knowledge towards CE					v	v			
	Business conflicts with industry peers						v			
Supply Chain	Incomplete supply chain for nurturing CE		v			v			v	
	Instability in obtaining circular materials						v		v	v
	Internationally recognized certifications require high upfront costs and time		v	v				v	v	

	Supplier's reluctance in accepting CE	v			v				v	
	Low traceability of materials flowing in the supply chain		v			v				
	Suppliers possess limited understandings towards CE		v							v