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ARTICLE

A Study of the Industrial Circular Economy Using an Essence Analysis Model

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ABSTRACT

The concept of a circular economy can be applied to different business fields. The development of the existing industrial cycles with an overemphasis on economic development and the twisting concept of a circular economy, has limited any substantial contribution of the circular economy to environmental resources. In some cases, resources are even being consumed to create resource recycling. This puts a greater burden on the environment. To gain an understanding of the actual value of a circular economy to the environment and resources, an "Essence Analysis Model" has been used in this study. This combines sustainable development issues in a multi-faceted and multi-leveled analysis of the industrial circular economy model to guide its development more directly towards fundamentals. An analysis of the results of the "Essence Analysis Model" was used to find and change the original strategy, and develop a means of improving the circular economy model. The results of the study make an essential contribution to the sustainable development of environmental resources and the reduction of greenhouse gas emission.

1. Introduction

The circular economy must combine the concepts of life cycle and time series to analyze the logic and influencing factors. All materials change at different times and these changes affect the final implementation of a circular economy. Whether or not this is about managing the source, or final disposal, waste should become a useful resource and whatever value remains should be maximized even though most products will have become unusable in terms of original functionality. New ideas and means of circulation and sustainability should be introduced.

In the concept of material circulation, waste is a resource. All resources and their components or related elements can be separated or restored using various technologies or methods, between input and output, after a certain time. The essence of the material cycle is to emphasize the limited nature of the earth's resources and reduce exploitation. With the implementation of a multiple reuse concept, objects can return to a point where they continue to provide value even after the end of their original-use life cycle. They can often be used as raw material for other products. In this way the traditional linear model becomes a closed circular model.

In this study essence analysis was used to determine if the existing circular economy model meets its output target. When a model cannot truly solve a problem, or the explored answers are mere representations and do not

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solve the fundamental problem, then the model needs to be changed. Every analytical model must have sequence and causality, as well as factors that have an impact on the model, all of which must be considered. These are all important for exploring the essential issues and for demonstrating decisive influence on the entire model. This whole process of exploration and change allows all the factors for the formation of modeling strategies to be found.

2. Literature review

2.1 Circular Economy

When the reuse value of an object is greater than the cost of disposal it becomes another resource. Conversely, when the reuse value is less than that of disposal, it becomes waste. Garbage is not all waste and can be a valuable potential resource [1]. In 1990, Pearce and Turner proposed the concept of the circular economy in their book, "Economics of Natural Resources and the Environment", which showed clearly that the traditional open economy did not include the concept of recycling. In contrast, the circular economy tries to establish a resource management infrastructure based on sustainability, making the economic system part of the ecosystem [2]. In 2013, Jeremy Rifkin pointed out in his book "The Third Industrial Revolution", that human beings will combine green energy and energy telecommunications technologies in the 21st century to enter a third industrial revolution, and the development of the industry, energy and resources are already moving in this direction [3]. The "Circular Economy" has become a development trend in recent years. There are similar terms, such as "a green economy", "an ecological economy" or "a low-carbon economy" and "circular economy" is one that has natural resources as its core [4]. Most research articles tend to focus on the reuse of resources, which is rather narrow, and they do not offer solutions that would allow a circular economy to move toward sustainability. To enable continuous recycling, more resources need to be consumed for the restoration of function, or the scrapping of waste products and their conversion into raw material for manufacture. Such implementation and promotion involves deviations in the track a circular economy and should be developed.

A circular economy is one of the solutions that arise from a green economy and four key elements constitute its real core: product design, reverse logistics, the business model and the Internet of Things (IoT) these are supported by policies and regulations. A circular economy can exist only if these four elements are all present to extend the time products stay in the supply chain. This maximizes the recycling rate and the number of cycles and also improves company profits [5]. In 2017, Chang wrote that the core values of the circular economy were: (1) Reduced resource exploitation; (2) An extended product life cycle; (3) Improved reuse of components and materials; (4) Reduced and activated "idle resources" to improve product utilization and reuse [6].

The origin and the definition of the essence of the circular economy perspective comes from the fact that the resources of our planet are limited. A circular economy has both industrial and biological cycles. The Industrial cycles involve products made from raw materials by manufacturing processes. "Raw material" is a general term covering everything that is harvested or extracted. The Biological cycles involve the processes and substances generated by animals and plants from production to termination. Long term strategic consideration clearly shows that planning is needed to achieve sustainability and "zero waste" and to solve the current climate change problems faced by mankind [7].

2.2 Definition of Essence

"Essence" is a term that does not arise very frequently in the literature and it has many different definitions and interpretations. In general, it is combined with titles to be discussed as part of reasoning. In 2016, Takashi gives a definition of essence as "the real reason behind problems and phenomena and the cause of problems and phenomena" in his book "Essential Thinking" [8]. He uses the concept of essential thinking to explore the root of problems and solve them, and this concept contributes to the early ideas in this study. The interpretation of essence in the field of religion is "one for all", but mainly it is still one word, "heart", and "Form itself is emptiness; emptiness itself is form". This concept is also in line with this study in defining the fundamental idea of the "Essential Analysis Model". The Wikipedia entry on essence defines it as the properties or particular characteristics of an object which gives it material form, original, or particular characteristics without which it would have no identity [9]. However, this definition only defines existing substances and so is not in line with the basic theory of this study. This study integrates a Buddhist view of the essence to explore the nature of affairs or materials, in addition to exploring the true problems behind them. The fundamental definition of essence is in line with the essential analytical study of the circular economy, as all substances, originally made together, can be broken down, decomposed and reduced to original substances.

3. Research Methods

An innovative research topic, the "essential analysis

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model", was first introduced at the 2018 Cross-Strait Harmony Forum. In this method an analytical approach is used to explore the fields of education and culture on both sides of the Taiwan Strait. The substantive research results clearly exposed the essence of the problems faced by the two sides in terms of education and culture [10]. The essential analysis model involves an exploration of the root causes hiding behind the external appearance of problems. A thorough and accurate conversion of the "qualitative" into the "quantitative" aspect is already a difficult task, and it is worth noting that this aspect of "essence" originates in philosophy. After some time, people in management also took a jump into this field of study. This is happening because human society more often than not merely handles surface problems, not solving those hidden in the background. This is why the perspective of "essence" has been applied to various behavioral patterns in the study of human society.

The "essential analysis model" explores the real reason for the problems presented by affairs or materials as well as making an overall analytical framework (see Figure 1). In this study four main steps are taken in the approach to the essential analysis model: the construction of a prototypical model, time series analysis, a change model strategy and evaluation, and feedback to implementation. Details of these four steps are given in Table 1.

Table 1. Framework of the "Essential Analysis Model"

Step	Item	Description
Constructing a prototypical model.	1. Clarify the input source and output target of the model.	Items or products of the original model to be analyzed are the input. Input can be a module, product or affair. Output target is a standard, grade or benchmark to be reached.
	2. Preparation of a model flowchart.	The flowchart shows the matters to be analyzed in their originally planned order as well as the entire process. The model only presents the main processes as a basis for the next procedure.
	3. Analysis of the cycle.	Analyze the positive and negative cycles of the model. A positive cycle indicates a stronger correlation between matters. A negative cycle shows a weaker correlation.
	4. Factor analysis	The analysis is divided into internal and external. This is a continuation of the previous step which analyzes the factors affecting this model.
	5. Dimensional analysis	A model with a single dimension cannot be used for effective analysis, several dimensions and factors are needed.
	6. Analysis of causal relationship.	Examine the created model and focus on the causal relationship between factors. If a factor is sufficient to affect the whole model, there is room for improvement. If this is not so, it can be deleted.
Time series analysis	1. Life cycle	List the life cycle of the analysis step by step. Clarify the input source and finish the output target.
	2. Change in time series.	Analyze the model for an increase or decrease in demand at different times.
	3. Find change points	During the process, time or other factors may change the direction of development in a model. Find the change points and determine their impact.
	4. Factor analysis of phase change.	The change in appearance or form of matter or material are key factors affecting the model changes themselves. The model may undergo changes or discontinuity.
	5. Root cause for drive.	The force that causes fundamental changes in matter or substance.
Strategy to a change model	1. Examine logic of model	Examine the logic of the model. After the original model steps have been completed, the overall logic is re-examined to determine if it was appropriate. The examination processes: 1. Objective: Must be specific, targeted, feasible, systematic and normative to the standards used to measure the achievement. 2. Model review: Input, output, conversion relationship, system goals and constraints, etc. 3. Effectiveness: Check the reactions and results the model and strategy have had on the social environment. 4. Assessment: Conduct a model policy assessment and the solutions based on specific value criteria. Consider various qualitative factors according to the analyzed basis. Compare the extent to which the objectives have been achieved in the system and measure them against the standards.
	2.Find a leverage point:	If the fundamental problems are relevant or cannot be resolved immediately, find a compromise which has a feasible solution.
	3.Analyze the range of influence:	To determine if the range of influence meets the original configured output objectives should the model have changed.
Assessment and feedback to implementation.	1.Evaluate the scope of this job	Confirm the beginning and end of the job scope.
	2. Evaluation	Quantify according to the requirements of the analysis model.
	3.Effectiveness evaluation	Compile performance indicators. Clarify the numerical standard or grade the indicators need to achieve.

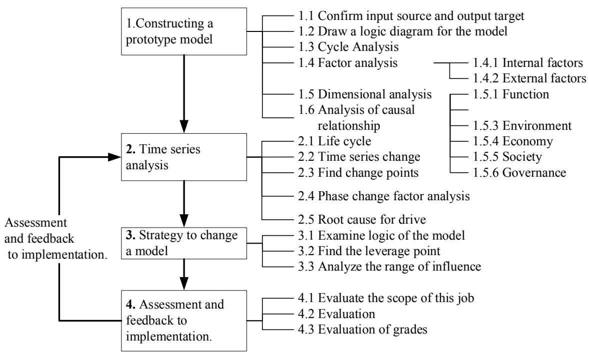

Figure 1. Main framework of essential analysis model

4. Essential analysis model for a circular economy

A circular economy is mainly divided into industrial and biological cycles. In this study the "essential analysis model" (Figure 1) was employed to analyze the industrial cycles. Greenhouse gases have a major impact on global warming, and the contribution of a circular economy to the environmental dimension is a priority. The classical economy model omits the extraction of raw materials and the necessary breakdown and manufacturing stages, as well as material decomposition after recycling, and only considers the cycles after product design. A circular economy considers decreasing the extraction of resources and testing of the emissions of greenhouse gases. Therefore, the output objectives during the model building process should take the carbon dioxide equivalent (CO_{2e}) index into consideration and attempt to reduce emission.

Figure 2 is an analysis diagram for such an industrial cycle. The positive and negative cycles of the model have been analyzed and it can be seen that the mining process is considered positive. This is because as the demand for products increases, the demand for raw materials used in their manufacture also increases, and this is directly related to product design. The use stage is negative because in the original design of a circular economy, repair, maintenance, replacement and idle resources can be re-used, service life can be extended, or the performance of a product can be kept at an acceptable level. The negative cycle indicates that development has a leverage point which is also related to sales. For example, a second-hand market can make full use of idle resources.

In this study the entire process was considered as an industrial circular economy, starting from the mining of raw ore, cracking of raw materials, parts manufacturer, product design, assembly, transportation, sales (marketing), use (consumer), termination, resource recovery and final dismantling. This included the calculation of CO2e, as well as other relevant factors that affect the industrial cycle model.

The life cycle of the entire industrial cycle is shown in Figure 3. After analysis of the time change, it was easy to find the four change points: product design, use, resource recovery and decomposition and remanufacturing. There are two phase changes and two root causes for drive. Product design is the key to this entire life cycle, because it considers recoverability, reusability, product durability, ease of repair, functionality, and residual value at the end of the life cycle. The constraints and restrictions of laws and regulations are also considered. Any change in these factors can affect the cycle performance of the whole product, and change the entire model. Product design is the root cause that drives the entire model and the product life cycle. In addition, the habits and values of product use and accession are key points affecting the whole model, especially when users have the correct perception of product recycling and it has become a habit. This improves the useful life of products, increases the recycling and reuse rate and extends the entire product cycle. Dismantling and remanufacture are vastly different from the traditional model in reverse logistics. The original manufacturer needs to recover the product from the consumers at the end of its useful life. However, for this model the original manufacturers need to have the capability for such recovery and must meet the requirements stipulated by laws and regulations. This can affect the economic development of the whole cycle. This is especially important at the governance level and the original manufacturers need to conduct reverse logistics. Compliance with the environmental laws and regulations is a burden and another important factor that influences recycling.

The strategy to a change model is detailed in Figure4. The premise is that it has to be more in line with the output objectives than the original model. The biggest difference, compared to the original model, is that this study is based on reducing the extraction of resources and the production of greenhouse gases. This brings the strategic changes to the entire model more in line with the vision of sustainability.

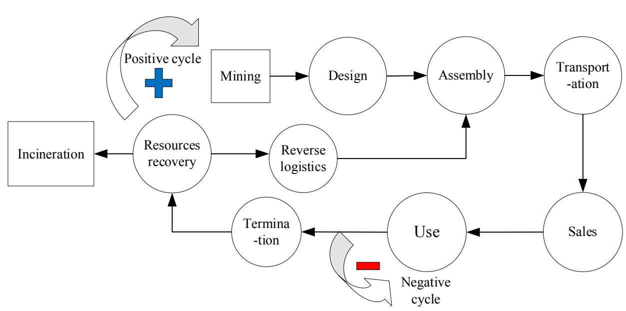

Figure 2. Diagram showing the analysis of logic

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The original industrial cycle does not take implementation into consideration. The last step of an essence analysis model requires an evaluation of the effectiveness of the strategies to the change model after implementation. The evaluation formula and calculation for each stage of a product life cycle is shown in Table 2. The re-use evaluation of a product at the end of life is not higher than the original manufacturing cost. However, should the value be higher than the original cost of a new product, a correction must be made to feedback to the analysis and the first three steps must be re-run in a new analysis.

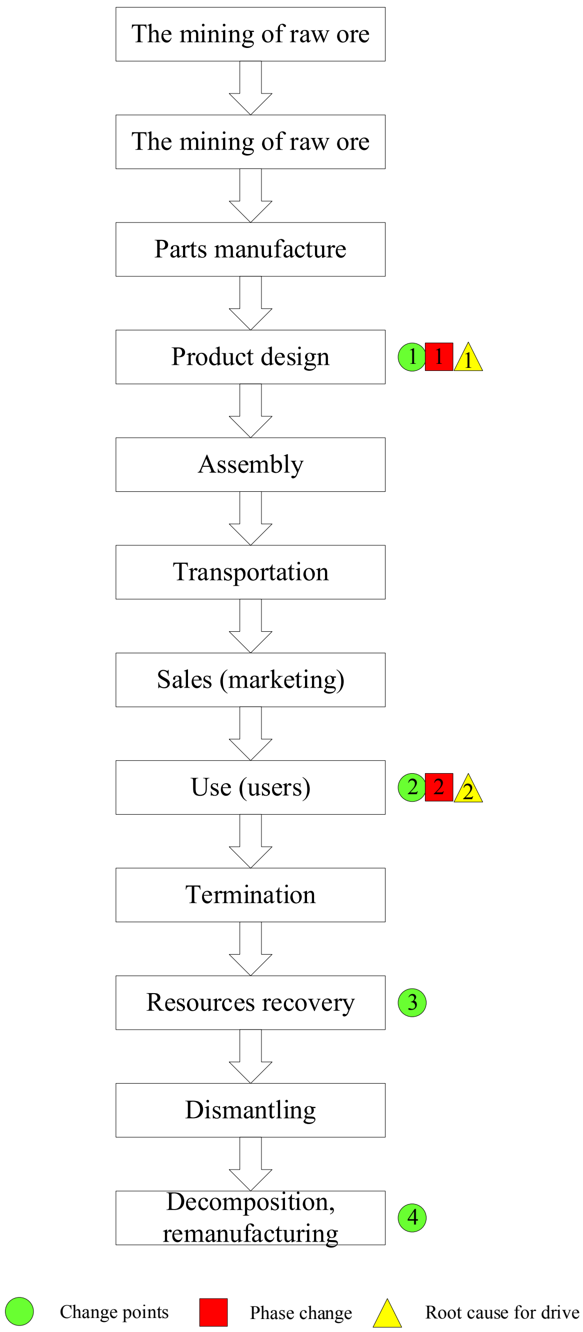

Figure 3. Time series analysis

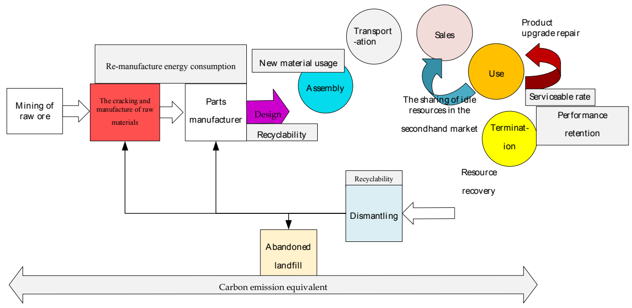

Figure 4. The Industrial Cycle model

Table 2. Evaluation and formula table for an industrial cycle

Item	Stage	Formula
1	Recovery and manufacture of raw materials	(Energy consumption in recovery and reduction / Energy consumption in original manufacture and reduction)×100 ≤ 1
2	Recovery and manufacture of raw materials	(Re-manufacture pollution per unit / Original pollution per unit)×100 ≤ 1
3	Recovery and manufacture of raw materials	(Re-manufacture energy consumption / Original manufacture energy consumption)×100 ≤ 1
4	Parts manufacture	(Re-manufacture energy consumption / Original manufacture energy consumption)×100 ≤ 1
5	Design stage	(Re-manufacture energy consumption / Original manufacture energy consumption)×100 ≤ 1
6	Assembly	(New material usage / Original material usage)×100 ≤ 1
7	Dismantling	(Actual recovery / Expected recovery originally planned)×100 ≥ 1
8	Use	(Number of repairs / Number of repairs originally planned)×100 ≤ 1
9	Use	(Product reuse efficiency / Original design performance)×100 =1
10	Each stage	(CO_2e/CO_2e Actual CO_2e equivalent / Designed CO_2e equivalent)×100 ≤ 1

5. Conclusion

A circular economy considers not just the economic aspect. If only the economic aspect were considered, the beauty of circular economy would not be realized, development might be limited and the effect would not withstand the test of time. In this study the essence of an industrial cycle was examined within a circular economy and it was found that the correlation between factors is necessary to an extent. When the residual value of a product after use is lower than the reuse value, it is regarded as waste. This is a topic worthy of attention when promoting a circular economy, and it is also a problem all countries in the world must face.

A circular economy should be sustainably structured and the environment, society, economy and governance

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as well as the environmental impact of greenhouse gases must receive consideration. The extraction of resources for the manufacture and processing of finished products, and even the end of product life cycle and disposal in a cycle, have different levels of carbon emission equivalents and must all be considered. This is important, no matter if it is a biological or an industrial cycle. These things can be easily overlooked if the economic dimension is the only one receiving consideration.

The essential analysis model was used in this study to demonstrate the problems of the existing circular economy, especially the effect on our planet of the greenhouse gases generated in the process. In terms of the industrial cycle, it is recommended that a consideration of recyclability be included at the earliest design stages. Recyclability should include reusability, the recovery rate and the use rate of new material for new products. In addition, we still need to assess the total of greenhouse gases from each product, from resource extraction to carbon emissions from remanufacturing and the resource consumption of original acquisition by mining or other means, decomposition and final reduction to show the true value and contribution of a circular economy.

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