

## Importance of Relational Database Approach to Achieve Circular Economy at A Regional Level

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#### Abstract

Since the Industrial Revolution, great improvements in production efficiency have created an important infrastructure for people to consume more and more. The fact that today's industrial economies can produce large quantities of products easily and at low costs, made it possible for the consumer to consume more goods and services with the income they have. Continuously developing financial instruments have also paved the way for individuals to consume without having any financial savings. Adding to all these developments, the abundance of producers in the market and the flexibility of enterprises to enter and exit the market, a competitive environment that appears in favor of consumers has been created. If the current production and consumption approaches and trends are insisted, it is clear that inevitable, sudden and uncontrollable dramatic changes on nature and natural resources will occur in more severe cases. In this context, the circular economy phenomenon, which has started to find its place in the agenda, has been the starting point of this paper. However the circular economy is not easy to achieve because current linear production and consumption habits are the greatest resistance to a cyclical economic transformation. Moreover, there is no platform that offers a holistic perspective, a framework in the management of resource flows. In this study, the circular economy phenomenon is explained in general terms, the obstacles of transition to circular economy are defined and it is tried to express how important the relational database management is in the transition to the circular economy.

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## 1. Introduction

A significant increase has been observed in the use of resources in the last century. When the historical course of production and consumption is examined, it is seen how the Industrial Revolution has changed the process. After the Industrial Revolution, in parallel with the developments in production technologies and processes, there has been a significant increase in production volume, production speed and product variety, and as a result, product availability has increased and product purchasing costs have decreased. Due to the economic growth experienced around the world, considering the global average, per capita resource use increased from 5 tons to 10.3 tons between 1950 and 2010. Krausmann et al. (2009) states that the resource use rate of human beings increases on average 3.4% every year. Examining the consumption data of 177 countries for the years 1950-2010, Schaffartzik et al. (2014) notes the explosion in resource use (resource use has tripled in the last 40 years alone). According to the authors, at the beginning of the 21st century, 66 billion tons of material were consumed on a global basis each year, which corresponds to approximately 10 times that of 100 years ago. In the last century, the use of energy from fossil fuels has increased 100 times (Tibbs, 1996). The carbon dioxide emission level has increased by 30-40% since the Industrial Revolution. Carbon dioxide emissions increased by 50% only between 1990 and 2012 (Vasiljevic-Shikaleska et al., 2017). Meadows et al. (1972: 11-12) explained the global environmental consequences that population growth and resource use will create in the future with the publication "The Limits to Growth". According to the results of the study, the growth will end in 2100. After their renewed studies in 1992, they corrected this year to 2050. With each passing day, the burden of environmental impacts on nature due to consumption (and production as the supply side) becomes more evident. Especially since the 1960s, ecological problems have started to find more place on the world agenda. Negativities such as global warming, soil-sea and air pollution, greenhouse effect and acid rains, erosion of the ozone layer, droughts, rising sea level, climate change, and increasingly destructive natural disasters have become more and more talked about (Walsh, 2007). In this paper I will try to emphasize the importance of usage of relational database management as an approach to support circular transition of local economies. For this purpose, general situation of present economic model and concept of circular economy explained and subject supported with two real case summaries.

## 2. Current Structure of Consumption

Global industrial production today is 20 times higher than at the beginning of the 20th century. (Meadows et al., 1992: 131). Since the Industrial Revolution, there have been great improvements in production efficiency and the resulting large product stocks, It has created an important infrastructure to direct and direct people to consumption (Worldwatch Institute, 2004: 12). The four-year production of industrial workers in the eighteenth century can now be carried out in one week at our reputation. While an automobile chassis was built in 12.5 hours in 1913, it began to be built in 1.5 hours in 1914 thanks to innovations such as the assembly line, and today, 300 cars are produced in a car factory in Japan with only 66 workers and 310 robots. Such productivity gains have drastically reduced costs and increased sales. Another example of this is the semiconductor market; In 1970, the cost of one megabit of computer power was around 20,000 dollars, while in 2001 the cost fell to 2 cents (McNeill, 2001: 315). With the global experience of this situation, the consumption behavior and attitudes of the societies have also experienced serious changes. There has been a transformation from the production of production goods to the production of consumer goods. This new system has been called "consumer capitalism" by Bocock (1997: 43). Increasing consumption and increasing world population in lifestyles have made the group, which can be defined as the consumer class, ever more crowded. According to Bauman (1999: 132), expenditure and consumption are positive values for today's consumption capitalism. Because capitalism has matured, has accumulated capital, has developed its production technology, has learned to increase its profits and production volume. Today's economy does not need mass labor, but society needs its members as consumers. Fromm (2004: 62-64) argues that unlike the 19th century, when saving was seen as a virtue, the main virtue of the 20th century was expenditure and consumption. According to him, the meaning of life has changed, the only source of freedom and happiness is perceived as having more and better objects.

## 3. Concept of Circular Economy

The main goal of neoclassical economics, which adopts the linear economy (non-cyclical), is to make economic development permanent. Neoclassical economics, which considers the efficient sharing of resources in the market, fails to develop a mechanism that takes into account scarce natural resources. This economic approach, which ignores the limitation of natural resources, is not sustainable according to the material and energy flows in terms of the economic model (linear economy) it presents (Frosch and Gallopoulos, 1989).

After the Second World War, a rapid development was achieved with the adaptation of many new technologies developed during the war period to the production processes, the global economy grew rapidly and the increasing use of resources brought about the problem of waste and pollution. In the 1970s, waste

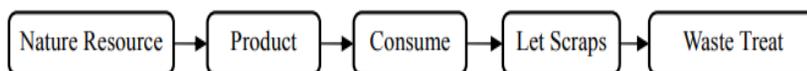
management became an important problem in the USA and Europe. With this period, the concept of 3R (reducing, reusing, recycling) started to gain popularity, and again in this period, polluter pays and end-of-pipe: the continuation of the current pollution process, the search for solutions after the occurrence of pollution. The situation of trying to eliminate the result instead of going down to the source of the pollution and eliminating it. For example, the principles of filtering the liquid wastes discharged into the stream or discharging the stream after adding other chemicals, installing filters on the factory chimneys have started to be considered as the basic rule (Reike, 2017: 3).

Considering the scarce natural resources, challenging the world's carrying capacity, and the current problems caused by production and consumption, it is obvious that a structural transformation is inevitable. Numerous new concepts have been developed to provide or serve this transformation. One of the concepts that has been developed for this transformation and has become more heard recently is the circular economy.

The concept of Circular Economy (hereinafter referred to by the abbreviation CE) emerged with the rethinking of industrial processes in the 1970s, inspired by the fields of industrial ecology and industrial metabolism (Frosch and Gallopoulos, 1989). Although the basis of the principles of CE has been stated much earlier by Boulding (1966), it is seen that the concept of CE was first used by Pearce and Turner (1990). The authors have tried to define the relationships between the environment and economic activities in their works and have tried to express a closed-loop material flow based on the principle that "everything is the input of something else". Some previous concepts like "Limits of Growth", "Cradle to Cradle", "Performance Economy", "Remedial Design" model have been shaped around CE. However, it can be said that the EllenMacArthur Foundation has served the efforts to bring this approach into a conceptual framework. A "butterfly diagram" has been developed by this non-governmental organization, whose aim is to experience a global transformation, in which material flows are defined under two cycles as biological and technical resources. The concept of CE, which became more popular in the 1990s, is basically based on the logic that production processes generate minimum waste by using minimum material and energy. In order to achieve this, the life cycle of the product being produced is redesigned (Murray et al., 2017). The main purpose of CE is to keep resources (raw materials, energy and other resources) in the cycle for as long as possible and to keep the amount of waste to be minimized by methods such as extending the life of these resources, reuse, renewal and repair.

In linear economies; Enterprises use energy to transform raw materials into final products, sell products to consumers, and become waste when products lose their functionality or no longer satisfy desires (Urbinati et al., 2017: 488).

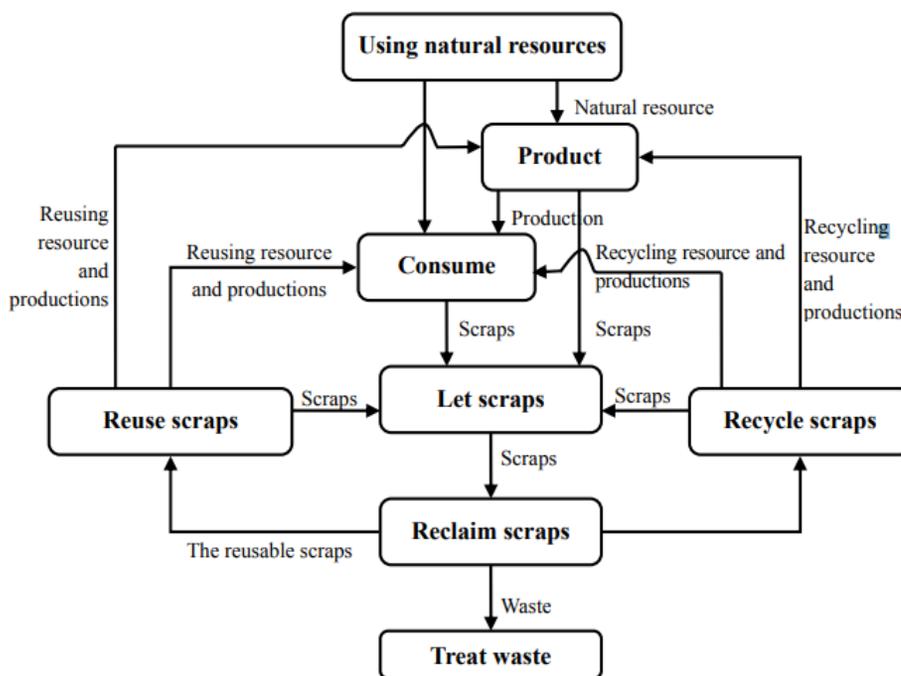
**Figure 1: The Linear or Traditional Economy**



Source: Yifang, et.al. 2007:5

The purpose of CE is to ensure the preservation of the value of the resources and materials used as long as possible and to use them as often as possible and to produce as little waste (if possible zero) as a result (Wilts, 2016). The CE aims to overcome the existing and dominant linear economic system (the traditional open-ended economy model that does not have a tendency to recycle and sees the environment as a waste storage) (Su et al., 2013).

**Figure 2: The Pattern of Circular Economy**



Source: Yifang, et.al. 2007:5

When different business models based on circular economy are examined, it is seen that they can be grouped under five different categories. These are:

- Extending product life,
- Service instead of product,
- Sharing platforms,
- Renewability,
- Resource efficiency and recycling.

Prieto-Sandoval et al., (2017: 23-24) argue that the following business models in three different categories should be implemented throughout the supply chain in order for CE to be achieved:

- Circular Innovation Models (CIM): Developing innovative processes to increase reuse and recycling potentials (consists of three models: the product design model, the process design model, and the circular supply model).
- Circular Use Models (CUM): It is aimed to produce the maximum value from the product by using it in an optimal way (consists of the sell-buy model, the sharing platform model, the product lifecycle model and the tracking facility model).
- Circular Output Models (COM): It takes into account the added value created by the output (waste) after the usage phase (consists of sub-business models such as providing technical support to improve life expectancy).

In addition, another issue that entrepreneurs should pay attention to is that new business models; It is not possible to take part in the circular economy without being supported by innovative technologies such as social media, mobile, data mining, cloud, and machine-to-machine communication.

#### 4. Region Based Circular Economy

An "ecosystem metaphor" is used by Industrial Ecology to reduce the negative effects of production and consumption systems on the environment and to increase resource efficiency. This metaphor is based on the logic that nothing in nature will be garbage, that the waste of one species will be the food of another (van Berkel, 2007).

It is important to understand the concept of industrial symbiosis in order to provide circular economy on a regional basis. The phenomenon of industrial symbiosis is based on the understanding that different industries establish a partnership-based system to gain competitive advantage, and this system involves the physical change of water, materials, energy and intermediate products. In summary, it is the situation where businesses with geographic proximity come together and establish cooperation networks among themselves (Chertow and Lombardi, 2005). These systems established by public and private sector enterprises can also be expressed as local partnerships based on the purchase and sale of waste products. Thus, added value production due to common economies increases and significant gains can be achieved for the environment. It is possible to produce more with less, lower costs, less emissions, more competitive initiatives and transition to more flexible societies.

One of the best example of industrial park based symbiosis was established in Denmark. In Kalundborg City, based on buying and selling wastes (gas, water, water

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vapor, ash, gypsum, oil and so on) has been established. Public and private enterprises can coordinate energy, water and material flows. Businesses have achieved a closed-loop industrial production by selling their wastes and purchasing other businesses' wastes in Kalundborg Industrial Park. Owing to established symbiotic system, energy savings equal to the annual electricity consumption of more than 75,000 families were achieved, while 45,000 tons of oil, 15,000 tons of coal, 90,000 tons of gypsum and 3 million cubic meters of water were saved annually. The release of excess carbon dioxide, 10,200 tons of sulfur dioxide and 4,500 tons of sulfur was prevented (Jacobsen, 2006).

For achieving CE in a regional base some steps needed to complete. The first step in this direction is to analyze the current situation of the region in order to achieve the relevant transformation. So following stages should be completed;

- To understand what opportunities are available for the transition to a circular economy within the value chain of a particular region
- To estimate the types of transformations can be experienced in different sectors that can enable the transition to a circular economy (to understand the types of transformations will be needed).
- To discover the potential of regional current activities and skills that suit the circular economy.
- To realize the Technologies which will we be needed to keep the materials and energy resources the particular region use in production more in the loop.
- To identify the ways of increasing the value of products provide throughout their lifecycle.

In the circular economy, an inventory showing the current potential of the region is needed and the actors that will take part in the operation of the process should be clearly stated. Building a symbiotic network of relationships is vital in this process. It is very important to see resource flows and identify possible matches with a holistic perspective to achieve success. At this point, a relational database management can be considered as an effective mechanism.

## 5. Using Relational Database for Circular Transtion

Advances in information and communication technologies have revealed the concept of "big data". So databases are vital to most modern businesses. Today, deriving meaningful relationships from huge data traffic and using them in daily life makes a difference in terms of competition. It is widely used in the information management process by storing and organizing large volumes of data. (Li, et al., 2005: 3410). Although technologies and standards for the hardware part of the database management have developed, it is not easy to generate meaningful relationships from huge data pools. There are some different approaches fort his purpose. One of these approached is called as relational database management

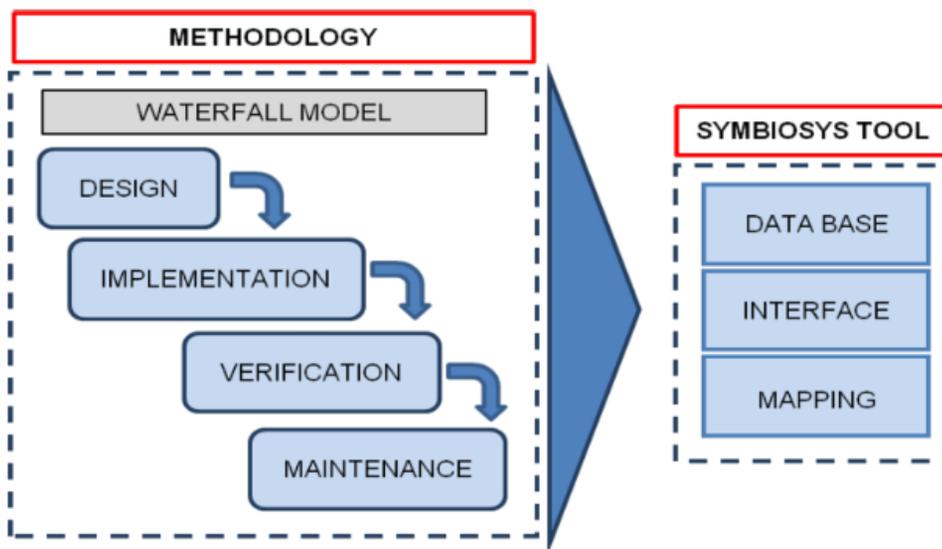
which is used to make sense of unstructured data is the system (Jung et al., 2015: 14).

When it comes to environmental impacts of production and consumption, relational database management should be considered. Relational database management is a unique tool for determining resource flows and making various planning in an economy. According to Yifang, et al. (2007) main methods used are the environment input-output (EIO) analysis and waste input-output analysis (WIO).

Yazan and Fraccascia (2020) argue EIO models (which are a specific set of Input-Output models) as useful tool to map the physical and monetary flows. According to them EIO models able to map different levels of flows among production processes. These levels are: inside the company, among companies in a supply chain, among companies in different supply chains.

In order to realize a circular economy in a particular region, it is necessary to know the internal and external logistics flows, resource flows, input and output types and quantities, wastes and by-products generated during production. Thus, the current circular economic potential in the relevant region can be discovered, possible matches can be identified and information flow between stakeholders can be provided. Using a relational database to achieve this will speed up, facilitate and make the process more efficient.

**Figure 3: Waterfall Model of The Symbiosys**



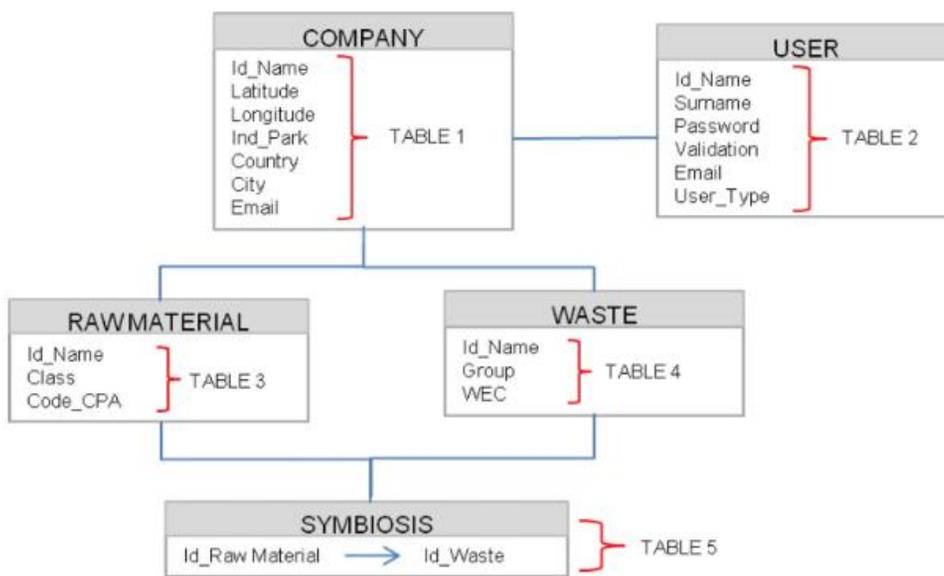
Source: Alvarez, R., and Ruiz-Puente, C. 2017: 1523

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In this study, examples from two different applications will be given. The first work belongs to Alvarez, R., and Ruiz-Puente, C. (2017), and they express a database architecture they call as "symbiosis tool". With this database architecture, the researchers focused on storing large volumes of data and analyzing them quickly and efficiently, making them accessible at all times by all users, and ensuring that the results contain a level of visibility that everyone can understand. For this, they used a model called waterfall model (Figure.3).

Researchers have used a relational database for programming of the SymbioSys. The database has an algorithm consisting of five tables related to each other (Figure 4). The first table consists of information about businesses. The second table, referred to by the username, contains user profiles for each business in the database. In this sense, there are two different user profiles: entrepreneur and employee. The third table contains the standard classifications for the products. Using this classification, the user defines the necessary inputs for production (raw material, by-product). The fourth table contains a standard waste classification hierarchy. Table five, referred to as symbiosis, represents the possible variation mappings between raw materials and waste.

**Figure 4:** Structure of the Relational Database of The Symbiosys

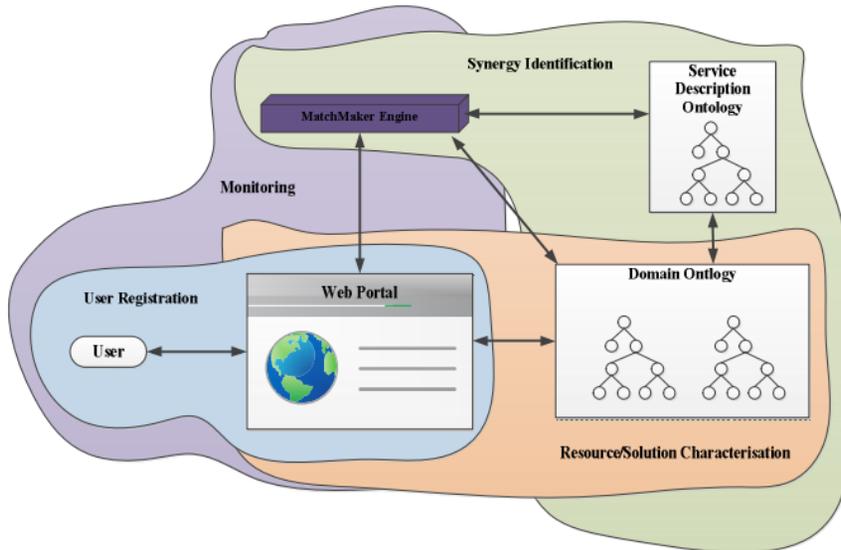


Source: Alvarez, R., and Ruiz-Puente, C. 2017: 1524

Another case will be explained in this paper is called as "eSYMBIOSIS - Development of knowledge-based web services to promote and advance Industrial Symbiosis in Europe". The aim of eSYMBIOSIS, a project funded by the European Union, was to create a web-based platform to support industrial symbiosis. Thus, automatic matching would be made between businesses similar to their economic and environmental objectives, and communication between the parties would be

established. As a result, it is expected that the amount of waste generated by the raw material / natural resources used will decrease.

**Figure 5. Structure of eSymbiosis Platform**



Source: Ceceljaa, F. et al. 2012:13

According to Ceceljaa, F. et al. (2012: 13) the eSymbiosis service supports all the functions of IS operation as shown in Figure 5. These are:

- The user registration via a web portal (activities of organization and contact information)
- Resource/solution characterisation (resources used in production, produced waste resources, processing Technologies)
- Synergy identification and input-output matching (matching the user description ontology eith all other use population)
- Monitoring of IS operation and reporting (user reports details of realized exchange operation periodically)

## 6. Conclusion

In its current form, the continuation of production and consumption habits is not considered sustainable. Considering the destructive effects of global warming that make itself felt more and more every day and the scarcity of natural resources, the current linear economy understanding should be abandoned immediately. The production and consumption volume and methods, which are much higher than the world's carrying capacity, have pushed global citizens, especially scientists, to

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new searches of innovative approaches. Circular economy is one of the concepts that have recently started to come into the agenda quite widely. Transition to the circular economy, which can be summarized as efforts to keep resources in use as much as possible with different approaches and business models, is a painful process. Current production technologies and the profitability of economies of scale show resistance on the supply side. The fact that consumers do not complain about the current structure encourages the supply side to continue in the linear economy model. In this context, a planned approach is required. The process of transition to circular economy can be handled on a regional basis. It would even be more correct to do so. Because each region has different characteristics, it will be more efficient if the vision and strategies to be developed are specific to the region. It is vital to define the potential and stakeholders for the circular economic structure for each region, regardless of its scale. In addition, discovery of possible exchange relations between stakeholders and informing and encouraging the stakeholders on the issue will also accelerate the process.

In this study, the issue of circular economy is discussed in general terms and it is tried to express how important the use of relational database is in transition to circular economy. For this purpose, two examples are given in general terms. When the literature is examined, it is seen that the relational database issue is mostly handled with the software dimension. However, the definition of potential collaborations and exchange relations within the region using a relational database is a separate topic that needs to be studied, and in this sense, it can be said that there is a gap in the literature.

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