

Circular Economy in Industry: Some Insights and Directions to Implement Circularity

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Abstract

This work presents a study about the circular economy concept, based on the interest to understand how industries can adopt an innovative business model at the same time the environment's conservation and the equilibrium between human beings and nature is promoted. This topic clearly includes both engineering and industrial management principles and that was seen as an opportunity to study the circular economy and its influence on enterprises, Portuguese ones in particular, but not only. The main idea was to gather the existing information, analyze it with practical examples of its application and comprehend how an interested industry can start applying it. The particular case of a Purchasing Department of a Portuguese company was used as test-bed. The main contribution of this work can be seen as a short story about Circular Economy, for non-familiar readers, as well as some directions for implementing circularity, in industry.

Keywords

Circular economy, Industry, Linear economy, Purchasing department.

1. Introduction

Planet Earth is starting to show some signs of weakness, so more people try to think about how it has been treated over time. After the Industrial Revolution and bearing in mind the rapid pace at which technology and science are evolving, are we paying enough attention to what surrounds us? Are we contributing to a sustainable – or even more positive than that – development? Is not this an appropriate time to try understanding which new business and management opportunities are within our reach?

The circular economy concept is becoming stronger over the last few years and it results from the critical analysis one can make about the way the world is developing. This idea is opposed to the linear economy concept, which is applied and unquestioned by most people and enterprises. Circular economy aims at supporting our planet and ourselves.

Our planet is not getting bigger, but its population is increasing as is the consumption per capita, which is leading planet Earth to an unbearable situation (Foster et al. 2016). Moreover, in a world where resources are not unlimited, prices are becoming higher and unstable and disruptions in the supply chain are more common, which brings uncertainties to many aspects of our everyday life (Geissdoerfer et al. 2016). The production model practiced from the 18th century onwards, after the Industrial Revolution, when productivity and the level of production rose substantially, has led to an alarming situation, both environmentally and financially speaking (Foster et al. 2016). Since that time, the use of finite resources has gone up only (Lacy and Rutqvist 2015).

Nowadays, production follows a linear model of continuous depletion of natural resources: taking, making, disposing. This model is being looked at with worries and more and more we see people willing to try and change things (Leitão 2015). In addition to population and Gross Domestic Product (GDP), primary energy use, water use, stratospheric

ozone, surface temperature, ocean acidification, tropical forest loss and terrestrial biosphere degradation, besides other indicators, are also increasing dramatically (Santiago 2016). The current socio economic development is having serious impacts in living systems and in the way the economy works.

The following sections provide, by this order: a description about the present situation and the concepts for the future (linear economy versus circular economy), the key aspects about circular economy in industry; a real case reflecting circularity in practice, and some major conclusions about this study.

2. Present and Future

2.1 Linear Economy

The millennials, people born roughly between 1980 and 2000, are, in a general way, unsatisfied by nature. While some years ago people stayed in the same enterprise for years, despite its adverse conditions, for example, nowadays instantaneous satisfaction is becoming more appreciated and people leave situations that are not seen as good enough much quicker than before (Stein 2018). That has its advantages but also its drawbacks. It makes people thrive for better and take risks, but obstacles are easily not overcome, but contoured.

People became much more powerful during the last decades. They started realizing the major influence they can have on other people, in the market and in the industry environment. This power can be used in an effective way and there is more room to be creative, to have influence on others, to fight for the causes people believe in. If anything is wrong and if this generation believes this, then probably a change will come.

Up until the 18th century, production was slow, not intense and of low volumes. That did not make most of the people think about its effects on the planet and on the enterprises, themselves. From that point in time on, production grew intensely and the impact on the environment became more evident. From 1900 to 2000, the production of solid residues in urban areas grew more than 10 times. This translates into a rising danger for ecosystems and human health. The linear economy is associated to the geographically uneven distribution of wealth. Industrial nations, which are more developed regions, used to have an abundance of resources. Because of that, when comparing human labor to material's costs, normally human labor was more expensive, so resources were used more easily. Material was cheap and labor expensive and thinking about sustainability of resources was not present in the equation, because that was not the cause of worries.

According to the European Commission, take, make and dispose has been the natural flow. Resources are extracted, goods are made and sold and everything that is not needed is disposed (both at the time of the product's creation and at the end of its short lifecycle). Creation of value was associated with the maximization of products sold, so production was fierce, as was competition between firms. While resources were available, and demand was stable, there were no concerns about these topics, but demand has been increasing a lot during the last years and resources are becoming scarce. Moreover, humankind is shifting from the densely populated and industrialized nations and is heading to the emerging markets. That means that mid class consumers are augmenting and so is consumption. Prices are going up and becoming volatile, competition is increasing even more, and companies are starting to face some serious difficulties.

This pace needs to be entirely replaced by "positive development" in which markets work to automatically, systematically make things better both locally and globally." (Greyson 2018). That is the idea behind the circular economy. At the end of the day, we are all connected. Everything is connected.

2.2 Circular Economy

The circular economy is one of the latest concepts associated with this effort to make things better and comes as an opposition to the linear economy. The idea is not only to not harm the Earth, but to be a positive force.

The circular economy is based on many concepts which have been developed over the years and that are continuously gaining importance, as well as the circular economy itself, such as (schools of thought): sustainability, biomimicry, blue economy, cradle-to-cradle, industrial ecology, natural capitalism, regenerative design, etc.

Circular economy is basically the sum of all the concepts mentioned before. Outputs are transformed in inputs; waste is a resource, no longer "just waste". This simple phrase quite well describes one of the circular economy's principles (Lazarevic and Valve 2017). The circular economy defends that output that is waste should be transformed into inputs, meaning that no waste is actually produced and so a loop is present.

This model of economy is restorative and regenerative. It is based on the value of circles: the power of minor/ inner circles (minimizing comparative material usage), the power of long circles (maximizing the number of consecutive

cycles and/ or time in a cycle), the power of cascade use (diversifying reuse across the value chain) and the power of pure circles (increasing material productivity) (Santiago 2016).

Circular economy is about effectively using materials, saving costs, developing new markets or growing into existing ones. It is about innovation and understanding that “when one tugs at a single thing in nature, he finds it attached to the rest of the world” (John Muir, Scottish naturalist and preservationist). The idea is to boost industrial competitiveness and job creation, while defending the planet and enterprises.

In 2014, about 30 scientific papers were published about the circular economy; two years later, this number exceeded 100 (Kirchherr et al. 2017). This is just one more proof of how much the concept is gaining momentum.

3. Circular Economy in Industry

Businesses must face the circular economy as pivotal. There are simple things that can be promoted easily, like recycling or promoting reutilization of old things, but there is more to it than this. Contests can be held, for example, where people are encouraged to use a set of things to create something else. The company could organize an annual competition and see their employee’s creativeness be applied, for example, trying to make it more usual to think outside the box.

Lifecycle thinking is needed, and designers should be more involved with material experts, scientists, manufacturers and recyclers to develop designs that include the circular economy concept. Knowledge is clearly power and different expertise is needed. Greater transparency is needed across supply chains to ensure that material can be tracked and recaptured successfully.

One enterprise should look at their surroundings and really pay attention to what is available locally, at what is possible to reach if a collaboration with other enterprises is begun.

Manufacturers should think about themselves as collaborators and deliverers of performance and not only as product makers and sellers. Science, technology, engineering and mathematics need to work together, more than ever. People need to be informed about the advantages of the application of the concept, so it is valued and seen as crucial. Marketing reaches people, good marketing can make a difference. It is important to inform about what is behind the decisions a company makes.

It is undoubtedly very important for an enterprise to know how to apply the circular economy, but this will not be totally successful unless customers value the idea. It is crucial to work in both things: the application itself and the acknowledgment of its importance.

Not so long ago, recycling started to be taught at school in Portugal. It was natural to witness kids teaching their own parents about its importance, about how important it is to not throw garbage into the ground, for example. Another great trend that is rising has to do with vegan choices. Because people believe these things, they are changing their habits, they are changing things. The behavior of others, the way the information reaches the consumer, the immediate costs and benefits, the promotion of sustainable ways, among others, are crucial factors. Consumers, who have a huge influence on each other, need to be informed and understand the advantages of applying this concept.

We should look at this relatively new way of thinking not only as a way of minimizing negative environmental impacts, reducing ecological footprints, neutralizing emissions and improving resources’ efficiency, but also as a radical innovation that does not aim only at transferring problems into the future by slowing the pace of our actions. The objective is more ambitious: the idea is to bring benefit, operational and strategical, micro and macro economically and at the product, process and business model levels (Leitão 2015). 3 R’s (reduce, reuse and recycle) are no longer enough; we should instead think about reducing, reusing, recycling, redesigning, remanufacturing and recovering (Winans et al. 2016).

Even though companies play an important role in the application of the circular economy, governments have a big influence on it as well and laws and regulations strongly help to put some actions into practice. Policy interventions become crucial enablers. Today it is still much more attractive to most of the companies to follow a linear model economy and that is why many governments start to promote incentives to make that financial advantage less pronounced (Lacy and Rutqvist 2015).

Frans Van Houten, Philips’ CEO, states: “At Philips we strive to make the world healthier and more sustainable through innovation. Our goal is to improve the lives of three billion people a year by 2025. For a sustainable world, the transition from a linear to a circular economy is a necessary boundary condition. A circular economy requires innovation in the areas of material, component and product reuse, as well as related business models. By using materials more effectively, economic growth will eventually be decoupled from the use of natural resources and ecosystems. In such an economy, the lower use of raw materials allows us to create more value.”. Renault also looks forward to reinventing the future of mobility through the application of the concept. Paul Polman, Unilever’s CEO, defends that “The concept of a circular economy promises a way out. Here products do not quickly become waste but

are reused to extract their maximum value before safely and productively returning to the biosphere. Most importantly for business leaders, such an economy can deliver growth. Innovative product designers and business leaders are already venturing into this space.”

In the United States of America, we may find the “Ecovative Design” enterprise. These are producers of packaging that can be totally composted at home by the buyer. Its founders found inspiration observing the way mushrooms bond the wood chips together and now sell packaging based on that. Eco-design is the basis of the enterprise (“Growing alternatives to petroleum-based packaging”). IKEA is considering the idea of leasing kitchens instead of selling them. Steve Howard believes this is the way to reach a smarter consumption path in the retail sector, while it makes people less attached to ownership.

4. Circularity in Practice

Circularity can be applied in industries. It is quite common to find different departments when comparing companies, but, in a general way, they are quite similar. We may find, for example, the departments of human resources, finance, marketing, logistics – internal and external, purchasing, research and development, maintenance, supply chain, manufacturing operations and engineering, quality, facility management and information and technology. It is easy to understand that the concept of circular economy has implications in most of those departments. Human resources need to be able to recruit people who value the topic and also encourage people to think about it. Marketing has a key role making customers aware of the advantages of the circular economy. On the other hand, suppliers who follow these principles should be valued and the maintenance team should be prepared to this new way of thinking.

What can the purchasing department, in particular, do to improve one enterprise’s circularity?

4.1 Purchasing Department

The technical purchasing department at Bosch Building Technologies makes the bridge between engineering and suppliers. The department where technical buyers work is called “Purchasing Engineering”. When a new project is conceptualized, this department becomes responsible to guarantee that the different tests that assure the future good functioning of the product can be made; for that, it needs to make sure that the correct material is available when necessary and in the right quantity. Besides that, the department is also responsible for choosing the suppliers for each component for mass production, agreeing the conditions in which the material will be bought in the future.

It is important to clarify that, for a new project, it is usual to work with catalogue components (already produced in the market and with a supplier part number associated to it) and customized ones. A customized component is made specially for the project and technical specifications are needed to specify the needs of that precise part. For these, the quality department has an increased importance. Technical buyers ask for their support for product and process validation and approval.

In the development phase, catalogue components are normally bought from distributors because, even though prices are slightly higher when compared to buying directly from suppliers, this resource more easily guarantees lower lead times (LT). When a company works in technological products, time is a crucial factor, because the company needs to make sure that the product is of higher value at the time it reaches the market. Because of this, its development must be complete as soon as possible. Moreover, it is easier to find minimum order quantity (MOQ) values that fit the actual demand in the distribution and not from suppliers directly. Because the department deals with testing phases, the needed quantities are smaller than the ones predicted for mass production and if a very high quantity was to be ordered, inventory costs would go up as well as the risk of having obsolete material in house.

Customized components involve, in most of the cases, the construction of tooling and machines that, being the company’s property, are in the supplier’s facilities. To make sure that these are used for the company only, a contract of loan is signed, where it is left clear that the material is the company but is located outside of its installation so that the supplier can build the part. The suppliers need to sign a template in which they compromise not to disclose confidential information concerning the project.

Requests for quotation (RFQ) are sent to a certain number of suppliers and are then received and analyzed. The company has an official platform to receive quotations. That way, all quotations are gathered and accessible to those of right and it is easier to prevent hackers to intercept e-mails exchanged between the company and suppliers.

Based on the estimated price and forecast for a certain part, it is known in advance that the purchasing volume is within some values. Requests for quotations are made based on the annual forecast and normally include several MOQ options, because, that way, it is easier to reach the best relation price-quantity. It is important to note that some material has an expiry date and that the costs of keeping stock also count.

With the most competitive suppliers for each reference, buyers must try to negotiate, mainly when talking about customized references. Based on the results and the total cost of ownership (TCO), the best option is selected, and the supplier is awarded. In most of the cases, the buyer tries to add possible second sources, so that if something happens with the main supplier, another can supply the material. Because of that, the basic conditions must be ensured. This includes the compliance with REACH and ROHS, norms that refer to the control of substances used in a certain product.

This concern is also present in the process of buying material. Buying it cannot result from one person's work alone. When it is necessary to buy something, one person does a shopping cart (SC), that is approved by one or more people (depending on the total value) and another person must convert the SC into a purchase order (PO). Moreover, if the PO is altered afterwards, this change needs to be approved as well. The four-eyes rule is, this way, applied. One person cannot buy material alone.

When all suppliers are selected and approved, the conditions (like price, lead time, minimum order quantity, standard packaging quantity and incoterms) are established and the environmental compliance assured, another department becomes responsible of placing orders, based on the forecast of the product. The technical buyers' department is only responsible for the development phase of the project.

Purchasing engineering members are divided into projects. Projects may be completely new or a change of an already existing product. In the first case, it is more common to deal with more new references, but in both cases, it is natural to have a bill of materials (BOM) with a lot of material that is already used in the plant. To understand if the reference is new or not, one shall look at its status in SAP. The status indicates if the component exists or not, if it can be ordered, if it is awarded to a certain supplier, if environmental compliance is checked, if it is in the tool building phase, blocked, to be discontinued and so on. Depending on the status of the material, the tasks to overcome are different. The status which normally implies more work is when a material is new.

4.2 Suggestions for Circularity

If the circular economy is to be put into practice, all the involved people must be informed and understand its importance. The leadership question is crucial. People need to understand its advantages and work towards a common goal. It is not enough to have managers acknowledging something if the workers on levels below do not value it. On the other hand, it is not sufficient to have workers that believe in something if managers do not do it.

Each department has its set of responsibilities and tasks, but they are all interconnected and able to influence each other.

In the purchasing engineering department, concern about the environment is already present; the company asks for compliance regarding REACH, ROHS and ROHS Future. One way to include the circular economy concept is to add it to the compliance report. This does not mean it should be mandatory for every supplier to have a certificate, for example, but to have an idea of those who are trying to apply it and briefly comprehend how. That could also have impact in the decision of what suppliers to contact for a certain reference. Imagine that for a certain reference, we look at the material group and find out there are 15 potential suppliers. Let us also imagine that, considering the expected purchasing volume, 3 suppliers must be contacted. The decision of which suppliers to contact is not random, and the suppliers are rated according to a lot of aspects. These aspects include lead times, prices, quality records, compliance, incoterms, conditions of payment and so on. Circular economy could also be added to the equation here, giving enterprises that apply it a better value when compared to others.

Another way to show how the concept is given importance is to actually apply the concept, giving the example. Taking the influence power that the technical buyer can have, it would also be interesting to, in a positive way, challenge the engineering responsible to follow the concept. We have, over the course of this work, understood that there are simple things we can do that are related to the circular economy, but it is also clear that major changes will inevitably be needed, and those changes affect the development phase in the early phase, even before the technical buyers are involved in the process. The product itself must be thought of considering its immediate use and all that follows it.

The department of Research and Development has a very crucial role here. A new product must be thought of taking this concern into account since the very beginning of the development. On the other hand, the company shall be prepared to give incentive to repairing the equipment sold. The whole mindset must be changed, and departments need to understand the contribution they can have to the successful implementation of such a new mentality and way of thinking and doing things.

Now, there is still not a global European certification regarding the circular economy, specifically. However, that could be an interesting part of the solution for the future. A platform would exist to clearly inform all the concerned public about which enterprises include the circular economy into their processes and products and how they do it (this

could also be a source for inspiration for other enterprises). This way, environmental aspects could be improved and, more than that: belonging to the platform could become a competitive advantage.

5. Conclusion

The circular economy is a rapidly growing concept which is gaining momentum in a lot of everyday aspects, including the way enterprises work. It includes a mentality change and the understanding that we will need to change the way we are developing. It is not only a matter of maintaining the environment healthy, but also a way of increasing competitiveness, reducing risks, dependency and unaffordable price. It is a way of creating more jobs and preparing for the future, considering the unsustainable way human race is evolving.

Some practical examples were given, with the aim of inspiring towards this idea and a practical case was presented, with the goal of critically analyzing how one's job may include this disruptive way of thinking. Interesting future developments would be the clear application of the concept throughout the company and the critical analysis of results. Our consumer reality is changing. People look for personalized products. Millennials buy online very easily and look for specific things, making the goods selling world come closer to the service-providing one. Moreover, there is a growing trend of people being concerned with the environmental and with the way they influence it.

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Biographies

José Vasconcelos Ferreira was born in Portugal in 1960. He received the M.Sc. degree in operational research and systems engineering from the Technical University of Lisboa, Lisboa, Portugal, in 1989, and the Ph.D. degree in engineering sciences from the University of Porto, Porto, Portugal, in 2005. He is an Associate Professor of Industrial Engineering and Management (IEM) with the University of Aveiro, since 2013, where he teaches since 1997 (Statistics, Logistics, Multivariate Data Analysis). He was Director of the IEM doctoral program, IEM graduate program, Member of the Department of Economics, Management and Industrial Engineering Council and Member of the Industrial Engineering Doctoral Program Council. He was Assistant Lecturer with the University of Porto. He is a member of the research unit on Governance, Competitiveness and Public Policies (GOVCOPP) working in the Decision-Support Systems' group. His research work focuses on systems engineering, logistics, multivariate data analysis, and operational planning at mass transit companies. He is co-author of several papers published in peer-reviewed publications and has more than twenty years of experience collaborating with the main urban mass transit companies in Portugal. He works in partnership with a spin-off company dedicated to Transportation Planning and Optimization.

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