A Systemic Circular Model for innovative sustainable recycling of thermoplastics

Modelo Circular Sistêmico para reciclagem sustentável inovadora de termoplásticos

DOI:10.34117/bjdv10n1-016

Recebimento dos originais: 01/12/2023
Aceitação para publicação: 03/01/2024

Gianlauro Casoli
Master of Science (MSc) in Sustainability
Institution: Research Lab on CSR, University of Parma
Address: Via JF Kennedy 6, 43125 Parma, Italy
E-mail: gc@ethicalfin.com

ABSTRACT
Sustainable recovery and recycling of plastics is becoming an increasingly important global issue. Waste from the plastics industry has seen an exponential increase, which is expected to continue in the future. Currently, the majority of the plastic waste generated is discarded and the gap between the amount of plastic waste discarded and incinerated compared to recycled is huge. Closing this gap requires addressing many systemic issues in the value chain through a more holistic, complex systems approach that better understands the different values, norms and behaviours intrinsic in patterns of relations between key stakeholders. Taking a complex systems perspective necessitates the advancement of new innovations and a more circular model for the recycling industry. It highlights specific innovations that provide disruptive ways to design and develop processes and products that go beyond traditional recycling technologies and systems to find new cost-competitive uses for plastic waste streams that are currently too expensive or not convenient to process. The work outlines a circular model for the plastics value chain to support these innovations. On the one hand, it focuses on increasing the level of global awareness and changing the mindset of society to move away from plastics and towards more innovative solutions. And on the other hand, it promotes legislation and financing that motivates companies in the plastics value chain to scale and grow these innovations. Such a circular model will not only ensure more sustainable production and consumption of plastics but provide a paradigm for addressing other global challenges.

Keywords: circular economy, systemic thinking, innovation, plastic and recycling industry, cultural change.

RESUMO
A recuperação e reciclagem sustentáveis de plásticos está a tornar-se uma questão mundial cada vez mais importante. Os resíduos da indústria de plásticos registraram um aumento exponencial, que se espera que continue no futuro. Actualmente, a maior parte dos resíduos plásticos gerados é descartada e o fosso entre a quantidade de resíduos plásticos descartados e incinerados em comparação com os reciclados é enorme. Para colmatar esta lacuna, é necessário abordar muitos problemas sistêmicos na cadeia de valor através de uma abordagem mais holística e complexa dos sistemas, que compreenda melhor os diferentes valores, normas e comportamentos intrínsecos nos padrões de
relações entre as principais partes interessadas. Adotar uma perspectiva de sistemas complexos requer o avanço de novas inovações e um modelo mais circular para a indústria de reciclagem. Destaca inovações específicas que fornecem formas inovadoras de projetar e desenvolver processos e produtos que vão além das tecnologias e sistemas de reciclagem tradicionais para encontrar novos usos competitivos em termos de custos para fluxos de resíduos plásticos que atualmente são muito caros ou não são convenientes para processar. O trabalho define um modelo circular para a cadeia de valor dos plásticos visando apoiar essas inovações. Por um lado, concentra-se em aumentar o nível de consciência global e mudar a mentalidade da sociedade para se afastar dos plásticos e avançar para soluções mais inovadoras. E, por outro lado, promove legislação e financiamento que motiva as empresas na cadeia de valor dos plásticos a ampliar e desenvolver essas inovações. Esse modelo circular não só assegurará uma produção e um consumo de plásticos mais sustentáveis, como também proporcionará um paradigma para enfrentar outros desafios globais.

**Palavras-chave:** economia circular, pensamento sistêmico, inovação, indústria plástica e de reciclagem, mudança cultural.

1 INTRODUCTION

The recycling sector and its related markets are one of the most turbulent and nowadays the most strategic areas for the recovery of thermoplastics after its first use and for the conservation of the environment and resources. One of the main problems faced globally by the industry is the higher cost of recycled plastic materials compared to virgin plastic from fossil fuel combined with a very low recycling rate. The situation is compounded by a huge general paradoxical mismatching between where plastic is discarded, basically in the western area of the world, and where plastic is recycled, primarily in Asia. In addition to that, there is a considerable conflict between the main stakeholders in perspectives and objectives. Oil and gas companies are interested in increasing the production of thermoplastics, as opposed to the governments and NGOs that try to promote less usage, production, and consumption.

The recyclers are primarily guided by a linear, cost and profit-oriented mentality without any social or environmental considerations. This reduces the incentive to properly recycle plastic waste, particularly waste that is contaminated or mixed with other materials and is therefore not as profitable to recycle or align to certain characteristics that the market requires. The situation is getting more complicated as new regulations around the globe and in Asian countries disrupt traditional business models for recycling. Adding to this, there is an evident shortage of proper infrastructure for collecting and
sorting the used plastics not to mention technical and environmental issues regarding mechanical and chemical recycling of thermoplastics.

To address these articulated and complicated points and overcome these barriers, new innovations and a new circular model for the recycling industry are required. So, the necessity of presenting a complex system approach grounded on circular thinking and the analysis of the dynamic patterns of relations in play among the different stakeholders in the considered context (governments, consumers, producers, recyclers and so on) is paramount. This allows, in connection also to a set of basic systemic holistic indicators, a more evident and emerging awareness of the interdependence of actions and decisions and a better understanding of the impact of these actions on other actors.

In this regard it is exposed, as an exemplification, an innovative start-up with possible tremendous potentialities in contributing for a change into a more circular and sustainable way the recycling sector. This company can regenerate unsorted residual municipal general waste (i.e. a mixture of organic garbage, different kinds of plastics, wood, paper and so on, with the exception of minerals, metals and PVC) into new highly recyclable thermoplastics material for different industrial usages distinct from traditional type of plastics. This new process not only allows the solutions of the collection and the sorting phases in the recycling operations, but more than that, is able to manage the vast majority of the garbage present in society and deposited in the landfill.

All of this provides opportunities to identify gaps within the current system and to arrive at circular solutions that disrupt the status quo in a way that creates more systemic and holistic change.

2 A SYSTEMIC ANALYSIS OF THE PLASTIC VALUE CHAIN

As mentioned in the introduction the situation in the recycling market is so complicated due to a widespread cost linear effective mentality, in particular in the developing countries, that leads to consider only certain types of plastic scrap that are economically viable to recycle according to market demand. In the specific, more than 60-70 percent of plastic scrap is colored but the majority of the requests are for natural colored plastic waste and so this situation creates many other issues in the recycling process as the recyclers are focused on plastic waste stream that are more profitable rather than on greater general recovery of plastic waste (Wong, 2020).

Also the recycling sector is strongly connected with prices volatility. The plastics market is tightly connected to the market for crude oil. Fluctuations in the price of oil
have a direct and significant impact on the price for virgin and recycled plastics, affecting the business model of recyclers\(^1\). This is combined with no innovation and lack of stringent local and international legislation to regulate the recycling processes and promote compulsory use of improved recycling methodologies to treat end of life thermoplastic products, in particular industrial packaging.

In spite of a huge capacity in terms of recycling facilities, which are mainly concentrated in S/E Asia countries with more than 20,000 recyclers, a lot of plastics that are apt to be recycled are not, in addition to the recycling materials unsold (Wong, 2020). The main reasons for this are the high cost of the recycling process itself and the characteristics of the related market with a total dependence on oil price and the type of demand that is focused only on certain types of recycled materials. As a result, a lot of sorted and unsorted materials globally go to landfill, incineration, burning for energy or scattered into the environment.

In the developing countries, in general, there is a lack of proper and adequate formal waste management infrastructures with no municipalities that pick up local trash, but only scavengers and informal workers. On the other hand, developed countries are equipped with materials recovery facilities (MRF), and after sorting, plastics materials or scraps are sold in the domestic market, where is able to absorb them, or abroad depending on their prices, types, and demand. The majority of plastic scrap present in the developing countries is waste imported from the developed ones (Wong 2020). Therefore a spatial difference has emerged between the primarily collection and processing of plastic waste created in Western countries and where is mainly shipped and recycled: in the Asian ones.

However, recent import/export regulations and policies in Asia have been implemented, in particular the Chinese initiative in 2017 for the worsening environmental conditions, the National Sword, to no longer accept shipment of mixed trash, wrong or low-quality recyclables, or plastic scrap in addition to stopping import licenses and further restrictions on recycled plastic pellet import from September 2020 (Wong, 2020). All of this has put pressures on plastic recyclers and have changed the dynamics of the recycling industry creating stronger movements firstly toward the other Southeast Asian countries like Malaysia, Indonesia and Thailand and then, after these countries have taken stronger steps to reduce the amount of polluted waste, to less regulated countries with

---

\(^{1}\) Plastics for Change: Why are plastic recycling rates so low? (2021) Available at: https://www.plasticsforchange.org/blog/category/why-are-plastic-recycling-rate-so-low
high rates of plastic waste mismanagement like Cambodia, Laos, Myanmar, Eastern Europe and Turkey, as well as Africa and Central and Latin America (Wong, 2019).

In addition, there has been pressure from regulations in Western countries. In Europe, European Directives and trade laws within different countries regulate the import and export of waste. The strictest trade international regulation is the Basel Convention, which prevents the transfer of different forms of hazardous wastes from developed to developing countries. An introduced amendment, focused on the transboundary movement of plastic waste, took effect in January 2021, placing further restrictions (Wong, 2020).

But these increasing regulations are not properly discriminative coordinated and systematically connected with other measures (i.e. creating local and international compulsory legal framework for the usage of recycled materials) and have produced shortages of plastic scrap in the global supply chain.

These greater restrictions have caused traders to decline to accept any waste shipments and have induced volume challenges for plastic recycling. In addition, recyclers face increasing penalties for circumventing rules, so they are less inclined to take risks and make more critical decisions about investments in their recycling operations (Wong, 2020).

The dynamics of the present situation in the global recycling industry is displayed in the simplified model in Fig. 2.1. The figure underlines the total dependence of the sector on oil prices and the huge inadequacy of the recycling industry to deal with the issue of plastic waste. The central reinforcing loop that brings a constant and increasing
amount of plastics to landfills is mainly influenced by the low price of oil that enables very cheap and competitive virgin plastics compared to the recycled ones. And so this produces less demand for recycled materials from the brand owners and manufacturers and less supply from the recycling outlets in the East and in the West. This in turn affects the quantity, quality, and the type of recyclable materials sorted and diverted from landfills by MRF, scavengers and informal workers and delivered to recycling outlets. The result is an increasing amount of the majority of local waste that ends up in the landfills.

2.1 THE NECESSITY OF CULTURAL CHANGE. A SHIFT IN THE PATTERNS OF RELATIONS

In order to comprehend how systems function, why they produce poor environmental and socioeconomic outcomes, and how those problems can be treated, it is necessary to understand the cultural heritage that is underlined and implicitly manifested in them and modify it creating a shift in the patterns of relations.

People form organizations, economy and society as complex systems embedded with different values, norms and behavior intrinsically mashed up, connected and framed in patterns of relations that shape the dynamics of the performance, in terms of quality, of the entities they create at different interrelated levels.

The framework of the systems is the element on which it is possible to intervene to create cultural change and what follows are its relevant characteristics (Doppelt & MacDonough, 2017):

- **Purpose/Motivation/Mindset and Approach:** Every system has a central purpose and approach (implicitly connected to its motivation and widespread mindset) that defines it as a discrete entity in relationship to the larger system in which it operates. The purpose of a system is defined by the system as a whole, not by any of its parts.

- **Integrity of the parts in order to achieve purposes:** The key pieces of a system can be removed without undermining its overall functioning; the pieces are part of a collection, not a system.

- **The way the parts are arranged determines the qualitative aspects of performance:** The level of integration of environmental, social and economic aspects defines if and how the system can achieve its purpose.
• **Interdependence and quality of actions:** As a consequence of the above point, it follows that the core components of a system form an interlinked set. In essence the interactions among the parts are controlled by rules that define how the system operates.

• **Feedback processes:** They are at the core of the functioning of a system, and they define the capacity of the system itself to operate and to pursue their aims. Left on its own, the system will seek to maintain equilibrium by retrieving and incorporating information from the external environment that allows it to make adjustments aimed at achieving its purpose.

For the purpose of creating cultural change that leads to systemic transformation in the framework of the systems, it is necessary to take into account some basic postulates (Sharmer, 2020):

• **It is not possible to deeply understand systems unless there is an intention to change them**

• **In order to change the systems, it is necessary to transform the mindset:** To create a shift it is fundamental to act in the systems at every level (structures and organizations, qualitative action and performance, paradigm of thoughts, purposes, approaches and motivations, feedback processes) together with a transformation of mindset that is the source of real change.

• **It is not possible to transform consciousness unless the systems are made aware of themselves:** It is important, as a means to avoid the decoupling between intentions and actions, that systems not only have to see themselves but also have to be deeply aware of the processes that are in play in them.

Therefore, a close relation exists among systems change, transforming consciousness and awareness as a consequence of creating cultural change. Through an increasing consumer sentiment for environmental issues, corporate commitments, anti-pollution regulations and the rising of new forms of finance and new business models, a global awareness is emerging as a stepping stone for creating cultural change. Market demand for recycled plastic has moved from niche to the new norm as a trend but the supply channels for this dormant demand are far from adequate. This is the reason for its inefficiency and high input costs together with a low-quality standard of feedstock (Woodring et al., 2021).
2.2 TAKING A COMPLEX SYSTEM PERSPECTIVE

In order to implement and develop the close relations above mentioned between systemic change and transforming mindset and awareness, a proper approach is paramount. In taking a complex system perspective there is the realization of the nature of socio-economic interconnections as a non-linear synergetic process in a dynamic non-equilibrium of chaos within order, order within chaos similar to biological systems (Casoli & Ramkumar, 2020). And like them they lead to unpredictable consequences that in turn feedback to influence individual actions in an endless cycle of adaptation and evolution (Krakauer, 2019). Complex systems perspective is a core concept as it reflects implicitly the adaptive and dynamic characteristics of socio-economic realities as complex systems (organic and interrelated; relations which build self-organized behavioural framework; emergence processes; dependence on future evolution of present events and characterized by several causes) (Casoli & Ramkumar, 2020). This perspective is rooted in the circular economy as a participatory process. Its characteristics must be lined up with resilience, flexibility, and adaptability in order to create renewed and strong industries with multidisciplinary leadership and capabilities. This will support diversity, robustness and richness in the network of relations initiating a virtuous circle in learning from the processes of biological systems. And it requires considering not only external operations but also an awareness of the chain of cause and effect of one’s actions. Being aware of the interdependence of actions and decisions, and consequently understanding the impact of these actions on other actors, is capital in this perspective (Casoli & Ramkumar, 2020).

Alongside these premises, the role of circular innovation in conjunction with innovative legislation and finance is the evident manifestation and consequence of the cultural shift required in the recycling industry.

Innovation in the upcycling process of plastic scrap is expressed by integrating horizontally, standardizing and consistently customizing the entire process from the collection of different types of plastic to the conversion of mixed plastics into consistent feedstock that is free from impurities and has high integrity. At the same time collaboration and partnership with local communities, NGOs, product designers and brand owners is crucial. In addition, recycling technologies are necessary to enable standardization and digital traceability of the type of recycled plastic used (e.g., QR codes for plastic collected from the oceans by a network of various organized collectors - NGOs and local communities, etc. - that certifies where the plastics come from, and that enables
producers of industrial products to offer an upkeep service if the goods are damaged or broken). Using this perspective, it is possible to move from a product-centric to a life-cycle centric model (Sean, 2020).

In this direction there is a need for suitable legislation, policy and governance at all levels, local and international, in collaboration with recyclers. This legislation should focus on requiring brand owners to use fully recycled plastics in packaging and bottles and to help create standards and formalization in a fragmented and chaotic sector, particularly in developing countries. The role of proper finance in underpinning innovation combined with accurate legislation is critical for the systemic change and coordination among the different stakeholders in building sustainable circular systems.

2.3 THE POWER OF INNOVATION: UBQ MATERIALS

Taking a complex systems perspective necessitates the development of more disruptive innovations in the plastic recycling industry. Such innovations must find new and alternative ways to recycle plastic, particularly non-recyclable plastics, and find new uses for this waste in order to redirect them into useful products for society in an economically viable way. Doing so will make these innovations more resilient to the systemic issues and shocks illustrated at the beginning of this section.

An example of such an innovation is UBQ Materials, a company that has introduced a novel material produced from waste. The company’s UBQ™ material is a bio-based thermoplastic produced using an advanced conversion technology. The inputs for the material are residual household waste streams diverted from landfills and transformed into a substitute for virgin plastics with applications across many industries.

A major problem with plastics recycling is the large amount of plastic waste mixed in general waste fractions, which end up in landfills. Much of this waste is difficult to recycle, as it is mixed with food residues or contaminated with general waste streams that make it expensive to sort, clean, and recycle. To address this issue, UBQ Materials developed a process that complements the traditional recycling industry and creates an additional closed loop in the plastics value chain (Barr 2020), (see Fig. 2.2).

---

2 An example in this direction is offered by the Malaysian Ocean Plastic recycling company Heng Hiap Industries with integrated traceability and digitization innovation. For more information https://henghiap.com/
The conversion and regenerative process used by UBQ Materials takes unsorted residual waste streams (with the exception of mineral, metals and PVC that are separated from the main waste stream and sent to recyclers) containing plastics and other wastes (food, garden waste, dirty paper & cardboard, unrecycled plastic waste, etc) headed for landfills and breaks them down into their natural components. A series of steps with pressures and designed temperatures, the highest at 220 degrees, that include sorting, shredding and shearing, and other processing conditions, break down these waste streams into their natural components: lignin, cellulose, natural fibers, and sugars. The material then moves to the next stage (Barr, 2020, Bigio, 2021).

The organic elements are blended into metrics where the plastics components in the waste are melted, and some physical and chemical processes happen (polymerization, esterification, oxidation and caramelization). These reactions take place in continuous randomly mixed processes in different chambers that create specific reactions that occur and craft a robust homogeneous thermoplastic composite matrix with interconnected fibers. At the molecular level of these fibers, the sugars from the mixed waste are integrated to form a caramel cover. Therefore, UBQ Materials is a new composition of matter patented with a typical olive gray color (Bigio, 2021).

The material then is pulverized and transformed into strands for further processing. Finally, the strands are cut into round or cylindrical pellets and depending on customer requirements, coloring agents are added to pigment the material. The final

---

3 For this reason no further detailed technical explanations regarding the producing processes are possible.
outcome is then sold to manufacturers, who can use the pellets as a substitute for virgin plastic, concrete, wood and minerals in different processes (injection molding, 3D printing, extrusion, compression, etc.) to produce a variety of final durable industrial goods (Bigio, 2021). UBQ™ can be compounded with additives commonly used in the industry to satisfy specific requirements such as strength or UV resistance and can be combined with the most common polymers present in the market (such as PVC, PE, PS, PP, but not engineered plastics). When it is mixed with them it sticks perfectly, keeping the balance of the other polymers and so it does not contaminate the recycling batch (Bigio, 2021). This is because UBQ™ is not a polymer chain but a fiber and a composite new material, so it can be combined in different ways without being affected (the plastics elements are in it, but typically they are not a huge amount). So, it is completely recyclable within the current recycling stream, unlike other bio-based plastics that have an impact on the recycling process.

In addition, UBQ™ itself is fully recyclable, but not biodegradable, and is a more resistant material than plastic, capable of being recycled up to 5 times without degrading its physical qualities. Plastics tend to deteriorate every time they are recycled because the polymer chains start breaking apart, which is why recycled plastics have less quality than the virgin ones. Even if they are very clean and pure and they are recycled only once the quality drops with each recycling round. The material is a USDA Certified Biobased product, labeled to certify that the majority of the content within the material is bio-based (Bigio, 2021).

On the basis of the work (i.e. Orientation Theory) of Bossel (1997) an adapted simplified framework and short analysis are proposed to evaluate the viability and sustainability of UBQ materials. In this context the terms viability and sustainability are intended as the capability of the company to exist and to thrive over time also in relation to its ecosystem.

---


7 UBQ Materials (2021): What is UBQ? The UBQ Material. Available at: https://www.ubqmaterials.com/whatismubq/the_ubq_material/
This analysis considers six basic orientors in the list below, that are the variables that help the system to be successfully ingrained in its environment and create the fundamental structure to reach its aims and satisfy its ideals (Bossel, 2007, p.185).

- **Existence**: The system must be compatible with and able to exist in the normal environmental state. The information, energy, and material inputs necessary to sustain the system must be available.

- **Effectiveness**: The system should on balance (over the long term) be effective (not necessarily efficient) in its efforts to secure scarce resources (information, matter, energy) from and to exert influence on its environment.

- **Freedom of action**: The system must have the ability to cope in various ways with the challenges posed by environmental variety.

- **Security**: The system must be able to protect itself from the detrimental effects of environmental variability, i.e., variable, fluctuating, and unpredictable conditions outside of the normal environmental state.

- **Adaptability**: The system should be able to learn, adapt, and self-organize in order to generate more appropriate responses to challenges posed by environmental change.

- **Coexistence**: The system must be able to modify its behavior to account for behavior and interests (orientors) of other (actor) systems in its environment.

The evaluation of each of these variables must take into account economic, environmental, and governance aspects. We consider below these aspects to analyze UBQ Materials.

First from an economic aspect, the company has no debts and is entirely funded and has a very solid equity base. It started operating commercially in 2019 and has been closing a relevant number of contracts since then. It has a very strong R&D operation to continue its expansion thanks to the development of new advanced materials (e.g., with innovative biodegradable properties totally made from organic waste) and the improved functionality of UBQ material itself, in order to expand the portfolio of its applicability. This is operated internally and in cooperation with a strong network of research centres and universities. The company is about to complete the construction of a new plant that will raise the production from the current pilot facility of 5,000 tons/year to 75,000 tons/year granted by an investment of $75 million funded by corporate capital (Bigio, 2020).
Second, there are many positive environmental benefits of UBQ™. Since the production process diverts waste destined for the landfill, the material prevents the emission of methane, ground water leakage and other negative impacts. Based on a Life Cycle Assessment by Quantis, every ton of UBQ™ produced prevents GHG emissions equivalent to 11.7 tons of CO2, designating the material as “The Most Climate Positive Thermoplastic Material on the Market” (Barr, 2020), (see Fig. 2.3).

Figure 2.3. Life cycle environmental impact of UBQ™ (Barr, 2020)

The resources employed in the regenerative process are only renewable energy from solar panels, installed as a part of a grid in which the electricity generated is reciprocally shared with the local community. Its operations are set to deal with different kinds of mixed general waste streams based on the location the company will operate in. The composition of the stream will be adjusted in order to stick with the right proportion of the basic elements in the metrics to produce UBQ materials.

Energy consumption is only 15-20 percent of what is employed to refine petrochemicals to obtain from monomers the polymers chains for virgin plastics. The high temperature utilized, generally more than 300°C, is not suitable to produce UBQ materials, as it does not melt at that temperature. There is no combustion in the UBQ production process, since the maximum temperature reached is 220°C and the generation

of residues and effluents is equal to zero. The factory in doing its activity does not produce any noise or smell (Tuviah, 2020).

Lastly, the company’s organization is agile and flexible as it is at its early stages with the possibility to communicate and implement easily the major entrepreneurial decisions with a good level of synergy among the teams. The advisory board, composed of a Nobel Prize winner in Chemistry, a former European Commissioner for Climate Action, and worldwide sustainability experts, is very active and has a good mix of scientific as well as strategic and policy making perspectives (Tuviah, 2020). The UBQ ecosystem is articulated and composed of several different entities, starting with agreements with local waste suppliers to continue with research companies, fruitful academic exchange, local associations, and foundations that promote sustainability etc. For its advanced value proposition based on circularity and sustainability (see Fig 2.3) and the strong engagement of the Board of Directors and the Advisory Board in turning the company as an example of a clean, circular, and environmentally friendly entity, UBQ, albeit in its early stage, creates synergetic processes with other stakeholders in its environment, contributing to pushing ahead the agenda of systemic change and circular economy. UBQ is a certified B Corp and ranks among the top ten B companies in the world that are most engaged in environmental issues in their everyday business practices⁹ (Bigio 2021; Tuviah 2020). Table 2.1 below shows, on the basis of the dynamics of the main general economic, environmental and governance aspects briefly analyzed, the potential of the company to thrive and fulfill each of the six basic orientors presented.

Table 2.1 Grading orientor satisfaction

<table>
<thead>
<tr>
<th>Ec</th>
<th>Re&amp;E</th>
<th>Gov</th>
<th>av. gr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Eff</td>
<td>4</td>
<td>4</td>
<td>3+</td>
</tr>
<tr>
<td>FoA</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Se</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Ad</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Co</td>
<td>4</td>
<td>4</td>
<td>3+</td>
</tr>
</tbody>
</table>

Source: By the Author

⁹ https://bcorporation.net/2019-best-for-the-world
The numbers represent a score to rate how well a development path can be expected to satisfy each of the basic orientors for each aspect considered: 4.0: Excellent; 3.0: Good; 2.0: Fair; 1.0: Deficient; 0.0: Fail. For finer grading, minus and plus are also provided to modify grades for the better (+: add 0.3) or for worse (−: subtract 0.3) (Bossel, 1997).

It emerges clearly from the table that “existence”, “freedom of action” and “security” are fully satisfied for the characteristics of UBQ to be adaptable, flexible with an internal synergistic organization. There is a strong commitment towards circular and sustainable practices, not to mention the innovative technology, the peculiarity of its activity, its production processes, and its final products along with considerable R&D operations.

The variables “effectiveness”, “adaptability” and “coexistence” are not the maximum score, albeit very good, as the company is young and due to its early stage, the economic, technical and governance challenges and uncertainties ahead are many. However, the potential of the company to be one of the change agents in the recycling and plastic industry are very high, as they can strongly contribute to tackling the most urgent, global environmental issues such as climate change and plastic pollution.

The orientor star in Fig. 2.4. below makes the characteristics of the dynamic patterns, underlined in the table, more evident and easily discernible and gives an immediate indication of the viability and sustainability of the system.
3 A SYSTEMIC CIRCULAR MODEL FOR INNOVATIVE SUSTAINABLE RECYCLING

The model formulated (Fig 3.1) is the dynamic representation of what has been discussed in the previous sections and presents a new circular model for innovative sustainable recycling of plastics. *The disengagement of the recycling industry from the oil price is one of the most important explicit elements to allow a shift in the recycling market towards a more circular model.* However, a cultural change and the transformation of the patterns of relations produce effective systemic change that create integrated and innovative solutions.

![Figure 3.1 A Systemic Circular Model for Sustainable Recycling](source: By the Author)

The role of circular innovation among the main actors of the recycling industry plays a key role in improving plastic recycling and reducing waste. This emerges as a consequence of the systemic shift in mindset and an increased global awareness of the systemic issues in the plastics value chain discussed in section 2. These elements are introduced in the model with the reinforcing loop underlined in red. At the same time the other reinforcing loop highlighted in brown displays how proper local and international legislation and supporting innovative finance can compel greater recycling innovations. Creating a compulsory legal framework for recycled materials can facilitate greater recycling of plastics and a consequent disengagement from the volatility of oil prices. In addition, suitable financing can act upon and create conditions for a positive shift in the recycling market by providing the necessary capital to move towards circular innovations, of which one of the key examples is UBQ materials.
The global result in terms of waste management is displayed in a diminishing reinforcing loop diagram in which there is a reduction of local waste that in turn reduces the general garbage in the landfills around the world and the amount of waste processed in the developed and developing countries by MRFs, NGOs, scavengers and informal workers.

4 CONCLUSION

The paper outlines the growing problem of plastic waste, which has seen an exponential increase that is expected to continue in the future if the present situation will endure. The majority of this waste is currently discarded and only a small percentage of the waste is recycled. Though there are projections that recycling of plastics will increase in the future, a variety of systemic issues in the plastics value chain might present barriers and hinder this development.

The volatility of oil prices that challenges the business model for plastics recycling, inadequate infrastructure and linear cost/revenue mentality of recycling plastic waste streams and global regulations that limit the exchange of waste between countries all threaten to delay and hinder advancements in the sustainable management of plastic waste. To address these issues, a complex systems perspective approach is introduced to challenge and address the problems in the plastics value chain and outlined the need for more novel innovations that disrupt the current status quo as well as a circular systemic model for supporting these ones.

Out of the many innovations, UBQ Materials is highlighted, which shows the possibilities for a disruptive transformation of the plastics recycling industry. By developing a novel process to transform mixed waste fractions containing plastic that would end up in the landfill into a new material, this methodology complements the existing recycling industry and creates an additional closed loop in the plastics value chain. However, such disruptive innovations alone cannot address the systemic issues present in the plastics value chain. A circular model that takes a complex system perspective focusing on resilience, flexibility, and adaptability is required in order to create a cultural and systemic shift towards a more robust innovative plastics value chain. This will create virtuous cycles of learning, support and build a complex network of relations that allow a greater awareness of the chains of cause and effect of multiple non-linear actions to create more positive impact and reduce global plastic waste.
To support the development of innovations, it is necessary to increase the level of global awareness of the plastic waste problem and shift the mindset towards these new solutions. This requires a cultural change and greater societal action from stakeholders from all levels of society.

Additionally, it is necessary to promote proper international, national, and local governance for new solutions. Recent EU initiatives like the Circular Economy Package in 2015, the related 2018 strategies and 2019 guidelines and recommendations to tackle the plastic waste problem, the Circular Economy Stakeholder Platform, and the Green Deal plus the EU Plastic Recycling Regulation in 2022 are good and encouraging starting points. But there is a lot of room for more of these initiatives in regions around the world to encourage more collective action globally. Finally greater financing and legislation to facilitate new innovations is essential to scale and grow disruptive solutions that can transform the plastics value chain.

ACKNOWLEDGEMENTS

The Author wants to express his deepest gratitude to Tato (Jack) Bigio, Co-Founder and CEO of UBQ Materials and his staff, in particular to Dr Rachel Malka Barr, VP Sustainability and Sophie Tuviah, VP Business Development & Sales. Also a special thanks to Dr Steve Wong, President and CEO of Fukutomi Recycling ltd and a recognized worldwide expert on plastic scrap treatment. Their support and availability were fundamental for the results of this work.
REFERENCES


Bigio, T. (2020, Nov 20). Personal communication [Phone interview]

Bigio, T. (2021, Apr 12). Personal communication [Phone interview]

Tuviah, S. (2020, Dec 3). Personal communication [Phone interview]

Wong, S. (2020, Nov 4). Personal communication [Phone interview]