Chapter 11
Circular Economy in Practice: The Benefits of Collaboration for Securing Material Flow in a US Study

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Abstract **Purpose**—This paper aims to describe an amiable approach of addressing challenges to transitioning to a circular economy through collaboration and knowledge sharing between different partners.

Design/methodology/approach—The design science research methodology is used to identify the problem of the circular economy, suggest solutions, develop a usable artefact based on gathered user feedback interviews (n = 15) with US recyclers and industry experts.

Findings—There are two main approaches to navigating the circular economy, soft and hard methods. *Hard methods* include investing in **digitalization** and newer **technologies** to improve one's processes. However, these methods require an initial capital investment and high operation costs, which can deter many SMEs. *Soft methods* on the other hand, include methods such as **collaboration and sharing of knowledge**. These methods require no initial investments, but rather rely on the use of learning from partners to improve their processes and gather data to evaluate internal structures. These soft methods are explained in detail and an artefact has been developed to showcase these approaches.

Business and social implications—This article furthers ideas of the circular economy regarding collaboration to identify the right sourcing partner. This is of growing importance to meet regulatory requirements of increasing recycling quotas on specific materials like secondary plastic.

Originality/value—The developed artefacts of **material sheet** and **utility analysis tools** improve the transparency of reusable material flows. It has been proven for a global producer of reusable plastic packaging solutions operating in the US with state-specific recycling content requirements. It provides a decision-framework to secure sourcing of secondary plastic to acceptable costs, CO_2 reduction/sustainability and partner's fit.

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A. H. Verkuil et al. (eds.), *Core Values and Decision-Making for Sustainable Business*, Sustainable Business Development,
https://doi.org/10.1007/978-3-031-78361-6_11

Keywords Circular economy · Material flow · Recycling material streams · Sustainable sourcing · SME

Introduction

Businesses are increasingly confronted with the challenge of transitioning their business model to a more sustainable one. This challenge is accelerated by the rising prices of foreign primary materials and the need to adapt one's material flows to mitigate resource costs (Weber & Stuchtey, 2019). These types of challenges are common for enterprises and signify a paradigm shift towards the philosophy of **circular economy (CE)**. This is defined by Guldmann (2017) as "a systems model in which every part of a product is considered a valuable resource that should be carefully handled from cradle to cradle. This extends not only to the traditional supply chain, but also beyond that to consider raw material sourcing and disposal". However, there is still a misconception over what CE embodies as it is not an end goal, but rather a means to an end (Weber & Stuchtey, 2019). Therefore, CE must be seen as a subset of sustainability which has the potential to provide ecological and financial incentives for businesses willing to adopt sustainable business models. As regulations are increasingly being implemented requiring more recycling content, the subsequent price increase in primary plastic materials is shaping new long-term outlooks on circularity (Jonker et al., 2022). This shift in responsibility from simple raw material recovery to producer ownership is directly resulting in the increase in secondary plastic demand across impacted regions.

Figure 11.1 shows the changing responsibilities in circularity.

Theoretical Relevance

Underlying problems for CE are very intricate and difficult to surmise without a proper understanding of the theory behind CE. It is often not easy for businesses to

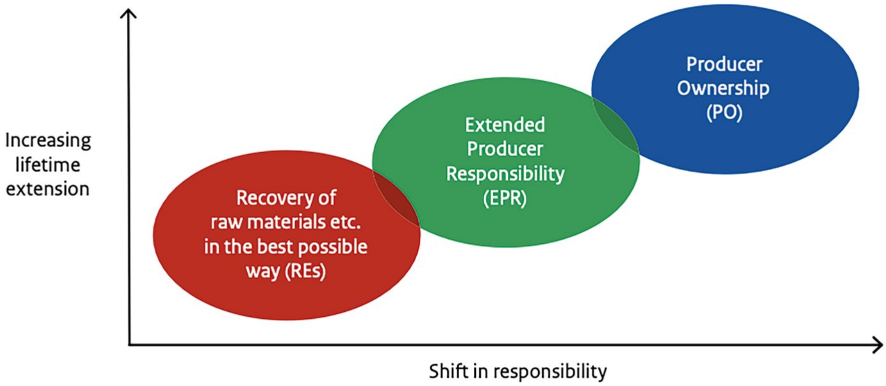

Fig. 11.1 Changing responsibilities in circularity; Source: Jonker et al. (2022)

understand the value of the CE and therefore many businesses do not shape their business models around this concept (Ellen MacArthur Foundation, 2013). The core principle of CE and sustainable strategies revolve around creating and retaining value. Through different types of actions, such as refurbishment, remanufacturing, reuse, and recycling, manufacturers and recyclers alike can benefit greatly (Reim et al., 2021). Adopting circular business models allows manufacturers and recyclers to manage their product lifecycles and thus empower their value chains with increased collaboration, knowledge, and transparency (Daaboul et al., 2016).

Business Relevance

Due to various economic and environmental factors, there is a growing need for businesses to adopt circularity into their business models (Lüdeke-Freund et al., 2019). Manufacturing companies, however, might hesitate as they are waiting for raw material prices to reach a lower price level. This is an unfortunate development as there is a strong indication that an economic adaptation of the CE could lead to net material cost savings (Guldmann, 2017).

Only 9% of plastic waste is recycled globally while 22% is mismanaged (OECD, 2022). In the US, most plastic waste is landfilled. According to the Organization for Economic Co-operation and Development, the United States of America is the leading country in per capita plastic waste generation. Companies need to meet regulatory requirements of increasing recycling quotas on specific materials like secondary plastic. However, recycled plastic is limited with high cost and limited availability.

Figure 11.2 shows global plastic waste and recycling.

This presents a challenge, but also an opportunity to address these recycling material streams on a very large scale. The recycling and reuse of raw materials and manufactured goods could provide manufacturing firms as well as waste management companies with the ability to reduce their production costs. This in turn would yield a competitive advantage due to the reduction of resource dependency on foreign primary and secondary materials (Weber & Stuchtey, 2019).

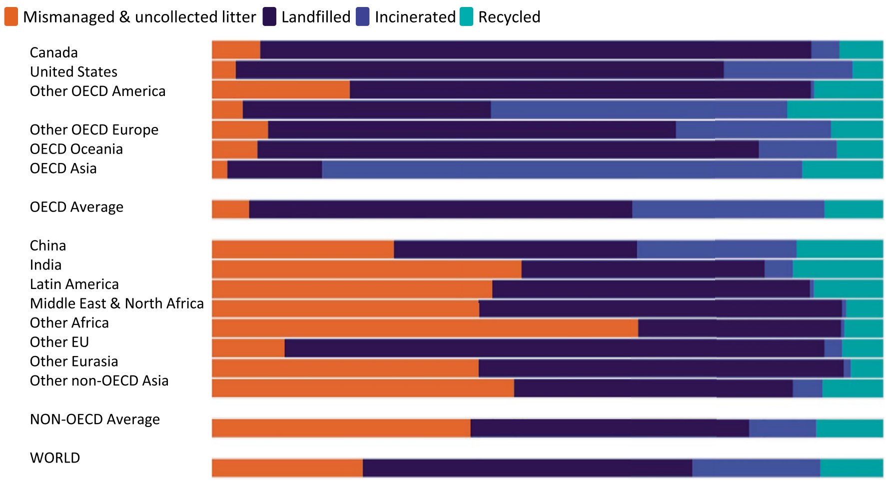

Fig. 11.2 Global plastic waste and recycling; Source: OECD (2022)

Key Concepts on Material Flows

Different articles have done a systematic review of the literature of circular economy and its related concepts, reflecting the ongoing importance of innovation and change within the circular economy ecosystem. In Table 11.1 we give an overview of key concepts from literature review articles.

Research Gap

In the current literature, there is a lack of case studies that analyze circular business model insights on the US recycling market due to various reasons such as lack of data, **collaboration**, and transparency (Heller et al., 2020). Studies as done by Reim et al. (2021) focus solely on large **Swedish manufacturing** companies and fail to address one of the biggest potential recycling markets worldwide. Admittedly stated, a broader case selection would provide scope for better cross-case analysis for future studies in the field (Reim et al., 2021). Additionally, Azizi et al. (2023) adds that **unstandardized methodologies** in this field leads to data limitations and narrow scope, reducing the significance of relevant and reliable information across regions.

The circular economy proposes strategies to retain and create value of resources (Garcia-Saravia Ortiz-de-Montellano & van der Meer, 2022). With new sources of value creation, closed-loop systems have the potential to offer a competitive advantage by providing cost advantages and creating new value (Ghisellini et al., 2016). By improving collaboration and reducing **data uncertainty** along the recycling

Table 11.1 Overview of key concepts from literature review articles; Source: Own contribution

Key concepts	Quotes from literature	Opportunities	Authors
Sustainable Sourcing	"The circular economy is a perspective with the explicit goal of **regenerating** natural, social, and economic capital in part by **cycling or cascading** products, parts and materials at their highest value for the longest time via a clear set of building blocks and capabilities."—Mishra et al. (2018)	• Optimize resource utilization and minimize waste generation which will lead to improved resource efficiency, reduced material consumption, and refurbishing processes. • Extend product lifecycles by promoting reuse, maintenance, and remanufacturing. • Offer new opportunities for collaboration and partnerships emphasizing product longevity and circularity of supply chains.	Ellen MacArthur Foundation (2013), Mishra et al. (2018), Reim et al. (2021)

(continued)

Table 11.1 (continued)

Key concepts	Quotes from literature	Opportunities	Authors
Recycling Value Chain	"Greater **coordination and cooperation** along the value chain is seen as essential to exploring and exploiting opportunities to increase plastic waste recycling."—Milios (2020)	• Recover and reuse valuable materials through the collection, refurbishment, and remanufacturing of products, leading to waste reduction. • Collaborate with stakeholders to share information, build networks, and increase knowledge to support each other with regulations and market demand. • Express requirements and facilitate better understanding of potential solutions for manufacturers and recyclers alike.	Milios (2020), Silva de Souza Lima Cano et al. (2022), Vlasopoulos et al. (2023)
Collaboration	"The recycling and dismissal activities could require and provide **information** on components, materials, and other resources through sharing and managing of data"—Terzi et al. (2010)	• Reduces the demand for primary resources and decreases waste generation. • Enables collaboration between, and informed decision making by, various stakeholders of a products lifecycle. • Provides an overview of the entire lifecycle of a product to identify the potentials for improving circularity.	Terzi et al. (2010), Daaboul et al. (2016), De Angelis et al. (2018), Takacs et al. (2022), Azizi et al. (2023)
Material Flow Analysis	"Material flow analysis is a systematic **assessment** of the state and changes of flows and stocks of **materials** within a system defined in space and time."—Brunner and Rechberger (2016)	• Leads to cost savings and resource efficiency through transparent assessment of processes and environmental impacts. • Addresses resource availability and potential scarcity by analyzing, planning, and allocating resources. • Offers insights into cost of waste, recycling/treatment facilities, and product design in waste management.	Duygan and Meylan (2015), Brunner and Rechberger (2016), Heller et al. (2020)

(continued)

value chain, manufacturers and recyclers can lead to the realization of new and effective solutions (Azizi et al., 2023).

Alongside a study of the US market, data challenges in **plastic material flows** could be addressed, leading to improved data collection, coordination, and transparency (Heller et al., 2020). Therefore, the research gap which needs to be addressed is to improve the understanding of plastic material production using case studies to promote and further collaboration between plastic recycling market actors.

Data Collection & Analysis

The Design Science Research (DSR) methodology used in this project follows the four phases laid forth by Hevner and Chatterjee (2010) to create a framework that can analyze recycling material flows. Prior to delving into the DSR phases, the planned data collection and analysis for each of the phases is presented.

Research Design

The collection and analysis of data will be chronologically ordered alongside the four phases of the DSRM methodology. The primary methods of data collection include relevant literature, interviews with **recyclers and experts (n = 15),** and workshops with the Swiss and US sourcing teams. Throughout these interviews, data is collected to identify challenges and suggest strategies and solutions more accurately. All interviews are checked for accuracy by cross-referencing to preserve the integrity of the information collected. The goal is to identify key concepts from the plastic recycling industry and compare the results with findings from the literature to create an all-encompassing artefact.

Following the process of this model, questions per phase were identified and expected outcomes defined.

In Table 11.2 we illustrate a summary of design science research phases.

Phases for Artefact Development

The research followed the Design Science Research with explorative interviews (n = 15) of US recyclers and industry experts alike. The interviews can be broken down into the following: (n = 10) US recyclers, (n = 5) industry experts ranging from private sector, public sector, and non-profit organizations. Alongside these

Table 11.2 Summary of Design Science Research Phases; Source: Own contribution based on Hevner and Chatterjee (2010)

Phase	Research question per phase	Operational view	Expected outcomes
Awareness	What are the **challenges and difficulties** of securing plastic materials in the US market?	Identify what challenges recyclers and plastic manufacturers face in the US recycling market.	Identification of pain points including regulatory, consumer, and financial challenges. Understanding of financial issues concerning plastic recycling materials such as supply and demand, PCR versus PIR, and product specifications.
Suggestion	What **strategies and solutions** could help in securing limited supplies of secondary plastic material?	Identify solutions and strategies that could be implemented to secure more recycling material.	Development of first version of a suggested solution with phases for how to create the artefact effectively.
Development	How can the **artefact** be designed and developed to provide a practical overview of **relevant material flows** of potential partners?	Construct an artefact using collected data from recyclers with the ability to analyze flows and identify key partners along the value chain.	Development of prototype which incorporates all the variables needed to effectively determine the best procedure in securing plastic recycling material streams. Understanding of the key variables that need to be collected by the artefact to be of practical relevance to the case study.
Evaluation and Feedback	How effective is the developed artefact in addressing the identified problems and **improving material flow** transparency?	Test the constructed model alongside a US plastic manufacturer and receive user feedback to analyze the strengths and weaknesses of the artefact.	Evaluate the identified factors by gaining feedback from experts concerning the requirements from the awareness phase and artefact designed

interviews, workshops with stakeholders are conducted to refine the collected data and draw a consensus on the key factors identified. These workshops were organized into three sessions: first session with two experts from Swiss sourcing team, second session with two experts from US sourcing team, and third session with both Swiss and US project stakeholders.

The following Table 11.3 provides an overview of the data collected and analyzed between the two steps:

Table 11.3 Data collection and data analysis per research step; Source: Own contribution

	Awareness phase	Suggestion phase	Development phase	Feedback and evaluation
Data collection	Literature Review	Literature Review; Stakeholder Meeting	Workshop with the Swiss sourcing team and US sourcing team	Workshop with project stakeholders from both Swiss and US teams
	10 interviews with recyclers	5 interviews with industry experts	Send data sheet to potential recycling partners	
Data analysis	Identify pain points	Development of phases for artefact	Identifying key variables of soft and hard factors	Potential improvements of data sheet

Results

Qualitative Analysis

After thorough analysis of the literature, there are several concepts which have repeatedly been mentioned as relevant to the topic in discussion. These challenges include topics such as strategy, resources, knowledge, price, collaboration, legislation, design, and value. These challenges all relate to each other in several ways, but their conceptual definition remains unique. These criteria occur often in tandem and thus share similar pains and hurdles.

The ten interviews conducted with potential recyclers of interest for the US plastic manufacturer provided a basis for understanding the current pain points within the US case study. These ten recyclers are all located in the surrounding states of Indiana to represent the interests and knowledge reflected by the US plastic manufacturer. With the conducting of the interviews, the documentation was developed using the Atlas.ti software, and subsequently key concepts were identified. This input was refined by creating several codes that structured the concepts identified by the Atlas.ti tool into more coherent and fluent concepts. To reduce redundancy in the data, codes were developed out of the found concepts which resulted in 24 codes that bundled together very similar concepts. Figure 11.3 depicts the frequency of the codes distinguishes a clear picture of most addressed concepts. It is important to note that several concepts identified by the software tool such as “Question”, “Speaker”, and “Names” were omitted to avoid redundancy and data inaccuracy.

The five interviews conducted with industry experts within the plastic recycling industry were refined into specific codes representing the requirements of the artefact and its characteristics. These five experts cover a variety of industries from the public sector, private sector, and non-profit organizations (NGOs). As with the recycler interviews, Atlas.ti software was used for deeper analysis of the interviews. The findings in Fig. 11.4 represent a mostly balanced priority of characteristics with availability and efficiency of resources showing the largest discrepancy. As identified by various researchers, concepts such as scope (Reim et al., 2021), resources

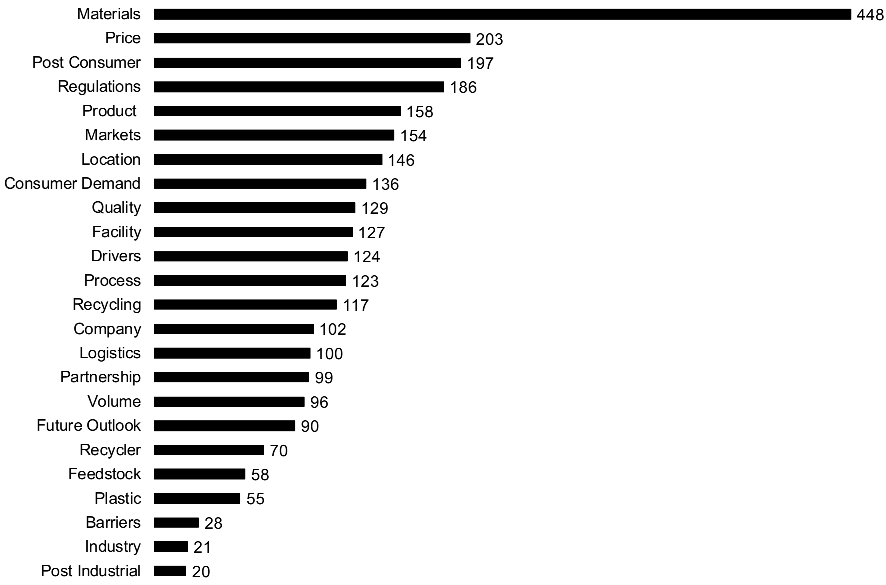

Fig. 11.3 Frequency of code applied-recycler interviews; Source: Own contribution

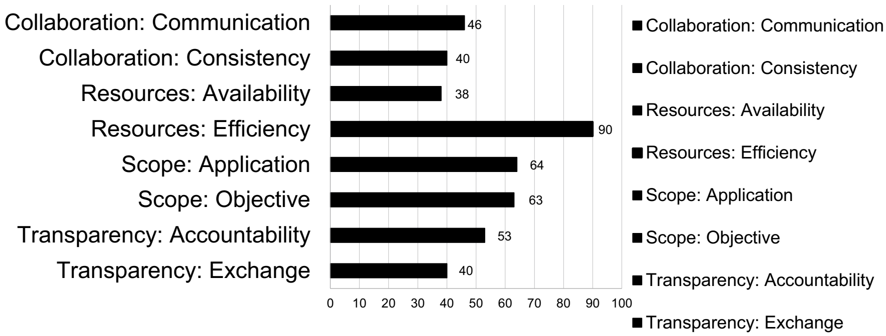

Fig. 11.4 Frequency of characteristics from expert interviews; Source: Own contribution

(Milios, 2020), transparency, and collaboration (Heller et al., 2020) play a significant role when breaking down the frequency of literature-based solutions. Combined with the five interviews conducted with industry experts, the frequency of these concepts can be interpreted to show a desire for a solution that can address resource efficiency and be specific to the scope in question. However, a balanced approach for creating an artefact that can address all characteristics seems to be most desirable. For specificity, these concepts are also further broken down into the two most frequent characteristics identified alongside the Atlas.ti software, leading to a concise examination of primary and secondary data.

Requirements for Artefact

The findings from both the primary and secondary data emphasize the importance of **materials/resources, pricing, regulations, and product quality** as challenges. Although there are similarities in thought, differences are also very evident. Results from these interviews reveal a difference in approach to priorities, namely concerning product design, value chains, product specifications, and location of facility/sourcing. If looking for a solution that reflects both values from secondary and primary data, requirements such as **scope, resources, collaboration, and transparency** can be broken down into more specific characteristics to identify key implications of the artefact.

The **scope** requirement can be broken down into the characteristics of application and objective. The application is specific to the design of the product, making it important to target applications within the scope of the artefact. It is equally significant to come up with an objective that the artefact must have since this will provide a structured approach to achieving circularity and thus securing material flows.

The **resource** requirement specifically mentions availability and efficiency as primary characteristics. These characteristics are crucial in not only identifying in a first step the availability of a more sustainable resource, but also the economic efficiency of a new resource. The availability of a resource in this context directly influences whether a more sustainable resource, such as post-consumer plastic, can be acquired in a big enough supply to maintain the current processing standards and targets. The efficiency of a resource impacts the quality and subsequent profitability of a product which was produced using the resource.

The **collaboration** requirement can be further analyzed by breaking it down into consistency and communication. These two characteristics of collaboration provide a balanced relationship between partners in that they address the consistency of delivery on materials and promote open communication. This leads to traceability along the production lines. Consistency is also very important within a partnership as it requires the supplier to deliver volumes of material regularly and the producer needs to take these resources off suppliers' hands, or the resources could be wasted. This indirectly requires communication to be effective to avoid any miscommunication concerning resource delivery, quality, and quantities needed.

The **transparency** requirement signifies two characteristics essential namely openness and accountability. Openness requires partners to be transparent, but also to be willing to change their business models and shift towards secondary plastic materials. For most recyclers and manufacturers, this requires a willingness for long-term investment and a shift in priority from linear to more circular thinking. This leads to accountability, as any tools or knowledge sharing which could allow for more traceability, would make market actors more accountable throughout their business processes.

Key Variables Identified

In a series of collaborative workshops, the development of a comprehensive artefact for data collection and utility analysis was undertaken with teams from Switzerland and the US. Participants, bringing extensive sales experience and insights into specific product qualities and quantities, worked on refining the material sheets and finalizing the weighted factors for analysis. Essential factors for data collection were analyzed, variables adjusted, and criteria for utility analysis weighted and rated. The final output included a thoroughly vetted material sheet and a robust utility analysis framework, ready for detailed examination of the results.

The **material sheets** and **utility analysis** can act as a basis for collecting data on potential partners. However, it is recommended to only collect basic information and not be overly complex. This leads to a breakdown into two requirements: soft and hard factors. Soft factors encompass collaboration and knowledge sharing, relying on partner learning to improve processes and gather data without needing initial investments. Hard factors involve investing in digitalization and new technologies to enhance processes, though they require significant initial capital and high operational costs.

Table 11.4 illustrates the final categories for soft and hard factors.

The **utility analysis** introduces a structured process to evaluate recycler inputs by factoring in various criteria. Each criterion is scored on a scale from one to five, with one indicating very poor performance and five indicating excellent performance. These scores are then aggregated and weighted according to their importance to US plastic manufacturers. An in-depth explanation is provided for each

Table 11.4 Final categories for soft and hard factors. Source: Own contribution

	Soft factors	Hard factors
Description	*Require exchange and disclosure* • Mutual understanding • Data sharing • Collaboration • Knowledge sharing	*Requires process improvements* • Initial capital investment • Operations investment • Invest in digitalization • Implementation of new technologies
Criteria	*Business Strategy* • Future plans (planned investments) • Partnerships (existing, planned) *Product Sourcing* • Sources of material • Geographic sources • Transportation • Technologies	*Processing and Applications* • Plastic material volume processed per month and year (in tons) • Use of production quality *Quantity and Quality* • Certifications for plastic material • Certifications for corporate social responsibility • Available (or needed) quantities of different plastic qualities per month (in lbs) • Specifications: Base quality, Melt flow rate, Impact modification, Stiffness modification, and colors

Categories	Criteria	Weighting (max. 100%)	Rating (1 low, 5 high)	Points
Material flows	Availability of secondary plastic materials (in volume)	90%	3	2.7

Fig. 11.5 Example of utility analysis criteria; Source: Own contribution

score to ensure transparency and traceability. These criteria are interchangeable and depending on user requirements, can be adjusted given the task needed to be fulfilled.

Figure 11.5 shows an example of utility analysis criteria.

Artefact Analysis

The artefact presents a variety of strengths and weaknesses for the US plastic manufacturer. Creating and identifying data points, such as available quantities and qualities of specific recyclers, provides the manufacturer with the ability to analyze and find recyclers that can fulfill the manufacturing requirements required for the short- and long-term. Also, understanding the priorities of recyclers provides a clear picture of future investments and capacities of volume when evaluating the possibilities of collaboration. The developed analysis tool provides the ability to rank potential collaborators and dynamically adjust weighted factors according to short- and long-term needs. However, it is crucial that the artefact remain dynamic to account for changes in needs, hence increasing the consistent effectiveness of the artefact.

The development and maintenance of the artefact can be strengthened through few changes. Prior to interviewing recyclers, providing a material sheet which is analyzed and developed in unison with recyclers would provide the artefact with a deeper understanding of available quantities and qualities. Expanding the search for appropriate recyclers can be done by conducting a pre-screening process. This would identify recyclers which score high on the highest weighted factors, such as use of injection molding, and result in a list of only the best possible recyclers for collaboration, prior to a more thorough analysis using the developed artefact. Further factors, such as consistency of delivery and willingness to adopt circular strategies, need to be included in the analysis of recyclers. This enables a more accurate alignment of economic and cultural tendencies of potential collaboration with US plastic manufacturers. The identified variables can become more detailed and thorough in their analysis with more input from third parties to not only reflect the needs of US plastic manufacturers. It would increase the scope of analysis tools to a wider range of plastic manufacturers across the US.

Discussion, Conclusion and Further Research

Findings

Several challenges were identified such as a lack of knowledge for newer solutions, lack of infrastructure for capturing waste streams, and lack of government incentives for more circular approaches. Reim et al. (2021) and De Angelis et al. (2018) conclude that the high cost of secondary materials and resource shortage are financial challenges that recyclers and plastic manufacturers both are currently faced with. Also, the ability to recapture value is not as simple as theorized, as certain plastic products are difficult to recapture due to their long product lifecycles. Consumer demand and regulations are forcing recyclers and plastic manufacturers alike to remain flexible to continuously offer the best product available for their end-consumers. This leads to a primary focus of recyclers and plastic manufacturers on profitability and cost savings regarding plastic materials. At the core of addressing these barriers, greater collaboration and coordination along the value chain will decrease operational losses and reduce external inputs, allowing for resource efficiency. This would allow for companies along the value chain to express their requirements explicitly and openly facilitating better solutions (Milios, 2020). Figure 11.6 describes the plastic waste recycling value chain.

Analysis of **material flows** can help identify the best potential partners for plastic manufacturers. According to information gathered throughout the workshops with both Swiss and US sourcing teams, the investment into newer technologies was also key. Such investments lead to an improved quantity and quality of products across the plastic recycling value chain. As Brunner and Rechberger (2016) and Daaboul et al. (2016) suggest, managing resource data and coordinating product lifecycles can enhance the necessary collaboration and partnership. This is because the sharing of information and optimization of processes can lead to more efficient practices, leading to less waste of manufacturing processes (Terzi et al., 2010). By sharing the burden of rising costs of secondary plastic materials market actors can also reduce the financial risk of transitioning to a CE.

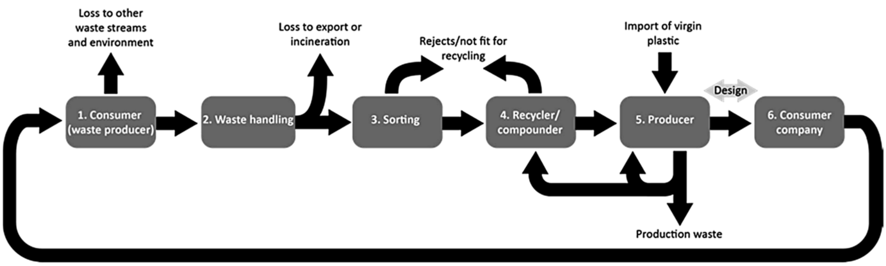

Fig. 11.6 Plastic waste recycling value chain; Source: Milios (2020)

Managerial Implications

The **material sheet** and **utility analysis tools** are the basis for identifying challenges and improving transparency of material flows. Due to the lack of available data of US recycling material flow streams, the data had to be cross-checked, and redundancies evaluated. It is essential to differentiate between flexibility of available qualities and consistency of delivery. This indicates a desire of manufacturers not only to understand what recyclers can provide, but how consistently they can provide certain materials. Ensuring a seamless collaboration and manufacturing process for the plastic manufacturer. According to Reim et al. (2021), investment into digitalization and maximizing value creation are the primary means for pursuing circular business models. However, contrary to this opinion, US plastic manufacturers do not have the infrastructure and advancements yet to support this. Therefore, they lean more towards collaboration and transparency as key factors for adopting circular business models.

The DSR methodology resulted in the creation of the artefact which consists of a material sheet and a utility analysis. Combined, they identify key variables and factors for the evaluation of **best suited sourcing partner** in the scope of the US plastic recycling market. Alongside the material sheet and utility analysis, plastic packaging manufacturers can gather data and analyze recyclers based on their short- and long-term needs. This comprehensive, data-driven assessment has proven to be effective in bridging the gap between players along the same value chain. The proper use of these tools allows for US plastic manufacturers to secure recycling flows through collaborative engagement such as aligning yearly production quantities, pre-ordering large quantities of material, and sharing short- and long-term investment plans. This will inevitably lead recyclers to reduce the burden of rising costs and an increasing shortage of secondary plastic materials. This, in turn, increases the circulation of resources and allows for the manufacturers and recyclers to pivot away from linear resource flows and adapt their business models to circular resource flows (Bocken et al., 2016).

Limitations

Although the understanding of circular resource flows is presented in the context of the US recycling market, the results can be generalized on a broader scale. As the concept of CE expands and consumer demand for sustainable products increases, other industries such as pharmaceuticals and retail sectors are also impacted. These markets also use recycling materials and through consumer demand and regulations will have to meet certain standards of sustainability (Silva de Souza Lima Cano et al., 2022). Their value chains can also benefit from tracking their own material flows through collaboration with the right partners and therefore, secure and increase the value of their own products.

As the developed artefact was created with a specific scope in mind, however, the artefact might pose limitations in its adaptation by different market sectors. Also, as this study analyzes the US recycling market, which is considered a developed country, plastic manufacturers and recyclers from less developed countries may not see the full value of the developed artefact. To adequately evaluate this concern, further case studies with a wider or different scope of reference are needed.

Impact and Transferability to Other Areas

Using the gathered inputs and conceptualizing their practical impact, not only for the scope in which it was investigated, provides examples of transferability to other areas. Across different industries, a similar principle of collecting performance data and conducting a utility analysis can provide any organization with great benefits. It can help analyze competitors and identify potential partners that one could work with. In lesser developed countries, promoting collaboration and coordination of business practices can help build infrastructure which will eventually lead to an increase in manufacturing capacity and plastic waste solutions. It is important to narrow a specific scope of reference when transferring the results of this case study, as it is core to be as specific as possible when identifying relevant data variables and analysis factors. However, the limited scope of reference for this case study can limit the possibilities of implementation across different markets and countries. As this study was solely focused on addressing the challenges and needs of the US recycling market, further studies in countries and markets with different waste and recycling infrastructure might come to different conclusions. Infrastructure will directly impact the limitations of manufacturing capacities due to a lack of advanced technology and the availability of non-bias, accurate data for interpretation.

Future Research

Finally, to fully understand the broader landscape of recycling markets, further studies must be conducted. This would generate more data and analyze the results identified for the US recycling market and expand upon the concept of CE. Further analysis should also be conducted into the impacts of product design through collaboration. The efficient design of products has already been proven to be an effective value proposition for circularity. Further research into the benefits of designing products in collaboration with actors across the value chain could pose even greater benefits for capturing and increasing the value of resources. Also, specifically for the US market, a more in-depth study of the current regulatory landscape of the US and impact of recycling content regulations is needed. Although these **regulations** are still only implemented in a minority of states, the increase in consumer demand will predictably lead to more regulations across the US.

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