Master's Thesis - master Innovation Sciences

Centralized road to a decentralized circular plastics economy

Nina Huijberts

Utrecht University

Student number: 0285110

Utrecht University supervisor: Dr. Laura Piscicelli

Dutch Blockchain Coalition supervisor: Arno Laeven

ABSTRACT

New digital technologies can enable and accelerate the transition to a circular economy for plastics. Blockchain technology, in particular, has the potential to improve waste management practices by facilitating the monitoring and tracking of plastics waste, can support the implementation of cryptocurrency payments and smart contracts, and facilitate rewards-based reuse and recycling initiatives. However, the number of active blockchain-based circular plastics projects remains rather low to date and only a few of them have reached the piloting or operational stages. The adoption and diffusion of new (sustainability) technologies like blockchain often require significant socio-cultural, economic and legislative changes, and technology-innovating firms need to engage with a broad range of public and private actors to create a supportive business ecosystem around their new technology. Entrepreneurs (from startups) and entrepreneurial managers (from small and medium enterprises (SMEs) and multinational enterprises (MNEs)) should strategically and collectively create this supportive business ecosystem around blockchain technology in a process called *strategic collective system building*. Existing strategic collective system building frameworks however do not discriminate between startup entrepreneurs and entrepreneurial managers in SMEs and MNEs. Yet, the two types of entrepreneurs have access to different (financial, physical, human, technological, reputational, organizational) resources and have different characteristics (firm age, size and level of diversification in business practices), which have an influence on what strategic collective system building goals and activities they pursue. This empirical study aims to fill these knowledge gaps by investigating how these entrepreneurs build supportive ecosystems for blockchain-based business models that enable a circular economy for plastics. The research adopts a qualitative, multiple case study design and data is collected through desk research and 12 semi-structured interviews. The interviews were analyzed using thematic analysis techniques and resulted in both qualitative as quantitative data. Results show common patterns in the type of collective system building goals and activities pursued by entrepreneurs: startups, with fewer resources, focused more on technological developments, whereas SMEs and MNEs, with more resources, focused on a broader set of activities e.g., market creation. Embedding blockchain technology in society was collectively neglected by all types of entrepreneurs and should receive more system building efforts to increase adoption of blockchain technology for circular plastics. Findings provide practical insights for entrepreneurs striving to develop and commercialize blockchain-based circular business models and extend existing knowledge on the processes of creating and orchestrating business ecosystems for the successful uptake of a blockchain-driven circular economy for plastics.

ACKNOWLEDGEMENTS

I would like to thank the Dutch Blockchain Coalition for providing the working space and facilities needed to write this thesis. I would also like to thank a few people, as this thesis would not have been possible without the inspiration and support of a number of individuals. First of all, I would like to thank Arno Laeven, my internship coordinator at the Dutch Blockchain Coalition, for all his support and providing insightful feedback on my ideas. I would also like to thank Peter Verkoulen, coalition manager at the Dutch Blockchain Coalition, for taking the time to help me with my research.

Secondly, I would like to thank Dr. Laura Piscicelli, my thesis supervisor at Utrecht University. You were willing to learn about blockchain technology and supported me every part of the process. You raised the quality of my thesis and pushed me out of my comfort zone. I am thankful to have had this experience with you. I would also like to express my gratitude to Dr. Maryse Chappin for her role as second supervisor and her extended feedback.

Finally, my sincere gratitude to my family and friends for their continuous support and love. I have doubted myself many times but thanks to my family and friends, I never gave up. This thesis would hardly have been completed without them.

CONTENTS

1. INTRODUCTION

1. 1 GLOBAL PLASTICS PROBLEM

Plastics are versatile materials involved in almost every aspect of daily life for i.a. clothing, packaging, building products and transportation vehicles and the demand for plastics keeps growing: the production of plastics has almost 200-folded itself since 1950 and is estimated to double within the next 20 years (Andrady & Neal, 2009; Schwarz et al., 2021). The success of plastics can be attributed to the characteristics of the material: they offer design versatility over a wide range of temperatures, are lightweight, strong, waterproof, long-lasting, and affordable (Andrady & Neal, 2009; Schwarz et al., 2021). However, under a business-as-usual scenario, plastics could be responsible for over 56 gigatons of cumulative greenhouse gas (GHG) emissions globally by 2050, which accounts for more than ten percent of the entire remaining carbon budget to stay below the 1.5°C change in global mean temperature (Arkin et al., 2019). GHGs in the plastics lifecycle are emitted from activities consisting of (1) fossil fuel extraction and transport, (2) refining and manufacturing, (3) managing plastic waste by means of recycling, landfilling or incineration and (4) its impacts on nature (Arkin et al., 2019). Plastics are currently part of a linear supply chain, also called the 'take-make-dispose' economy, and only 16% of the plastic waste is collected for recycling because most of the plastic waste consists of mixes and a sufficient sorting and recycling infrastructure is not in place (Böckel et al., 2021; Hundertmark et al., 2018; Jeswani et al., 2021; Schwarz et al., 2021). Nevertheless, the demand for plastics keeps increasing, resulting in an immense volume of plastic waste that goes to landfills (40%) or gets incinerated (25%) (Hundertmark et al., 2018; Schwarz et al., 2021). Incineration emits the most GHGs and is the primary driver of plastic waste emissions (Arkin et al., 2019). The remaining plastic waste (19%) leaks into the environment where it degrades into macro, micro and nano plastics, harming local ecosystems (Andrady & Neal, 2009; Issac & Kandasubramanian, 2021; Schwarz et al., 2021). To mitigate the negative impacts of the plastics lifecycle, the associated GHG emissions must be reduced by transitioning rapidly away from the linear, fossil fuel economy (Arkin et al., 2019).

1.2 THE CIRCULAR PLASTICS ECONOMY AND BLOCKCHAIN

The negative impacts of the plastics lifecycle have been recognized by the United Nations in Sustainable Development Goals (SDGs) 12.5 and 14.1, which aim to "*substantially reduce waste generation through prevention, reduction, recycling and reuse*" (Böckel et al., 2021, p.525) and "*prevent and significantly reduce marine pollution of all kinds* […]" (United Nations, 2021). The concept of circular economy is an integral part of the SDGs and has enormous potential because of its capacity to reduce waste, close resource cycles, and change business models (Böckel et al., 2021). A circular economy is defined by Morseletto (2020) as: *"an economic model aimed at the efficient use of resources through waste minimization, long-term value retention, reduction of primary resources, and closed loops of products, product parts, and materials within the boundaries of environmental protection and socioeconomic benefits*" (p.1). To reduce the impact of plastics on the environment and achieve the SDGs, developing of a circular plastics economy has great potential.

New digital technologies as AI (artificial intelligence), IoT (internet of things), machine learning and blockchain can be used to support the sustainability transformation of the linear economic paradigm (Andersen et al., 2021; Böckel et al., 2021; Chauhan et al., 2022; Chidepatil et al., 2020; Chikhi et al., 2022). Blockchain technology in particular has been identified as a significant facilitator in the circular economy due to its ability to contribute to the information sharing infrastructure, which is one of the required system conditions of a circular economy (Ajwani-Ramchandani et al., 2021; Böckel et al., 2021; Chidepatil et al., 2020; Kouhizadeh et al., 2020). Blockchain is a decentralized and distributed virtual database that maintains a list of records in the form of blocks (Böckel et al., 2021; Sandhiya & Ramakrishna, 2020; Steenmans et al., 2021). These blocks contain transactional data e.g., transfer of payments and a cryptographic hash of the previous blocks (Steenmans et al., 2021). Because of these cryptographic linkages the hashes provide between the blocks, blockchain is immutable, meaning that it is impossible to alter committed blocks without breaking the link to the hash (Böckel et al., 2021; Steenmans et al., 2021). Therefore, blockchain can provide secure information with verifiable origins (Steenmans et al., 2021). Different blockchain types exists (i.e., public permissionless, public permissioned, consortium and private permissioned), which vary in access rights of the network participants (Böckel et al., 2021). Because the permission type and associated rights to access and update information on the blockchain define the degree of centrality and transparency, the suitability of the kind of blockchain depends on its application and context (Böckel et al., 2021). A public blockchain, for example, is not appropriate for storing confidential firm data, and a consortium blockchain is not appropriate for a matter of public concern (Böckel et al., 2021). Thus, depending on the blockchain design, the information is publicly or privately accessible, enabling transparency and security (Böckel et al., 2021; Chidepatil et al., 2020; Steenmans et al., 2021). An overview of different blockchain types and associated reading, writing, and committing rights is given in table 1.

Blockchain type		**Read**	**Write**	**Commit**	**Example**
Open	*Public permissionless*	Open to anyone	Anyone	Anyone	Bitcoin, Ripple, Ethereum
	Public permissioned	Open to anyone	Authorized participants	All or subset of authorized participants	Sovrin
Closed	*Consortium*	Restricted to authorized set of participants	Authorized participants	All or subset of authorized participants	Hyperledger, Corda
	Private permissioned	Fully private or restricted to a limited set of authorized nodes	Network operator only	Network operator only	Internal bank ledger between parent company and subsidiaries

TABLE 1. ADJUSTED FROM HILEMAN AND RAUCHS (2017). EXPLAINING DIFFERENT BLOCKCHAIN TYPES AND ASSOCIATED READ (WHO CAN ACCESS THE LEDGER AND SEE TRANSACTION), WRITE (WHO CAN GENERATE TRANSACTIONS AND SEND THEM TO THE NETWORK), AND COMMIT (WHO CAN UPDATE THE STATE OF THE LEDGER) RIGHTS (HILEMAN & RAUCHS, 2017).

Furthermore, smart contracts, which can automate transactions and their recording without the use of middlemen, are made possible by blockchain technology (Steenmans et al., 2021). A smart contract is in essence a computer program and data that can be used to digitally monitor, execute, and enforce agreements (Steenmans et al., 2021). Smart contracts support transaction automation, reducing certain administrative tasks and increasing cost effectiveness (Steenmans et al., 2021).

A growing body of academic writing demonstrating the advantages of blockchain technology for resource and waste management emerged throughout the years (Steenmans et al., 2021). More specifically, literature provides insights about how blockchain's distinguishing characteristics can be relevant to enable a circular plastics economy (e.g., Ahmad et al., n.d.; Böckel et al., 2021; Chidepatil et al., 2020; Lynch, 2018; Ongena et al., 2018; Pulsfort et al., 2021; Sandhiya & Ramakrishna, 2020; Sankaran, 2019; Sen Gupta et al., 2021; Steenmans et al., 2021). The technology allows for circular sourcing of renewable inputs and resource efficiency by building up a shared information infrastructure on a blockchain (Ajwani-Ramchandani et al., 2021; Böckel et al., 2021; Kouhizadeh et al., 2020). For example, blockchain technology can work as a trust-based platform between waste segregators, recyclers and recycled feedstock buyers because all information is stored on the blockchain (Sankaran, 2019). Blockchain can thereby improve the reliability of information about the availability, quantity, quality, and suitability of recycled plastic feedstock, making manufacturers more motivated to procure recycled feedstock instead of virgin polymers and encouraging plastic recycling (Chidepatil et al., 2020; Sandhiya & Ramakrishna, 2020). The prior described platform enabled by blockchain is not the only use-case: worldwide blockchain-based initiatives to transform the linear 'take-make-dispose' plastics economy are continuously being developed since 2014 in areas such as 1) cryptocurrency payments, 2) cryptocurrency-based reuse and recycling rewards, and 3) monitoring and tracking waste, counting up to 21 initiatives globally in 2021, although several were discontinued later on (Steenmans et al., 2021). These enterprises pursue different ways to achieve a blockchain-based circular plastics economy. For example, the startup OpenLitterMap is concerned with incentivizing citizens to recycle their waste by providing cryptocurrency-based rewards, whereas project recichain by BASF is concerned with providing technological solutions to monitor and track plastic waste. Initial scoping showed that most of these projects are led by sustainable startups, although small and medium-sized enterprises (SMEs) and multinational enterprises (MNEs) are also increasingly experimenting with blockchain-based circular business models.

1.3 Research Gap

Despite the potential of blockchain to enable a circular plastics economy, the application and diffusion of blockchain-enabled circular plastics initiatives remains limited to date, especially considering that blockchain technology originated in 2008 (Nakamoto, 2008). This can largely be explained by the fact that the adoption of innovative sustainability technologies[1], such as blockchain, often requires significant socio-cultural, economic, and legislative changes as new sustainability technologies have to compete with established technologies, who are embedded in the prevailing socio-technical regime (Planko et al., 2016). Technology-innovating firms thus need to engage with a broad range of public and private actors (e.g., suppliers, customers, governments, competitors, media) to build a supportive business ecosystem around their new technology (Iansiti & Levien, 2004). The process of building a supportive business ecosystem around a new technology has its roots in system building literature and is described as "*the deliberate creation or modification of broader institutional or organizational structures in a technological innovation system carried out by innovating actors [and includes] the creation of a supportive environment of an emerging technology in a more general way*" (Musiolik et al., 2012, p. 1035). The innovating actors in a sustainability transition process are often entrepreneurs and entrepreneurial managers[2], who in collective efforts can strategically shape the macro environment in such a way it supports the implementation and user acceptance of their technology, thereby stimulating adoption (Planko et al., 2016). System building is a resource driven process (Musiolik et al., 2012, 2020), and as every firm owns distinguishing resources, it can be concluded that different firms play different roles in an emerging innovation system (Markard et al., 2011). The role of different types of firms and associated entrepreneurs and entrepreneurial managers is thus important to research in the blockchain-driven circular plastics economy context, where a variety of firms (startups, SMEs and MNEs) with different characteristics and available resources, e.g., firm size, financial assets or knowledge, are active. Current literature addresses system building and its relationship with resources, however, this relationship within the blockchain-driven circular plastics economy remains unexplored. So, more research is needed on the efforts taken by the entrepreneurs and entrepreneurial managers and how these differ depending on the type of actor, since the existing literature has not addressed this aspect yet.

This leads to the following research question: *How do different entrepreneurs and entrepreneurial managers act strategically to increase the adoption of blockchain-technology for a circular plastics economy?* To answer the research question, it first needs to be established what goals and activities the entrepreneurs and entrepreneurial managers are pursuing to stimulate adoption. Then, after observing the entrepreneurs' and entrepreneurial managers' characteristics and available resources, a common pattern may be found in the way they strategically act upon these goals and activities. Accordingly, the research question will be divided into two sub-questions: *SQ1*: *What goals and activities are pursued by entrepreneurs and entrepreneurial managers to increase the adoption of blockchain-technology for a circular plastics economy?* And *SQ2: How do firm's characteristics and available resources influence the type of goals and activities pursued by these entrepreneurs and entrepreneurial managers?*

---

[1] The definition for a sustainability technology is obtained from Planko et al. (2016): "*Sustainability technologies are technologies which enable more efficient use of resources, less stress on the environment and even cleaning of the environment*", p.2328.

[2] Entrepreneurs generate new business opportunities and can either be a new entrant to a new market (startup) or can be incumbents (SMEs or MNEs guided by entrepreneurial managers) who take advantage of new developments by diversifying their business strategy (Hekkert et al., 2007).

1.4 SOCIETAL, THEORETICAL, AND PRACTICAL CONTRIBUTIONS

The aim of this research is to create a greater understanding of entrepreneurial activities aimed at building a supportive ecosystem for blockchain-based business models that enable a circular plastics economy. The absence of literature regarding the role of entrepreneurs and entrepreneurial managers to build such a supportive ecosystem for blockchain technology in the context of the circular plastics economy limits entrepreneurs' understanding of how they are key players in this sustainability transition. Exploration of the literature gap will also contribute to the entrepreneurship and transition literature on how entrepreneurial processes that drive sustainability transitions emerge. Moreover, existing frameworks do not pay sufficient attention to how distinctive firms' characteristics and resources influence the way entrepreneurs and entrepreneurial managers pursue different goals and activities to overcome system barriers to stimulate adoption of a sustainability technology. This thesis will provide an overview of what firms are involved in blockchain projects to achieve a circular plastics economy and will present their available resources so a greater understanding of how distinctive characteristics and resources of a firm influence their strategy processes can be created. This leads to the practical benefit that entrepreneurs and entrepreneurial managers can better understand how to distribute goals and activities among the actors in the field based on available resources.

This research is fulfilled as part of an internship at the Dutch Blockchain Coalition (DBC), whose main goal is to increase knowledge and use-cases of blockchain technology to accelerate the decentralized digital infrastructure in the Netherlands. In 2021, the DBC started to develop knowledge and use-cases around the theme Energy and Climate. This includes circularity and traceability of raw materials and their GHG emissions. This research helps the DBC and their partners from the business community, governments, and knowledge institutions to understand how the blockchain-based circular plastics ecosystem is shaped and whether and how they can support this ecosystem.

2. THEORY

This section discusses the strategic collective system building framework as developed by Planko et al. (2016) that helps entrepreneurs and entrepreneurial managers to create a favorable macro environment for new sustainability technologies. Then, the relationship between system building and firm resources and characteristics will be discussed. The need for an extended framework will be explained and a conceptual framework will be presented.

2.1 CREATING A FAVORABLE ENVIRONMENT FOR NEW SUSTAINABILITY TECHNOLOGIES

The concept of strategic collective system building was developed by Planko et al. (2016) and has its roots in both strategic management literature and technological innovation system (TIS) literature. Based on both literary streams, Planko et al. (2016) created a strategy framework for entrepreneurs and entrepreneurial managers to help them generate system-building strategies that contribute to the creation of a favorable macro environment for new sustainability technologies. Strategies in this context are regarded as actions entrepreneurs and entrepreneurial managers undertake to achieve one or more system building goals. The proposed strategic goals are composed of a set of system-building activities (figure 1).

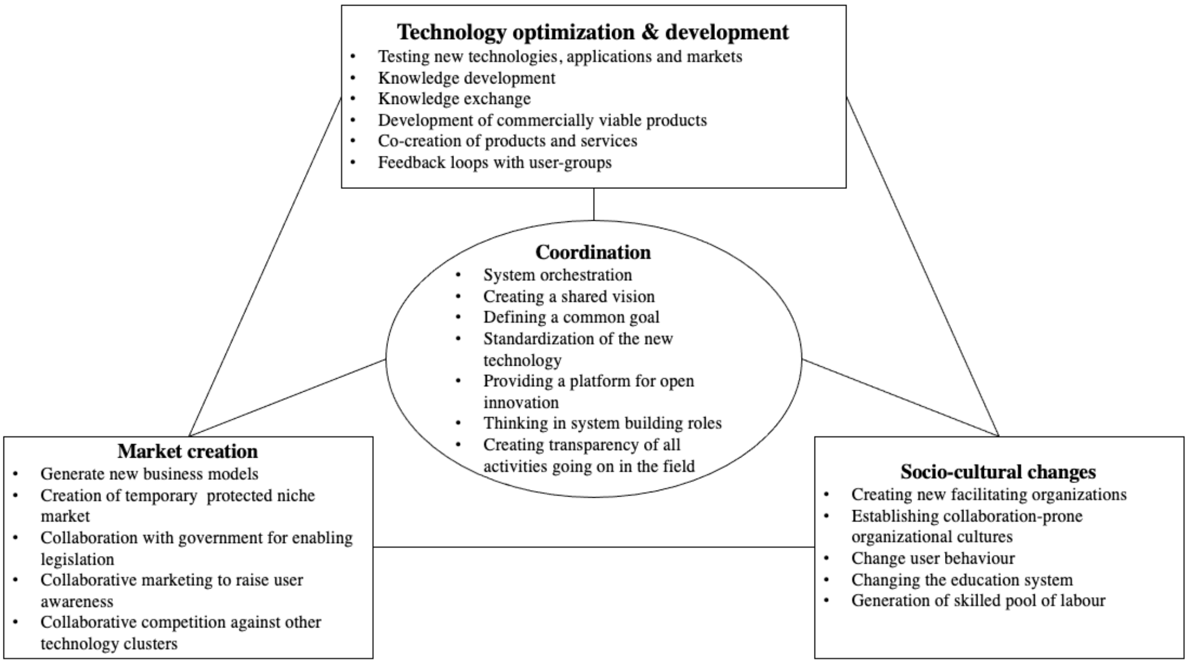

FIGURE 1: STRATEGY FRAMEWORK INCLUDING STRATEGIC COLLECTIVE SYSTEM BUILDING GOALS AND ACTIVITIES. ADJUSTED FROM PLANKO ET AL. (2016).

In total, four key goals are found: technology optimization and development, socio-cultural changes, market creation and coordination. Technology optimization and development is aimed at "*developing, testing and optimizing the technology and complementary products and services*"(Planko et al., 2016, p. 2239) and includes the activities of testing new technologies, applications, and markets; knowledge development; knowledge exchange; development of commercially viable products; co-creation of products and services and feedback loops with user-groups. Socio-cultural changes are aimed at "*embed[ding] the new technology in society; changing values and norms in favor of the new technology*" (Planko et al., 2016, p. 2239) and includes the activities of creating new facilitating organizations; establishing collaboration-prone organizational cultures; change user behavior; changing the education system and generation of a skilled pool of labor. Market creation is aimed at "*creating a market for the technology; raising user awareness and demand for the product*" (Planko et al., 2016, p. 2239) and includes the activities of generating new business models; creation of temporarily protected niche market; collaboration with the government for enabling legislation; collaborative marketing to raise user awareness and collaborative competition against other technology clusters. Finally, coordination is aimed at *"coordinat[ing]* *and align[ing] all individual and collective system building efforts, to bundle forces and use resources efficiently"* (Planko et al., 2016, p. 2239) and includes the activities of system orchestration; creating a shared vision; defining a common goal; standardization of the new technology; providing a platform for open innovation; thinking in system building roles and creating transparency of all activities going on in the field. The first three areas are identified as system-building goals the entrepreneurs are collectively striving for, whereas the latter aims to accelerate the system-building process by managing and aligning the system-building efforts, therefore coordination is visualized at the center of the triangle, on a different level than the other three proposed goals (Planko et al., 2016). Network of entrepreneurs and entrepreneurial managers can use the framework to identify which activities have been given (in)sufficient attention, and to divide tasks and distribute roles between network partners (Planko et al., 2016).

2.2 Firm resources and firm characteristics influencing strategy and system building

The ability to pursue strategies is an important feature this thesis attributes to entrepreneurs and entrepreneurial managers. Entrepreneurs and entrepreneurial managers have discretion in making decisions, yet they are bound (though not completely determined) by the institutional structures in which they are situated (Farla et al., 2012). The goals that entrepreneurs and entrepreneurial managers aspire to attain, as well as the actions they pursue and the resources they use to achieve these goals, are referred to as strategies (Farla et al., 2012). Resources, e.g., financial budget or technological know-how, are important for system building, especially for emerging technologies, where entrepreneurs and entrepreneurial managers begin with their possessed resources and continually expand these resources while collaborating with other firms (Musiolik et al., 2012, 2020). Resources are expanded to outperform competitors, but also to actively shape the emerging field of their new technology in which they are active (Markard et al., 2011; Musiolik et al., 2012). Throughout the years, multiple classifications of firm resources emerged (Barney, 1991, 2001; Collis & Montgomery, 2008; Dollinger, 2008; Grant, 1999), where most classifications described organizations to be socio-technical systems comprised of tangibles and intangibles (Kraaijenbrink & Groen, 2008). Equipment, machinery, finance, and human resources are examples of tangible resources (Farla et al., 2012). Assets such as technological know-how, an actor's reputation, social contacts, and network links are examples of intangible resources (Farla et al., 2012). Furthermore, resources can also be seen as being controlled not only by firms, but by entire industries or developing technology sectors (Farla et al., 2012). According to Markard et al. (2011), a TIS can - in addition to the firm level resources - also be seen as a set of collective resources that generate positive externalities and are constantly (re-)created and modified by the people involved, however, are not owned by any firm. This can be divided into two sub-groups: network resources and system resources (Markard et al., 2011). Network resources are available for network members, while outsiders do not have access to these resources (Markard et al., 2011). Network resources include trust among network members, shared goals, and network culture (Markard et al., 2011). System resources are available for system 'members' and include specific regulation, collective expectations, and technological standards (Markard et al., 2011). Firm resources are created at firm level, network resources are created in networks, and system resources are created at the system level and can be the result of purposive strategic action or emerge in a less strategic way (Markard et al., 2011).

From the literature review by Farla et al. (2012), it became evident that system building strategies depend on the resources that are available to each individual or firm, as well as at the level of the socio-technical system (e.g., technology reputation, collective expectations). The pursued strategies also depend on the actor: different actors pursue different strategies, distinguishing incumbent actors and newcomers (as entrepreneurs) (Farla et al., 2012). For example, Farla et al. (2012) explained that incumbents support the established socio-technical systems and allocate resources accordingly, whilst newcomers advocate for alternative configurations and system transformation. In this research we only focus on *firm* resources to understand the difference between entrepreneurs from startups and entrepreneurial managers from SMEs and MNEs and exclude network and system resources. Literature is only beginning to understand the role of system builders and the process of system building, thus examining actors solely based on firm resources and firm strategies can already be essential to better understand strategic system building (Musiolik et al., 2020).

2.2.1 FIRM RESOURCES

Scholars researched the relationship between firm resources and firm strategy making in literature on the resource-based view (RBV). The RBV was introduced by Barney (1991) to understand how a firm can exploit strategic resources to achieve sustained competitive advantage (SCA). SCA occurs when a firm implements a value creating strategy that is not concomitantly implemented by any current or future competitors and when these competitors cannot replicate the strategy's advantages (Barney, 1991). In the RBV, resources are heterogeneous, immobile, and difficult to utilize and can result in SCA when these resources are valuable (they exploit opportunities and/or neutralize threats in a firm's environment), rare (amongst current and future competitors), inimitable and non-substitutable (Barney, 1991). The RBV in this thesis will be used to structure firms based on a set of resources, rather than focusing on SCA as Planko et al. (2016) emphasized the need to abandon individual competition and rather focus on value creation as a business ecosystem because the business ecosystem has to compete in clusters against other clusters with alternative technologies (Planko et al., 2016).

Resources are, according to Grant (1991), the key constants on which a firm can build its identity. Based on this identity, firms know what they are capable of doing and, hence, can formulate a strategy (Grant, 1991). Resources, therefore, provide direction for a firm's strategy (Grant, 1999; Markard et al., 2011; Schoenecker & Cooper, 1998). As the availability of firm resources allow to distinguish firms from each other (Markard et al., 2011), the different roles the entrepreneurs (from startups) and entrepreneurial managers (from SMEs and MNEs) take to facilitate the adoption of a sustainability innovation, can be understood. Accordingly, one can argue that strategic collective system building strategies deployed by firms depend on available resources and that the entrepreneurs and entrepreneurial managers pursue system building goals and activities that exploit their firms' resources. Consequently, it is also possible that some resources are more influential than others in the development of an innovation (Markard et al., 2011). In the research by Farla et al. (2012), especially knowledge, status, political contacts and financial means were crucial resources to develop and implement strategies to achieve a sustainability transition.

2.2.2 FIRM CHARACTERISTICS

Besides firm resources, firm attributes as size, age and diversity can also influence decision and operations of the firm (Uzoka & Anichebe, 2020; Schoenecker & Cooper, 1998). These attributes are not per se strategically advantageous but rather commonalities to many firms and, therefore, can be defined as firm characteristics that distinguish one firm from another (Uzoka & Anichebe, 2020; Schoenecker & Cooper, 1998). Thus, firm resources and firm characteristics are two different properties that can both influence strategic decisions and, therefore, can influence strategic collective system building.

Multiple variables for firm characteristics are presented in literature (Cohen & Klepper, 1996; Dean et al., 2000; Dewan et al., 1998; Johansson & Lööf, 2008; Kraft, 1989; Schoenecker & Cooper, 1998; Varadarajan, 2011; Zaiem et al., 2011), however firm size (usually indicated by the number of employees or sales), the age of the firm, and the diversification of the firm (i.e. the extent to which a firm operates in multiple lines of business) are the most frequently mentioned in the literature. The firm characteristics size, age and diversification are highly intertwined with each other. For example, the older the firm, the more likely it will have more employees, thus a bigger size. The bigger the firm, the more likely it will be more diversified (Cohen & Klepper, 1996) (e.g., as a result of keeping up with the constant changing macro-environment). Besides firm characteristics being intertwined with each other, they are also intertwined with firm resources. For example, the older the firm, the more knowledge and capabilities the firm has (Song & Chen, 2014). On the other hand, the more financial development a firm has, the more this boosts the growth of the firm (Beck et al., 2008), thus likely also the firm size.

SIZE

Micro-companies (here, startups) are characterized by employing fewer than 20 people and tend to focus on improving their technological capabilities to meet the market needs (Garengo et al., 2005). Yet, another study stated that the amount of research and development (R&D) generally increases with firm size, however, large firms are not necessarily superior engines of technological developments (Cohen & Klepper, 1996). After all, the diversity that different R&D projects bring can also contribute to technological development due to the avoidance of a technological lock-in (Cohen & Klepper, 1996). The relationship between firm size and entry timing into new industries based on new technologies is also researched. Although factors that influence entry timing are highly dependent on the type of industry, increased firm size was related to earlier entry in the minicomputer industry (Schoenecker & Cooper, 1998). Apparently, large firms can enter markets earlier due to their capabilities that outweigh bureaucratic effects (Schoenecker & Cooper, 1998).

AGE

The age of a company is a simple observable characteristic that can indicate how effectively its resources are aligned with the needs of the competitive environment (Thornhill & Amit, 2003). As a firm gets older, its knowledge structure and capabilities stock deepen and broaden, but these resources may go out of sync with the current environment (Song & Chen, 2014). The biggest problem for older organizations therefore is the problem of strategic transformation so it can handle the changing competitive conditions (Thornhill & Amit, 2003). Young firms, on the other hand, aim to gain a competitive advantage (Thornhill & Amit, 2003), therefore pursuing other strategies to survive than older firms. This is also reflected in their marketing practices: younger firms (younger than 7 years) are more growth-oriented, meaning they aim to expand their customer base more compared to older firms (Kilenthong et al., 2010).

DIVERSIFICATION

Multiple forms of diversification exist, e.g., related and unrelated diversification. Related diversification refers to firms extending their scope into related products and markets, whereas unrelated diversification refers to firms extending their scope into unrelated products and markets (Dewan et al., 1998). Firm diversity is frequently associated with reduced R&D intensity and, consequently, delayed entry in new markets (Schoenecker & Cooper, 1998). Yet, organizations that have diversified from a common technological core may have R&D capabilities that allow them to enter a closely related new industry sooner (Schoenecker & Cooper, 1998). Nevertheless, in the minicomputer industry diversity did not appear to be related to entry timing (Schoenecker & Cooper, 1998). Research remains inconclusive about the relationship between the level of diversity and entry timing in a new market, and thus R&D developments.

2.3 STRATEGY FRAMEWORK EXTENSION

Planko et al.'s (2016) strategic collective system-building goals and activities were only tested in one single case study, the Dutch smart grid. The framework, however, can be criticized by the fact that it does not differentiate between entrepreneurs from startups vs entrepreneurial managers from SMEs and MNEs. Yet, the two types of entrepreneurs have different characteristics and have access to different resources, which may have an influence on what goals and system building activities are pursued. Therefore, the strategic collective system building framework might benefit from an extension concerned with the RBV as the RBV can be used to explain strategies of organizations in technological innovation systems (Markard et al., 2011). This research will therefore not only aim to verify the applicability of the strategy framework by Planko et al. (2016) in the context of blockchain and the circular plastics economy, but moreover will try to understand whether and how the pursued system building goals and activities differ among entrepreneurs from firms with different characteristics and resources. This extended framework allows entrepreneurs and entrepreneurial managers to better understand how their characteristics and resources influence system building goals and activities and could facilitate them to make decisions on strategy.

As blockchain technology is an information technology (IT), an appropriate classification of resources would have to acknowledge the digital, technological character of the firm. The classification of Grant (1991) that consists of financial resources, physical resources, human resources, technological resources, reputational resources, and organizational resources is therefore a suitable starting point to observe the resources an IT-related firm owns as it has a specific category concerned with technological resources, but also takes into account other resources as financial budget, collaborations and knowledge. The variables of the resources can be found in table 2. Table 2 also presents, when available, the expected resource distribution among startups, SMEs and MNEs as resource distribution literature among blockchain specific firms is not available. When reviewing the firms based on resources, especially SMEs and MNEs who have unrelated diversity may have more resources at their disposal that are not per se aimed at blockchain technology. Therefore, these firms should be reviewed, where possible, based on their relevant resources available for blockchain technology developments. Reputation for example is based on the stakeholder's overall evaluation of the firm, thus making it impossible to review this resource aimed at only blockchain technology if the firm has more non-blockchain related projects.

Resources	Variables
Financial	Financial resources are represented by money assets and include among other things a firm's borrowing capacity, a firm's ability to raise new equity and cash (Dollinger, 2008). This also includes finances from support programs or public authorities (Musiolik et al., 2012). Firm size is correlated with financial performance (Garengo et al., 2005). Generally, SMEs are financially more constrained than MNEs (Mittal et al., 2018).
Physical	Physical resources include the utilized physical technology in a firm, the machines, the firm's access to raw materials and the geographic location (Barney, 1991). The geographic location may also promote entrepreneurship when entrepreneurs are located in a center that promotes technology and innovation by providing formal and informal networks, physical infrastructure such as roads, or incubator organizations, for example Silicon Valley (Dollinger, 2008). SMEs, due to their lack of financial resources, have more difficulties in adopting advanced manufacturing technologies than MNEs (Mittal et al., 2018).
Human	Human resources include the abilities of employees in terms of e.g., intelligence, training, relationships, experience, insights, judgement, creativity, social skills and vision (Barney, 1991; Dollinger, 2008). Employees of SMEs are more experienced in specialized products/services than MNEs, however, MNEs have more experience in a broader field (Müller & Voigt, 2017). SMEs generally have fewer workshops and trainings than MNEs, and micro firms (here, startups) have the lowest level of training (Cagliano & Blackmon, 2001; Mittal et al., 2018).
Technological	Technological resources include the IT infrastructure including IT readiness, assets e.g., computers, equipment, robots etc., software applications, IT investments and protected knowledge by patents, trademarks, copyrights, and licenses (Dollinger, 2008; Liang et al., 2010). Some scholars also include the manager's technology knowledge and staff training (Liang et al., 2010), however, in this research this is included in human and organizational resources. Technological resources in SMEs are focused on specific areas, whereas MNEs have technological resources available in multiple areas (Mittal et al., 2018). Due to financial constraints, MNEs have technological resources more readily available than SMEs (Mittal et al., 2018).
Reputational	Reputation is a strategic resource valued by various authors (e.g., Caviggioli et al., 2020; Dollinger, 2008; Grant, 1991; Helm, 2005; Lange et al., 2011; Mahon & Wartick, 2003), and is defined as "*a stakeholder's overall evaluation of a company over time*" (Helm, 2005, p.95). Reputation includes both the individual reputation of the firm, and their reputation concerning their proposed solution for a given issue (Mahon & Wartick, 2003). According to Dollinger (2008), product quality, management integrity and financial soundness are the most important criteria for reputation. New firms have minimal history to develop reputation (Lange et al., 2011).
Organizational	Organizational resources include a firm's structure, routines, and systems (Dollinger, 2008). This results in a firm's ability to plan, monitor, control and coordinate systems and have informal relations among groups within the firm and between the firm and its environment, and to make decisions (Barney, 1991; Dollinger, 2008). Organizational resources also reside in a team, a department or functional area e.g., research and development, marketing, and operations, thereby distinguishing itself from human resources, where the focus is on an individual (Dollinger, 2008). MNEs have a complex and formal organizational structure compared to SMEs, which is also reflected in their decision-making: MNEs make decisions based on market research that is discussed by a board of advisors, whereas SMEs can make decisions based on 'gut feeling', which involves uncertainty (Mittal et al., 2018). SMEs also have a lower number of alliances with universities/research institutes than MNEs (Mittal et al., 2018).

TABLE 2. DEFINITION TABLE OF THE RESOURCE VARIABLES INCLUDING TYPICAL DISTRIBUTION BASED ON RESOURCE CLASSIFICATION PROPOSED BY GRANT (1991).

2.4 Proposed conceptual framework

Building on RBV and strategic collective system building literature, the conceptual framework of this thesis is proposed in figure 2. Figure 2 shows the influence of the firm's characteristics (size, age, diversification) and the firm's (financial, physical, human, technological, reputational, and organizational) resources on the system building goals and activities pursued by entrepreneurs and entrepreneurial managers to create a favorable environment for their new technology. As firm characteristics and firm resources are intertwined, this (bidirectional) relationship is also illustrated in figure 2.

The strategy framework and whether all proposed strategic collective system building activities are relevant to the blockchain-driven circular plastics economy is not tested before, which makes this empirical case interesting. By examining the relevance of all system building goals and activities entrepreneurs and entrepreneurial managers can pursue with regards to blockchain technology, this thesis makes an addition to literature. Moreover, by adding a new dimension to the strategy framework by taking into account firm resources and firm characteristics, this advances knowledge and entrepreneurs and entrepreneurial managers will have the tools to create a favorable macro environment for blockchain technology in the plastics context.

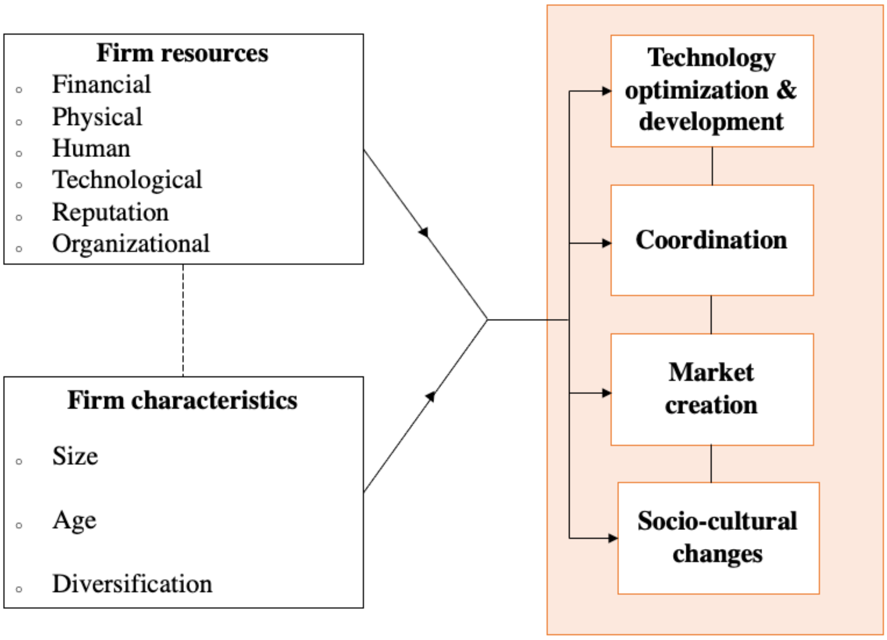

FIGURE 2. CONCEPTUAL FRAMEWORK THAT PROPOSES THAT FIRMS' RESOURCES AND CHARACTERISTICS INFLUENCE STRATEGIC COLLECTIVE SYSTEM BUILDING GOALS AND ACTIVITIES PURSUED BY ENTREPRENEURS. FIRM CHARACTERISTICS AND FIRM RESOURCES ARE HIGHLY INTERTWINED AND THEREFORE A NON-DIRECTIONAL RELATIONSHIP BETWEEN THESE TWO IS VISUALIZED WITH A DOT-LINE.

3. METHODS

From the literature review, it became evident that entrepreneurs can strategically shape the macro environment in a way it supports their sustainability technology. This research aimed to extend the strategic collective system building framework by Planko et al. (2016) by investigating whether and how different types of entrepreneurs, distinguished based on firm characteristics and possessed firm resources, pursued different system building goals and activities to create a favorable macro environment for blockchain technology in the circular plastics economy context. This research addressed this qualitatively in a multiple case study design (Yin, 2003) to fully explore all the activities that are ongoing in the global blockchain-driven circular plastics economy field and to find empirical evidence whether and how resources and characteristics influence a firm's system building goals and activities. Choosing a multiple case study design suited the explorative nature of this research, providing the ability to discover similarities and differences between cases.

3.1 DATA COLLECTION

3.1.1 DATA COLLECTION METHODS

Data was collected through desk research and interviews. Desk research was aimed at compiling a list of global initiatives in the field of blockchain for a circular plastics economy and resulted in a list of 29 firms that can be found in appendix A. Actors were referred to as startups when their firm had less than 20 employees, as SMEs when the firm had between 20 and 499 employees and as MNEs when the firm had more employees than SMEs (Garengo et al., 2005). The firms with more than 499 employees also delivered goods/services in more than one country, therefore they are referred to as an MNE. The list was established by appealing to the DBC and their partners, by literature from Steenmans et al. (2021) and by web searches on Google using search terms as "blockchain plastics companies" and "blockchain plastics startups". When an actor was found, the specific name of that actor was googled or searched within LinkedIn to collect data about their specific activities, type of blockchain, project initiation/phase and their (inter)national focus of operations, see appendix B. The list is not exhaustive and also includes discontinued projects. The requirement to be added to the list was to be 1) a firm mainly focused on plastic (waste) circularity or having a project on plastic (waste) circularity and 2) using blockchain technology to realize this. When multiple firms were working in collaboration on a project, e.g., Circularise and Porsche, the firms most focused on developing and/or achieving a blockchain-driven circular plastics economy and thus pushing the technology (via collaborations), in this case Circularise, was added to the list in appendix A. This assessment was based on reviewing the firms' websites to examine their main activities. Sometimes, this approach resulted in two collaborating firms that were both individually added to the list, e.g., Kryha and BASF. These two firms worked together on a plastic project enabled by blockchain technology, but they individually also established their own blockchain projects and push the technology.

Besides desk research, this research collected data through semi-structured in-depth interviews with actors from the compiled list. These interviews contained both qualitative as quantitative data as the interviewees were asked to use a 3- and 5-point Likert-scale to answer several questions.

3.1.2 SAMPLING STRATEGY INTERVIEWS

In total, 12 firms from various countries were interviewed (6 startups, 3 SMEs and 3 MNEs), see table 3. One firm was interviewed twice with two different persons in different positions. The interviewees were selected using purposeful sampling (Maxwell, 2012). This entails a strategy in which particular settings, persons are deliberately selected for the important information they can provide that cannot be obtained from other sampling strategies (Maxwell, 2012). The interviewees were entrepreneurs or entrepreneurial managers who were either CEO or managers and/or the (co-)founders of the firm or blockchain-department. They were also strategy makers within their organization. The distinction was based solely on number of employees instead of revenue because revenue data was often unavailable due to the lack of annual reports provided by the sampled firms. The interviewed MNEs all started in the 20th century and are between 50 and 150 years old, however their blockchain departments only started between 2015 and 2020. The interviewed startups and SMEs started their firm or department between 2015 and 2019. Of the three SMEs interviewed, two started as a blockchain startup, whereas the other started as a non-blockchain startup and later diversified their business practices by implementing blockchain technology. MNEs were more diversified in business practices as the blockchain department was only a part of a larger R&D department, where multiple projects and technologies were active. Although the startups and SMEs mostly worked on all types of sustainability traceability or reward systems and not solely plastics, practices remained in the blockchain-sustainability sector using no or few other technologies.

Name	**Blockchain application**	**Founding year firm or blockchain department**	**Level of diversification**
Startup 1	Monitoring and tracking waste	2018	Related diversification
Startup 2	Cryptocurrency-based reuse and recycling rewards	2017	Related diversification
Startup 3	Monitoring and tracking waste	2016	Related diversification
Startup 4	Monitoring and tracking waste	2015	Related diversification
Startup 5	Cryptocurrency-based reuse and recycling rewards	2019	Related diversification
Startup 6	Monitoring and tracking waste	2019	Related diversification
SME 1	Monitoring and tracking waste; consultancy	2017	Unrelated diversification
SME 2	Monitoring and tracking waste	2016	Related diversification
SME 3	Monitoring and tracking waste	2018	Related diversification
MNE 1	Monitoring and tracking waste	2017	Unrelated diversification
MNE 2	Monitoring and tracking waste; consultancy	2015	Unrelated diversification
MNE 3	Monitoring and tracking waste	2020	Unrelated diversification

TABLE 3. INTERVIEWED FIRMS. DUE TO NON-DISCLOSURE AGREEMENTS THE BLOCKCHAIN APPLICATION AREA HAS BEEN GENERALIZED.

Firms focusing on developing traceability systems generally aimed to track and trace plastic supply chains and make them more transparent. This results in reliable data about the plastics and whether it is recycled. Blockchain technology is used to record the data about the plastics' lifecycle. Firms focusing on developing reward systems generally aimed to reward citizens for their recycling efforts or their data collection efforts by localizing plastic waste around the globe. Some SMEs and MNEs also took a consulting role and advised other companies on how and where to implement blockchain technology. Their advice however was not limited to plastics nor sustainability, but also cryptography or financial systems. All firms developing own solutions are still in development/pilot phase or minimum viable product phase and want to scale-up soon to a commercial level. Notably, only two of the three identified applications areas by Steenmans et al. (2021), were captured in this research. The interviewed firms were solely focusing on cryptocurrency-based reuse and recycling rewards and monitoring and tracking waste, and no interviewed firms were using cryptocurrency payments. According to Steenmans et al. (2021) cryptocurrency-based reuse and recycling rewards is a distinct application case of the cryptocurrency payment usage type, however, initiatives identified by the authors from the latter category as Bounties for the Ocean, Jay Philips Partnership and Prismm Environmental seemed inactive or unreachable. Apparently, the cryptocurrency-based reuse and recycling reward application is more fruitful than solely cryptocurrency payments.

3.1.3 Interviews

Semi-structured interviews were chosen to give opportunities for the interviewees to provide unexpected insights while being loosely guided in the topic under discussion. First, the firm's characteristics (size, age, diversification) were validated. Then, the interviewees were asked an open question about their approach to successfully commercialize their blockchain-based solution to see whether they naturally mentioned system-building goals and activities. Due to the global orientation of this research, it was important to discover what they perceived to be the main barrier to diffuse blockchain as this might differed per country (e.g., as a result of local policies) and therefore influence their approach. This helped to understand whether all the interviewees were working in comparable contexts. Then, the system-building framework[3] was presented and explained to the interviewees, and they were asked which goals they pursued. They were also asked to rate the importance and development of the activities in the global blockchain-driven circular plastics economy context from their perspective, using a 5-point Likert scale, from 'not important/not developed' to 'very important/very developed, respectively. The average of the associated activities of one system building goal is presented as the score for that system building goal. This allowed for a systematic comparison of the answers for all the proposed goals and activities and for identifying underdeveloped activities. Then, the interviewees were asked about their available resources, which was, beside a qualitatively discussion, reviewed based on a 3-point Likert scale, from not available, to some extent available and available. After discussing available resources, they were asked how these resources influenced the (strategic collective system building) goals and activities they pursued. Lastly, they were asked how firm characteristics as firm age, firm size and level of diversification in business practices influenced the (strategic collective system building) goals and activities they pursued. The interview guide can be found in appendix C.

The interviews lasted 55 minutes on average, with a duration from 40 to 75 minutes, and were conducted in March 2022. All interviews were recorded and transcribed with the approval of the interviewees. The collected interview data were handled and presented in an anonymous format and are subject to a strict policy of confidentiality.

3.2 Data analysis

The interviews were transcribed verbatim and coded and analyzed using thematic analysis techniques (Kiger & Varpio, 2020).

3.2.1 Coding

The transcribed interviews were analysed using the NVivo software and were open coded. Open coding is "*the process of breaking down, examining, comparing, conceptualizing and categorizing data"* (Bryman, 2012,p. 569). Then, axial coding was applied. This process of coding entails the re-examination and re-definition of the categories formed during the open coding process and makes connections between the categories. These connections were made by '*linking codes to contexts, to consequences, to patterns of interaction, and to causes*' (Bryman, 2012, p.569). This iterative process, which reached theoretical saturation in three coding rounds, resulted in multiple categories, for instance perceived system barriers for blockchain technology in the plastics industry and (system building) activities to overcome these system barriers. The associated sub-categories were, if possible, connected to the system building activities as presented by Planko et al. (2016). Besides coding, quantitative data from using the Likert-scale resulted in an overview of perceived importance and development of system building goals and activities by entrepreneurs and entrepreneurial managers in the blockchain-driven circular plastics economy context and also the resource distribution among the different types of firms (startups, SMEs, MNEs).

3.2.2 Validation and reliability

Measures were taken to guarantee validity and reliability. The use of an interview guide with probes ensured that the interviews were consistent, increasing both validity and reliability of the findings. To enhance the reliability, a part of the interview guide was based on the original interview guide by Planko et al. (2016) and as guidance, a visualization of the theoretical framework was shared with the interviewees during the interviews. The open questions minimized the likelihood that valuable insights would be ignored, thereby increasing the validity. To ensure reliability and validity in the quantitative part, the scores given by means of the Likert-scale were triangulated with the interviewees' explanation for the scores. This, however, did not result in changes in the analyzed quantitative data. When interviewees were unable to provide a score, this data point was left out. This happened two times for two different questions by two different interviewees. The codes and quantitative data were discussed with an experienced researcher in the field of innovation sciences to check if the researcher interpretated the statements, relationships and overall data similarly.

---

[3] The system building activity of 'establishing collaboration-prone organizational cultures' was changed into the activity 'changing the perception of the new technology' as a result of recent developments by the original authors on the strategic collective system building framework in May 2020.

4. RESULTS

In order to understand why certain system building goals and activities are pursued, first the global perceived system barriers that hamper greater blockchain adoption for circular plastics will be discussed. Then, activities to overcome these system barriers for blockchain technology in the plastics space are presented, making linkages to the system building activities. Second, the importance and development of the system building goals and activities as presented by Planko et al. (2016) in the blockchain-plastics context are discussed. Subsequently, the differences in terms of characteristics and resources between entrepreneurs from startups and entrepreneurial managers from SMEs and MNEs are presented. Lastly, differences between pursued system building goals and activities are discussed based on the entrepreneurial type.

4. 1 IDENTIFIED SYSTEM BARRIERS FOR BLOCKCHAIN TECHNOLOGY IN THE PLASTICS INDUSTRY

4.1.1 LACK OF EDUCATION AND NEGATIVE PERCEPTIONS

Entrepreneurs and entrepreneurial managers from startups, SMEs and MNEs perceived the lack of education, including negative perceptions, as one of the biggest barriers for a wider blockchain adoption. An entrepreneurial manager from MNE 2 said: "*I think lots of people have a misconception still surprisingly about the use of blockchain and the complexity of it and they're quite scared whenever you use the word blockchain*". Misconceptions include the energy usage of blockchain ("*blockchain is so energy inefficient*", MNE 3), the way blockchain deals with confidentiality ("*everyone is not that happy to expose things [on the blockchain]",* SME 3), and that it is seen as "*this new trendy thing and nobody is really taking it seriously*" (Startup 4). Beside misconceptions, there are also customers who do not even know what blockchain is or only know Bitcoin as a cryptocurrency, that can "*vary $10,000 USD in a week*" (Startup 5), which scares users.

4.1.2 LACK OF USE-CASES AND REGULATION IN THE PLASTIC INDUSTRY

Beside the lack of education in the plastic industry or (potential) customers, blockchain technology lacks use-cases in the plastics industry. As an entrepreneur from startup 4 for example explained: "*the plastic problem is a huge problem, and you have 20 something startups trying to solve that problem, which is ridiculous [..] There's space for hundreds of companies, not 20 companies."* Available use-cases are mostly in development or pilot phase, and not commercially available nor scalable yet. This is mainly due to the young character of the industry – all the interviewed firms started working on blockchain in the last 8 years - resulting in a lack of standardization of plastic waste data and interoperability between different blockchains. Therefore, a lot of research and development remains to be done.

Legislation also forms a barrier for greater blockchain adoption from a waste-regulation perspective, but also from a technological perspective as data protection laws. For example, different jurisdictions have different reporting requirements for waste management, hampering the development of standardized or interoperable solutions. Also, data protection laws like the General Data Protection Regulation (GDPR) are not suitable for blockchain technology due to opposite objectives (i.e. right to erase data (GDPR) versus immutability (blockchain)) and there is legal uncertainty about how data protection laws can be applied for blockchain technology.

4.1.3 LACK OF COLLABORATIONS AND CLEAR BUSINESS CASE

An inter-network barrier was also mentioned by a few entrepreneurs and entrepreneurial managers. The interviewed firms were not formally collaborating and sometimes did not even know of each other's existence. One entrepreneur from startup 2 said: "[*there's more] competition and idea stealing than there is 'let's work together and solve a big problem'."* Nevertheless, the need for collaboration with other blockchain actors was acknowledged by entrepreneurs and entrepreneurial managers from startups, SMEs and MNEs, as an entrepreneurial manager from MNE 2 explained: "*if there's a true intention to enable circularity, then the collaboration kind of has to be at the center of that, right*?" Another barrier with the adoption of blockchain technology in the plastics industry is the complexity that rises whenever one goes beyond the borders of one's own company, as it is difficult to align all parties in the supply chains to pursue one common goal. This could indicate the importance for activities in the system building goal coordination, and includes activities as *system* *orchestration, creating a shared vision* and *defining a common goal*. Lastly, there is a lack of a clear business case ("*In circular economy it is not about circular, it's about economy [...]",* Startup 4), meaning that implementing a blockchain solution to achieve a circular plastics economy should prove to be cheaper than non-blockchain solutions ("*you have great speeches and have a lot of great press about being sustainable, but ultimately what it comes down to is: can they make money off of it? Or can they save money? And if we can use blockchain to show that, then obviously the adoption will be much, much faster",* Startup 3).

4.2. Identified system building goals and activities to overcome identified system barriers

Different system building activities were pursued to stimulate the adoption of blockchain technology in the plastic space.

4.2.1 Knowledge exchange, knowledge development and enabling legislation

The most mentioned activity by startups, SMEs and MNEs was engaging in (in)formal relationships with other firms but also associations or governments with purposes ranging from *knowledge exchange* and *knowledge development* to stimulation of institutional debates by *collaborating with the government for enabling legislation* or receiving funding. Knowledge exchange refers to talking to other firms pursuing sustainability goals or participating in industry consortia, but not per se exchanging knowledge with other blockchain-technology solution developing firms. Knowledge development refers to experimenting and running pilots with their self-developed blockchain solutions. Collaborations with the (local) governments were sometimes achieved through clients: "*we're a small startup and we cannot go to the government to convince them to do something. But our customers can"* (Startup 4). For some firms, the (in)formal relationships were also used to promote own solutions by means of consultative sales *("consult [our customers] and then try to sell alongside it",* SME 2) or to create awareness e.g., by means of non-profit organizations that stimulate (plastic) circular economy developments.

4.2.2 Commercially viable products, "time will solve it" and educating customers

Besides these (in)formal relationships, entrepreneurs and entrepreneurial managers also overcome system barriers by the *development of commercially viable products*, thereby being able to show the benefits of using blockchain technology, as one interviewee from startup 3 quoted Kevin Costner: "*If you build it, they will come."* Some entrepreneurs and entrepreneurial managers from startups, SMEs and MNEs also mentioned that blockchain remains an emerging technology and "*time will solve it*" (SME 2), where 'it' refers to lack of user awareness, lack of regulation and lack of commercially viable products. However, all MNEs and some SMEs and startups were also actively trying to educate industry-customers and/or end-consumers by spreading the word about blockchain application in the plastics context by organizing lunch alerts or collaborating with nonprofits or creating online content as blogposts, referring to the system building goal *changing perception of the new technology*.

4.2.3 Standardization and new business models

Other activities were mentioned as well, however, to a lesser extent. For example, SME 2 was actively pushing standardization efforts to enable interoperability between different solutions and different blockchains, thereby pursuing *standardization of the new technology*. Also, *generate new business models* by means of implementing blockchain technology to generate financial benefits and new value propositions was mentioned a few times by startups, SMEs and MNEs.

4.2.4 Summary of pursued system building goals

Prior identified activities to overcome barriers gave an overview of the system building activities naturally pursued by entrepreneurs from startups and entrepreneurial managers from SMEs and MNEs. Most mentioned activities were part of the system building goal of technology optimization and development (*knowledge exchange, knowledge development, development of commercially viable products)*. Some entrepreneurs and entrepreneurial managers tried pursuing *changing perception of the new technology* by educating the customers, which is part of socio-cultural change. Few entrepreneurs and entrepreneurial managers were also pursuing market creation activities, as *generate new business* models and *collaboration with government for enabling legislation*. Although barriers were identified at the coordination level, only *standardization of the new technology* was intuitively named as a system building activity.

4.3 Importance and development of system building goals and activities as presented by Planko et al. (2016)

The strategy framework including the system building activities was presented to the interviewees to see whether the framework is applicable in the blockchain-plastics space. On average, all system building activities were seen as moderately to very important and were seen as not developed to moderately developed (figure 3). Although the numerical differences were small, technology optimization and development activities were rated as most important and most developed and market creation activities as least important for system building. Coordination activities were the least developed according to the interviewees.

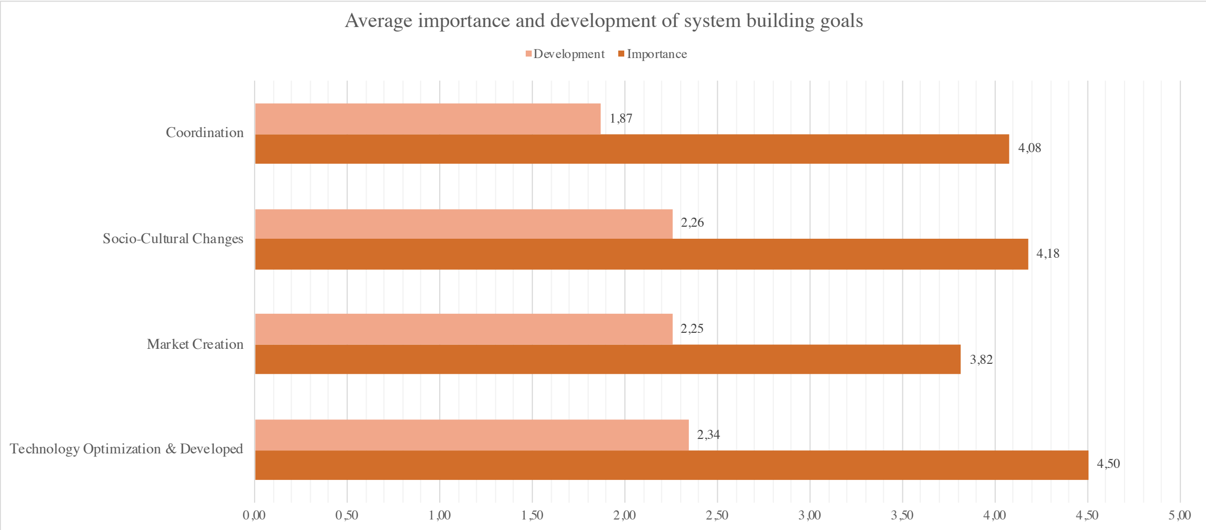

FIGURE 3. AVERAGE IMPORTANCE AND DEVELOPMENT OF SYSTEM BUILDING GOALS.

When the interviewees were asked which system building goal they were pursuing, all 12 interviewed firms were to some extent pursuing technology optimization and development, of which 7 firms (4 startups, 1 SME, 2 MNEs) were also to some extent pursuing market creation and 6 firms (1 startup, 3 SMEs, 2 MNEs) were to some extent pursuing coordination. Despite efforts to change the perception of the technology by educating customers, none of the interviewed firms said to be actively pursuing the system building goal social-cultural change. See figure 4.

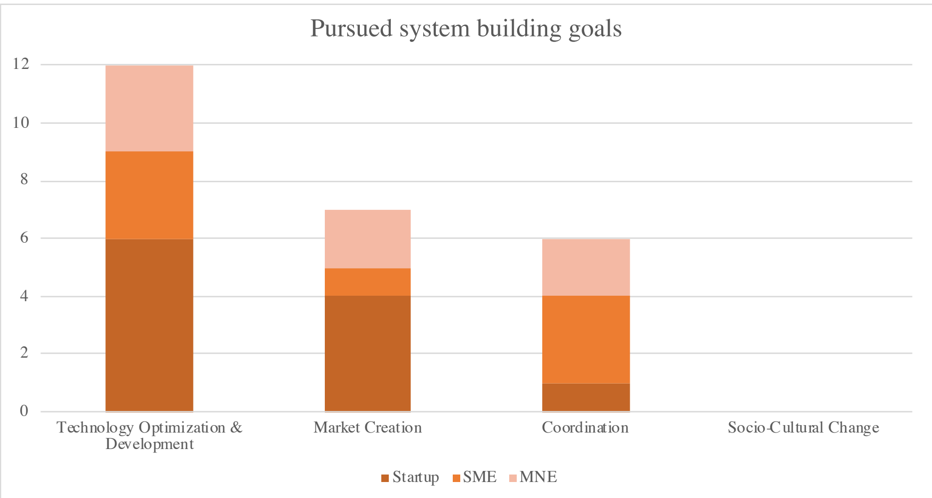

FIGURE 4. PURSUED SYSTEM BUILDING GOALS PER STARTUP, SME AND MNE.

4.3.1 TECHNOLOGY OPTIMIZATION AND DEVELOPMENT

All firms were pursuing technology optimization and development activities. This strategic area was rated between important and very important, but only slightly to moderately developed. Almost all firms, regardless their size, were developing new solutions using different types of blockchains. Some used public permissionless blockchains as Ethereum, some used consortium blockchains as Hyperledger and Corda, and some used self-developed private permissioned blockchains. One interviewee did not want to disclose which blockchain they were using as they were still in the process of approving. In general, both startups, SMEs and MNEs mainly developed upon existing blockchains. However, startups were more diversified in their utilized blockchains, whereas SMEs and MNEs solely developed upon Ethereum or Hyperledger. On average, all activities were seen as equally important, however, the highest score was assigned to *development of commercially viable products*. An entrepreneurial manager from MNE 2 said "*that's necessary for the scalability and sustainability from a financial perspective of such a solution*." It appeared that the global development of the activity *feedback loops with user groups* was difficult to answer, as interviewees were not aware of the practices of other blockchain-plastic actors. For example, the entrepreneurial manager from SME 3 explained to be unaware of the efforts of others, but he hoped feedback loops with users is developed *"[…] because if you don't listen to your clients or whoever is going to use the system, then you're going to fail. So, feedback is really important."* No differences were noticeable between startups, SMEs and MNEs based on given scores on both importance and development of the activities. All activities were rated between slightly and moderately developed. A summary of the given scores is visualized in figure 5.

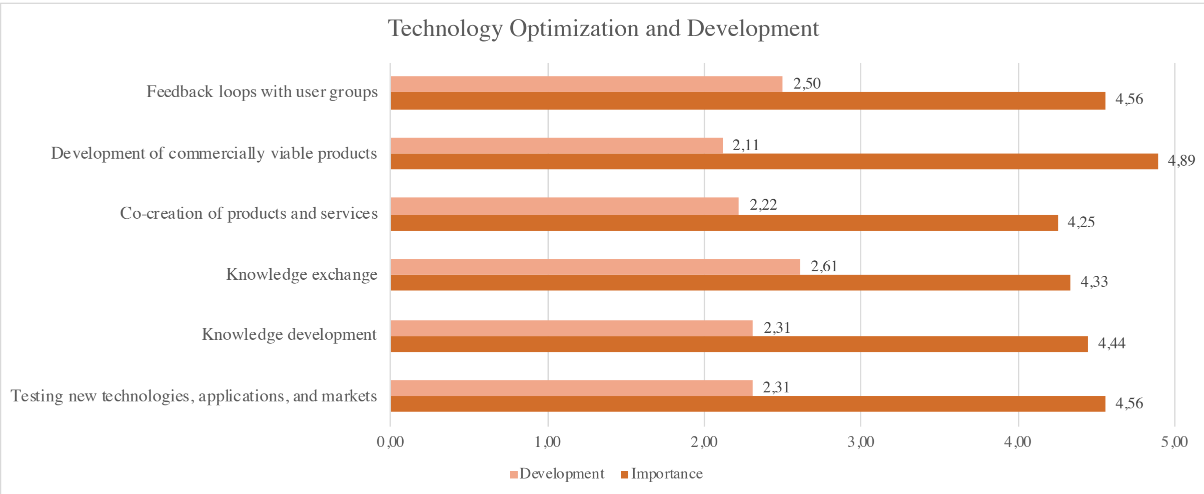

FIGURE 5. AVERAGE SCORES GIVEN TO TECHNOLOGY OPTIMIZATION AND DEVELOPMENT ACTIVITIES.

4.3.2 MARKET CREATION

Seven firms were pursuing market creation as a system building goal. The four startups that pursued this system building goal were developing both traceability systems and reward systems. The one SME pursuing this system building goal (SME 2) was developing a traceability system. The two MNEs (MNE 1 and MNE 2) pursuing this system building goal were developing a solution themselves and/or taking a more consultative role or validated ideas with clients. The most important activities by the entrepreneurs and entrepreneurial managers were *collaboration with government for enabling legislation* and the *generation of new business models*. Collaboration with government is needed because startups, SMEs and MNEs are "*ahead of the government*" (MNE 1) and *"otherwise you will have things like GDPR that don't make sense for blockchain, right?"* (SME 2). The *generation of new business models* is also important as blockchain technology for a circular plastics economy is new and therefore requires different incentivization and value creation from the linear way it is done now. The activity of *collaborative competition against other technology clusters* was the least important activity of this system building goal, although on average it was still seen as moderately important. An entrepreneurial manager from SME 3 explained: "*It's not us against them. It's a matter of solving a problem. […] You can combine different technologies*." Other technologies include machine learning, robotics, and computer vision.

The activity of *creation of temporarily protected niche market* was on average rated as a moderately important activity for system building, however, answers varied. One entrepreneur from Startup 6 summed it up: *"I don't think blockchain needs it. But the environment needs it. So, it's two different answers [...] On the market you definitely need governments to put the regulations to enable a circular economy. When it comes to blockchain technology, it should definitely not be protected. Either it is better than other technologies or it's not, then you should do something else*." An entrepreneurial manager from MNE 1 said a protected niche market with associated legislation (e.g., obligation to proof sustainability of the plastics or a minimal consumption quota for recycled plastics) would make the commercial side of blockchain-solutions for circular plastics more attractive.

All activities were rated between slightly and moderately developed, however, *collaborative competition against other technology clusters* was rated between not developed and slightly developed. This could be the result of the lower importance this activity has according to the interviewees. A summary of the givens scores is visualized in figure 6.

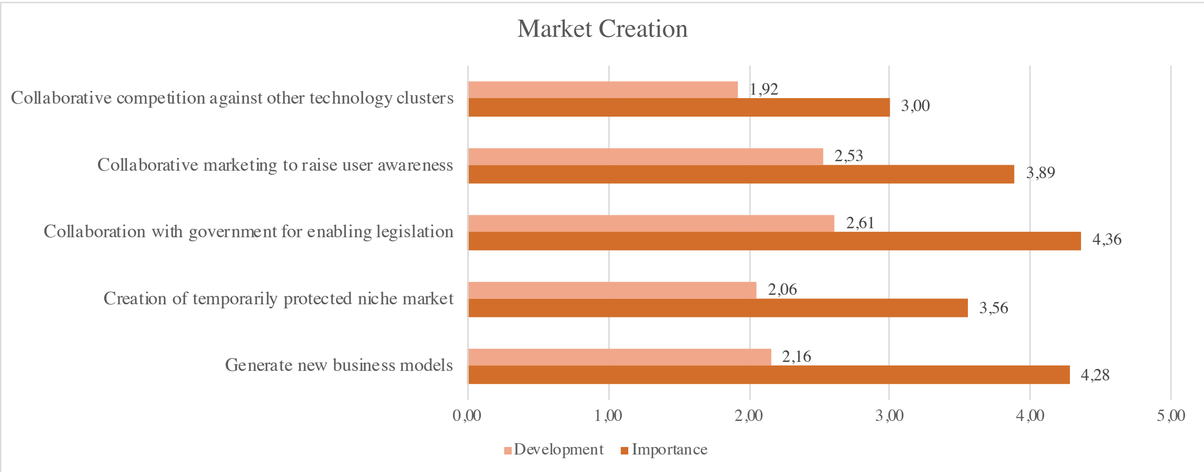

FIGURE 6. AVERAGE SCORES GIVEN TO MARKET CREATION ACTIVITIES.

4.3.3 SOCIO-CULTURAL CHANGES

Despite the identified barriers lack of education and bad perception and the high scores given for the presented activities in social-cultural changes (see figure 3), none of the interviewed firms said to be actively pursuing the goal of social-cultural change. Entrepreneurs and entrepreneurial managers from startups, SMEs and MNEs believed that socio-cultural changes will be the result of their other system building efforts and did not dedicate resources on pursuing these activities: "*the social cultural change will happen organically once the technology is there, and we can prove the value"* (Startup 2). On the contrary, as indicated before, all entrepreneurs and entrepreneurial managers said that the activities presented in socio-cultural changes were important and needed further development. The only activity pursued by most of the startups, SMEs and MNEs was *changing perception of the new technology* as indicated in the prior section by means of educating industry-consumers and/or end-consumers through lunch alerts, online content creation or collaborations with associations.

The three most important activities according to the entrepreneurs and entrepreneurial managers were *generating a pool of skilled labor, creating new facilitating organizations,* and *changing perception of the new technology*. The least important activity was *changing user behavior*. The *generation of a pool of skilled labor* was two times connected to *changing the education system* to make young people familiar with blockchain technology and circular economy. An entrepreneur from Startup 3 also mentioned the lack of gender equality as they struggled to find female blockchain-experts. *New facilitating organizations*, for example the DBC, were seen as important because they could help bring together different parties and push new ideas forward, however, the interviewees lacked experience with these facilitating organizations due to the lack of such organizations on a global level. Only one interviewee, an entrepreneurial manager from MNE 3, thought that facilitating organizations were not needed right now as the manager explained that adoption of blockchain technology for circular plastics is still so immature that facilitating organizations will not make a difference yet, but will only slow things down as it is hard to get anything done while working together, as the manager explained from experiences while working in other consortia. Entrepreneurs from startups and entrepreneurial managers from SMEs and MNEs gave similar (high) scores to the importance of *changing the perception* of blockchain technology. This is in line with the open questions, where all types of entrepreneurs and entrepreneurial managers mentioned bad perception and misconceptions as one of the biggest barriers for a greater blockchain adoption. Lastly, different opinions existed about the importance of *changing user behavior*. This was mainly due to the different views on who the exact users were (industry or end-consumers). An entrepreneurial manager from SME 3 explained "*it's important in terms of the companies that are going to utilize the [blockchain] platforms. […] some of them don't even have a SAAS system and there are brown envelopes changing hands with money in some way. So, you have to change that user behavior.*" Multiple entrepreneurs and entrepreneurial managers took the end-user perspective, and for these end-users blockchain technology should be an under the hood technology and *"just an app*" to "*limit that hard change*" (MNE 3). Therefore, they argued it unnecessary to change user behavior, hence rated this activity as less important. An entrepreneur from startup 6 had a different perspective and said, "*it's important to use blockchain to change behavior.*" The activity of *changing the education system* was the least developed activity, and was rated between not developed and slightly developed, whereas the other activities scored between slightly developed and moderately developed. A summary of the givens scores is visualized in figure 7.

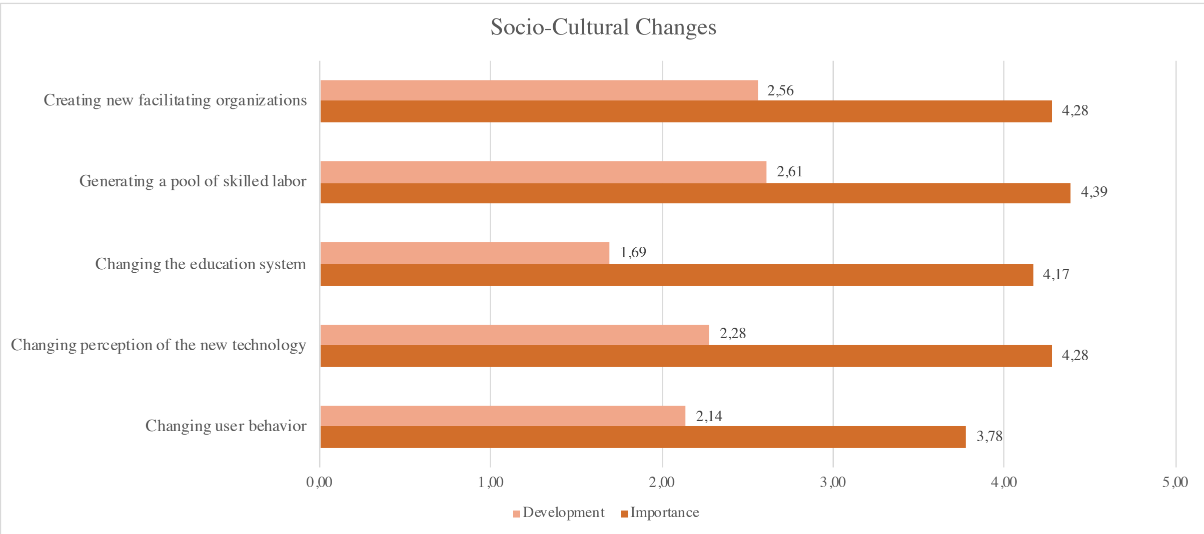

FIGURE 7. AVERAGE SCORES GIVEN TO SOCIO-CULTURAL CHANGES ACTIVITIES.

4.3.4 Coordination

Six firms were pursuing coordination as a system building goal. Notably, only one startup pursued coordination, and that was the biggest startup of all interviewed startups with 16 employees. All SMEs were pursuing coordination and two of the three MNEs were pursuing coordination. The one MNE that currently did not pursue coordination said to grow into that role in the future, after their solution was finalized. All activities in this system building goal were on average rated between moderately and very important. The most important activity according to all entrepreneurs and entrepreneurial managers was *thinking in system building roles* and was rated between important and very important. This implicates that entrepreneurs and entrepreneurial managers agree that it is important to not think only about company sales but instead consider which role a firm can play in building the ecosystem around blockchain technology in the circular economy context. An entrepreneurial manager from SME 2 explained: *"[...] even though companies are from the face of it competing and using blockchain, if you dig deep, a lot of them are using blockchain in a very different way […], so it seems like you're competitors, but in fact you might be collaborating about these efforts."* Other activities rated between important and very important were the activities *system orchestration* ("*for us [implementing blockchain technology in the plastics industry] only makes sense if our supply chain partners adopt the same solution. Otherwise, it just becomes too complex"*, MNE 1) and *defining a common goal*. The latter, however, was rated as important to very important by entrepreneurs from startups and entrepreneurial managers from SMEs, whereas entrepreneurial managers from MNEs rated this activity as moderately important. Different common goals were mentioned, e.g., solve the plastic waste problem, reduce carbon emissions, make circular economy profitable and achieve blockchain standards to enable interoperability. However, entrepreneurial managers from MNEs said it would be very hard to set a common goal with so many different actors and explained it was good to have diversity in goals "*because it allows us to experiment and develop in different ways, because none of us knows what is best to enable that circular economy and we can't focus on everything at once. So, it's good that we have different focus areas"* (MNE 3). All interviewees rated *providing a platform for open innovation* as least important and least developed of all activities in this system building goal. The interviewees lacked experience with such platforms to say something about their importance. Some mentioned hackathons, consortia, and collaboration groups, but open innovation platforms were unknown. Answers varied for the importance and development of *standardization of the new technology* due to the two different domains of blockchain technology in the plastics industry, namely: blockchain technology standards and plastic standards. Some standards are available for blockchain technology, and this is why multiple firms are developing on established blockchains as Ethereum, Hyperledger and Cardano. Standards can provide interoperability between different blockchain solutions, yet an entrepreneurial manager from MNE 2 explained that there is already interoperability and did not see the lack of standardization as an issue as it is also beneficial to avoid a technological lock-in. Some standards are available for plastics, e.g., ISCC PLUS[4], however, as the plastic problem is a global problem, and every jurisdiction has different reporting requirements resulting in different data at local levels, more standards are needed according to an entrepreneur from startup 4. The activities of *creating a shared vision* and *creating transparency of all activities going on in the field* were on average rated as important, however, they were assessed as not developed or slightly developed. The creation of *a shared vision* was considered to be, just like *defining a common goal*, difficult to achieve on a global level due to the large number of active parties in the plastics value chain, and diversity in visions might be beneficial for the development of the circular plastics economy. Whether *creating transparency of all activities going on in the field,* e.g., by means of publishing (online) data and/or updates on certain technological or commercial developments by blockchain-driven circular plastics firms, will change soon was doubtful according to the interviewees due to the commercial, competitive nature of these blockchain companies. However, according to an entrepreneur from startup 3, "*[there] needs to be transparency because that is the proof of impact*." A summary of the given scores for the coordination activities is visualized in figure 8.

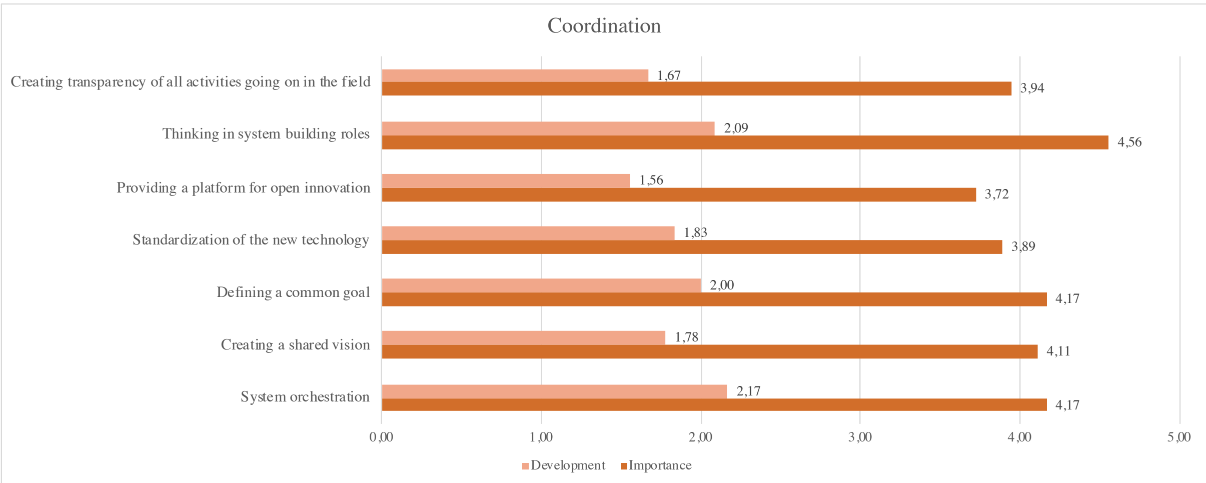

FIGURE 8. AVERAGE SCORES GIVEN TO COORDINATION ACTIVITIES.

[4] ISCC PLUS is a standard for recycled and bio-based materials and provides traceability along the supply chain and verifies that companies meet environmental and social standards (ISCC, n.d.).

4.4 Relationship between system building goals and activities and entrepreneurial type

This section discusses the relationships between the different types of entrepreneurs and the strategy framework with associated system-building activities as presented by Planko et al. (2016). First, the differences between entrepreneurs and entrepreneurial managers will be presented, followed by differences in pursued goals.

4.4.1 Differences between entrepreneurs and entrepreneurial managers

The availability of resources showed to increase gradually from startups to MNEs, see figure 9. The main difference can be found in financial resources. Startups had very limited access to financial resources, whereas SMEs and MNEs had (more) financial resources available, see figure 10. Besides limited financial resources, human resources were also scarce for startups compared to SMEs and MNEs. Startups had fewer people working for the company, mainly as a result of insufficient financial resources, resulting in the inability to hire more people that had experience with plastics and blockchain technology. Other differences in resources can be found in reputation. MNEs were well-known on a global level mainly due to non-blockchain business practices, whereas startups and SMEs were less known and/or only known due to their blockchain business practices. Therefore, MNEs already had a customer base with whom they could work together, sell services, or validate products/services. Startups and SMEs had to look for these relationships with customers more actively as they did not have an existing customer base. Only one SME already had a customer base from their previous non-blockchain related practices. Entrepreneurs from startups and SMEs started mostly because of passion and prior knowledge about the plastics industry, whereas entrepreneurial managers from MNEs started their department as a way of dealing with competition and/or reputation ("*we very much see ourselves as a technology company. So, therefore, that's where we want to show and build our reputation […] But it also has to do with competition: if other people in the market are selling certain technologies and services, then it's like a potential encroachment on what we do. So, I think there's also that dynamic at play*", MNE 2). Technological resources, physical resources and organizational resources were for all types of firms (to some extent) available, and included cloud space, computer facilities and possibilities to collaborate with universities.

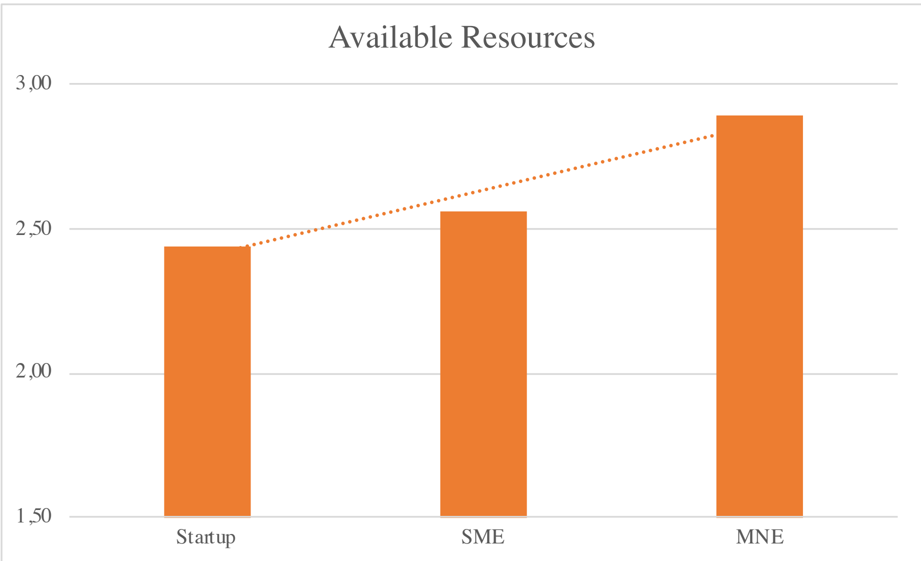

FIGURE 9. AVERAGE AVAILABLE RESOURCES FOR STARTUPS, SMES AND MNES.

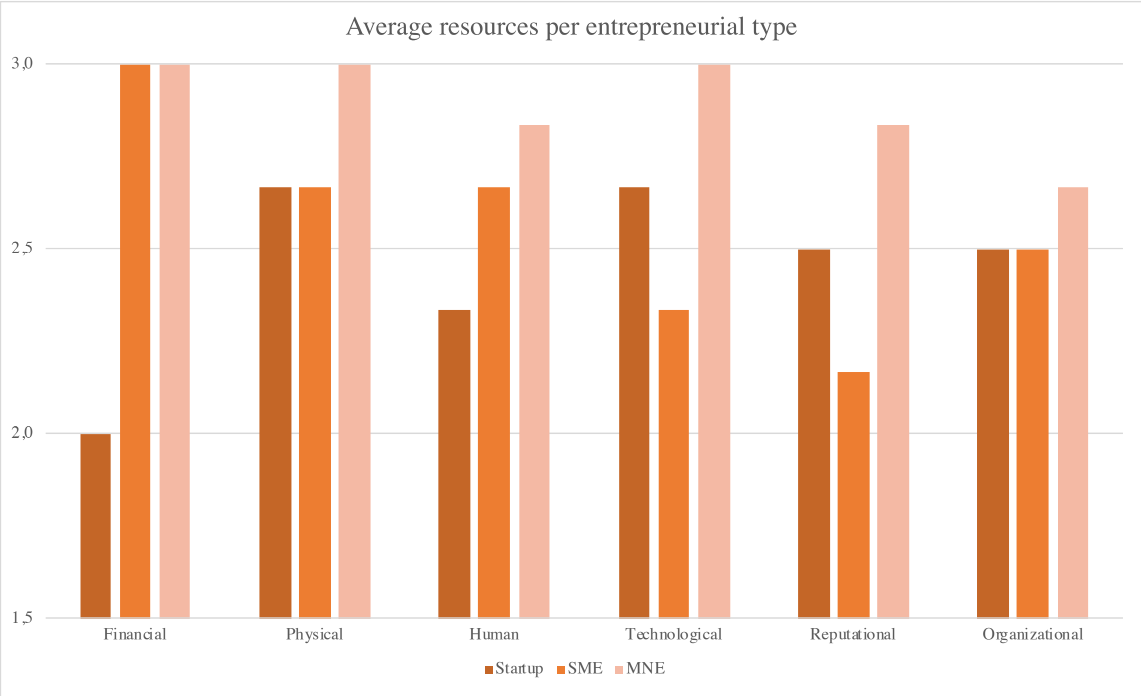

FIGURE 10. AVERAGE AVAILABLE RESOURCES PER TYPE OF RESOURCE.

4.4.2 Difference in pursued system building goals per entrepreneurial type and associated resources and characteristics

The amount of pursued system building activities increased by firm size and available resources. The founding year of the firm or the blockchain department did not seem to influence the amount of pursued system building goals. Entrepreneurs and entrepreneurial managers said that especially financial budget and number of employees influenced (thus, financial and human resources/firm size) what and why they were doing certain system building goals and associated activities. An entrepreneur from startup 4 stated: *"The size of the team is a mirror of the resources that we have."* Another entrepreneur from startup 2 added: "*The[se] characteristics are going to define your potential"* and therefore influence the system building goals and activities a firm pursues. Startups were currently pursuing one or two goals, whereas SMEs and MNEs were pursuing two or three goals. Startups, despite differences in application area (traceability solutions vs reward systems) currently pursued the same system building goal of technology optimization and development and market creation, and barely pursued coordination. An entrepreneur from startup 6 currently pursuing technology optimization and development and coordination, used to be pursuing market creation in the past. The entrepreneur explained: "*We started with the behavior change, like can we use incentives to make changes in how people […] behave when it comes to plastic waste? […] and then testing it in the market […] and then it's about building optimal technology and development, which takes time."* Moreover, the entrepreneur explained: "*You need to stay ahead of the technology optimization, then you need to put it into the market and follow up [with] keep[ing] the feedback loops from users and […] knowing what to do next if you want more changes. It's always a loop."* All interviewed SMEs pursued coordination and technology optimization and development, and only one SME said to be also pursuing market creation. An entrepreneur from SME 3 explained that they used to pursue market creation in the past but are now solely focusing on technology optimization and development and coordination. However, in the future they expect to go back to pursuing market creation and even socio-cultural changes. The manager explained that market creation was necessary in the beginning to get partners onboard to develop the business-to-business side of the solution but will be needed again in the future to bring in consumers as well and therefore require marketing budget to reach these consumers. The manager associated their future marketing activities with socio-cultural changes, as the manager expected that to be a result of their marketing efforts. Another entrepreneurial manager from SME 1 also explained the dynamic interplay between pursued system building goals and activities: "*We started from technology, then we realized that the customers needed more help. So, then we started providing that as well."* This indicates that the more clients the firm gets, implicating firm growth, the more system building goals a firm pursues beyond technology optimization and development. Two of the three MNEs pursued all system building goals except social-cultural changes. One MNE was solely focusing on technology optimization and development and no other goals. This can likely be explained by firm characteristics: the MNE focusing on only one system building goal was an independent venture within the MNE, whereas the other two MNEs were part of a larger R&D department. This might result in different strategic goals, hence explaining the difference in system building focus.

Entrepreneurs and entrepreneurial managers stated that the availability of their resources changed over time. Especially human resources changed for startups and SMEs, as they gained knowledge (blockchain technology and marketwise) and/or hired more employees. Financial resources also increased for some of the startups and SMEs. One MNE also mentioned to have secured more R&D money, thereby their financial resources increased even more. It seems that, since only human and financial resources are pointed out as resources that changed the most over time, these resources are especially influencing the pursued system building goals and that entrepreneurs and entrepreneurial managers with more financial and human resources can more easily pursue goals beyond the goal of technology optimization and development. The development of these resources for firms is therefore likely to be important for the development of the creation of the favorable macro-environment.

The perception of the importance and development of the presented system building activities differed between entrepreneurs and entrepreneurial managers, see figure 11. On average, startups rated the activities as more important and less developed than SMEs. SMEs on average rated the activities as more important but as developed as MNEs. MNEs rated the system building activities between moderately important and important, and thought the activities were slightly to moderately developed. This might be explained by the fact that the more developed an activity already is, the less important it is now for system building around blockchain technology in the plastics space. The difference in perceived development of system building activities could also be explained by the fact that MNEs and SMEs, due to their higher availability of resources, have a better idea of development in the ecosystem and therefore have a more optimistic perception on the development, whereas startups may know to a lesser extent what is going on due to their fewer resources. The fact that startups and SMEs started their business based on passion and prior knowledge of the plastics industry and/or blockchain technology and felt necessary to become a solution-developer to enable a circular plastics economy could explain why the importance differs between startups and SMEs versus MNEs. Startups and SMEs might be more pessimistic about the current solution developments in the ecosystem and, therefore, rate importance higher because they assume there is still a lot of system building work to be done.

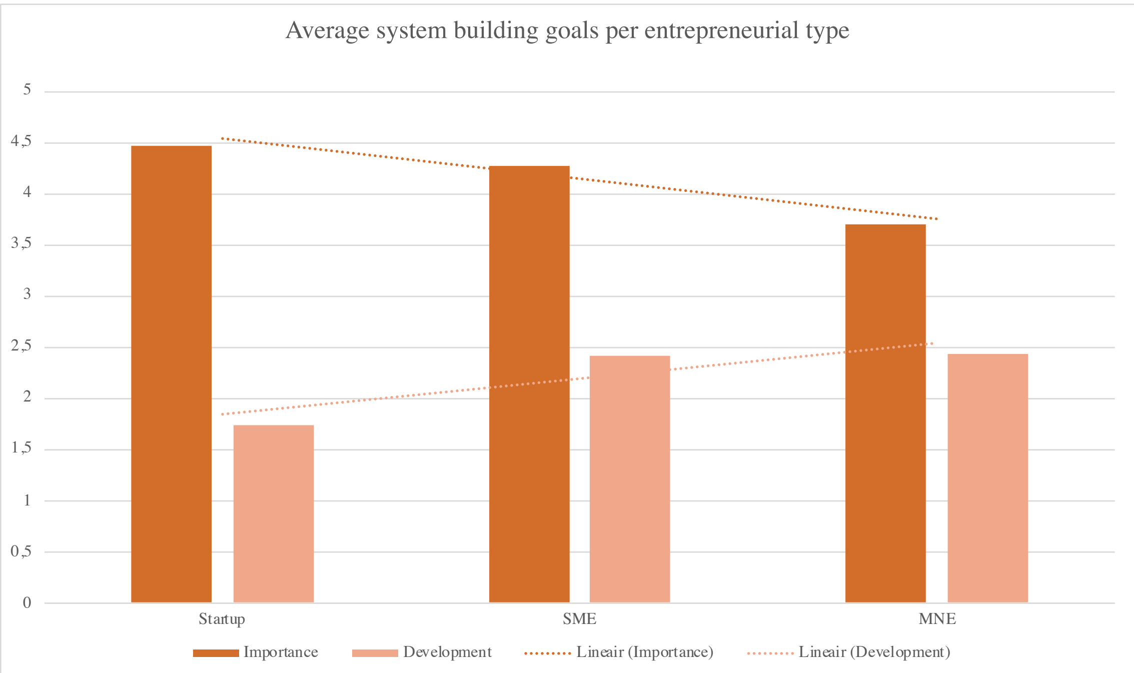

FIGURE 11. AVERAGE SYSTEM BUILDING ACTIVITIES IMPORTANCE AND DEVELOPMENT PER TYPE OF FIRM.

5. DISCUSSION

This section covers the theoretical framework, discussing theoretical implications and avenues for further research. Then, managerial implications will be given, followed by the limitations of this study.

5.1 THEORETICAL IMPLICATIONS AND FURTHER RESEARCH

For this research a theoretical framework was developed, connecting firm resources and firm characteristics to pursued strategic collective system building goals. The next section discusses the strategic key areas as developed by Planko et al. (2016), the RBV and how this research contributes to the further development of strategic collective system building literature.

5.1.1 STRATEGIC COLLECTIVE SYSTEM BUILDING FRAMEWORK

The system building goals and activities developed by Planko et al. (2016) have proven to be applicable in the blockchain-driven circular plastics economy context as the entrepreneurs and entrepreneurial managers on average rated every activity between moderately and very important and no new collective system building goals / activities were mentioned by the interviewees. Some activities were, however, linked to each other, e.g., *generating a pool of skilled labor* and *changing the education system*, highlighting the intertwined nature of the system building activities within one system building goal. The ravels between multiple system building goals also became apparent: achieving goals in one category accelerates the achievement of goals in other categories, as suggested by Planko et al. (2016). Especially the achievement of socio-cultural change was seen as the result of other system building efforts. The next section discusses the theoretical implications per system building goal.

TECHNOLOGY OPTIMIZATION AND DEVELOPMENT

As all interviewed firms were pursuing technology optimization and development activities and rated this as most important system building goal, technology optimization and development seems to have the highest priority by all different types of entrepreneurs and entrepreneurial managers. Ultimately, all blockchain-driven solutions are still in development and more research and development is required to increase the amount of use-cases for a circular plastics economy, as the lack of use-cases was currently seen as a system barrier. As blockchain technology is still a rather new technology, it makes sense that most firms are pursuing technology optimization and development, as this is necessary to ultimately show the benefits of using blockchain technology for a circular plastics economy, in other words: showing by example. As all firms are dedicating resources to the system building goal of technology optimization and development, the development of this goal will likely increase over time. Nevertheless, as an entrepreneur from Startup 3 stated: "*you never stop developing, you never have a finished product, there's always something more to add*", implicating that this will remain an important system building goal for entrepreneurs and entrepreneurial managers to pursue, despite the global efforts this goal receives.

MARKET CREATION

On average, market creation was rated as the least important system building goal, however, after technology optimization and development, it was the most pursued system building goal. Having a market is crucial for the further development of blockchain-based applications for circular plastics ("it's all about *economy* in circular economy"), however, the activities as presented by Planko et al. (2016) caused confusion for the interviewees. Some interviewees did not understand how to 'collaboratively' raise user awareness or compete against other technology clusters. It became evident that the market is very competitive and although blockchain-actors would like to work together both horizontally (with supply chain actors in the industry) as vertically (other blockchain solution developers for circular plastics), they are hesitant to engage into vertical collaborations. Horizontal collaborations might be easier to accomplish as there is less competition between these actors: ultimately the entire plastic supply chain needs to achieve a circular plastics economy, and whatever technological solutions helps, e.g., blockchain technology, could be beneficial. Vertical collaborations with other blockchain-actors might be more difficult to achieve due to the competitive, commercial nature of the blockchain-driven circular plastics ecosystem. Bundling resources to collectively develop one solution has two sides because there are many ways to use blockchain technology to help with the transition to a circular plastics economy, which is highlighted by all the different types of blockchains that are used. On the one hand, the development of such a solution can go faster due to the greater amount of available resources, but on the other hand, it may result in a technological lock-in. However, as stated by an entrepreneur from Startup 4, the plastic waste problem is a global problem and many elements need to be solved, meaning that there is space for hundreds of firms, not just 29 firms as scoped in the desk-research of this thesis. Maybe the problem is not the lack of vertical collaborations, but the lack of actors in the blockchain-driven circular plastics ecosystem.

The lack of regulation was seen as a system barrier and consequently *collaboration with government for enabling legislation* was rated as an important activity. However, due to the global nature of the plastic problem but local regulations, this activity might benefit from additional research that explains what type of collaborations are required to achieve changes in local but also national or international waste legislation. It currently remains unclear which types of firms should pursue changes in legislation on what level (local, national, international). Moreover, due to the lack of blockchain-technology lobbying associations, it could be beneficial to add the activity of *creating facilitating organizations* also to market creation, so the blockchain-plastics actors are represented in a facilitating organization to achieve better regulation for blockchain technology and plastics.

SOCIO-CULTURAL CHANGES

One of the biggest system barriers identified by all entrepreneurs and entrepreneurial managers was the negative perception of blockchain technology. Yet, all entrepreneurs and entrepreneurial managers believed the achievement of socio-cultural changes would be the result of other system building efforts, and therefore would not actively pursue all the activities in this goal. The neglection of this goal also became apparent in the smart grid ecosystem as researched by Planko et al. (2016), yet, neglecting this area is one of the main obstacles to a successful implementation of a new technology (Planko et al., 2016). Entrepreneurs and entrepreneurial managers, considering the lengthy time horizons of socio-cultural changes, should start working collectively to pursue the presented activities rather sooner than later, as there is a chance that the technology may commercially fail if it cannot be embedded in society, despite its technological advancements (Planko et al., 2016). Changing the perception of blockchain technology was done by educating the industry and customers, however, activities as *changing the education system*, *generating a pool of skilled labor* and *creating new facilitating organizations* were barely pursued. It could be possible that these types of activities are not appropriate for startups, SMEs and MNEs due to the lack of return of investment on these activities, but that non-profit organizations or governments could play a more active role in pursuing these activities. This might indicate that the framework as developed by Planko et al. (2016) is also applicable for a broader set of actors, and not exclusively entrepreneurs and entrepreneurial managers from (commercial) firms.

COORDINATION

The system building goal coordination was rated as an important goal, however, it was the least developed goal. Also, only one startup was actively pursuing this system building goal, whereas other startups were not. Therefore, coordination seems to be a role only larger firms tend to take, yet have not made much progress in. Notably, *thinking in system building roles* was rated as the most important activity of all activities in general, yet this is an activity solely possible when there is a high degree of coordination and system orchestration achieved (Planko et al., 2016), which is not the case in the blockchain-driven plastics ecosystem according to the interviewees. More system building work remains to be done to develop the coordination activities, however, this is the core of the problem: vertical collaborations are lacking and, therefore, coordination activities as *defining a common goal, creation of a shared vision* or *thinking in system building roles* are difficult to develop.

The activity of *creating transparency of all activities in the field* appeared to be difficult to achieve in the blockchain-driven circular plastics economy ecosystem due to the high level of competition. One interviewee did not even want to disclose what type of blockchain they were going to implement, and almost all interviewees also wanted their answers to be anonymized, implicating the opposite of transparency solely in just this research. However, it could be beneficial to have a certain level of transparency in the field according to entrepreneurs and entrepreneurial managers, but it remains unclear whether *all* activities should be transparent or there is also a way to preserve the commercial nature of this ecosystem.

5.1.2 A Resource-based view on strategic collective system building

Resources and characteristics appeared to be influencing the pursued strategic collective system building goals by entrepreneurs and entrepreneurial managers. This is in line with literature from amongst others Farla et al. (2012), who explained that system building is a resource-driven process and that different actors pursue different strategies.

The availability of resources increased from startup to SME and MNE. This is in line with the literature as provided in table 2. Nevertheless, there were two exceptions. Physical resources were almost equally available for the different types of firms, which can be explained by the fact that firms developing blockchain solutions do not necessarily require these for the development of their solution and having only a small availability of physical resources is already sufficient. Organizational resources were also almost equally available for the different types of firms. This might be the result of the probing questions, which asked the interviewees to rate this resource-based on the complexity of pursuing (horizontal or vertical) collaborations with other firms or institutes and the amount of R&D. As horizontal collaborations were less complex than vertical collaborations and all interviewed firms pursued technology optimization and development as primary system building goal (implicating R&D activities), it might have been the case that all interviewed firms rated this resource as available. Financial, human and reputational resources appeared to be the most influential resources to have to pursue multiple system building goals in the blockchain-driven plastics space. This is partly in line with the findings by Farla et al. (2012), where amongst others knowledge and financial means were crucial resources to develop to achieve a sustainability transition. Nevertheless, pursuing multiple goals does not implicate that the developments of system building will speed up. It remains unclear whether pursuing multiple system building goals is beneficial for the development of a favorable macro environment, as this means resources must be divided within one firm or department to engage in multiple activities.

Size, age and diversification also seemed to influence pursued system building goals by entrepreneurs and entrepreneurial managers. As expected from literature of Garengo et al. (2015) and Cohen and Klepper (1996), both smaller and larger firms engaged into technology optimization and development. No differences in entry timing were found in this research, although it was a possibility that SMEs and MNEs started developing blockchain technology applications earlier in time than startups, as found by Schoenecker and Cooper (1998), or later in time, as found by Song and Chen (2014). According to Kilenthong et al. (2010), firms younger than 7 years are more growth-oriented than older firms. As almost all startups and SMEs existed for less than 7 years at the time of this research, this might explain why these entrepreneurs and entrepreneurial managers are failing to pursue system building goals in a *strategic* and *collective* way: this may not be a blockchain technology-specific system building issue, but a general issue associated with new technologies. To improve its applicability, the strategy framework could make a distinction in activities that should receive more attention on the short-term (<7 years) (e.g., technology optimization and development) and long-term (>7 years) (e.g., socio-cultural change and coordination) in future research. This also builds further on the comment by MNE 3, who explained that as adoption is still immature, collaboration-groups as consortia can slow down blockchain-based use-case developments instead of speeding up. Diversification did not appear to have a direct impact, although it was noticeable that larger, older firms were diversified, whereas smaller, younger firms were not diversified. In general, resources and characteristics appeared to be intertwined, e.g., the older the firm, the larger the firm, the more diversified the firm, the more resources the firm has. This confirms the expected bidirectional relationship as presented in the conceptual framework in figure 2.

Lastly, it appeared that entrepreneurs and entrepreneurial managers adjusted strategic collective system building goals over time, and sometimes returned to earlier pursued goals after some years. However, more research should be executed to understand the process behind this and how this influences the further development of the supportive ecosystem for blockchain-enabled circular plastics. As this research only observed the firm perspective of resources, and not the network and system perspective of resources as proposed by Markard et al. (2011), further research might benefit from an addition of the network and system perspective to explain how (strategic collective) system building goals are changed over time. Nevertheless, it is likely that changes in pursued strategic collective system building goals are influenced by the availability of resources as resources also appeared to be changing over time.

5.2 Managerial implications

Entrepreneurs and entrepreneurial managers can use the framework by Planko et al. (2016) for the development of a favorable macro environment for blockchain technology in the circular plastics economy context. Not every activity is as important to pursue according to the interviewees, but in general all activities were considered beneficial to pursue. The main issue remains in *collectively* pursue system building activities, thus, making use of vertical collaborations. Therefore, entrepreneurs and entrepreneurial managers should consider participating in e.g., round tables and consortia to enhance these vertical collaborations. Due to the competitive nature of the researched ecosystem, these round tables and consortia could be initiated by non-commercial organizations. In the Netherlands, the DBC could take this role and unite different startups, SMEs and MNEs to further discuss what is needed to build a favorable macro environment. Due to the public-private nature of the DBC, vertical as horizontal collaborations between blockchain firms and non-blockchain firms become possible. As the plastic problem is an international problem, non-commercial organizations that facilitate this transition should also be connected to create an international network. For example, the DBC can work together with the International Association for Trusted Blockchain Applications (INATBA), which stimulates blockchain technology use cases at European level, but also with national organizations as the Italian Blockchain Partnership (Italy), Alastria (Spain), BerChain and Blockchain Bundesverband (Germany). Besides the lack of collectively pursuing system building goals and activities, none of the firms said to be actively pursuing the goal of socio-cultural changes. The prior identified facilitating non-commercial organizations should play a more active role in pursuing these activities as development of this goal may otherwise stagnate, hampering the embedding of blockchain technology in society. This also stresses the importance of having such facilitating organizations, as commercial firms are clearly not actively pursuing this goal. Lastly, it has become evident that the availability of resources, especially financial and human resources, are required for firms to engage into (more than one) strategic collective system building goals, and therefore, entrepreneurs and entrepreneurial managers have to be actively collecting resources. This also includes for example national or international subsidy programs.

5.3 Limitations

This study has some limitations. First, not all firms in the blockchain-driven circular plastics economy ecosystem were interviewed. More initiatives of SMEs and MNEs were invited to participate but explained to not have time for an interview, thus, this resulted in a low representation of SMEs and MNEs in the sample. Also, not every startup that was working on developing a blockchain solution for a circular plastics economy that was reached out to replied. It remains unclear whether these startups are still active or just did not want to participate in the study. As the key aim of this research was to show the differences in approaches by entrepreneurs and entrepreneurial managers regarding strategic collective system building, this hampers the generalizability of the extended framework. Besides the limitations in the sample, limitations are also present in the interviews. Sometimes interviewees were unable to give a score using the Likert-scale, hampering the average scores especially for the questions about the global development of certain activities. This can be explained by the lack of vertical collaborations between blockchain-firms, resulting in a lack of awareness of activities pursued by others. The interviewees also struggled with the exact meaning behind certain system building goals as the proposed activities referred to blockchain technology as circular plastics. This resulted in different answers on some of the questions, e.g., blockchain and/or plastic standards. Further research should make use of more in-depth probing questions.

6. Conclusion

This research aimed to understand how entrepreneurs from startups and entrepreneurial managers from SMEs and MNEs act strategically to increase the adoption of blockchain technology for a circular plastics economy. A theoretical framework was developed based on system building literature and the RBV-literature. Twelve firms from various places around the globe were interviewed to learn more about their strategic collective system building efforts in the blockchain-driven circular plastics economy and how these efforts were influenced by firm characteristics and available resources. Results indicated that the system building activities developed by Planko et al. (2016) were seen as important to increase the adoption of blockchain technology for a circular plastics economy but were globally not developed yet and therefore require more work by system actors. Moreover, results indicated that system building happens in the blockchain-driven circular plastics economy ecosystem, however, not in a strategic manner. The entrepreneurs and entrepreneurial managers were aware that they have to solve problems and overcome barriers at the system level, yet they did not collectively plan system level changes. Strategies were formed at firm level and collaborations were used to achieve their companies' objectives.

The amount of system building goals a firm pursued is influenced by firm size and available firm resources. On average, the larger the firm, the more available resources, the more system building goals a firm pursued. Especially financial, human and reputational resources differed per startups, SMEs and MNEs, where startups generally had the lowest amount of resources available. There seemed to be a dynamic interplay between the different system building goals pursued by entrepreneurs and entrepreneurial managers: firms altered strategic collective system building goals over time but can also pursue more goals simultaneously. This implicates that startups, SMEs and MNEs have different roles in the development of the favorable macro environment for blockchain technology, and SMEs and MNEs have a more diversified role in this development due to the higher amount of pursued system building goals. Startups generally were solely focusing on technology optimization and development, whereas SMEs and MNEs were also focusing on coordination and market creation. Especially the system building goal coordination seemed to be a role only larger firms take, and startups do not. Socio-cultural change was rated as an important system building goal, yet it was widely believed to be the result of other system building efforts and therefore, no resources were dedicated to actively pursue this goal. Nevertheless, this strategic goal must be pursued actively as well and therefore non-commercial organizations as non-profits and governments could step in to dedicate resources to this strategic goal.

Despite the global plastic (waste) problem, the amount of firms focusing on creating a circular plastics economy utilizing blockchain technology remains rather low to date. Even with the system building efforts by these active firms, the issue may not only be the lack of *strategic collective* system building work performed by the active startups, SMEs and MNEs, but the lack of active firms in general. System actors, including governments and non-profits, should strategically divide system building tasks and collectively build a supportive macro environment for blockchain technology for circular plastics, thereby also attracting more firms to enter this ecosystem. Thus, the trend towards a decentralized circular plastics economy, ironically, necessitates centralized, collective action.

REFERENCES

Ahmad, R. W., Salah, K., Jayaraman, R., Yaqoob, I., & Omar, M. (2021). Blockchain for Waste Management in Smart Cities: A Survey. *TechRxiv*, 1–17. https://doi.org/10.36227/techrxiv.14345534.v1

Ajwani-Ramchandani, R., Figueira, S., Torres de Oliveira, R., & Jha, S. (2021). Enhancing the circular and modified linear economy: The importance of blockchain for developing economies. *Resources, Conservation and Recycling*, *168*. https://doi.org/10.1016/j.resconrec.2021.105468

Andersen, A. D., Frenken, K., Galaz, V., Kern, F., Klerkx, L., Mouthaan, M., Piscicelli, L., Schor, J. B., & Vaskelainen, T. (2021). On digitalization and sustainability transitions. *Environmental Innovation and Societal Transitions*, *41*, 96–98. https://doi.org/10.1016/j.eist.2021.09.013

Andrady, A. L., & Neal, M. A. (2009). Applications and societal benefits of plastics. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*(1526), 1977–1984. https://doi.org/10.1098/rstb.2008.0304

Arkin, C., Rached, S., Malik, B., Allen, C., Guerrero at GAIA, L., Vahk at Zero Waste Europe, J., Lenker at FracTracker Alliance, B., Feaster, S., Carrillo, V., Gwinn, J., & Albar Díaz, M. (2019). *Plastics & Climate: The Hidden Costs of a Plastic Planet*. www.ciel.org/plasticandclimate

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99–120. https://doi.org/10.1177/014920639101700108

Barney, J. (2001). Is the Resource-Based “View” a Useful Perspective for Strategic Management Research? Yes. *The Academy of Management Review*, *26*(1), 41–56. https://about.jstor.org/terms

Beck, T., Demirguc-Kunt, A., Laeven, L., & Levine, R. (2008). Finance, Firm Size, and Growth. *Journal of Money, Credit and Banking*, *40*(7), 1379–1405.

Böckel, A., Nuzum, A. K., & Weissbrod, I. (2021). Blockchain for the Circular Economy: Analysis of the Research-Practice Gap. In *Sustainable Production and Consumption* (Vol. 25, pp. 525–539). Elsevier B.V. https://doi.org/10.1016/j.spc.2020.12.006

Bryman, A. (2012). *Social Research Methods* (4th ed.). Oxford University Press.

Cagliano, R., & Blackmon, K. (2001). Small firms under MICROSCOPE: international differences in production/operations management practices and performance. *Integrated Manufacturing Systems*, *12*(7), 469–482. http://www.emerald-library.com/ft

Caviggioli, F., Lamberti, L., Landoni, P., & Meola, P. (2020). Technology adoption news and corporate reputation: sentiment analysis about the introduction of Bitcoin. *Journal of Product and Brand Management*, *29*(7), 877–897. https://doi.org/10.1108/JPBM-03-2018-1774

Chauhan, C., Parida, V., & Dhir, A. (2022). Linking circular economy and digitalisation technologies: A systematic literature review of past achievements and future promises. *Technological Forecasting and Social Change*, *177*, 121508. https://doi.org/10.1016/j.techfore.2022.121508

Chidepatil, A., Bindra, P., Kulkarni, D., Qazi, M., Kshirsagar, M., & Sankaran, K. (2020). From Trash to Cash: How Blockchain and Multi-Sensor-Driven Artificial Intelligence Can Transform Circular Economy of Plastic Waste? *Administrative Sciences*, *10*(2), 23. https://doi.org/10.3390/admsci10020023

Chikhi, T., Antonio De Santa-Eulalia, L., Mosconi, E., Antonio Risso, L., Godinho Filho, M., & Miller Devós Ganga, G. (2022). Going Beyond Blockchain Adoption’s Hype to Improve Supply Chain Sustainability:

Evidence From Empirical and Modelling Studies. *Proceedings of the 55th Hawaii International Conference on System Sciences*, 6053–6062. https://hdl.handle.net/10125/80075

Cohen, W. M., & Klepper, S. (1996). A Reprise of Size and R & D. *The Economic Journal*, *106*(437), 925–951. https://www.jstor.org/stable/2235365

Collis, D. J., & Montgomery, C. A. (2008). Competing on Resources. *Harvard Business Review*. www.hbr.org

Dean, D. L., Mengüç, B., & Myers, C. P. (2000). Revisiting Firm Characteristics, Strategy, and Export Performance Relationship: A Survey of the Literature and an Investigation of New Zealand Small Manufacturing Firms. In *Industrial Marketing Management* (Vol. 29).

Dewan, S., Michael, S. C., & Min, C.-K. (1998). Firm Characteristics and Investments in Information Technology: Scale and Scope Effects. In *Research* (Vol. 9, Issue 3). https://www.jstor.org/stable/23011270

Dollinger, M. J. (2008). *Entrepreneurship : strategies and resources*. Marsh Publications.

Farla, J., Markard, J., Raven, R., & Coenen, L. (2012). Sustainability transitions in the making: A closer look at actors, strategies and resources. In *Technological Forecasting and Social Change* (Vol. 79, Issue 6, pp. 991–998). https://doi.org/10.1016/j.techfore.2012.02.001

Garengo, P., Biazzo, S., & Bititci, U. S. (2005). Performance measurement systems in SMEs: A review for a research agenda. *International Journal of Management Reviews*, *7*, 25–47.

Grant, R. M. (1999). The resource-based theory of competitive advantage: Implications for strategy formulation. *California Management Review*, *33*(3), 114–135. https://doi.org/10.1016/b978-0-7506-7088-3.50004-8

Helm, S. (2005). Academic Research Designing a Formative Measure for Corporate Reputation. *Corporate Reputation Review* , *8*(2), 95–109.

Hileman, G., & Rauchs, M. (2017). *Global Blockchain Benchmarking Study*.

Hundertmark, T., Mayer, M., McNally, C., Simons, T. J., & Witte, C. (2018, December 12). *How plastics waste recycling could transform the chemical industry*.

Iansiti, M., & Levien, R. (2004, March). Strategy as Ecology. *Harvard Business Review*, 68–81.

ISCC. (n.d.). *ISCC for the Circular Economy and Bioeconomy*. International Sustainability & Carbon Certification.

Issac, M. N., & Kandasubramanian, B. (2021). Effect of microplastics in water and aquatic systems. *Environmental Science and Pollution Research*, *28*(16), 19544–19562. https://doi.org/10.1007/s11356-021-13184-2/Published

Jeswani, H., Krüger, C., Russ, M., Horlacher, M., Antony, F., Hann, S., & Azapagic, A. (2021). Life cycle environmental impacts of chemical recycling via pyrolysis of mixed plastic waste in comparison with mechanical recycling and energy recovery. *Science of the Total Environment*, *769*. https://doi.org/10.1016/j.scitotenv.2020.144483

Johansson, B., & Lööf, H. (2008). Innovation activities explained by firm attributes and location. *Economics of Innovation and New Technology*, *17*(6), 533–552. https://doi.org/10.1080/10438590701407349

Kiger, M. E., & Varpio, L. (2020). Thematic analysis of qualitative data: AMEE Guide No. 131. *Medical Teacher*, *42*(8), 846–854. https://doi.org/10.1080/0142159X.2020.1755030

Kilenthong, P., Hills, G. E., Hultman, C., & Sclove, S. L. (2010). Entrepreneurial Marketing Practice: Systematic Relationships with Firm Age, Firm Size, and Operator's Status. *International Symposium on Marketing & Entrepreneurship*, 1–15.

Kouhizadeh, M., Zhu, Q., & Sarkis, J. (2020). Blockchain and the circular economy: potential tensions and critical reflections from practice. *Production Planning and Control*, *31*(11–12), 950–966. https://doi.org/10.1080/09537287.2019.1695925

Kraaijenbrink, J., & Groen, A. (2008). *Towards a Functional Resource-based Theory of the Firm*.

Kraft, K. (1989). Market Structure, Firm Characteristics and Innovative Activity. *The Journal of Industrial Economics*, *37*(3), 329–336.

Lange, D., Lee, P. M., & Dai, Y. (2011). Organizational reputation: A review. In *Journal of Management* (Vol. 37, Issue 1, pp. 153–184). https://doi.org/10.1177/0149206310390963

Liang, T. P., You, J. J., & Liu, C. C. (2010). A resource-based perspective on information technology and firm performance: A meta analysis. *Industrial Management and Data Systems*, *110*(8), 1138–1158. https://doi.org/10.1108/02635571011077807

Lynch, S. (2018). OpenLitterMap.com – Open Data on Plastic Pollution with Blockchain Rewards (Littercoin). *Open Geospatial Data, Software and Standards*, *3*(1). https://doi.org/10.1186/s40965-018-0050-y

Mahon, J. F., & Wartick, S. L. (2003). Dealing with Stakeholders: How Reputation, Credibility and Framing Influence the Game. *Corporate Reputation Review*, *6*(1), 19–36.

Markard, J., Musiolik, J., & Worch, H. (2011). System resources in emerging technological fields: Insights from resource-based reasoning for innovation and transition studies. *IST 2011 Conference*. www.cirus.ch

Markard, J., & Worch, H. (2009). Technological innovation systems and the resource based view- Resources at the firm, network and system level. *DIME Workshop*. www.cirus.ch

Market Analysis for Plastic waste recovery by regional blockchain networks. (2019).

Maxwell, J. A. (2012). *Designing a Qualitative Study*. https://www.researchgate.net/publication/43220402

Mittal, S., Khan, M. A., Romero, D., & Wuest, T. (2018). A critical review of smart manufacturing & Industry 4.0 maturity models: Implications for small and medium-sized enterprises (SMEs). In *Journal of Manufacturing Systems* (Vol. 49, pp. 194–214). Elsevier B.V. https://doi.org/10.1016/j.jmsy.2018.10.005

Morseletto, P. (2020). Targets for a circular economy. *Resources, Conservation and Recycling*, *153*. https://doi.org/10.1016/j.resconrec.2019.104553

Müller, J. M., & Voigt, K.-I. (2017). Industry 4.0-Integration strategies for SMEs. *International Association for Management of Technology*, 1–15. https://www.researchgate.net/publication/317070483

Musiolik, J., Markard, J., & Hekkert, M. (2012). Networks and network resources in technological innovation systems: Towards a conceptual framework for system building. *Technological Forecasting and Social Change*, *79*(6), 1032–1048. https://doi.org/10.1016/j.techfore.2012.01.003

Musiolik, J., Markard, J., Hekkert, M., & Furrer, B. (2020). Creating innovation systems: How resource constellations affect the strategies of system builders. *Technological Forecasting and Social Change*, *153*. https://doi.org/10.1016/j.techfore.2018.02.002

Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System*. www.bitcoin.org

Ongena, G., Smit, K., Boksebeld, J., Adams, G., Roelofs, Y., & Ravesteijn, P. (2018). Blockchain-based smart contracts in waste management: A silver bullet? *31st Bled EConference: Digital Transformation: Meeting the Challenges, BLED 2018*, 345–356. https://doi.org/10.18690/978-961-286-170-4.23

Planko, J., Cramer, J., Chappin, M., & Hekkert, M. (2016). Strategic collective system building to commercialize sustainability innovations. *Journal of Cleaner Production*, *112*, 2328–2341. https://doi.org/10.1016/j.jclepro.2015.09.108

Pulsfort, J., Wankmüller, C., & Reiner, G. (2021). *The impact of blockchain-enabled tokenization on plastic waste: an empirical study*.

Sandhiya, R., & Ramakrishna, S. (2020). Investigating the Applicability of Blockchain Technology and Ontology in Plastics Recycling by the Adoption of ZERO Plastic Model. *Materials Circular Economy*, *2*(13). https://doi.org/10.1007/s42824-020-00013-z/Published

Sankaran, K. (2019). Carbon emission and plastic pollution: How circular economy, blockchain, and artificial intelligence support energy transition? *Journal of Innovation Management*, *7*(4), 7–13. https://doi.org/10.24840/2183-0606_007.004_0002

Schoenecker, T. S., & Cooper, A. C. (1998). The role of firm resources and organizational attributes in determining entry timing: A cross-industry study. *Strategic Management Journal*, *19*(12), 1127–1143. https://doi.org/10.1002/(SICI)1097-0266(1998120)19:12<1127::AID-SMJ7>3.0.CO;2-4

Schwarz, A., de Ruiter, R., Zondervan, E., van Eijk, F., & Huybrechts, L. (2021). *A circular economy for plastics*.

Sen Gupta, Y., Mukherjee, S., Dutta, R., & Bhattacharya, S. (2021). A blockchain-based approach using smart contracts to develop a smart waste management system. *International Journal of Environmental Science and Technology*. https://doi.org/10.1007/s13762-021-03507-8

Song, M., & Chen, Y. (2014). Organizational attributes, market growth, and product innovation. *Journal of Product Innovation Management*, *31*(6), 1312–1329. https://doi.org/10.1111/jpim.12185

Steenmans, K., Taylor, P., & Steenmans, I. (2021). Blockchain Technology for Governance of Plastic Waste Management: Where Are We? *Social Sciences*, *10*(11), 434. https://doi.org/10.3390/socsci10110434

Thornhill, S., & Amit, R. (2003). Learning about Failure: Bankruptcy, Firm Age, and the Resource-Based View. *Organization Science*, *14*(5), 497–509. https://doi.org/10.1287/orsc.14.5.497.16761

United Nations. (2021, December 21). *Conserve and sustainably use the oceans, seas and marine resources for sustainable development*. Department of Economic and Social Affairs: Sustainable Development.

Uzoka, P. U., & Anichebe, A. S. (2020). Effect of Firm Attributes on Firm Performance: An Interaction Approach. In *International Journal of Academic Accounting* (Vol. 4). www.ijeais.org/ijaafmr

Varadarajan, R. (2011). Marketing strategy: discerning the relative influence of product and firm characteristics. In *AMS Review* (Vol. 1, Issue 1, pp. 32–43). Springer. https://doi.org/10.1007/s13162-011-0003-4

Yin, R. K. (2003). *Case Study Research* (Third edition, Vol. 5). Sage Publications, Inc.

Zaiem, I., Ben, A., & Zghidi, Y. (2011). Product Adaptation Strategy and Export Performance: The Impacts of the Internal Firm Characteristics and Business Segment. *Contemporary Management Research*, *7*(4), 291–312.

APPENDIX

A. LIST OF ACTORS UTILIZING BLOCKCHAIN TECHNOLOGY TO ENHANCE PLASTICS CIRCULARITY

Due to non-disclosure agreements the project initiation year has been deleted.

Name firm, type firm, collaboration	Usage type	Blockchain*	Project stage
Agora Tech Lab (SU)	cryptocurrency-based reuse and recycling rewards; tokenization	Holochain	Operational
Arep	traceability	?	Discontinued
BanQu (SU) Collaborating with i.a.,: *Bavaia Breweries Colombia (ABInBev), Coca-Cola Africa*	traceability	?	Operational
BASF (MNE) Collaborating with: *Kryha*	traceability; sustainability; enhanced sorting; consortium; data integrity; incentivize with loyalty program when well sorted (Brazil); monetization of plastics within the value chain	Hyperledger Besu	Operational
Bounties Network (SU) Collaborating with: *MakeDao*	cryptocurrency-based payments	Ethereum	Unclear
ChemChain (SU) Collaborating with i.a.: *Chemchain, Solvay, Dow*	traceability; tokens	Hyperledger Fabric	Operational
Circularise (SME) Collaborating with: *Domo, Covestro, Porsch, Marubeni, Mitsubishi Chemical Holdings, Asahi Kasei, PPG & UL*	traceability; sharing data	Ethereum	Operational
Circulor (SME) Collaborating with i.a.,:	traceability; sustainability; risk management	?	Operational

TotalEnergies, Innovate UK, Recyclng Technologies			
Eiravato (SU)	traceability	?	Operational
Empower (SU)	traceability; monetisation of plastic (even for unbanked)	?	Operational
GreenToken (SAP) (MNE)	Traceabilty of chain of custody for raw materials	Quorum	Operational
IBM (MNE) Collaborating with i.a.,: *The Plastic Bank, Mitsui Chemicals, Nomura research, Asahi Kasei Pharma, Toyama Environmental Improvements, Mobius Packaging, Lion*	traceability and accountability	Hyperledger Fabric	Operational
Jay Philips Partnership (?)	export of waste; cryptocurrency payment	Bitcoin	Discontinued
JellyCoin (SU)	cryptocurrency-based reuse and recycling rewards	?	Operational
KleanIndustries (with platform Klean Loop) (SME)	Dapp for waste & energy sector; crypto currency based recycling rewards (KleanCoin)	?	Operational
Kryha (SME) Collaborating with i.a.,: *BASF*	Consultancy company	Ethereum	Operational
Lidbot (?)	smart bins	IOTA	Unclear
OpenLitterMap (SU)	cryptocurrency-based recycling rewards; traceability	?	Operational
Parry & Evans (?)	cryptocurrency-based payments; traceability	Bitcoin	Discontinued

Prism Environmental (?)	cryptocurrency-based reuse and recycling rewards; tokenization	Bitcoin	Discontinued
Receum (?)	cryptocurrency-based payments	?	Discontinued (was predecessor for W2V Eco Solutions)
RecycleGO (SU)	traceability	?	Operational
RecycleToCoin (?)	cryptocurrency-based reuse and recycling rewards	Ethereum	Unclear
Save Environment Token (?)	cryptocurrency-based recycling rewards; traceability	?	Unclear
Save Planet Earth (SU)	first-ever Gold Standard certified carbon credit NFT; carbon credit exchange that uses $SPE as curency	Phantasma blockchain; Binance Smart Chain	Operational
Shell* (MNE) Collaborating with: *Worley, Flowserve, Bureau Veritas, Ventil, Kryha* *Not plastic related blockchain project currently ongoing, however, are scoping the market and have several other traceability systems based on blockchain-technology.	traceability; material passports	Ethereum	Operational
Swachhoin (SU)	cryptocurrency-based reuse and recycling rewards	?	Discontinued
The Plastic Bank (SME) Collaborating with: *IBM*	transparency, traceability, and rapid scalability.	Hyperledger Fabric	Operational
W2V Eco Solutions (SU)	traceability; cryptocurrency-based recycling rewards	VeChain	Unclear

SU= Startup, SME= Small-medium enterprise, MNE = Multinational enterprise, ? = no data available

* '?' means this information was not available online or deleted due to NDA

B. SOURCE MATERIAL FOR BLOCKCHAIN-BASED PLASTICS INITIATIVES

Name firm and type	Source
Agora Tech Lab	Agora Tech Lab. 2021. Waste Management fueled by Blockchain. Available online: https://www.agoratechlab.com (accessed on 4 December 2021) Reflow. 2021.Agora Tech Lab: creating circular economies by rewarding responsible behavior. Available online: https://reflowproject.eu/best-practices/agora-tech-lab-creating-circular-economies-by-rewarding-responsible-behavior/ (accessed on 4 December 2021) Crypto Academy. 2021. Meet Agora Tech Lab (ATL) – The First Global Initiative to Decentralized Waste Management. Available online: https://crypto-academy.org/meet-agora-tech-lab-atl-the-first-global-initiative-to-decentralized-waste-management/?feed_id=128&_unique_id=617ac0dd4db89 (accessed on 4 December 2021)
Arep	Digital SNCF. 2017. Data-tritus- How blockchain simplifies waste sorting. Available online: https://www.digital.sncf.com/actualites/data-tritus-comment-la-blockchain-simplifie-le-tri-des-dechets (accessed on 3 January 2022)
BanQu	BanQu. 2021. Traceable. Transparant. Equitable. Available online: https://banqu.co (accessed on 4 December 2021) BanQu. 2021. How Coca-Cola uses BanQu to optimize the recyclables value chain. Available online: https://banqu.co/use-cases/how-coca-cola-uses-banqu-to-optimize-the-recyclables-value-chain/ (accessed on 4 December 2021) AbInBev. 2019. BanQu Raises Series A Extension Round From ZX Ventures/AB InBev To Continue Its Geographic Expansion and Product Development In The Supply Chain Transparency & Traceability Space For Global Brands. Available online: https://www.ab-inbev.com/news-media/innovation/banqu/ (accessed on 4 December 2021)
BASF	BASF. 2021. Envisioning Plastics Circularity. Available online: https://www.basf.com/ca/en/who-we-are/sustainability/Sustainability-in-Canada/reciChain.html (accessed on 3 December 2021) BASF. 2021. reciChain – Physical Movement. Available online: https://www.basf.com/ca/en/who-we-are/sustainability/Sustainability-in-Canada/reciChain/recichain---physical-movement.html (accessed on 3 December 2021) BASF. 2019. Cooperation through transparency: ReciChain project promotes waste value chain in Brazil. Available online: https://www.basf.com/tw/en/who-we-are/sustainability/whats-new/sustainability-news/2019/starting-ventures-recichain-brazil.html (accessed on 3 December 2021)
Bounties Network	The Bounties Network. N.d. Available online: https://bounties.network/gettingStarted (accessed on 4 December 2021) LinkedIn. 2021. Available online: https://www.linkedin.com/company/bounties-network/about/ (accessed on 4 December 2021) Beylin, Mark. 2018. Bounties for the Oceans: Incentives to change the world. Available online: https://medium.com/bounties-network/bounties-for-the-oceans-incentives-to-change-the-world-8f3429fd01e9 (accessed on 6 January 2022). Calderon, Justin. 2019. Poorer communities in the developing world bear the brunt of plastic pollution. Could a new digital payment system spark a clean-up revolution? Available online: www.bbc.com/future/article/20190613-a-simple-online-system-that-could-end-plastic-pollution (accessed on 6 January 2022).

	Pop, Simona. 2018. Bounties for the Oceans: Philippines pilot., Available online: https://medium.com/bounties-network/bounties-for-the-oceans-philippines-pilot-db4319b00012 (accessed on 6 January 2022). The Bounties Network. N.d. Bounties for the Oceans: Manila. Available online: https://bounties.network/manila.html (accessed on 6 January 2022).
ChemChain	ChemChain. 2020. Track Chemicals along the value chain. Available online: https://chemcha.in (accessed on 2 December 2021) Solvay. 2021. Available online: https://www.solvay.com/en/news/chemical-product-information-solvay-use-blockchain-smooth-running-circular-economy (accessed on 2 December 2021) EU. 2021. Blockchain Platform to Track Chemicals along the Value Chain. Available online: https://cordis.europa.eu/project/id/875783 (accessed on 2 December 2021)
Circularise	Circularise. 2021. Trace your materials from source to product. Available online: https://www.circularise.com (accessed on 2 December 2021) European Union. N.d. Circularise Plastics: an open standard making the plastics supply chain more transparent, fair and profitable. Available online: https://circulareconomy.europa.eu/platform/en/good-practices/circularise-plastics-open-standard-making-plastics-supply-chain-more-transparent-fair-and-profitable (accessed on 2 December 2021)
Circulor	Circulor. 2021. Leading Supply Chain Traceability. Available online: https://www.circulor.com (accessed on 2 December 2021) Circulor. 2021. TotalEnergies, Circulor, Innovate UK and Recycling Technologies partner to develop blockchain-enabled traceability solution for recycled plastic waste. Available online: https://www.circulor.com/total-press-release (accessed on 2 December 2021)
Eiravato	Eiravato. 2021. Available online: https://www.eiravato.com (accessed on 4 December 2021) Burke, Eilane. 2019. Eiravato takes its plastic waste fight to Luxembourg. Available online: https://www.siliconrepublic.com/startups/eiravato-plastic-waste-circular-economy-luxembourg (accessed 4 December 2021) O'Brien, Ciara. 2018. Eiravato raises €550,000 to help firms turn waste into profit. Available online: https://www.irishtimes.com/business/innovation/eiravato-raises-550-000-to-help-firms-turn-waste-into-profit-1.3678970 (accessed on 4 December 2021) LinkedIn. 2021. Eiravato. Available online: https://www.linkedin.com/company/eiravato/?originalSubdomain=ie (accessed on 4 December 2021)
Empower	Empower.eco. 2021. The Future of Plastic is Circular. Available online: https://www.empower.eco (accessed on 4 December 2021) Sheffield, Hazel. 2018. Norway's Empower is using blockchain to clean up the world's oceans. Available online: https://www.independent.co.uk/news/business/indyventure/plastic-waste-recycling-blockchain-empower-oslo-innovation-a8565906.html (accessed 4 December 2021)
GreenToken	GreenToken. 2022. Available online: https://www.green-token.io (accessed on 4 January 2022) SAP. 2022. Venture Voices: A year of and with GreenToken by SAP. Available online: https://sap.io/venture-voices-a-year-of-and-with-greentoken-by-sap/ (accessed on 4 January 2022)
IBM	Ledger Insights. 2021. IBM, Mitsui Chemicals, Nomura Research start plastic recycling blockchain consortium. Available online: https://www.ledgerinsights.com/ibm-mitsui-chemicals-nomura-research-start-plastic-recycling-blockchain-consortium/ (accessed on 3 December 2021)

	Ledger Insights. 2021. Asahi Kasei trials plastic traceability platform with IBM blockchain. Available online: https://www.ledgerinsights.com/asahi-kasei-trials-plastic-traceability-platform-with-ibm-blockchain/ (accessed on 3 December 2021) Mitsui Chemicals. 2021. Mitsui Chemicals, IBM Japan to Start Joint Efforts Toward Building a Blockchain-Based Resource Circulation Platform. Available online: https://jp.mitsuichemicals.com/en/release/2021/2021_0426.htm (accessed on 3 December 2021)
Jay Philips Partnership	Jackson, Mike. 2018. How Bitcoin and blockchain technology can benefit the waste management industry. Available online: https://www.recyclingwasteworld.co.uk/in-depth-article/how-bitcoin-and-blockchain-technology-can-be-put-to-good-use-in-the-waste-management-industry/168216 (accessed on 3 January 2022) LinkedIn. 2021. Available online: https://www.linkedin.com/in/mike-jackson-62b23152/ (accessed on 3 January 2022)
JellyCoin	Lanz, Antonio Jose. 2019. Argentina to reward waste management with new "wastecoin" called JellyCoin. Available online: https://decrypt.co/8695/argentina-reward-waste-management-with-new-wastecoin-called-jellycoin (accessed on 3 January 2022) Pongratz, Nicholas. 2021. Blockchains Break Through the Rubbish: Waste Management and the Future. Available online: https://beincrypto.com/blockchain-breaks-through-rubbish-waste-management-future/ (accessed on 3 January 2022) Malloy, Chris. 2021. Even Garbage is Using Blockchain Now. Available online: https://www.bloomberg.com/news/articles/2021-03-18/even-garbage-is-using-blockchain-now (accessed on 3 January 2022)
KleanIndustries (with platform Klean Loop)	KleanLoop. N.d. KleanLoop DApp. All waste has value. Available online: https://kleanloop.io (accessed on 6 December 2021) Klean Industries. 2021. Klean Industries Blockchain Solution Called the KleanLoop™ is Nominated for Business. Available online: https://apnews.com/press-release/globe-newswire/business-technology-environmental-equipment-and-services-blockchain-environment-05da8cbc8e61c97ae186b9a48fdf2a97 (accessed on 6 December 2021) LinkedIn. 2022. Available online: https://www.linkedin.com/company/kleanindustries/ (accessed on 6 January 2022)
Kryha	Kryha. 2021. Our work. Available online: https://kryha.io/our-work/ (accessed on 2 December 2021) Kryha. 2021. Recichain, an ecosystem to empower social waste recycling. Available online: https://kryha.io/cases/recichain/ (accessed on 2 December 2021)
Lidbot	IOTA Foundation. 2021. Community Spotlight: Lidbot — building the future of waste management. Available online: https://blog.iota.org/lidbot-and-iota-building-the-future-of-waste-management-680504f4e303/ (accessed on 16 December 2021) Lidbot. N.d. Smart waste management. Available online: https://lidbot.com (accessed on 16 December 2021)
OpenLitterMap	OpenLitterMap. 2021. #OpenLitterMap. Available online: https://openlittermap.com (accessed 6 on December 2021) Seán Lynch, 2018. OpenLitterMap.com – Open Data on Plastic Pollution with Blockchain Rewards (Littercoin). Available online: https://opengeospatialdata.springeropen.com/articles/10.1186/s40965-018-0050-y (accessed on 6 December 2021) Hamilton, Alex. 2021. Littercoin: A Cardano Project Attempting to Tackle a Massive Environmental Quandary. Available online: https://adapulse.io/littercoin-a-cardano-project-attempting-to-tackle-a-massive-environmental-quandary/ (accessed on 5 January 2022)

Parry & Evans	Sanderson, Paul. 2017. Prismm Environmental and Parry & Evans become first companies to trade recyclable paper using Bitcoin in UK. Available online: https://www.rebnews.com/prismm-environmental-and-parry-evans-become-first-companies-to-trade-recyclable-paper-using-bitcoin-in-uk/ (accessed on 3 January 2022) Writer, Staff. 2017. Prismm and Parry & Evans make Bitcoin history. Available online: https://www.labelsandlabeling.com/news/latest/prismm-and-parry-evans-make-bitcoin-history (accessed on 3 January 2022)
Prism Environmental	Sanderson, Paul. 2017. Prismm Environmental and Parry & Evans become first companies to trade recyclable paper using Bitcoin in UK. Available online: https://www.rebnews.com/prismm-environmental-and-parry-evans-become-first-companies-to-trade-recyclable-paper-using-bitcoin-in-uk/ (accessed on 3 January 2022) Writer, Staff. 2017. Prismm and Parry & Evans make Bitcoin history. Available online: https://www.labelsandlabeling.com/news/latest/prismm-and-parry-evans-make-bitcoin-history (accessed on 3 January 2022) Jackson, Mike. 2018. How Bitcoin and blockchain technology can benefit the waste management industry. Available online: https://www.recyclingwasteworld.co.uk/in-depth-article/how-bitcoin-and-blockchain-technology-can-be-put-to-good-use-in-the-waste-management-industry/168216 (accessed on 3 January 2022)
Receum	Recereum. 2017. Recereum is blockchain-based platform for turning waste and recyclables to real value. Available online: https://recereum.com (accessed on 6 January 2022) Recereum. N.d. Recereum Whitepaper. Available online: https://recereum.com/files/WhitePaper-Recereum.pdf (accessed on 6 January 2022)
RecycleGO	RecycleGO. 2020. The Future of Recycling starts with RecycleGo. Available online: https://www.recyclego.com (accessed on 4 December 2021) Pongratz, Nicholas. 2021. Blockchains Break Through the Rubbish: Waste Management and the Future. Available online: https://beincrypto.com/blockchain-breaks-through-rubbish-waste-management-future/ (accessed on 3 January 2022) Malloy, Chris. 2021. Even Garbage is Using Blockchain Now. Available online: https://www.bloomberg.com/news/articles/2021-03-18/even-garbage-is-using-blockchain-now (accessed on 3 January 2022) LinkedIn. 2021. Available online: https://www.linkedin.com/company/recyclego/ (accessed on 3 January 2022)
RecycleToCoin	Recycle-to-coin. 2021. Recycle-to-coin. Available online: https://positiveblockchain.io/database/recycle-to-coin/ [the provided website https://www.recycletocoin.com is no longer attached to the initiative on 6 January 2022]
Save Environment Token	SET. 2020. Save Environmental Token. Available online: https://www.set4earth.com (accessed on 4 January 2022) Save Environment Token (SET). 2018. What is Save Environmnet Token (SET) and how does it work? Available online: https://medium.com/save-environment-token/what-is-save-environment-token-set-and-how-does-it-work-4b8388d9860f (accessed on 6 January 2022)
Save Planet Earth	Save Planet Earth. 2021. Save Planet Earth. Available online: https://saveplanetearth.io (accessed on 6 December 2021) LinkedIn. 2021. Available online: https://www.linkedin.com/company/saveplanetearth/ (accessed on 6 December 2021)
Shell	Shell. 2021. Plastics. Available online: https://reports.shell.com/sustainability-report/2020/respecting-nature/plastics.html (accessed on 2 December 2021) Shell. 2021. Blockchain. Available online: https://www.shell.com/energy-and-innovation/digitalisation/digital-technologies/blockchain.html (accessed on 2 December 2021)

Swachhoin	Swachhcoin. 2018. All you need to know about Swachhcoin. Available online: https://medium.com/@swachhcoin/all-you-need-to-know-about-swachhcoin-53bb58e12c3d (accessed on 6 January 2022)
The Plastic Bank	The Plastic Bank. 2020. Begin your Journey to Stop Ocean Plastic. Available online: https://plasticbank.com (accessed on 2 December 2021) IBM. 2021. Plastic Bank. Available online: https://www.ibm.com/case-studies/plastic-bank-systems-linuxone (accessed on 2 December 2021) LinkedIn. 2021. Available online: https://www.linkedin.com/company/plasticbank/?originalSubdomain=ca (accessed on 2 December 2021)
W2V Eco Solutions	W2V Eco Solutions. N.d. Available online: https://drive.google.com/file/d/1eG480hSIHHavqFAwrUgHN7s4bgSB10rP/view (accessed on 6 December 2021) W2V Eco Solutions. 2021. About W2V Eco Solutions. Available online: https://w2v.io (accessed on 6 December 2021)

C. INTERVIEW GUIDE

Dear participant,

Thank you for your time today. I highly appreciate it.

Before we start, I hope you can sign the following **consent form**, which was sent to you by e-mail a few minutes before we started.

Very roughly said, I am interviewing you to find out what you are doing to stimulate blockchain-technology adoption in the context of the circular plastics economy. A circular plastics economy is a system in which plastic is getting recycled/more properly managed (no illegal dumping) resulting in waste minimization, reduction of primary resources and closed loops of plastics.

Let's start the interview.

Purpose of the question	**Main question**	**Probes**
Icebreaker	Can you tell me something about your company and your position in the company?	
Check facts about initiative/firm (firm attributes)	In what year was the company established? How many employees does your company have now? If applicable: How many are on the blockchain-department? Would you describe your firm to be diversified in its business practices? (Definition: the extent to which a firm operates in multiple lines of business) What are you doing with blockchain?	Is your company utilizing different technologies (diversified) or only blockchain technology (not diversified)? How does your initiative contribute to a circular plastics economy? Where is the initiative active? At what stage of implementation is your initiative? e.g. (pilot; development; operational; discontinued) Is your provided solution scalable (and ready for uptake in users)?
Context	What is, according to you, the main barrier to a greater blockchain adoption in the circular plastics economy context on a global level? Are there any specific challenges that hamper blockchain adoption in the country your initiative is active?	(Technology development & optimization) Is there enough technological development? (Socio-cultural changes) Are traditional waste firms ready to consider blockchain? What is the attitude of end-consumers towards the blockchain technology?

		(Market creation) Are there sufficient/appropriate policies to stimulate further development of blockchain technology for sustainability purposes?
Strategies	What are *you* doing to stimulate the adoption of your blockchain [initiative/product/service]? *If interviewee struggles with question: what are you doing to let your business grow?*	What are the goals? Why did you choose that goal? What activities have you done so far to achieve these goals? Why exactly these activities?
Collective efforts + strategies part 2	Do *you* engage in collaborations with other firms (or organizations e.g., the government) in order to increase the adoption of your [initiative/ product/service]? *If applicable: Can you tell me a bit more about your collaborations, for example, do they pursue the same goals as you to stimulate adoption or are they pursuing different goals than you?* Do you think *other* blockchain-plastic actors have a lot of collaborations? What is the main purpose of these collaborations, you think? *If applicable: What are other people (with whom you do not collaborate with) doing to stimulate the adoption of blockchain technology in the plastic field / or the general sustainability field?*	(Coordination) With whom do you collaborate? Do you think collaborations/ working together is necessary to increase the adoption/implementation of your initiative? How do activities other blockchain initiatives pursue affect what your company is doing? (e.g., to get more money, to exchange knowledge, to create leverage to lobby ?
System Building	[Show interviewee the framework by Planko et al. (2016)] As you can see, there are four goals including associated activities you can pursue according to this framework to stimulate adoption of new sustainability technologies. [Walk through the framework and mention activities to	

	make sure the interviewee knows what is meant with each goal] Which one, if applicable, is your firm pursuing right now? (Technology development and optimization, market creation, socio-cultural changes and/or coordination?) Have you always pursued this specific goal(s) with certain activities, or have these goals changed over time? e.g., you were in the past more concerned about technology optimization but right now more concerned with market creation? [We are going through each strategic goal, and I will ask you how important and developed each area globally is according to you] Can you rate the following based on a scale of 1-5 of importance for your firm? How important and developed are the following activities in the context of blockchain-driven circular plastics economy? You can rate them from 1 to 5, where: 1 = not important / not developed 2 = slightly important / developed 3 = moderately important/ developed 4 = important / developed 5 = very important / very developed	

This tool was created by Julia Planko and Maryse Chappin, with technical support by Kevin Molenaar. It is based on the paper by Planko et al. (2016). **Technology development & optimization**		Important (globally)?	Developed (globally)?
1	Testing new technologies, applications, and markets		
2	Knowledge development		
3	Knowledge exchange		
4	Co-creation of products and services		
5	Development of commercially viable products		
6	Feedback loops with user groups		
Market Creation		Important (globally)?	Developed (globally)?
1	Generate new business models		
2	Creation of temporarily protected niche market		
3	Collaboration with government for enabling legislation		
4	Collaborative marketing to raise user awareness		
5	Collaborative competition against other technology clusters		
Socio-cultural changes		Important (globally)?	Developed (globally)?
1	Changing user behavior		
2	Changing perception of the new technology		
3	Changing the education system		
4	Generating a pool of skilled labor		
5	Creating new facilitating organizations		
Coordination		Important (globally)?	Developed (globally)?

1	System orchestration		
2	Creating a shared vision		
3	Defining a common goal		
4	Standardization of the new technology		
5	Providing a platform for open innovation		
6	Thinking in system-building roles		
7	Creating transparency of all activities going on in the field		

Resources (part 1) Ice-breaker	[Show resources classifications by Grant (1991).] What have been the most important company resources for the development of your blockchain initiative? e.g., knowledge, money, collaboration, leadership style? Can you rate the following resources your company has available internally for the blockchain initiative on a scale of 1-3? 1= not available 2 = to some extent available 3 = available	
		Availability
	Financial resources - *Money assets, borrowing capacity, ability to raise new equity and cash* Do you have a large budget specifically available for your blockchain initiative?	
	Physical - *Buildings, facilities, machinery, supplies, geographical location*	

	Do you have sufficient computer capabilities to facilitate your blockchain [initiative/product/service]?	How do you ensure the 24/7 working of your [product/service]? What happens if your computers fail? Do you have a 24/7 backup computer to ensure that the blockchain will never turn off?
	Human - *Abilities of employees in terms of e.g., intelligence, training, relationships, experience, insights, judgement, creativity, social skills and vision in relation to blockchain technology* Do your employees have sufficient knowledge and experience with blockchain?	
	Technological - *IT readiness, assets e.g., computers, equipment, robots, software applications, IT investments and protected knowledge by patents, trademarks, copyrights, and licenses* Do you have sufficient IT capabilities and equipment for your blockchain initiative? Do you have any patents/trademarks/copyrights or licenses?	
	Reputation - *Individual reputation of the firm, and their reputation concerning their proposed solution for a given issue* - *Product quality, management integrity and financial soundness* How do other companies see you? (as a company/promotor of a blockchain initiative). What is your company's reputation in the field?	
	Organizational - *ability to plan, to monitor, to control and coordinate systems and have informal relations among groups within the firm and between the firm and its environment, and to make decisions. Organizational resources also reside in a team, a department or functional area e.g., research and development, marketing, and operations, thereby*	

	distinguishing itself from human resources, where the focus is on an individual Is it easy for your firm to collaborate with other firms or universities/research institutes? Is your company flat or hierarchal? Do you have a lot of R&D going on?	
Collaborations to acquire resources	Which specific resource has changed the most in terms of availability since founding [your company/your department]? Why do you think this has changed? How have you acquired resources that were not available internally?	E.g., did you acquire more financial assets as main change, or did you develop more knowledge on blockchain?
Resources (part 2)	Do you feel your company's resources influence the way you have tried to stimulate adoption of your [product/service]? *If interviewee struggles: Do you feel your company's resources influence the way you have tried to grow your business [product/service]?*	Do you ever evaluate what resources you have and take that into account when pursuing a certain firm goal to stimulate adoption? For example, when you gained more financial resources, did you change your initiative objectives? Could you describe this change in terms of system building goals as presented before?
Firm attributes	Do you feel the characteristics of your company – in terms of size, age and diversification – have influenced somehow the goals and strategies that you pursued to stimulate the adoption of blockchain and your initiative?	
Future looking	What trends do you expect in future blockchain for circular plastics? If there's anything that you think I didn't cover, and you would like to add?	