SCALABILITY SOLUTIONS FOR AUTOMATED TEXTILE SORTING

– A CASE STUDY ON HOW DYNAMIC CAPABILITIES CAN OVERCOME SCALABILITY CHALLENGES

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This study provided the opportunity to explore fascinating recent developments in automated textile sorting and its potential to contribute to more circular and sustainable textiles. We are deeply grateful to all the participants in this study, who donated their valuable time and shared their experiences, insights, and perspectives on this multifaceted topic.

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Our hope is that this study can contribute to the ongoing discussions regarding circular economy within the textile industry and its continuous improvement for the better.

"*We are still dealing with the dream of turning base matter into gold.*"

-David Graeber (2012) "Afterward: The apocalypse of objects: degradation, redemption, and transcendence in the world of consumer goods" in *Economies of Recycling: the Global Transformation of Materials, Values and Social Relations*

Abstract

Background – In light of the negative social and environmental impacts of the textile industry, a paradigm shift towards a more circular economy is inevitable. Automated textile sorting embodies a crucial but missing link to connect forward and reverse supply chains for circular economy, however scalability challenges exist.

Purpose – Therefore, the study explores how dynamic capabilities can overcome scalability challenges specific to automated textile sorting pilots in Northwestern Europe to create commercially viable solutions.

Methodology – A single case study using an abductive approach guided by the dynamic capabilities view explores automated textile sorting pilots' approaches to dynamic capability microfoundations. Primary data include semi-structured interviews, which is complemented by secondary data documents, and both were analysed qualitatively via thematic analysis.

Findings – The data reveal that known scalability challenges remain and new scalability challenges related to market disruptions exist, such as COVID-19. Scalability challenges are overcome through novel approaches to the microfoundations undergirding dynamic capabilities. These are found to take place in a continuous, overlapping process, and collaboration is found across all dynamic capabilities.

Practical implications and research implications –As collaboration plays a prominent role, it should be integrated in approaches to dynamic capabilities. This study also adds to the literature on circular economy in the textile industry by confirming that known scalability challenges for automated textile sorting pilots remain, and new scalability challenges are developing in terms of market disruptions. Actors in the automated textile sorting supply chain may use these findings to support efforts to scale up automated textile sorting. For textile industry brands and recyclers, the findings can assess their readiness to participate in the automated textile sorting supply chain and support the achievement of their 2030 goals to use greater volumes of sorted textile waste fractions as feedstocks for their production processes and to be a collaborative member of the used textiles supply chain.

Keywords: Circular Economy, Automated Textile Sorting, Used Textiles, Textile Waste, Dynamic Capabilities

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List of Abbreviations

ATR-FTIR	Attenuated total reflection Fourier transform infrared
ATS	Automated textile sorting
BM	Business model
CAQDAS	Computer-assisted qualitative data analysis software
CE	Circular economy
CEAP	EU Circular Economy Action Plan (2020 version)
DC	Dynamic capabilities
EC	European Commission
EEA	European Environmental Agency
EMF	Ellen MacArthur Foundation
EPR	Extended producer responsibility
EU	European Union
IR	Infrared
IVA	The Royal Swedish Academy of Engineering Sciences
NGO	Non-governmental organisation
NIR	Near infrared
NMR	Nuclear magnetic resonance
PACE	Platform for Accelerating the Circular Economy
PCT	Post consumer textile
PRC	People’s Republic of China
RBV	Resource based view
R&D	Research and development
REACH	Registration, Evaluation, Authorisation, and Restriction of Chemicals
RSC	Reverse supply chain
SC	Supply chain
VIS	Visual spectroscopy
WTO	World Trade Organisation

1 Introduction

This chapter provides the background of this study, the practical and research problems to be addressed, and specifies the research purpose, question, as well as the delimitations.

1.1 Background

The fashion industry is associated with speed and rapid change, a business environment requiring flexibility and quick response, offering new products continuously to maintain competitive advantage (Hvass 2014). Currently, the fashion industry adopts a linear model consisting of three key elements: take (the utilisation of raw materials), make (the production of garments), and waste (the disposal of used garments) (EMF 2017; Brydges 2021). This linear model, along with the fast fashion trend, encourages the production of inexpensive, low-quality textile products. Large, international fast fashion retailers design garments to be sold at low prices and used not more than ten times, which perpetuates the phenomenon of throwing away garments before their full value is realised (Birtwistle and Moore 2007). As a result, current consumption estimates put global fibre production at 130 million tonnes by 2025 (Dahlbo et al. 2017) demonstrating that the textile industry is resource-intensive (EEA 2019). Although increased production and consumption may arguably stimulate the economy, it brings undesirable social and environmental consequences, including continuously growing volumes of post-consumer textile (PCT) waste (Hvass 2014; Brydges 2021).

One potential solution to this problem is the adoption of circular economy (CE) principles. Geissdoerfer et al. (2017, p.759) define CE as “a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops”. Thus, the “three Rs”, reduce, reuse, and recycle, become a core concept for CE (Murray, Skene and Haynes 2017; Lahti, Wincent and Parida 2018). In the context of textile recycling, textile waste may be used as feedstock for production, which reduces the need for virgin materials. Hence, textile recycling can lead to the conservation of natural resources, such as reductions in water, energy, and chemical consumption (Dahlbo et al. 2017). Yet, an efficient recycling market requires appropriate volumes of suitable feedstocks, and automated textile sorting (ATS) is recognised as a crucial link between textile waste and textile recycling activities (Elander 2019; Cura et al. 2021).

Despite the recognised benefits of textile recycling, the rates are low. In 2008, estimates show that only 20% of Swedes’ discarded clothes were collected, which indicates that large volumes went to incineration instead (Ljungkvist, Watson and Elander 2018). The European Commission estimates that European consumers discard 5.8 million tonnes of textiles annually, where only 26% is recycled while the rest goes to landfill or incineration (Bukhari, Carrasco-Gallego and Ponce-Cueto 2018). A lack of awareness of proper disposal practices may result in a lack of efficiency and scale in the collection and sorting of textiles for reuse and recycling (Koszewska 2018), which is further exacerbated by fragmentation and a lack of regulatory alignment of collection and sorting processes (Ljungkvist, Watson and Elander 2018).

To combat this, the EU has recently begun to promote CE principles (Korhonen, Honkasalo and Seppälä 2018). In 2020, the EU adopted a new CE Action Plan (CEAP), which addresses the textile sector and promises an EU Strategy for Textiles in 2021, including measures to ensure improvements in textile sorting, re-use, and recycling (EC 2020). Previously, revisions to the EU Waste Directive (2018) established increasing targets for the reuse and recycling of waste streams, which include the separate collection of textile waste by 2025 that is expected to be funded in part by textile extended producer responsibility (EPR). Based on this, the volume of separately collected textile waste in the EU is expected to increase, and the share of low-quality, low-value used clothing items (non-reusable items) in the textile waste stream is also expected to increase (IVA 2020). Therefore, there is an urgent need to scale the domestic ATS and recycling market, as several countries outside the EU, like the PRC, are tightening regulation of textile waste imports (WTO 2017; Goldberg and Luo 2020; PKU Law 2020).

Although the literature on CE in the textile industry multiplied in recent years (Jia et al. 2020; Marques, Marques, and Ferreira 2020; Mishra, Jain and Malhotra 2020; Onur 2020; Shirvanimoghaddam et al. 2020; Brydges 2021; Colucci and Vecchi 2021; Ki, Park and Ha-Brookshire 2021), Brooks et al.'s (2018) finding that closed-loop initiatives fail to flourish in the fashion industry due to the scale and pace of consumption in the context of capitalism remains accurate. Fashion organisations hesitate to engage in CE approaches due to internal and external barriers. Organisational strategies and operations are based on a linear approach, which promotes a culture in contradiction to CE principles (Jia et al. 2020). In response, Riba et al. (2020) find that to convert from a linear to CE, new business models (BMs), strategies, manufacturing processes, design innovations, and ATS and recycling technologies need to be introduced.

Clearly, there is a need to efficiently sort the increasing amounts of non-reusable textile waste by content and colour to capture its high value-adding applications (Elander 2019; Cura et al. 2021). ATS has the ability to quickly and automatically sort large volumes of textile waste into specified, high-quality fractions critical to support efficient textile recycling (Elander 2019; IVA 2020; Cura et al. 2021). As a result, ATS organisations can potentially act as the new material brokers that will connect buyers and sellers of used textiles as secondary raw materials for production (IVA 2020). Currently, ATS faces the task of successfully scaling their operations to an industrial, commercially viable level to be able to manage increasing amounts of low-quality, non-reusable textile waste. Therefore, a better understanding of how the scalability challenges specific to ATS can be overcome to create commercially viable solutions is needed.

1.2 Research problem and gap

Existing literature addresses textile waste processing in terms of recycling, reuse, and upcycling, showing that these approaches have the potential to reduce environmental impact (Sandin and Peters 2018). Yet, more in-depth research regarding the collection and ATS processes is required. Past research tends to focus mainly on manual sorting, as ATS is relatively new in the textile sector context (Norris 2019; Nørup et al. 2019; Pal, Sandberg and Paras 2019). Some researchers treat ATS in passing instead of central to the issue of textile waste management (Islam 2021). Other researchers identify challenges related to ATS (Karell and Niinimäki 2019; Ki, Chong and Ha-Brookshire 2020) but have not had the opportunity to investigate multiple perspectives within the ATS supply chain (SC) on how key scalability challenges can be overcome. Although ATS has a true potential to scale up the textile CE, due to several challenges, this is not yet realised. This indicates that more study is needed to narrow the research gap on how the scalability challenges specific to ATS in Northwestern Europe can be overcome to create a commercially viable solution (Karell and Niinimäki 2019; Ki, Chong and Ha-Brookshire 2020).

Research on scaling ATS in the SC/BM context is necessary, as ATS is the missing link for textile CE. Manually sorting non-reusable textiles according to fibre content is inefficient and unreliable (Cura et al. 2021). To efficiently increase the volumes of accurately sorted used textile fractions used as feedstocks for textile recycling processes, there is a need to research economically viable, efficient, and effective ways to sort used textiles according to fibre content and colour. Cura et al. (2021, p.2) explain, "Automated recognition and sorting lines provide a method for ensuring better quality of the fractions being recycled and thus enhance the availability of such recycled fractions with accurately known material content". Therefore, ATS can be this efficient and effective link, and more research is needed on how to make it economically viable.

Furthermore, the literature providing insights into ATS predominantly investigates the technical perspective. For instance, methods related to attenuated total reflection Fourier transform infrared (ATR-FTIR) (Peets et al. 2017; Riba et al. 2020) and near-infrared (NIR) spectroscopy (Blanch-Perez-del-Notario, Saeys and Lambrechts 2019; Zhou et al. 2019; Zhou et al. 2019; Chen, Tan and Lin 2020; Liu, Li, and Wei 2020; Riba et al. 2020; Cura et al. 2021) are applicable methods for quality control and for identifying and classifying textiles by content and colour for recycling purposes. Additional research looks at how the sorting technology itself may be engineered, or how the spectroscopy can be improved (Englund et al. 2018; Elander 2019; Cura et al. 2021). Therefore, research has shown that the necessary technology for "scaling-up" ATS exists; however, research on innovative BMs, new stakeholder relationships, and other factors to create a market for inbound/outbound fractions of ATS facilities are missing from the literature. In this study, the terms "pilot" and "scale-up" are defined according to Bocken, Schuit, and Kraaijenhagen (2018), who find that "in a pilot, real customers use the actual, commercial service and/or product including the business model elements", and new BMs are evaluated through pilots to test all assumptions at the same time in a large-scale pilot before scaling up (Bocken, Schuit and Kraaijenhagen 2018, p.83).

Based on the foregoing, this study intends to contribute to the literature by narrowing the existing research gap regarding how the dynamic capabilities (DC) framework can facilitate CE on an ATS industry level. So far, there is limited research on DC for CE, and prior research focuses on DC approaches towards CE implementation on an organisational level (Katz-Gerro and Sintas 2019; Prieto-Sandoval et al. 2019; Khan, Daddi and Iraldo 2020a, 2020b, 2021; Scarpellini et al. 2020), specifically in terms of eco-innovation (Gabler, Richey and Rapp 2015; Portillo-Tarragona et al. 2018; Kiefer, González and Carrillo-Hermosilla 2019) or environmental proactivity for competitive advantage in dynamic environments (Garcés-Ayerbe and Cañón-de-Francia 2017). Further, few studies look at approaches to DC for CE in the context of new ventures and early-stage firms (Adam, Strähle and Freise 2018).

Against this background, the **purpose** of this study is:

To explore how dynamic capabilities can overcome scalability challenges specific to ATS pilots in Northwestern Europe to create commercially viable solutions.

To that end, the **research question** is:

How can dynamic capabilities overcome scalability challenges faced by ATS pilots in Northwestern Europe to create commercially viable solutions?

1.3 Delimitations

The delimitations of this study include the timeframe within which data will be collected, which is the first half of 2021. It further includes the chosen used textile sector in Europe as the industry context, because new EU policies and legislative frameworks are focused on implementing CE principles for the textile sector, which is expected to increase the volumes of textile waste collected and increase the demand for recycled textiles. Northwestern Europe is specifically chosen as this region contains several ATS pilots that are commercially active and publicly disclosed. Further, Northwestern Europe has several EU Member States that are close to being ready to implement the separate collection of textile waste and textile EPR, as well as several universities, innovation centres, funders, and companies focused on textile CE. This makes research in this specific delimited context of ATS pilots in Northwestern Europe of interest. (Hemkhaus et al. 2019; Terra 2020)

2 Literature Review

This chapter provides a narrative state-of-the-art review of the literature on ATS in textile reverse supply chain networks and ATS's key scalability challenges.

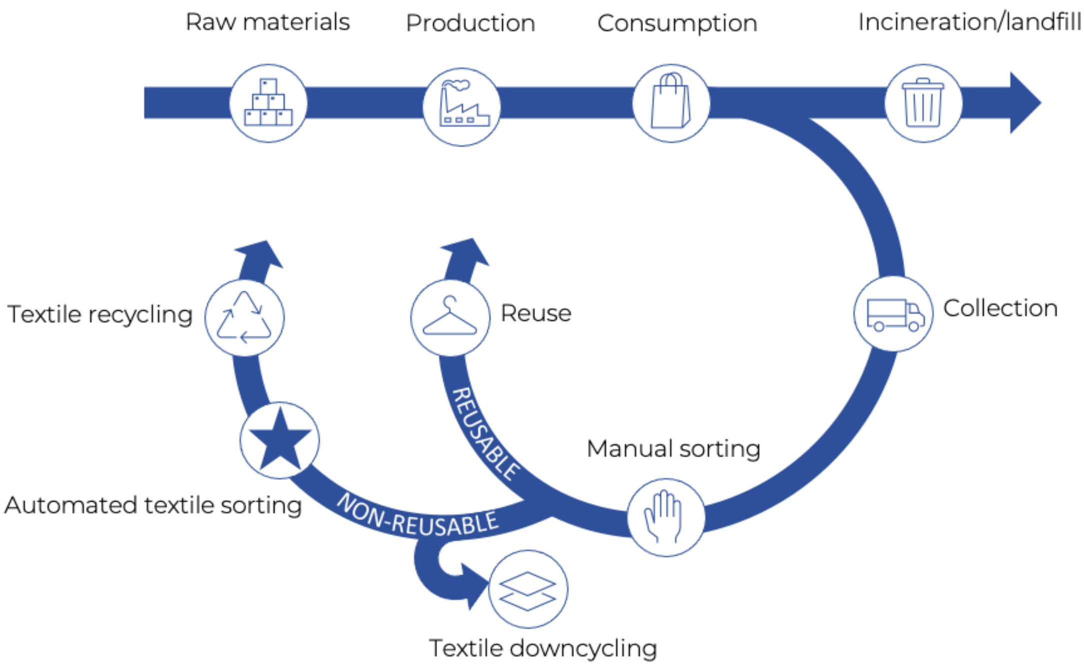
To move from a linear to a CE, companies follow sustainable initiatives, including reuse, resale, upcycling, and recycling. Of these, reuse provides a greater environmental benefit when compared to recycling, but reuse alone cannot address all aspects of textile waste management (Sandvik and Stubbs 2019). Textile recycling plays an important role in textile waste management by extending the life of textile materials and utilising their full value (Ljungkvist, Watson and Elander 2018). In this way, textile recycling is indispensable to capture the value of non-reusable textile materials, which is currently estimated to be lost in an amount of more than USD 100 billion each year (EMF 2017).

2.1 Overview of ATS in the RSC

The current reverse supply chain (RSC) of used textiles involves various actors with different objectives and operations, leading to a complex and diverse network. For instance, in the Nordics, charitable organisations are key actors involved in collecting, sorting, and reusing used textiles for local resale to fund social initiatives. Recently, private collectors entered the used textiles market through collaborations with several retailers. While private collectors often export all their collected used textiles from the Nordics, charities perform a labour-intensive, initial manual sorting to separate a fraction that is reusable in the Nordics. The remaining fractions that are non-reusable in the Nordics are exported to other European sorting facilities for further processing; hence, the market for non-reusable fractions remains undeveloped in the Nordics. (Palm et al. 2014)

Often, non-reusable textiles are predominantly incinerated or landfilled rather than recycled. This requires an improved textile waste management system within the Nordic region. Palm et al. (2014) concludes that the efficiency of a textile waste management system is dependent on a profitable market for textile waste, the purity of textile waste in terms of correct separation, and customer satisfaction through accessibility and convenience of collection systems. ATS can support such a system. Figure 1 illustrates a simplified ATS SC demonstrating the importance of the ATS link between non-reusable manual sorted fractions and automated sorted fractions as feedstocks for textile recycling.

Figure 1 Simplified ATS SC adapted from secondary data



In a later study, Palm et al. (2015) highlight the importance of a strategy for textile waste management based on common goals, leading to high commitment and cooperation. This might further facilitate transparency and information sharing across the entire SC, which connects both forward and reverse activities, to realise the potential of increased volumes and profitability. The lack of useful data regarding exact volumes of sorted textile waste fractions hinders effective planning processes as no quantitative policy goals or regulations for these sorted textile waste fractions can be developed or their effectiveness measured. This further leads to a low rate of investment to increase efficiency, for example, a general lack of private investment in ATS and bundling used textiles to create fractions of higher quality for textile recycling. (Palm et al. 2014, 2015)

A recent study by Pal, Sandberg and Paras (2019) examined the role of used clothing brokers/manual sorters in the context of multidimensional value creation in RSCs. Noting the existing research on value creation between buyers and sellers, including Sandberg, Pal, and Hemilä (2018), this comprehensive multi-case study found that one of the established used clothing broker/manual sorters invested in the establishment of an ATS pilot, although this fact was secondary to the main discussion. Still, this is evidence of the relevancy and potential future value that ATS offers used clothing networks (Pal, Sandberg and Paras 2019). Further, the case studies that include manual sorters open an avenue for studies on ATS in the RSC, where this study intends to contribute. As initially highlighted in section 1.2, there exists a gap in research due to the dominance of manual sorters in the RSC of used textiles and the novelty of ATS, literature on ATS is limited.

ATS is essential for textile recycling processes, because fibres from different origins are processed differently. Traditionally, natural fibres are recycled using mechanical methods while synthetic fibres are often recycled using thermal or chemical methods (Riba et al. 2020). Technological advancements in textile recycling for cellulosic and synthetic materials and the ability to identify content and colour in an automated way during the textile sorting process is an important prerequisite for increasing the rate of textile recycling (Antikainen et al. 2017; Watson et al. 2017; Hemkhaus et al. 2019; Roos et al. 2019).

Textile recycling's potential is not fully realised due to a lack of automation in the feedstock process (Niinimäki and Karell 2020). Elander and Ljungkvist (2016) find the current textile recycling process is not economically viable as it faces, among other challenges, high costs due to the initial, labour-intensive, manual sorting process, which lacks efficiency. Initially, the sorting process starts with a manual sorting that separates the reusable used textiles from the non-reusable used textiles; then the manually-sorted reusable fractions are graded based on experienced workers' judgment on look and hand feel according to market, seasonality, product type, and gender specifications (Englund et al. 2018; Niinimäki and Karell 2020). The ability of manual sorting experts to assess the reusable fractions is a developed skill that requires an excellent command over quality parameters (Nørup et al. 2018). Yet Nørup et al. (2019) conclude that high-quality reusable fractions are decreasing in volume, and non-reusable textile fractions are increasing in volume.

Therefore, ATS can contribute immensely to the quick and efficient sorting of non-reusable used textile fractions on content and colour, which complements the initial manual sorting process (Karell and Niinimäki 2019). This is demonstrated in Figure 1. Clearly, improving the textile recycling rate and making the entire SC profitable requires efficient used textile collection and sorting (Cura et al. 2021). Ljungkvist, Watson and Elander (2018, p.37) explain:

> *The ideal scenario for all actors would be that the increasing share of non-reusable textile begins to raise real income for the collection and processing industry and not be the economic deadweight it is today. This requires both technological advancements through research and development in new sorting and recycling technologies in Europe and increased demand for recycled fibres from the fashion industry in particular.*

As volumes of collected non-reusable used textiles are expected to increase in the future with the implementation of the EU Waste Directive (2018), this further urges the adoption of ATS. Presently, ATS is at a pilot stage and attempting to scale up while research to advance ATS continues to progress.

For example, Englund et al. (2018) note several existing technologies used to identify and sort materials, including Raman spectroscopy, which works via laser light of different wavelengths but has limitations in terms of detecting materials from a distance and dark colour recognition. Englund et al. (2018) further note nuclear magnetic resonance (NMR), which can be suitable for small-scale qualitative analyses of fibre blends but is not feasible at a large scale yet. Another example is Zhou et al. (2019), which proposes an NIR model for spectroscopy. Further, Riba et al. (2020) developed an algorithmic approach to ATS that uses ATR-FTIR spectra to identify and sort textiles. Riba et al.'s (2020) method provided accurate identification of textile content without prior analytical evaluation of the sample.

Another aspect of ATS advancement is in colour sorting, which is explored by Zhou, Zou, and Wong (2021) through a computer vision-based sorting system that separates textile waste based on colour. Presently, colour sorting is an inefficient, manual process, and it is often difficult to accurately judge by eye a highly specific colour range among the wide variety of colours available. Also, used textiles can be faded or stained during use, which alters their colour. Therefore, Zhou, Zou, and Wong (2021) present techniques for camera selection, construction of a standard colour database, and the formation of the statistical model.

The technological advancement of ATS is promising for scaling to a commercially viable level. Carlsson et al. (2015) suggest that ATS feasibility requires the integration of further value-adding features, such as occupational measures, legislation, and general guidelines to help to streamline the process to collect and sort textile materials. Moreover, a new BM associated with risk assessment (supply and demand risk, control risk, process risk, product risk) is essential for the planning and establishing of an ATS facility (Carlsson et al. 2015). Also, the ability to confirm the presence of substances of concern in used textiles is required to ensure health and safety concerns are addressed for reuse or recycling of textiles (Carlsson et al. 2015).

Further, in a study of second-hand clothing and textile recycling economies, Norris (2019) highlights a few developments and actors in the field of ATS that could provide feedstock for textile recycling but finds the full-scale development and implementation of this technology is several years away. One of Norris' main questions centres on whether once such systems operate at scale, will it be in the form of proprietary closed-loop systems or open systems/open network platforms that coordinate resource exchange. Her case study reveals that a manual sorter in the UK hopes for the viability of ATS as an investment and as support for advances in fibre-to-fibre textile recycling, which will ultimately create new recycling markets that would benefit manual sorters. Norris' anthropological and human geographical case approach provides a fresh perspective on the value and intellectual property relationships in used clothing networks. It also demonstrates the manual sorter's continued interest in a mutually beneficial relationship with ATS. (Norris 2019)

2.2 Key scalability challenges

To provide a summary of the key scalability challenges faced by ATS pilots, one can start with the internal challenges. From an internal perspective, there are technological limitations in terms of capacity and speed in accurately processing large volumes of textile waste for recycling; related to that are limitations to maintaining the continuity of inbound and outbound feedstocks (Norris 2019). There are also technological limitations in terms of the NIR sorting equipment's ability to identify the diverse material and chemical components of heterogeneous, complex garments and their trims, which affects accuracy/quality/purity of sorted fractions (Palm et al. 2014; Antikainen et al. 2017; Ljungkvist, Watson and Elander 2018; Karell and Niinimäki 2019; Norris 2019; Ki, Chong and Ha-Brookshire 2020; Cura et al. 2021; Islam 2021). The structural complexity of used clothing and the use of blends of cellulosic and synthetic materials makes identification of pure fractions more difficult, yet designers and producers of clothing are not always aware of the challenges that design or design budgets cause at end-of-life (Karell and Niinimäki 2019). In addition, the ATS equipment and plant facility implementation is currently expensive, which creates financial challenges and limits investment interest without proven economic feasibility (Palm et al. 2014; Ljungkvist, Watson and Elander 2018; Norris 2019). Economic incentives are required to establish new ATS technologies at scale to support CE (Ljungkvist, Watson and Elander 2018).

From the external perspective, one of the challenges faced by ATS pilots is that chemical recycling technology is not fully developed and operating at a commercial scale. Therefore, chemical recyclers are not yet ready to buy regular, large, non-reusable sorted textile fractions as feedstocks for recycling. This makes demand uncertain and results in a small or non-existent market for several types of non-reusable sorted textile fractions. For example, although research and development are ongoing, current chemical processes often cannot tolerate the cellulosic and synthetic blend percentages present within a large portion of the textile waste stream. This results in an immature market for most ATS fractions. Therefore, in the past, most non-reusable textile waste has been either downcycled into low-value rags/wipers or insulation or disposed of via incineration/landfill, as there is a lack of a suitable market (Palm et al. 2014; Antikainen et al. 2017; Ljungkvist, Watson and Elander 2018; Hvass and Pedersen 2019; Karell and Niinimäki 2019; Norris 2019).

The literature further reveals that there is a disconnect between manual and automated textile sorters, because they are not yet acting in concert in an integrated and complementary manner despite all sorting processes having an integral role. Initial manual sorting processes determine the destination of used textiles, i.e., whether they will be reused or go through ATS to be feedstock for recycling per the EU waste hierarchy (Bukhari, Carrasco-Gallego and Ponce-Cueto 2018). Plainly, manual sorting is important to separate textile waste for reuse based on hand feel and vision, while ATS technology can separate non-reusable textile waste into desirable fractions for textile recycling based on content and colour (Elander 2019). Manual sorting and ATS's current disconnect, however, impacts their efficiency and ability to reach economies of scale (Elander and Ljungkvist 2016).

Further contributing to the challenge is that ATS actors are mainly acting separately, whether intentional or not. Granted, at the ATS pilot stage, it is difficult to build immediate economic relationships between ATS actors. Therefore, the lack of connection and communication is not surprising. Still, even if dialogue between actors is at an early stage, there is a lack of significant transparency and collaboration. (Palm et al. 2014; Antikainen et al. 2017; Hvass and Pedersen 2019; Karell and Niinimäki 2019; Norris 2019; Sandvik and Stubbs 2019)

Also, aside from the existing provisions related to government grants and funding for innovation and R&D, a wide-spread implementation and strong enforcement of a legal scheme for the separate textile collection of textiles and extended producer responsibility (EPR) at a national level within Europe does not exist at this time. This would include consumer education on used textile disposal. Although the EU Waste Directive (2018) requires the separate collection of textile waste by 2025, and there are some provisions for EPR in process, it is a new legal frontier for the textile sector. There is also a lack of policies and legal frameworks specifically directed to support the accelerated development of ATS pilots and the textile recycling markets to be served. The CEAP includes references to textile sorting and textile recycling, but the specifics on implementation and requirements are vague at this time, although an EU Strategy for Textiles is expected in or about Q3 of 2021. As many regulations, such as EU REACH and EU labelling requirements, became effective before the push for CE in the textile sector and before advancements in ATS and textile recycling, unintended administrative barriers to offering and recycling sorted textile fractions must be addressed. (Antikainen et al. 2017; Ljungkvist, Watson and Elander 2018; Hemkhaus et al. 2019; Hole and Hole 2020; Ki, Chong and Ha-Brookshire 2020)

A related challenge is a lack of formal standards or industry agreement in terms of inbound and outbound sorted fraction quality criteria and definitions/terminology. The existence of such standards would support a mutual understanding and be used to ensure clear communication about quality, measurement, and other specifications. Business interaction and trade in used textiles would be facilitated by such standards. (Palm et al. 2014; Antikainen et al. 2017; Ljungkvist, Watson and Elander 2018)

3 Theoretical Framework

This chapter presents the theoretical framework that guides and serves as the foundation of this study.

When translating CE principles into concrete business strategies, models, and operations, organisations face several challenges (Ormazabal et al. 2018). To overcome these challenges, research suggests that a dynamic capabilities (DC) view can support a proactive sustainable approach (Wu, He and Duan 2013; Mousavi, Bossink, B. and van Vliet 2018; Khan, Daddi and Iraldo 2020a). Yet, there is little known about how specific skills, processes, and activities can bolster efforts to overcome challenges and attain CE implementation (Kabongo and Boiral 2017; Khan, Daddi and Iraldo 2020a, 2020b, 2021), especially in terms of small organisations and new ventures (Adam, Strähle and Freise 2018). Understanding how to scale ATS in this context is necessary, because ATS ensures high quality sorted textile fractions as the feedstocks for recycling, and thus can increase the available volumes of accurately sorted used materials by content for recyclers and brands (Cura et al. 2021). Manual sorting is important for reuse, however, when sorting non-reusables for fibre content, ATS is more efficient and reliable (Cura et al. 2021). Therefore, to efficiently increase the volumes of accurately sorted used textile fractions available for textile recycling, it is appropriate to use the DC view within the field of strategic management to investigate how DC can overcome the key scalability challenges faced by ATS pilots in Northwestern Europe to scale their operations to an industrial level and create commercially viable solutions.

The DC theory provides guidance on how organisations operating in dynamic, highly volatile business environments can create and maintain competitive advantage. Over the years, Teece and colleagues (1997; 2007, 2012, 2018a, 2018b) made several contributions to this theory. In an early definition, Teece, Pisano, and Shuen (1997) drew upon the Resource Based View (RBV) perspective within the field of strategic management and described DC as “the firm’s ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments” (Teece, Pisano and Shuen 1997, p.516). The competitive advantage of an organisation relies on the development of diverse management skills and a unique combination of organisational, functional, and technological resources (Teece, Pisano and Shuen 1997). In developing an integrative approach to DC, Teece, Pisano, and Shuen (1997) draw upon research in various management themes.

Where the RBV is static and does not address how valuable resources can be generated or refreshed in changing environments, in contrast, the DC perspective is “dynamic” and attempts to address how resources evolve as time progresses to maintain an advantage in the market (Ambrosini and Bowman 2009). The RBV neglects the dynamism of markets and is constrained in its static view as the heterogeneity of resources across firms is assumed to persist over time and lead to long-time competitive advantage (Eisenhardt and Martin 2000). As a result, DC is preferred over the RBV to answer the question of how ATS pilots overcome scalability challenges.

Later, Teece (2007) revised his DC framework due to increased volatility caused by the increased globalisation, which forces organisations to embrace the ability to shape the business environment through innovation and collaboration within the industry to remain competitive. As a result, management should focus on essential, higher-order DC, namely sensing, seizing, and reconfiguring. Sensing describes the ability to identify and assess opportunities and threats; seizing describes the ability to mobilise resources to address new opportunities; and reconfiguring describes a continued renewal process (Teece 2007). These DC are supported by "microfoundations", defined as "the distinct skills, processes, procedures, organisational structures, decision rules, and disciplines" of an organisation (Teece 2007, p.1319). Additionally, ordinary capabilities and organisational routines enable the efficient performance of organisations (Teece 2012). In contrast to ordinary capabilities, Teece (2012) notes that DC are only partly routinised to enable creativity and innovation.

Further, Teece (2018b, p.366) clarifies that the DC framework is an adaptation of the systems theory approach to "the globally competitive environment of the business enterprise". Therefore, the organisation and its external business environment--including the market, technological, and regulatory environment--is seen as a whole with several subsystems; hence, enterprise changes should align with or accommodate all elements (Teece 2018b). This requires an understanding of how developing new capabilities affects existing capabilities and external ties, and how implementing a BM requires coordinating assets across all relevant activities (Teece 2018b). In addition, the systems approach facilitates shaping the external environment, such as influencing industry and government decision-making (Teece 2018b). According to Teece (2018b, p.366), "the key is an integrated approach" by promoting a "unifying strategic vision" and facilitating "collaboration across internal units".

Although systems theory's logic influenced the DC framework, it has its limitations in terms of strategic management. "An awareness that everything is interrelated" is helpful, but it does not provide guidelines on how to identify critical business relationships (Teece 2018b, pp.362–363). While Teece (2012) recognises the importance of top management's ability to develop and implement DC in a proactive manner, systems theory neglects the key role of the top management, where it is solely a part of the system aiming to maintain balance and survival instead of seeking to thrive. Thus, systems theory indicates a reactive management approach, yet in a dynamic business environment, proactivity is critical (Teece 2018b).

Naturally, the DC framework is not without critics. In contrast to Teece, Pisano and Shuen's (1997) view that DC are unique and emerge from path-dependent history, Eisenhardt and Martin (2000) suggest that DC show significant similarities across organisations and can be "best practices", which indicates they are homogenous and substitutable. Eisenhardt and Martin (2000) describe DC as strategic and operational routines that modify the organisational resource base to generate new value creating strategies. Teece (2012) argues that this definition of DC as organisational routines and managerial rules is too restrictive, leaving no space for creativity and innovation.

In addition, Winter (2003) argues that if all competitors invest in the same DC, e.g., innovative product development and R&D, then costly investments may not be profitable as markets become saturated. In Winter's view (2003, pp.992–993), DC do not replace strategic analysis for long-term competitive advantage, and organisations should decide whether "ad hoc problem solving" or DC are more beneficial to accomplish organisational change. Teece (2012) acknowledges the critical role that top management plays in steering an organisation based on their deep understanding of markets and customer needs and describes this as "non-routine strategising and entrepreneurial activity, some of which might appear rather ad hoc" (2012, p.1399). Thus, Teece (2012) highlights the individuality of organisations and that similar DC may lead to different outcomes.

Zahra, Sapienza, and Davidsson (2006, p.918) also highlight top management's critical role by defining DC as "the abilities to reconfigure a firm's resources and routines in the manner envisioned and deemed appropriate by its principal decision-maker(s)". Their definition indicates a managerial proactive approach to strategic management and that change originates from within the organisation. This is partly in line with Teece (2012), where certain DC are based on the proactivity of top management and their ability to anticipate changes in the business environment. Because reconfigurations within and outside the organisation are costly, they should only be done when top management determines it is necessary (Teece 2007).

Furthermore, both Zahra, Sapienza, and Davidsson (2006) and Ma, Zhou, and Fan (2015) agree that the development and use of DC varies strongly between established and young organisations, because younger organisations have limited resource and knowledge bases and less expertise in creating and integrating distinct capabilities. This assumption is in line with Teece's (1997; 2012) proposition that the development of DC is path dependent. The current ATS pilots are novel networks/consortia with diverse SC partners; thus, their use of DC might reflect the findings of Zahra, Sapienza, and Davidsson (2006) and Ma, Zhou and Fan (2015).

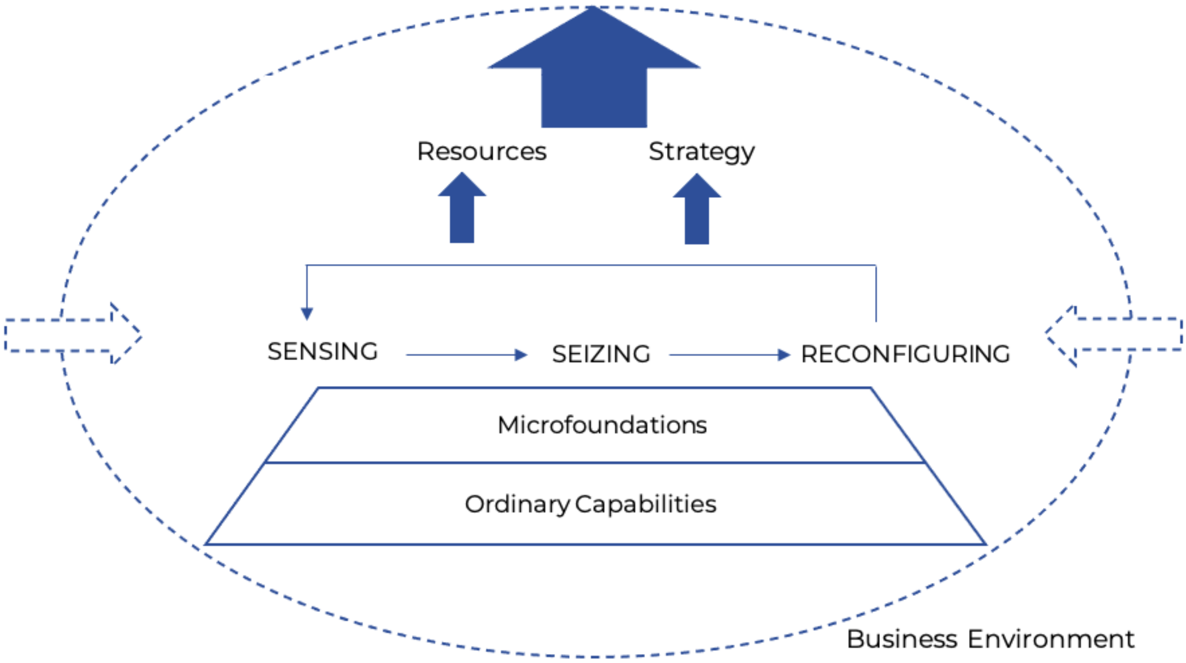
Zahra, Sapienza, and Davidsson (2006) found that DC are predominantly developed by trial-and-error, improvisation, and imitation rather than planning and experimenting, implying a less rigid, unstructured way of learning that leads to an increased amount and speed of change in routines, processes, and resources. The key goal for younger organisations is to fill gaps in their capability portfolio and building DC promotes exploring novel resources and new ways to use existing resources.

According to Ma, Zhou, and Fan (2015), which focused on tech start-ups in China's emerging market, young organisations do not have established routines – Teece (2007) calls them "ordinary capabilities" – and instead have to learn from practice. Gaining knowledge about the market, technologies, and BMs is accomplished through an active interaction with the market. In contrast to the systematic scanning and analysis of established firms, this market knowledge is constantly updated through daily business practice and relies on the current knowledge and experience of the entrepreneur. Further, novel organisations heavily rely on collaboration to mobilise and arrange external complementary resources, because their resource base and access to resources are limited. In the context of the DC of reconfiguring internal resources and external networks, Ma, Zhou and Fan (2015) highlight that focusing and maintaining distinct core competences plays a fundamental role for young organisations in identifying and attracting complementary external resources.

Here, the DC framework by Teece (1997; 2007, 2012, 2018a, 2018b) serves as the guiding theory despite its critics, because it provides insight into how organisations incorporate, create, and reconfigure internal and external resources/competences to address changing conditions and shape fast-paced, volatile business environments. As the EU Waste Directive (2018) requires the separate collection of textile waste by 2025, textile waste streams will increase in volume and decrease in quality (IVA 2020). This will change the business environment in the used textile industry, especially in the context of textile sorting and recycling. ATS will also be affected by the fast-changing, trend-based business environment of the fashion industry, as recyclers and brands begin to incorporate more recycled materials in their production processes, resulting in changing specifications and demand. Therefore, more research is needed to understand how DC can overcome the key scalability challenges faced by ATS pilots to create commercially viable solutions.

Figure 2 illustrates the key components of the DC theoretical framework where the dashed border represents elements external to the organisation, and the wide arrows indicate a strong influence. This framework inherits a nested hierarchy of DC, microfoundations, and ordinary capabilities, which is in accordance with Teece (2018b). The distinct DC, namely sensing, seizing, and reconfiguring, represent a sequential process (Khan, Daddi and Iraldo 2020a, 2020b, 2021).

Figure 2 DC framework adapted from Teece (2018b)



Each DC is supported by underlying microfoundations, which include distinct skills, processes and other organizational activities (Teece 2007). Sensing encompasses a set of activities that identify new business opportunities and threats through scanning, creation, learning, and interpreting; its activities include identifying customer needs and demands, monitoring and analysing market developments, supplier and competitors, as well as R&D activities to continuously explore and develop new technologies to create new knowledge (Teece 2007; Prieto-Sandoval et al. 2019; Khan, Daddi and Iraldo 2020a, 2020b, 2021). Thus, sensing activities require access to stakeholders' information (Prieto-Sandoval et al. 2019). According to Khan, Daddi, and Iraldo (2020a, 2020b, 2021), *market monitoring and technology scanning, idea generation, knowledge creation,* and *experience-based learning* are essential sensing microfoundations for CE implementation. In contrast to that, Adam, Strähle and Freise (2018), who investigated DC for early-stage organisations offering a product-service-system, (PSS), found that the network development capability, network governance and empathic capabilities are microfoundations of sensing.

Seizing encompasses a set of activities that focuses on mobilising internal and external resources and competences (Teece 2007). Teece (2007) explains that seizing activities include investment decisions, selection or creation of (new) BMs, improvement of technological skills, preservation of assets and resources, and supplier and customer management to build strong relationships. Similarly, Khan, Daddi, and Iraldo (2020b, 2020a, 2021) identify *strategic planning, BM and governance,* and *collaboration* as the microfoundations that undergird the seizing capability. Similar to Khan, Daddi and Iraldo, Adam, Strähle and Freise (2018) find the ability to collaborate essential for the seizing capability. In addition, customer-focused communication and customer integration are necessary microfoundations to seize opportunities in the context of PSS (Adam, Strähle and Freise 2018). Prieto-Sandoval et al. (2019) find that the ability to create a "green" culture and to train and increase workers' ability to propose improvements are important seizing capabilities in small and medium enterprises, as well as improving BMs and transforming obsolete jobs into new employment opportunities.

Reconfiguring encompasses the recombining of organisational resources and employment of new resources to address challenges and emerging opportunities, such as BM redesign, asset realignment, specification of routines, or the redeployment through transfer, mergers, acquisitions, or divestments (Teece 2007). Teece (2007) highlights the importance of organisational routines to enable the renewal and orchestration of resources and competencies while sustaining continuity, however, routines should not be reconfigured immediately but adapted gradually in steps. Reconfiguring is an iterative process that can react to continuous changes in the business environment. Prieto-Sandoval et al. (2019) find reconfiguring maintains competitiveness and note that a leader's vision and environmental awareness, the capacity to design and reconfigure sustainable BMs, as well as knowledge management and development are key microfoundations for reconfiguring. Khan, Daddi, and Iraldo (2021) specify reconfiguring's microfoundations as *organisational restructuring*, *technological upgradation*, *knowledge integration* and *best practice adaptation*. In the context of PSS, network learning capabilities and governance, as well as orchestration of PSS are fundamental microfoundations (Adam, Strähle and Freise 2018).

While a number of microfoundations are discussed in the literature, few prior studies using DC in the CE context identify specific indicators for how Teece's (2007) sensing, seizing, and reconfiguring capabilities might be approached. Khan, Daddi, and Iraldo (2020a, 2020b, 2021) present skills, processes, and activities for CE implementation as indicators that underlie the microfoundations of DC, developed and tested through qualitative and quantitative research, as well as the insights from several respected and peer-reviewed studies, including Teece (2007) and Mousavi, Bossink, and van Vliet (2018), and others (Wilden et al. 2013; Eurostat 2014; Wilden and Gudergan 2015; Mousavi and Bossink, B.A.G. 2017). As a result, this structure is empirically grounded and reliable. A summary of the microfoundations and indicators identified in the literature appears in Table 1.

Table 1 DC, microfoundations, indicators

Dynamic capability	Microfoundation	Indicator	References	
Sensing	Market monitoring & technology scanning	• Identification of customer needs • Tracking of new market trends • Analysing competitors' actions • Observing technological developments	Wilden et al. (2013) Wilden and Gudergan (2015)	Khan, Daddi and Iraldo (2020a, 2020b, 2021) Teece (2007) Mousavi and Bossnik (2017) Mousavi, Bossnik and van Vliet (2018)
	Idea generation	• Organising brainstorming sessions • Involving customers and suppliers in product development process	Eurostat (2014)	
	Knowledge creation	• Undertaking R&D to create new knowledge for developing new products/ processes • Undertaking R&D to try out new ideas having strategic/ operational implication	Eurostat (2014) Prieto- Sandoval et al. (2019)	
	Experiential learning	• Assessing potential environmental impacts of products/ processes/ services • Networking with public organisations/ industrial associations/ universities/ others	Wilden et al. (2013) Wilden and Gudergan (2015)	
Seizing	Strategic planning	• Formulation of a strategy • Finding strategic partners • Planning investments • Capital budgeting • Planning requisite human resources	Wilden et al. (2013)	Khan, Daddi and Iraldo (2020a, 2020b, 2021) Teece (2007) Mousavi and Bossnik (2017)
	Business model & governance	• Redesigning/ transforming BMs • Restructuring of governance structure	Prieto- Sandoval et al. (2019)	

Dynamic capability	Microfoundation	Indicator	References	
Seizing	Collaboration	• Collaboration to acquire requisite knowledge/ skills • Collaboration to acquire requisite raw materials/ resources • Interdepartmental cooperation	Mousavi, Bossnik and van Vliet (2018) Adam, strähle and Freise (2018)	Khan, Daddi and Iraldo (2020a, 2020b, 2021) Teece (2007) Mousavi and Bossnik (2017)
Reconfiguring	Organisational restructuring	• Merger with or acquisition of another organisation • Changed organisational structure		Khan, Daddi and Iraldo (2020a, 2020b, 2021) Teece (2007) Mousavi and Bossnik (2017)
	Technological upgradation	• Made slight modifications in existing technology/machinery • Introduced new or significantly improved technology • Acquisition of a new manufacturing plant	Eurostat (2014) Wilden and Gudergan (2015)	
	Knowledge integration	• Organised training to employees • Acquisition of existing know-how	Eurostat (2014) Prieto- Sandoval et al. (2019)	
	Best practices adaptation	• Adopted new business practices for organising procedures • Adopted new methods of organising external relations • Adopted new or significantly improved logistics	Eurostat (2014) Mousavi, Bossnik and van Vliet (2018) Wilden et al. (2013) Wilden and Gudergan (2015)	

4 Methodology

This chapter describes the rationales for the research strategy, the approach to theory development, research design, research methods, and research quality.

4.1 Research strategy and approach

This qualitative, exploratory study explores ATS pilots by generating rich descriptions of their business processes as a phenomenon without any manipulation for data collection purposes (Bell, Bryman and Harley 2019). The approach to theory development is abductive, which combines deductive and inductive reasoning by moving between theory and empirical data (Saunders, Lewis and Thornhill 2019). Abductive approaches are common in business research, as appropriate aspects of theory are applied to an empirical observation ("theory matching”), and it is commonly used in case studies to help develop an understanding of new phenomena (Dubois and Gadde 2002; Kovács and Spens 2005; Bell, Bryman and Harley 2019).

Here, the abductive approach follows Ketokivi and Choi’s (2014, p.236) “theory elaboration” mode of case study research, which requires investigation of general theory and the empirical context with a “reconciliation of the general with the particular”. The abductive approach is appropriate for elaboration as it reconciles theory within the case context leading to new insights. Based on the research question, this study combines DC theory and its underlying microfoundations to explore and better understand how ATS pilots’ approaches to the microfoundations can create solutions to overcome scalability challenges. Several scalability challenges are expressed in the literature, and therefore, how approaches to the microfoundations underlying DC can overcome them requires an abductive approach.

4.2 The case study

A case study design is appropriate as the research question asks “how”, it does not require control over events studied, and the focus is on contemporary events (Yin 2018). In exploratory research, where the phenomenon studied is not fully understood, a case study contributes by creating one path forward for further research on the phenomenon (Voss, Tsikriktsis and Frohlich 2002). Moreover, a case study is helpful in terms of elaborating on existing theory in a new context (Ketokivi and Choi 2014). It helps narrow contextual gaps in theory where the researched phenomenon is not yet clearly explained, and the general theory may be elaborated on by applying it to the phenomenon (Eisenhardt and Graebner 2007; Barratt, Choi, and Li 2011; Ketokivi and Choi 2014). Thus, a case study is helpful in understanding emerging business practices (Voss, Tsikriktsis and Frohlich 2002).

Here, there is little known about how DC can overcome challenges to attain CE (Kabongo and Boiral 2017; Khan, Daddi and Iraldo 2020a, 2020b, 2021), including in contexts of small organisations and new ventures (Adam, Strähle and Freise 2018), such as ATS pilots’ efforts to scale up in Northwestern Europe. Therefore a qualitative, exploratory case study can help to understand DC in the context of this phenomenon (Ketokivi and Choi 2014). Further, the context of the case is Northwestern Europe in the first half of 2021. It is a time of transition in terms of shifting from a linear economy to one more closely aligned with CE. At this time, EU Member States are determining how to comply with the EU Waste Directive (2018) requiring the separate collection of textile waste by 2025, and how to implement textile EPR to fund it. The CEAP (EC 2020), promises more national and domestic action to implement CE principles in the textile industry, and a Strategy for Textiles is in public consultation with adoption expected in the third quarter of 2021 (EC 2021).

Thus, the single case phenomenon is ATS pilots in Northwestern Europe overcoming key scalability challenges to go from pilot to commercial scale. This is appropriate as it is a "revelatory" case (Yin 2018, pp.50–51). A revelatory case "can uncover some prevalent phenomenon previously inaccessible", which justifies a single case study (Yin 2018, p.51). Here, it was not until recently that ATS pilots existed in Europe at the pilot stage ready to transition to commercial scale, and only a few pilots have reached the point of a plant/line serving actual customers (Terra 2020).

This single case study has a holistic, single unit of analysis, which is appropriate for a qualitative study (Scholz and Tietje 2002; Yin 2018). Because this study explores the "global nature" of the ATS pilots' approaches to DC, and because DC (sensing, seizing, and reconfiguring) are mainly "holistic in nature", this is also appropriate (Yin 2018, p.52). Here, the single *unit of analysis* for this exploratory, qualitative study is the ATS pilots' approach to Teece's (2007) DC microfoundations.

Of the few pilots that have reached the point of attaining a plant/line facility serving actual customers, three pilots, A, B, and C, were selected for this study. The motivation for studying these three ATS pilots is as follows. Their activities are funded, and they operate as going concerns. They have long-term investment from national and local governments and/or NGOs. Further, their facilities/equipment are invested in by multiple municipalities, local provinces, other government organisations, and NGOs. At the same time, the ATS pilots' respective operations are in close partnership with a diverse consortium of actors spanning the SC. Because the ATS pilots are operating at an early stage commercially and have the resources to continue operations, they are appropriate to study through the DC lens (Zahra, Sapienza and Davidsson 2006; Ma, Zhou, and Fan 2015; Adam, Strähle and Freise 2018).

In addition, the ATS pilots serve inbound and outbound customers and are attempting to scale up to process larger volumes of textile waste for more customers in light of EU Waste Directive (2018) requirements. They have also published information in the public domain regarding their business activities, which makes studying their approach to DC microfoundations accessible. Each ATS pilot is part of a respective consortium of partners that are active together as a group and include representation from diverse actors, e.g., funders, research organisations, brands, collectors, sorters, machine equipment manufacturers, waste management companies, and textile recyclers. Together, they contribute to the ATS pilot funding and business activities. The ATS pilots use reference libraries, mathematical algorithms, and optical NIR/VIS-based technology, cameras, and line equipment/robotics intended to scan and sort textile material based on content and colour.

The ATS pilots are similar in terms of the timing of their pilot stage; launching their facilities; their funding/investment; consortium/partnerships; scanning and sorting technology; and relative regional locations. The ATS pilots are successful in terms of attaining plants/lines, customers, future funding, and are currently operating as going concerns attempting to scale up. Therefore, the ATS pilots' approaches to DC microfoundations are explored in a global sense to understand how DC can overcome the ATS pilots' key scalability challenges to scale up to commercially viable solutions. Thus, the three ATS pilots A, B, and C constitute a single, exploratory case, and they are briefly summarised in Table 2.

Table 2 Summary of ATS pilots A, B, and C

Characteristic	Pilot A	Pilot B	Pilot C
General location	Northwestern Europe	Northwestern Europe	Northwestern Europe
Capacity estimates	pilot facility: ~1 tonne/hour	pilot facility: 4.5 tonnes/hour 8,000 tonnes/year full-scale facility: 24,000 tonnes/year	pilot facility: 1,000-5,000 tonnes/year full-scale facility: 5,000-20,000 tonnes/year
Sorting capability	content and colour	content and colour	content and colour
Partnership/ consortium	yes	yes	yes
Plant/line launch	Q1 2020	Q4 2020	Q1 2021
To maintain confidentiality, detailed information that could potentially reveal the identity of the pilots, their partners, or individual respondents is not disclosed here, but it is available upon request subject to approval and non-disclosure agreement.			

4.3 Primary data collection

Primary data is data collected specifically for this study, which intends to provide new insights regarding the research question, and is collected directly from the original source (Farquhar 2012). To collect primary data, this study used generic purposive sampling within the ATS pilots consortia of partners. This is an appropriate non-probability sampling where samples are selected based on a researcher's judgment that a participant will be helpful in answering the research question (Saunders, Lewis and Thornhill 2019). Here, generic purposive sampling helps to gain perspectives from ATS pilot consortia partners with requisite knowledge and diverse SC roles (Saunders, Lewis and Thornhill 2019). Within each sampled partner, a person most knowledgeable in a management position regarding the ATS pilot was identified. These persons most knowledgeable are in management or upper-level management positions, they have decision-making power, and they have recently worked with or are actively working in partnership with an ATS pilot. As this study is elaborating on DC theory, and not testing statistically, the generic purposive sampling is appropriate (Eisenhardt and Graebner 2007).

A total of 12 semi-structured interviews took place from March 24th to April 20th. Two interviews included two persons most knowledgeable from the same organisation, resulting in primary data collection from 14 respondents in total. The first day of interviews served as test interviews where the clarity of the interview questions was confirmed. Each interview ran approximately 30-45 minutes. Table 3 summarises the primary data collection.

Table 3 Summary of primary data

PRIMARY DATA				
Interview/ Respondent No.	**Respondent's Position**	**SC Role in ATS Pilot Consortium**	**Pilot**	**Date**
R01	Director	Collector	A	24 March 2021
R02	Senior Manager	Research Organisation	B	24 March 2021
R03	Manager	Research Organisation	C	26 March 2021
R04	Leading Researcher/Analyst	Funder	A	30 March 2021
R05	Manager	Recycler	B	31 March 2021
R06	Area Manager	Equipment Manufacturer	C	31 March 2021
*R07	*R07.1 Manager *R07.2 Engineer	Equipment Manufacturer	A	01 April 2021
R08	Director	Recycler	A	01 April 2021
*R09	*R09.1 Leader *R09.2 Developer	Brand	B	08 April 2021
R10	Manager	Brand	C	14 April 2021
R11	Manager	Brand	B	15 April 2021
R12	Leader	Waste Management Company	B	20 April 2021
The star asterisk "*" symbol indicates that two respondents from the same organisation were interviewed together, and they are distinguished as R0X.1 and R0X.2. To maintain confidentiality, information that could potentially reveal the identity of the pilots, their partners, or individual respondents is not disclosed here, but it is available upon request subject to approval and non-disclosure agreement.				

The semi-structured interview method was used to gain new insights regarding the phenomenon studied (Farquhar 2012; Bell, Bryman and Harley 2019; Saunders, Lewis and Thornhill 2019). This format permitted asking respondents open questions related to a list of topics that answered the research question and contemplated DC theory. Each respondent was asked open questions in a similar way based on a research protocol and interview guide (see Appendix 1). Respondents replied in an open way resulting in in-depth responses rich in information. Table 4 summarises the interview questions and their topics.

Table 4 Interview questions and topics

Interview Question No.	Topic of Question
1	Respondent's background and SC role/activities within the ATS pilot consortium
2	Perceptions on key scalability challenges holding ATS pilots back right now and in the near future
3	Perceptions on key capability - sensing
4	Perceptions on key capability - seizing
5	Perceptions on key capability - reconfiguring
6	Catch-all question

Before the interview, respondents were contacted in the same way via email and given a summary of the research (See Appendix 1). Respondents were also given detailed information about the interview process, the university's GDPR policy, terms of confidentiality, and the interview questions to be asked (See Appendix 1). This met ethical requirements by informing and managing respondent expectations and explaining their rights as interview participants (Creswell 2018; Bell, Bryman and Harley 2019; Saunders, Lewis and Thornhill 2019). Due to the COVID-19 pandemic, interviews were conducted online via synchronous, audio/video platforms, such as Zoom, Google Meet, and Microsoft Teams. Interviews included face-to-face interaction with minimal connectivity issues. All researchers attended the interviews, took notes, and had the opportunity to serve as the main interviewer and/or ask follow-up questions based on the research protocol and interview guide.

Interviews were recorded with respondents' permission, and audio files were immediately sent to GoTranscript for clean verbatim transcription to create a written account of the primary data collected (Saunders, Lewis and Thornhill 2019). GoTranscript maintains a strict confidentiality policy, is GDPR compliant, and has non-disclosure agreements in place with transcription personnel, which meets ethical requirements (Creswell 2018; Bell, Bryman and Harley 2019; Saunders, Lewis and Thornhill 2019). Further, any inadvertently included personal information (names, proper nouns, identifiable places) that could potentially identify respondents was removed and substituted with generic nouns approved by the respondent. To ensure the accuracy of the transcript, the recording was listened to several times to resolve any transcription error, known as data cleaning (Saunders, Lewis and Thornhill 2019). After data cleaning, the transcript was sent to the respondent for review, edit, and approval as soon as reasonably possible after the interview. Once the transcript was approved, the audio recording was deleted, and the approved transcript was uploaded to a case study database in Dedoose, a computer-assisted qualitative data analysis software (CAQDAS) that supports coding and thematic analysis. Dedoose was selected as it is respected and recommended among social science researchers, complies with GDPR requirements, has collaborative coding capabilities, and data analysis and reporting features. (Saldaña 2016; Bell, Bryman and Harley 2019; Saunders, Lewis and Thornhill 2019)

4.4 Secondary data collection

Secondary data in the form of documents originally compiled for a purpose other than this study were collected for analysis to support and complement primary data findings (Saunders, Lewis and Thornhill 2019). Sources of secondary data regarding the ATS pilots were provided by a respondent and collected from pilot websites, news articles, and published reports prior to and contemporaneously with the interviews (Farquhar 2012). Once downloaded from the source, the secondary data were uploaded to the case study database in Dedoose to be analysed together with the primary data.

Table 5 summarises the secondary data collection, which consists of a total of 240 pages.

Table 5 Summary of secondary data

SECONDARY DATA				
Document No.	**Description**	**Pilot**	**Source***	**Date**
D01	Reference sheet	A	Pilot website	December 2018
D02	Official report	A	Pilot website	October 2019
D03	Official report	A	Pilot website	February 2020
D04	Official report	A	Pilot website	March 2020
D05	Summary presentation	B	Pilot website	November 2019
D06	Operation presentation	B	Pilot website	January 2021
D07	“About” web page	B	Pilot website	April 2021
D08	News article on new plant	B	Pilot website	November 2020
D09	News article on new plant closing the loop	B	Pilot website	November 2020
D10	News article on research update	C	Pilot website	November 2020
D11	News article on plant	C	Pilot website	November 2020
D12	“About” web page	C	Pilot website	April 2021
D13	Pilot presentation	C	Pilot website	November 2019
D14	Plant scaling presentation	C	Pilot website	November 2019
D15	Public report	C	Pilot website	May 2019
D16	Scanner Q&A for pilot partners	C	Respondent R06	February 2021
*To maintain confidentiality, information that could potentially reveal the identity of the pilots, their partners, or individual respondents, such as URLs, is not disclosed here, but it is available upon request subject to approval and non-disclosure agreement.				

4.5 Primary and secondary data analysis

The primary and secondary data were uploaded to a case study database in Dedoose for thematic analysis. Nowell et al. (2017) recommend thematic analysis for both primary and secondary data. "Thematic analysis" is "a method for identifying, analysing, and reporting patterns (themes) within data" (Braun and Clarke 2006, p.79). The thematic analysis method is recognised as a qualitative, descriptive method that is broadly applicable in qualitative research (Vaismoradi, Turunen and Bondas 2013; Nowell et al. 2017). Thematic analysis can produce trustworthy findings when examining different perspectives in interview data and summarising key aspects of a large amount of data due to its structured approach. One disadvantage is that it is not as prevalent in academic literature as grounded theory. Therefore, it is important to follow a documented approach that addresses criteria for trustworthiness and consistency. (Nowell et al. 2017)

To that end, this study follows the thematic analysis approach presented in Nowell et al. (2017), which is based on Braun and Clarke's (2006) six-phase method and includes criteria for trustworthiness. Braun and Clarke's six-phase method (2006) is: (i) familiarising yourself with the data; (ii) generating initial codes; (iii) searching for themes; (iv) reviewing the themes; (v) defining and naming themes; and (vi) producing the report. Further, Nowell et al. (2017) list criteria for trustworthiness that include: prolonged engagement with the data; triangulation of data collection; member checking; documenting and reflecting on codes/themes, using a well-organised archive to maintain data; use of an underlying coding/theory framework as an initial guide; peer debriefing; researcher triangulation; diagramming to make sense of theme connections; vetting themes and subthemes by team members and consensus; and reporting on the reasons for theoretical, methodological, and analytical choices throughout the study.

Here, thematic analysis began as soon as possible after data collection by reviewing the research protocol to ensure an understanding of the process and initial code structures (see Appendix 1). Researchers were assigned a primary and secondary data set to code guided by an initial code structure based on challenges identified in the literature review in Chapter 2, and the DC theoretical framework identified in Chapter 3. This assisted theory matching between the theory and empirical data enabling an abductive approach where codes could also emerge (Yin 2018).

While coding at the sentence and/or paragraph level, researchers wrote analytic memos for review and discussion (Saldaña 2016). The analytic memos consisted of notes about the data source, the case phenomenon, the ATS pilots' challenges and approaches to DC, and reflections on code choice, code definition, or emergent codes. This supported researcher reflexivity and critical thinking (Saldaña 2016). The researchers discussed codes when there were immediate questions. Codes and patterns that did not fit well within initial code structures were noted as emergent (Saldaña 2016). Researchers switched their data sets and reviewed all data and each other's coding. Analytic memos were used to record comments regarding excerpts and coding (Nowell et al. 2017). There were a total of 2,970 code applications; 584 coded excerpts (some had more than one code applied) where 310 coded excerpts were marked as best examples; and 173 analytic memos. The data analysis took over one month to complete. As last steps, together the researchers debriefed their coding and reviewed all 173 analytic memos to address each one and reach consensus (Nowell et al. 2017). Together, they discussed initial and emergent codes, themes, where emergent codes fit under themes, and mapped a draft conceptual framework. This took three day-long meetings of discussion via Zoom with all three researchers present and actively participating in the discussion. Upon reaching consensus, a report of the 310 best examples was generated. From there, the researchers created an outline of key findings and patterns/trends on which to report. (Braun and Clarke 2006; Nowell et al. 2017)

Table 6 provides a sample of the application of themes, sub-themes, and codes to best example data excerpts. A full datasheet is available upon request.

Table 6 Sample application of themes, sub-themes, and codes to best example data excerpts

<table>
<tr><th>DC</th><th>Microfoundation</th><th>Indicator</th><th>Best example data excerpt</th><th>Data source</th></tr>
<tr><td rowspan="4">Sensing</td><td rowspan="4">Market Monitoring and Technology Scanning</td><td>Tracking new market trends</td><td>“We should act fast to make sure that the country will become one of the forerunners in this new industrial sector, where the aim is saving in resources of raw materials, energy, water etc. and reducing the impact on the environment for sustainable developments and products. In future, textile recycling would be as important industrial activity as textile manufacturing is today.”</td><td>D15</td></tr>
<tr><td>Observing technological developments</td><td>“As far as I know, there are a few companies who are busy with this. I'm pretty aware of what one of these companies based in the UK is doing. They are now in the pilot pre-production phase of their process. The moment that we are able to chemically recycle poly-cottons will be an enormous breakthrough, because the poly-cottons that we are sorting out using the automated textile sorting machine, after cutting and cleaning, those poly-cottons can go into that chemical recycling process, and it will deliver the outcome of the chemical recycling process, which is polyester and cellulose. From cellulose, you can make paper, for example, you can do a lot with that.”</td><td>R01</td></tr>
<tr><td>Identifying customer needs</td><td>“Since last year, we’re improving, we're getting results. To give a slight forecast for the actual plant and for its capacity in terms of output volume in the next few years, the output volumes are increasing at a greater rate than we had projected back in 2017, and that's due to the whole industry, which has demonstrated a noticeable increase in demand for sustainable, recycled materials.”</td><td>R12</td></tr>
<tr><td>Identifying needs of all stakeholders*</td><td>“Basically, all these scalability questions and issues, we accessed through kind of stakeholder like groups or focus groups or so on. So, we analysed together with stakeholders from every part of the value chain, what were the challenges and how to tackle them.”</td><td>R04</td></tr>
<tr><td colspan="5">The star asterisk “*” symbol indicates an emergent indicator that was not part of the initial code structure.</td></tr>
</table>

4.6 Research quality

Although case studies are widely used in business research, disadvantages exist. Case studies may lack the objectivity and rigour of other research designs (Farquhar 2012). In addition, complex generalisability issues arise, even in multiple cases (Yin 2018). Regarding the single case, some researchers find it provides a greater opportunity for in-depth, rich study (Dyer and Wilkins 1991; Dubois and Gadde 2002, 2014; Voss, Tsikriktsis and Frohlich 2002). Yet, other researchers find multiple cases offer better results in terms of robust data for testable theory with greater external validity (Eisenhardt 1989; Eisenhardt and Graebner 2007; Yin 2018). Nevertheless, even Eisenhardt and Graebner (2007) appreciate that single cases can offer rich descriptions of phenomena, which has research value. Still, a single case has limitations. It may limit the generalisability of conclusions and risk bias/exaggeration of data collected (Voss, Tsikriktsis and Frohlich 2002). As this study explores and elaborates on DC theory in a new context, and is not testing DC theory, some single case limitations may be mitigated as discussed below (Yin 2018).

4.6.1 Construct validity

Construct validity refers to "identifying correct operational measures for the concepts being studied" (Farquhar 2012; Yin 2018, p.42). It is increased by using multiple data sources (Yin 2018). Here, data triangulation is supported by primary data collection during 12 interviews where 14 respondents from diverse SC roles across three ATS pilot consortia gave their perspectives. Secondary data consisted of 16 websites, news, and report documents of 240 pages regarding the three ATS pilots.

Construct validity is further increased by establishing a "chain of evidence" through the research question, research protocol/interview guide, data collection, findings, and analysis (Yin 2018, pp.135–136). A case study database where the collected data are maintained and coded in an orderly fashion also helps in this regard (Yin 2018). Here, researchers followed a research protocol/interview guide (see Appendix 1) and used a case study database in Dedoose to help establish a chain of evidence (Voss, Tsikriktsis and Frohlich 2002).

Further, Yin (2018) suggests having case study participants review the resulting case report to improve construct validity. Here, time did not permit gathering participant feedback on the case report, however, the transcripts were approved by the respondents and the final report will be sent to all respondents per their request. Nevertheless, it remains a weakness that the case report lacks participant review and comment. The researchers attempt to mitigate this weakness by ensuring compliance with the research protocol and interview guide; attending all interviews; ensuring accurate transcripts; meeting frequently during the workweek to discuss the study; checking each other's work and coding; participating in supervisor tutoring and peer review. These actions add a layer of checks intended to improve construct validity. (Yin 2018)

4.6.2 Internal validity

Internal validity seeks “to establish a causal relationship, whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships” (Yin 2018, p.42). Although this does not apply to exploratory studies, as internal validity deals with the presence of causal relationships between variables and results in explanatory or causal case studies (Farquhar 2012), the concerns underlying internal validity may be addressed in terms of making inferences (Yin 2018). Here, the presence of both data and researcher triangulation, as well as efforts to ensure accurate primary data, support the quality of inferences made in the study.

4.6.3 External validity

External validity or generalisability refers to “showing whether and how a case study’s findings can be generalised” (Yin 2018, p.42). The typical concern is whether results may be generalised to other contexts (Yin 2018). Yet, for exploratory case studies, the concern is not statistical but “analytic generalisation” in terms of being “generalisable to theoretical propositions and not to populations or universes” (Yin 2018, pp.20–21, 38–42, 45–46). Here, the case study intends to “shed empirical light on” theory by elaborating on DC theory in the context of ATS pilots in Northwestern Europe scaling up to support textile CE, and it does not intend to “extrapolate probabilities” (Yin 2018, pp.21, 38; Bell, Bryman and Harley 2019). In terms of analytical generalisability, as there is a textile sector interest in CE, the elaboration on DC theory in the instant context have the potential to be applied in related contexts beyond the exact specifics of this single case.

4.6.4 Reliability

Reliability refers to “demonstrating that the operations of a study, such as the data collection procedures, can be repeated with the same results” (Yin 2018, p.42). Reliability may be increased by minimising bias in the study. Here, the research protocol/interview guide was followed, and a case study database was used for organisation and structure to improve reliability. The procedures involved were recorded in a transparent manner, and researcher triangulation, supervisor tutoring, and peer review contributed to reliability. (Yin 2018)

5 Findings

This chapter presents the findings from the thematic analysis of the primary and secondary data. An overview of the key scalability challenges faced by ATS pilots is in Table 7, and overviews of DC, microfoundations, and indicators employed to overcome the key scalability challenges are presented in Table 8, Table 9, and Table 10 for sensing, seizing, and reconfiguring, respectively. As mentioned in chapter 4.5, there were a total of 584 coded excerpts from the primary and secondary data, where 310 coded excerpts were marked as best example excerpts of the primary and secondary data, and of those best example excerpts, the following 79 quotes from the primary data were selected as examples to illustrate the findings and are supported by citations to the secondary data, as well.

5.1 Key scalability challenges

The following subsections review the findings related to key scalability challenges. The internal and external challenges found in the data are summarized in Table 7.

Table 7 Key scalability challenges, internal and external

KEY SCALABILITY CHALLENGES
Internal Challenges
• Capacity and speed • Continuity of input and output feedstock volumes • Identification accuracy issues • Obtaining funding for high costs and expenses
External Challenges
• Narrow textile recycling technology specifications • Lack of information sharing/collaboration; disconnection with stakeholders • Lack of targeted law and policy support and/or implementation • Lack of industry-wide standards • Immature or under-developed markets, SCs, and BMs • Impact of market disruptions*
The star asterisk “*” symbol indicates an emergent challenge that was not part of the initial code structure.

5.1.1 Internal key scalability challenges

Capacity and speed

The full capacity and speed of ATS facilities can handle a fraction of regional textile waste (R02). Throughput bottlenecks arise from mechanics/robotics:

> *[1] There are two robots at the front of the machine who are picking up a garment and putting it on a conveyor belt, and then it's going through the scanner. [...] The technology of the robots is too slow.* (R01)

Continuity of input and output feedstock volumes

Finding suppliers of regular inbound feedstocks is challenging (R02). ATS pilots must often hold sorted fraction inventory to reach batch processing minimums (R07.1). Further, meeting customers' specifications for outbound feedstocks poses challenges:

> *[2] What you need to have is a sufficient volume on specification to deliver directly to the production companies, and not only a one-off volume. You should have a constant stream available for purchase to those production companies of the same specifications and volumes.* (R01)

Identification accuracy issues

Garments' structural/content complexity challenges ATS technology (R01; R10; D16). Accurately identifying blends of several fibres or similar spectra is difficult (R07.1). Also, identifying the presence of chemicals of concern is challenging (R01; R02; R03; R04; R10; D15). R02 explains:

> *[3] There is the quality, safety issue that we have to address [...] for this to start scaling. [...] we have to address that in a statistical way using probabilities.*

Obtaining funding for high costs and expenses

Constructing and operating/maintaining ATS facilities is expensive (R01). The large upfront investment makes end-markets crucial (D04). Yet, ATS pilots have two-sided marketplaces where value propositions to inbound customers (those selling or offloading textile waste) and outbound customers (those buying sorted textile fractions) are dependent (R01; R03; R08):

> *[4] Money is basically the chicken and egg problem. [...] Are we first, or are they first? [...]Now, we are not at that scale that we can pay them to have that money to potentially invest in future technologies. That sort of ecosystem isn't there. So that kick start needs to happen, probably with some money from brands to governments to help the innovation.* (R08)

5.1.2 External key scalability challenges

Narrow textile recycling technology specifications

Few outbound customers use heterogeneous sorted fractions as feedstock for textile recycling, yet that is most of the textile waste stream (R01; D15). R02 explains:

> *[5] If you ask a cotton recycler what the specification would be, then the first answer is all-white, all-cotton, very cheap, and huge volumes. [...] If you as a buyer from the plant would say that 99% isn't necessarily a strict specification [...] volumes available would be much larger and the price of them would be much lower [...].*

Also, scaling on popular sorted fractions generates mixed fractions that remain difficult to sell (R02). The secondary data confirms these challenges (D3).

Lack of information sharing/collaboration; disconnection with stakeholders

The data show a lack of information sharing/collaboration and disconnection in the ATS SC (R01; R02; R04; R10).

> *[6] [M]any times the value chain is very disconnected and really paired textile collectors and textile sorters are the ones who are running the automated sorting technology but don't have the close contact with the manufacturers, brands, even sometimes with their recyclers.* (R04)

> *[7] The really big actors, [...] sometimes they won't tell us what their plans are. Sometimes, they will just specify what type of feedstock they're after.* (R02)

> *[8] Our market and the textiles production market of garments has got a total disconnect.* (R01)

The secondary data also note brands/consumers lack information on the possibilities and benefits of recycled materials (D15).

Lack of targeted law and policy support and/or implementation

Respondents indicate a need for supportive legislation:

> *[9] For our ATS technology--what is really important is that there is a broader structure in the world that supports this.* (R07.1)

The conflict between CE policy and existing legal requirements is mentioned (R02; R09.1).

> *[10] These policies [...] saying [...] we should be 100% circular [...] Then [...] that everything should be 100% defined, [...] Those are conflicting.* (R02)

Further, regulations on movement of goods impact use of sorted textiles in overseas production:

> *[11] Is it "waste" or a "new raw material" being transported, legislation looks differently up on this depending on the country. The stricter the regulations are on the movement of goods, the more complicated it will be [...].* (R09.2)

The secondary data confirm the urgency to update legislation to accommodate CE (D15).

Lack of industry-wide standards

Presently, there is no industry-wide agreement on quality standards or terminology (R12; D15):

> *[12] There is a quality journey that we need to do. [...] there's a quality structure that needs to be in place, so we can match certain standards to that, which the fashion industry aims to have.* (R12)

Immature or under-developed markets, SCs, and BMs

Respondents noted ATS's immature markets, SCs, and BMs:

> *[13] [W]e try to develop something that has to serve certain markets we hope that will exist in the future. But it's also the reality that the market is not really there yet. … The resources are there. There is the technology to sort it. There is technology to recycle it. It's just that everybody has to get involved.* (R07.1)

> *[14] There are so many other categories of the textiles that are sorted that don't really have just anywhere to go and no one wants to buy them.* (R04)

Margins, pricing, and costs are yet to be finalised:

> *[15] It's a very immature model, and this is a group of partners where some of the actors aren't used to working together. […] it's a little bit unclear for everybody what their roles are, and to be even more specific, where their own margins are. For instance, pricing is not by any means set, and everybody is trying to catch as much margin for themselves. […] We don't fully know yet what the true cost of running the plant is. I don't know what they're paying for high-quality inbound materials, or what they're charging for taking low-quality inbound materials. […] The very specific costings are still up to the different parties to find specific agreements that work for them both.* (R02)

The secondary data note most brands are not sourcing PCT fractions due to "price, quality, consistency, and colour availability" (D4). Further, most brands' production is far from textile processing/recycling centres, there are missing links in the chain, and a lack of clear, far-reaching collection plans considering global production (D15).

Impact of Market Disruptions

The impact of market disruptions, like COVID-19, arose:

> *[16] Last year, the pandemic was a big bump in the road. This is not only in terms of the fashion industry, but it also affects the entire textiles industry and the industries that it touches; it is the customers' customers' market that needs to bounce back.* (R12)

Also, its potential chilling effect on willingness to pay more for recycled materials, implying difficulty competing against virgin materials:

> *[17] [B]rands were also ready to pay a kind of premium price for those materials with recycled yarns, but right now, and maybe it's also the effect of the pandemic, that they are not ready anymore to pay this price.* (R05)

5.2 Dynamic Capabilities

The following subchapters review the findings for DC: sensing, seizing, and reconfiguring.

5.2.1 Sensing capability

Guided by the DC framework and its underlying microfoundations in Chapter 3, the ATS pilots' approaches to the sensing capability were identified in the primary and secondary data. The indicators found in the data for each microfoundation are summarised in Table 8.

Table 8 Sensing capability microfoundations and indicators

SENSING CAPABILITY	
Microfoundations	**Indicators**
Market Monitoring and Technology Scanning	• Identifying customer needs • Identifying needs of all stakeholders* • Tracking new market trends • Tracking new regulatory trends* • Observing technological developments
Idea Generation	• Organising brainstorming sessions • Involving customers and/or suppliers in product development process • Mapping aspects of SCs* • Modelling aspects of SCs*
Knowledge Creation	• Undertaking R&D activities collaboratively to test new ideas and create new knowledge*
Experience-Based Learning	• Assessing potential environmental and social impacts of products, processes, services* • Assessing potential risks* • Networking with public organisations, industrial associations, universities, and others
The star asterisk "*" symbol indicates an emergent indicator that was not part of the initial code structure.	

5.2.1.1 Market monitoring and technology scanning

Market monitoring and technology scanning is approached by identifying customer needs, tracking new market trends, and observing technological developments. Also, some emergent indicators were found: tracking new regulatory trends and identifying the needs of all stakeholders.

Identifying customer needs

Various respondents and documents mentioned the importance of identifying customer needs to scale up (R02; R07; R10; R12; D09; D13; D15). For example, respondents found that customer needs shape the specifications of outbound sorted fractions, as R10 explains:

> *[18] So, even though there is automated textile sorting, you have to first start from the end of the process and ask, "Who is the final customer? [...]".*

R07.2 emphasises adapting to customer needs: "*[19] because every customer has specific needs, [...]. So, we try to adapt and try to make certain changes that will fit the needs of the customer*". D15 further supports this when discussing a market survey conducted to understand customer needs before establishing a plant for end-of-life textiles.

The quality of the sorted fractions is especially important to customers, R08 explains:

> "*[20] [...] what comes in and out for the sites is important to all, that is the quality. We need quality because if the quality is not right, you also have a problem with producing these [recycled] materials*".

Customer needs also determine the flow of accepted inbound materials, as all materials do not have the same outbound demand (R02). Yet, demand for sorted textile fractions is increasing and driving scalability forward. R12 explains:

> *[21] To give a slight forecast for the actual plant and for its capacity in terms of output volume in the next few years, the output volumes are increasing at a greater rate [...], which has demonstrated a noticeable increase in demand for sustainable recycled materials.*

Identifying needs of all stakeholders

Respondents see their SC activities as interconnected with each other, which emphasises identifying needs of all stakeholders as a solution to overcome challenges. R04 states:

> *[22] Basically, all these scalability questions and issues, we accessed through kind of stakeholder like groups or focus groups or so on. So, we analysed together with stakeholders [...], what were the challenges and how to tackle them.*

In another example, R02 explains how to bring partners of various experience, size, and resources together by taking a neutral role and helping partners to consider multiple perspectives and learn how to best work together to address all stakeholders' needs:

> *[23] We're typically in those discussions as a mediator [...] one partner is a massive global retailer, and one partner is the local public waste management company, then that's a very uneven playing field. [...]It's a way of helping everybody see their different perspectives, and to again, take a neutral role.*

Tracking new market trends

Respondents see an increased demand for sustainable materials as a new market trend that can help scale ATS pilots. For instance, in the future, textile recycling will be a core activity in the SC (D15). Also, market trends indicate a focus on brand accountability for sustainable claims. R12 explains:

> *[24] For the fashion industry, it has made a major shift since two to three years ago. Before that, there were a lot of brands that were greenwashing in terms of their sustainability goal. [...] Today, if you write a sustainability goal, you must follow it [...].*

Tracking such market trends helps to identify and harness increased demand for outbound sorted fractions. The secondary data also emphasise the dawn of a new, more-sustainable industry and market with technology developments, such as automating the sorting process (D15), which R07.1 explains: "*[25] the textile waste is very low value today, so we cannot have too much processing cost. [...] we must automate it as far as possible to reduce the cost of sorting textiles*".

Tracking new regulatory trends

New regulations regarding textile waste can change business and consumer behaviour. For example, R08 shares their interest in tracking new regulations concerning the separate collection of textile waste: "*[26] what is going to happen with that [textile waste] is important as well, because that's probably a stock that we want [...], something we could probably recycle*". Also, tracking regulations can help the organizations' agendas and to plan ahead (D15; R12). R12 explains:

> *[27] There are a lot of laws that are coming that will be helping us to push this agenda, as well. For example, the national textile collection law. It will apply in Sweden by 2025.*

Policy instruments help drive development where EPR for textiles is underway. R01 states:

> *[28] Actually, what we are doing is already working on the installation of our processes in advance and in anticipation of the introduction of the EPR scheme in the Netherlands.*

Observing technological developments

Technological developments impact ATS pilots and help them to scale. For instance, textile recycling developments enable market creation for more types of sorted textile fractions, which in turn allow for investments in needed advancements in ATS technologies (D09). For instance, R10 emphasises, "*[29] [T]hey recognise a lot of fibre mixes, but maybe when it's a multilayer garment, like a jacket, [...] this is where the trouble still remains*". The NIR technology sorts by content and colour, yet developments are ongoing in identification of complex garments, for instance by using "*[30] a hyperspectral camera [...] to recognise these different things"* as stated by R03. Also, a number of technologies are under development for separating polyester-cotton blends, for which there is a huge demand (R01; R03). R03 emphasises, "*[31] there are a lot of technologies under development for poly-cotton, [...], and then various technologies, and they will come commercial in 5 to 10 years*".

5.2.1.2 Idea generation

Idea generation is approached by organising brainstorming sessions and involving customers and/or suppliers in the product development process. Also, indicators have emerged, including mapping and modelling aspects of SCs.

Organising brainstorming sessions

Respondents mentioned that organising brainstorming sessions with partners helps to find solutions for customers and to generate new ideas to scale up. R02 explains one brainstormed idea for a new use for sorted fractions:

> *[32] We are trying to figure out, ok, maybe a padding for another type of product, maybe if you're making outdoor seating pads, [...]. The motivation for that is both to help everybody identify their own unique selling point, but also, coming back to getting use out of and getting someone to buy all types of material.* (R02)

When brainstorming, business customers are encouraged to be bold and cut their own path in terms of innovation; not sit on their hands and wait for a bigger player to develop something first. R02 explains:

> *[33] We had one of the partners present an inspiration case that we are doing something different [...] I want to also help the other brands to see where they can lead the way themselves.*

Involving customers and/or suppliers in product development process

Involvement of customers and/or suppliers in the product development process is further emphasised to scale up (D14). The ATS pilot works closely with spinners and knitters to capture value and create new yarns from end-of-life textiles (D04). Additionally, the NIR scanning equipment manufacturer and waste collectors work together to define the user experience and the possibility to use the scanner in different operations (D16).

Mapping aspects of SCs

Mapping the SC results in a better planning and efficiency. R03 emphasises, "*[34] [S]o we had this kind of workshops where we mapped the whole textile recycling, reuse products, and chain, what you have there [...].*" R05 also talks about mapping the waste stream: "*[35] [T]here is really a huge analysis so far about the waste stream really mapping the current situation*". SC mapping supports an understanding of ATS actors' needs, requirements, and systems, which is helpful before establishing a textile recycling facility and scaling up (D15).

Modelling aspects of SCs

Modelling future costs for collecting, sorting, and pre-processing helps with planning and pricing. For example, cost models estimate the full cost of one kilogram of recycled fibres as raw material for a new product by costing the required collection, sorting, and recycling processes (D15). Further, modelling future SCs supports the ATS pilot's efforts to scale up (D15). The knowledge gained about collection, ATS sorting, and costs/pricing helps to set up an ATS facility BM. R12 explains:

> *[36] The next challenge is that we're setting up a whole new supply chain. We're taking post-consumer textile flows, we're taking mixed material that hasn't been really used at this scale or in the way that we're using automated technology to sort it. Now, we're comparing it to virgin fibre.*

5.2.1.3 Knowledge creation

To explore new areas of knowledge and to gather new insights, collaborative R&D activities play an important role.

Undertaking R&D activities collaboratively to test new ideas and create new knowledge

In their initial stage, ATS pilots focus on learning by experimenting together on a small scale for testing and evaluating feedback (R09; R10; D15).

> *[37] Regarding using the post-consumer textile waste in the yarns and fabrics and ready-made garments, we can do it, and we're just going to have to find a way of how to scale it up and use it even more.* (R10)
>
> *[38] One of our first products where we have used post-consumer cotton went on sale during April 2021 [...]. This helps us to understand the sorting, testing the material for chemical compliance, finding suppliers that can treat and work with this post-consumer material, [...] By doing these smaller trials, evaluating them, then we can decide how to take our next steps in scaling it up.* (R09.1)

The introduction of novel products on a smaller scale is a helpful way to learn how to create value from PCT waste. This requires new organisational processes, which are completely different from regular production processes. R09.1 mentions that "*[39] it's super interesting to build this up and really being part of designing a supply chain that can do this*".

Additionally, the chemical content in PCT waste is a new area of research. PCT waste comes from unknown sources; hence, it is difficult to determine whether any hazardous substance is present or not. R09.1 explains: *[40] We know how to set up our supply chain for virgin materials; there, we can control [...]. But when we work with recycled textiles, it's going to be different, when it comes to knowing the chemical content in the materials [...]".* Therefore, chemical contamination in PCT waste needs to undergo further research, and the results need to be shared with all stakeholders to increase industry knowledge (D03).

Multiple R&D projects are described in the supporting documents. For instance, desktop research is an effective source of information where industrial and annual reports are analysed before estimating the PCT flow in ATS pilots (D01). Also, findings from research conducted through interviews with industry stakeholders and publicly available data, aiming to understand key barriers to scale up the market of recycled PCT waste and ATS technologies, are reported (D03; D04). Additionally, different test phases to optimize the optical material identification are summarized (D14). Further, feedback from stakeholders and partners that give insightful information to shape the ATS process is summarized (D15). The involvement and active participation of all companies helps to define expectations.

5.2.1.4 Experience-based learning

Experienced-based learning is approached by networking with public organisations, industrial associations, universities, and others to overcome scalability challenges. Also, assessing potential environmental and social impact of products, processes, services and assessing potential risk to overcome scalability challenges emerged as indicators.

Assessing potential environmental and social impact of products, processes, services

Respondents mentioned how they assess the potential environmental and social impacts of their ATS products, processes, and services to help them scale (R01; R02). R01 explains:

> *[41] We are going to develop what we call the environmental contribution reporting tool, [...]. This, combined with all the operational data, gives us the opportunity to, for instance, determine what our contribution is on CO_2, water reduction/use, and other industrial elements.*

Assessing the social impacts is crucial, because dust from sorting processes can impact human health; therefore, safety measures have to be assigned, such as protective equipment in risk zones or dust management in textile processing to protect facility workers. For example, dust management has to align to the guideline provided by the Ministry of Social Affairs and Health (D15).

Assessing potential risks

Risk management helps to identify potential risks and prepare for them by planning required resources to avert or tackle the risks. Risk management aims to anticipate upcoming challenges. By assessing potential risks and potential challenges in overcoming those risks, risk scenarios can then be analysed to avoid unexpected consequences and losses (D15).

Networking with public organisations, industrial associations, universities, and others

Networking with different stakeholders helps to meet and share ideas and knowledge with a wide range of people working in the same industrial field. R05 explains, "*[42] [W]e also do yearly conferences about this topic and invite all kinds of stakeholder groups to discuss also on that*". Moreover, different projects have networked nationally and internationally to create a common ground for sharing knowledge and experience (D15).

5.2.2 Seizing capability

Guided by the DC framework and its underlying microfoundations in Chapter 3, the ATS pilots' approaches to the seizing capability's microfoundations were identified in the primary and secondary data. The indicators found in the data for each microfoundation are summarised in Table 9.

Table 9 Seizing capability microfoundations and indicators

SEIZING CAPABILITY	
Microfoundations	**Indicators**
Strategic Planning	• Formulation of a strategy • Finding strategic partners • Planning investments • Capital budgeting • Collaboratively seeking funding and grants* • Evaluating own resources, strengths, weaknesses, and opportunities* • Influence and propose new standards, guidelines, laws, and/or policies*
Business Model	• Redesigning or transforming BMs internally • Redesigning or transforming BMs with partners*
Collaboration	• Collaboration across SC to acquire requisite knowledge, skills, raw materials and/or resources* • Interdepartmental cooperation • Building trusted relationships in the local context*
The star asterisk "*" symbol indicates an emergent indicator that was not part of the initial code structure.	

5.2.2.1 Strategic planning

Strategic planning is carried out in terms of formulating a strategy, finding strategic partners, planning investments and capital budgeting. Additionally, the following emergent indicators were identified: collaboratively seeking funding grants, evaluating own resources, strengths, weakness, and opportunities, as well as influencing and proposing new standards, guidelines, laws, and/or policies.

Formulation of a strategy

The importance of formulating a strategy is explained by R01, R09.2, R10, R12 and in the documents D14 and D15. Respondent R12 highlights that more complex, unexpected challenges require "*[43] a strategic, long-term goal to address them".*

Evidently, organisations formulate their strategy by setting well-defined targets (D14; D15). By doing so, they emphasise their commitment to the shift towards CE. In this context, R09.2 and R11 state:

> *[44] The reason for participation in the ATS pilot is that we are going circular, where one of our commitments is to only use renewable and recycled materials by 2030 [...]. (*R09.2)

> *[45] We have our targets and our promise to 2028 to have 100% more sustainable materials in our products, and also that all our products should be designed and produced for a circular system [...].* (R11)

Finding strategic partners

The ATS pilot is described as a group of strategic partner pioneers engaged in CE (D14). Further, finding strategic partners is necessary to support overcoming scalability challenges (R09.1; R09.2). Also, R06 and R12 value essential customers as partners to gain access to different markets and infrastructure.

> *[46] We are lucky that they are creating the whole infrastructure of this whole new solution. And we are part of these, so they are relying on us.* (R06)

> *[47] There's a palette of different types of fibre types, that really goes into which type of market it's suitable for. For outgoing customers, we're speaking with around 40 to 50 different types of partners, who are representing different types of industries [...].* (R12)

Planning investments

It is not easy to plan investments to overcome scalability challenges as there is no clear answer whether to first invest in the ATS facilities or in chemical recycling to scale up the textile waste industry (R03). R04 recommends investing in strategic partners to find a solution together by stating the following: " *[48] I think investing resources in regenerating those relationships is a good way to start addressing these challenges or start finding ways of addressing these challenges"* (R04).

Capital budgeting

Some of the data discussed capital budgeting. For instance, the allocation of financial resources of the ATS pilot is described and visualised (D13; D15). R02 describes that they prioritised investments in technological developments: *"[49] the colours recognition is a few months away, because we have chosen to optimise material sorting first"*.

Collaboratively seeking funding and grants

Organisations participate in the ATS pilots to seek funding and grants collaboratively as stated by R01 and R07.1. R01 highlights that together with their partners they were "*[50] successful in getting government funding"*, which is essential because "*[51] to build such a concept in the real-world, it costs a lot of money"* (R01). Organisations have it easier to seek funding based on their group participation in the ATS pilot (D12).

Evaluating own resources, strengths, weaknesses, and opportunities

R03 explains that they must assess their options for further research in this area due to limited resources. Similarly, R07.1 states that as a small private company they must evaluate the availability of their resources as blindly working on ideas is not feasible. According to R05, regular self-assessment is natural for an organisation with a long-term perspective.

> *[52] [W]hen you are a company who has a vision or a long-term perspective, then you will normally easily see the need to start those activities. Also, on the other side, normally when you take care of your people and also how you want to do the business, it's normal that you regularly check yourself and see what is the direction in the future.* (R05)

Influence and propose new standards, guidelines, laws, and/or policies

Influencing and proposing new standards, guidelines, and policies might have long-term effects; hence, it influences the ATS pilots' strategic planning.

Reports, aiming to change the conditions in the industry and facilitate a shift towards CE, are created collaboratively (D02; D04; D15). For instance, recommendations for collectors, sorters, recyclers, policymakers, manufacturers, and brands to overcome socio-cultural barriers, physical barriers, and economic barriers are summarized (D04). Similarly, recommendations for the EU government to, for example, modify international waste shipment legislation to solve CE discrepancies are included in the reports (D02; D15)

Additionally, R02 mentions that actors in the ATS pilot project gave comments to ERP policy drafts. Similarly, R11 states that they support trade organisations and the government in taking decisions regarding upcoming ERP legislation by explaining their perspective as a brand and their business operations. Further, R09.1 states that they actively take part in public discussions with legislators and external partners.

> *[53] For example, regarding legal requirements, we need to explain and give clear examples of why it's a challenge but also provide guidance and possible solutions on how to move forward. Then, we can help authorities and companies with solutions that would better enable companies to go circular. Changing legislation is often a slow process, but often we can be proactive and go ahead and often also go beyond the legal requirements.* (R09.1)

5.2.2.2 Business model

ATS pilot organisations redesign or transform their BMs internally to tackle scalability challenges. However, it was not found that they were transforming or reconfiguring their governance structures. Instead, examples of emergent indicators were found, such as redesigning and transforming BMs together with partners.

Redesigning or transforming BMs internally

R01, R06, R12, and D15 confirm that organisations redesign and transform their BMs internally to tackle scalability challenges. For instance, R01 states that they redesigned and transformed their BM to create a business case for reusing materials. This process took several years. Also, R12 highlights that transforming internally is not an easy and quick process but can be described as a "journey" that requires long-term commitment.

> *[54] But we have been transforming internally now in the last couple of years. We are going for that journey, and we have a strategic goal set for 2030. That journey will take us from a waste collection or waste handling company to really a resource company. We can provide the market with the necessary feedstock, and we can build on that. It's a transformation that has been going on for the last couple of years or so. We're not really there yet, but we're getting there.* (R12)

Redesigning or transforming BMs with partners

Involved actors built a new kind of multi-stakeholder business ecosystem around textile recycling together (D15). Also, R02 elaborated on the need to identify the business case collaboratively as all partners cannot expect to do business with new partners in the same way as they have before on the global, mature virgin textile market.

> *[55] For instance, even if you are a large global player, you cannot take all the profit yourself. You have to allow the public waste management company running the plant to have some margins to operate the plant, and for the large global actors, you have to make them understand that they are working with a local public organisation. You have to explain to them that they cannot assume that they can do business with a local public organisation as they would do with one of their private suppliers based in Asia, for instance.* (R02)

The fact that there are no definitive terms of business for textile waste yet requires adapting case by case. R02 further explains that the aim is to find a solution together, so that everyone has a financial gain, whether by paying the inbound supplier or by charging less than the incineration fees.

5.2.2.3 Collaboration

Organisations within the ATS pilot collaborate to acquire both knowledge/skills and to acquire raw materials/resources. Therefore, these indicators are merged. Additionally, the indicator has been extended to highlight that the ATS pilots promote collaboration across the entire SC. Also, examples of interdepartmental cooperation are found. Moreover, the indicator of building trusted relationships in the local context has emerged from the data.

Collaboration across SC to acquire requisite knowledge, skills, raw materials and/or resources

Organisations within the ATS pilots mostly collaborate to acquire both requisite knowledge/skills and raw materials/resources. For instance, R09.2 explains that they joined the pilot "*[56] in order to go circular"* by gathering an understanding about the sorted fractions and to gain access to these fractions.

Moreover, organisations collaborate with partners across the entire SC. R12 describes that "*[57] within the pilot project, there are 19 partners, and those 19 partners come from every step in the value chain. [...] There needs to be a joint collaboration between serious actors that know what they're doing [...]".*

Furthermore, according to R03, R09.1, and R09.2, collaboration seems inevitable for the transition towards a CE within the textile industry, because "*[58] it's a complex matter, but luckily, there are a lot of different actors working together. Nobody can fix it alone, so a lot of collaboration is needed"* (R03).

Also, partners within the ATS pilots collaborate to use complementary technological expertise. The adaptation of a textile database to the customer's needs requires the partnership of the NIR equipment manufacturer who owns the algorithm (D16). Also, R01 discusses the cooperation with another company to build a digital highway by using a specialised management software package.

The common goal, to scale up to support the transition towards CE, facilitates an open dialogue and a sharing of costs. This allows all participants to gather new insights into the field of the textile waste industry as the aim of the project is to create a *"[59] national ecosystem of knowledge"* by *"[60] building a platform for the creation of a new and strong industry with multidisciplinary collaboration*" (D14). Accordingly, one participant describes that they benefitted by gathering a broad picture of present challenges and possibilities. They believe that challenges can be tackled by pooling the expertise of all partners (D15).

Additionally, openness is promoted to publicly raise awareness, for instance, through cooperation with universities for student projects, as well as through websites, social media, blogs, webinars, and other media outlets. Promoting textile recycling and raising awareness must be one of the main targets in the future. (D15)

Collaboration seems essential for overcoming scalability challenges, but different interests and power imbalances can hinder fruitful work. R02 describes that the variety of large global textile actors, smaller national and local actors, as well as public actors have to understand each other's perspectives and make realistic demands during negotiations, because the collaboration must be profitable for every partner. Therefore, collaborating with research organisations offers the possibility to involve a neutral mediator to find reasonable solutions for all. In this context, R02 describes the following:

> *[61] In that situation, in my role as a project manager or as facilitator of the collaboration, my role is to help them both gauge what is reasonable. That's where it's very helpful I would say for the project and for the collaboration and for the facility that we are there as a free-standing partner, who doesn't have any commercial interest in this. We don't have anything to gain either way. Whoever takes the big margin, it doesn't really matter for us.*

Nevertheless, although collaboration within each ATS pilot is high, international collaboration between the pilots is sparse. R11 talked to different ATS pilot partners and highlights that this collaboration can be beneficial:

> *[62] It's interesting to talk to people who are running different types of automated sorting technologies [...] and try to understand if really, they're all encountering the same challenges or because of their development following different paths, they're actually coming across different challenges and they could actually complement each other and help to find the solutions.*

Interdepartmental cooperation

R09.1 describes the cooperation with their public affairs department to better take part in legislative discussions. As a big partner organisation, they have many resources and many different departments where employees focus on different issues, so that they can cooperate internally and help address certain challenges together.

Building trusted relationships in the local context

The ATS pilots aim to solve the issue of increasing textile waste on a national level; hence, local relationships are essential, which is implied in the setup of each ATS pilot. A local production line including ATS, cleaning, and fiberising of textile waste set up via cooperation between various local partners (D04). Additionally, R04 explains that they invest financial and time resources for the purpose of "*[63] developing a community that understands your needs and understands your challenges and that can help you find the right partners to solve it*". Also, R08 explains that what they have done well is "*[64] building up relationships for the future*".

5.2.3 Reconfiguring capability

Guided by the DC framework and its underlying microfoundations in Chapter 3, the ATS pilots' approaches to the reconfiguring capability's microfoundations were identified in the primary and secondary data and are summarised in Table 10.

Table 10 Reconfiguring capability microfoundations and indicators

RECONFIGURING CAPABILITY	
Microfoundations	**Indicators**
Organisational Restructuring	• Changed organisational structure
Technological Upgradation	• Acquisition or construction of a new plant* • Introduced new technology • Made modifications in existing technology or machinery
Knowledge Integration	• Organised training to employees • Organised training for potential future workforce* • Acquisition of existing know-how
Best Practice Adaptation	• Adopted new methods of managing external relationships • Adopted new or significantly improved logistics • Adopted new internal business practices
The star asterisk "*" symbol indicates an emergent indicator that was not part of the initial code structure.	

5.2.3.1 Organisational restructuring

Organisational restructuring is approached via changing organisational structures, such as enhancing or adding roles or departments.

Changed organisational structure

A changed organisational structure is indicated by partners bolstering their existing departments by assigning new responsibilities to employees, such as a point of contact for textile associations and authoring position papers on textile CE law and policy (R05). There are investments in internal hires also; R04 explains:

> *[65] They're still looking into and hired someone internally to work on innovation projects, business developments in relation to this new fraction of textiles that before they did nothing with. Before this, they sold to downcyclers. Now they've invested in someone internally to really see how they can create more value out of that. That hopefully helps them to solve some of the financial challenges they have with using the [automated textile sorting] machine or the initial investment of it.*

In addition, external hires bring specialised CE development skills to partners' existing departments (R12). R12 shares, "*[66] Within my own department of business development, we've grown 100% in terms of staff in the last two to three years.*" New employees contribute to ATS pilot scaling by market planning, setting up SCs for outbound customers, structuring material flows, and setting up the business case (R12). Further, new departments and new branches accommodate the new commercial business of the ATS pilot (R12). R12 explains:

> *[67] We set up different departments […]. We are not only one company, but now we're also actually three. I only work with the commercial side of [the ATS pilot]. Another branch works with our mission statement related to our municipalities. So, we are working in different types of areas to be effective.*

5.2.3.2 Technological upgradation

Technological upgradation is approached in terms of acquiring or constructing a new plant, which is emergent; introducing new technologies; and modifying existing technologies.

Acquisition or construction of a new plant

Acquiring an ATS line in an existing plant (D11) or constructing a new plant or line emerged as crucial (D14; R02; R07). It is a milestone in scaling up (D06; D08; D11; D14; D15). The plant or line is used for commercial purposes and allows quick testing of improvements; R02 and R07.1 explain:

> *[68] We don't consider it a pilot anymore. We passed the pilot stage, so we are calling it a commercial facility now. We're getting up to scale, of course, but the plant is a commercial plant, and it's starting to be operated as a commercial plant now.* (R02)

> *[69] This year, we will start a new project related to the ATS machine. It's a government-funded project. […] The goal of the project is to build a [new] high-volume processing line. [...] The goal is to build a pilot plant in our own facility, so that the engineering team is closer to the [ATS] machine, and we can quickly make improvements.* (R07.1)

Introduced new technology

Introducing new technology that helps digitalise, integrate, and harness data from ATS processes is key and done collaboratively (R01). R01 discusses an ATS "digital highway":

> *[70] What we started to do in cooperation with another company is building a digital highway, we do this by using a specialised management software package. […] Now, we need to build on optimising--installing the whole chain, [...] It's very important to know what you're doing, and to analyse things in a good way, you need to have the data available. That's why we are putting so much effort in the digital highway and all the elements on top of that.*

Further, investments in new machinery and robotics optimise ATS processes and improve efficiency:

> *[71] One of our partners, together with the machine manufacturer, is developing a new cutting and cleaning machine, and then the materials are clean and are available as feedstock for the recycling industry.* (R01)

> *[72] Another recent implementation that we did there were the picking robots. There is a robot that picks the textiles one by one, because the ATS machine can process more or less one piece per second in theory. If you use manual labour in Europe to do that process, in most countries, it's too expensive.* (R07.1)

Pilot partners in one region are considering the potential of using government-funded electronic information platforms to facilitate commercial connections between textile waste producers, managers/sorters/processors, and recyclers. They consider information required to determine qualities and properties of used textiles in anticipation of using an electronic information platform for textile waste and side flows. (D15)

Made modifications in existing technology or machinery

Respondents indicated they are constantly modifying and improving their existing technology and machinery:

> *[73] The material identification is fully functioning already, the colours recognition is a few months away [...].* (R02)

> *[74] Our role is to overcome all technical issues and make the machine reliable, and also, make it fit to market needs. What we mean by that is, in the beginning, we started sorting with a machine of six fibre types. Then, we quickly learned the variation in textiles and fibre compositions is really large. So, we extended the line, for example, to 45 sorting categories, and now, we have a line running at 90 sorting categories. [...] Overall, it's to develop that process to install the machinery, to make the software, to make everything work. [...] It's a work in progress. Every machine we delivered has another scanner, has another software, because every time, it improves, and we improve the process. It's not that we make a fixed product for this application*. (R07.1)

The secondary data confirm the sorting technology continually undergoes several improvements over time to add features like colour sorting and detection of woven or knitted structures (D02).

5.2.3.3 Knowledge integration

Knowledge integration is approached in terms of organising training to employees and acquiring existing know-how. Further, it emerged that training is also organised for the potential future workforce.

Organised training to employees

Some pilot partners' employees participated in joint webinars and demonstrations intended to educate on sustainability communication and CE design (R02; D15). Joint workshop case discussions were crafted to inspire pilot partners' employees to consider how they could use sorted textile fractions creatively in products (R02).

Organised training for potential future workforce

There is now a change in the regional training and curriculum of textile and apparel design students, e.g., student textile samples will mainly consist of mono-materials and only a few carefully selected blended materials. This was influenced and supported by an ATS pilot to give a future workforce a better understanding of how to contribute to the efficiency of ATS and textile recycling by making it easier to achieve pure sorted fractions. (D15)

Acquisition of existing know-how

One respondent noted their experience in the plastics industry (R03) and another shared how know-how from the plastics industry aids solutions for ATS (R12). For example, ATS trials were completed using the existing know-how of an industrial demolition waste sorting line able to separate heterogeneous mixes of large pieces of wood, metal, stone, plastic, and cardboard (D15).

The purpose was to see if the existing industrial know-how could manage the more delicate work of identifying and separating different textile materials. An industrial robot accustomed to hefty, rough demolition waste was trained to recognise textile materials, and its accuracy was studied. Suggestions were made on how to reconfigure the industrial demolition line to work with light and supple textile materials, e.g., programming the robotic arms to lift and lower the textiles on the line rather than tossing or throwing them. (D15)

5.2.3.4 Best practice adaptation

Best practice adaptation is approached in terms of adopting new methods of managing external relationships, adopting new or significantly improved logistics, and adopting new internal business practices.

Adopted new methods of managing external relationships

In terms of managing external relationships, one respondent notes that it was essential to maintain good communications with textile associations to share industry views with policy makers and legislative bodies. R05 states:

[75] In the meantime, it's really a regular task within the group [to talk to textile associations about textile law and policy]. Of course, that is a cost, but we see it's really as an important thing we have to do and to have a voice over these associations.

Regarding management of external relationships, respondents indicated cooperation was required throughout the SC (R01; R02; R03; R04; R07; R09; R11; R12). The secondary data also reflect this, e.g., one of the partner brands expressed the hope that the whole SC would cooperate going forward (D15).

Adopted new or significantly improved logistics

The data reflect that the pilots are looking into adopting new or significantly improved logistics solutions. R09.1 shares:

[76] For example, to avoid long transport and stacking up supply chains, we need to figure out where on the market we will have ATS close to our suppliers, or if we can set up supply chains in terms of logistics.

The secondary data analyses centralised handling versus distributed, local handling of separately collected textile waste volumes. Local handling reduces the need for transport and increases the local availability of sorted textile fractions, yet smaller textile volumes locally must economically justify the investment. In contrast, centralised handling with economies of scale makes ATS investment economically feasible, yet has higher transport costs. (D15)

Adopted new internal business practices

Respondents discussed how their internal business practices changed to accommodate ATS pilot initiatives. "[A] new way of working", different management systems, and new mindset were expressed (R02; R12). R12 shared:

[77] We set up […] a new way of working, a different project management system. […] We have a different mindset now than what we had back in 2015. [...] when we are setting up new kinds of businesses, new business ventures, I would say, the ATS plant is one of the perfect examples that the commercial market development came in back in 2017, 2018. Then, we were looking for the business case and looking for scalability to understand how the business is going to work, and how do we use our resources as good as we can. [...] you cannot just build a new plant and say, "Now, we're open!" There's a lot of transformation that has been done and has to be done. I would say that there's a mindset here today that wasn't here when I started about four years ago.

Moreover, respondents shared a new way of working without a rigid structure. For instance, R07.1 and R07.2 support each other in the same organisation and had this exchange regarding their current internal business practices:

> *[78]*
>
> *R07.1: There is a basic structure, but to say …*
>
> *R.07.2: But is there? …*
>
> *R07.1: Okay, there is not really a process. […] It's not like, for example, in the car industry, one can imagine if there was an issue for a car, there is a written procedure for every possible issue you might encounter. We don't have that. Also, because it's new, it's not a repetitive thing. The things that might have worked in the past to solve some issues might not work in the future. There's not really a big script. There is some structure. There is a team. There are people working on it. It's doing the best we can for every customer. That's how we work. But it's not really a very structured procedure for every problem we encounter.*

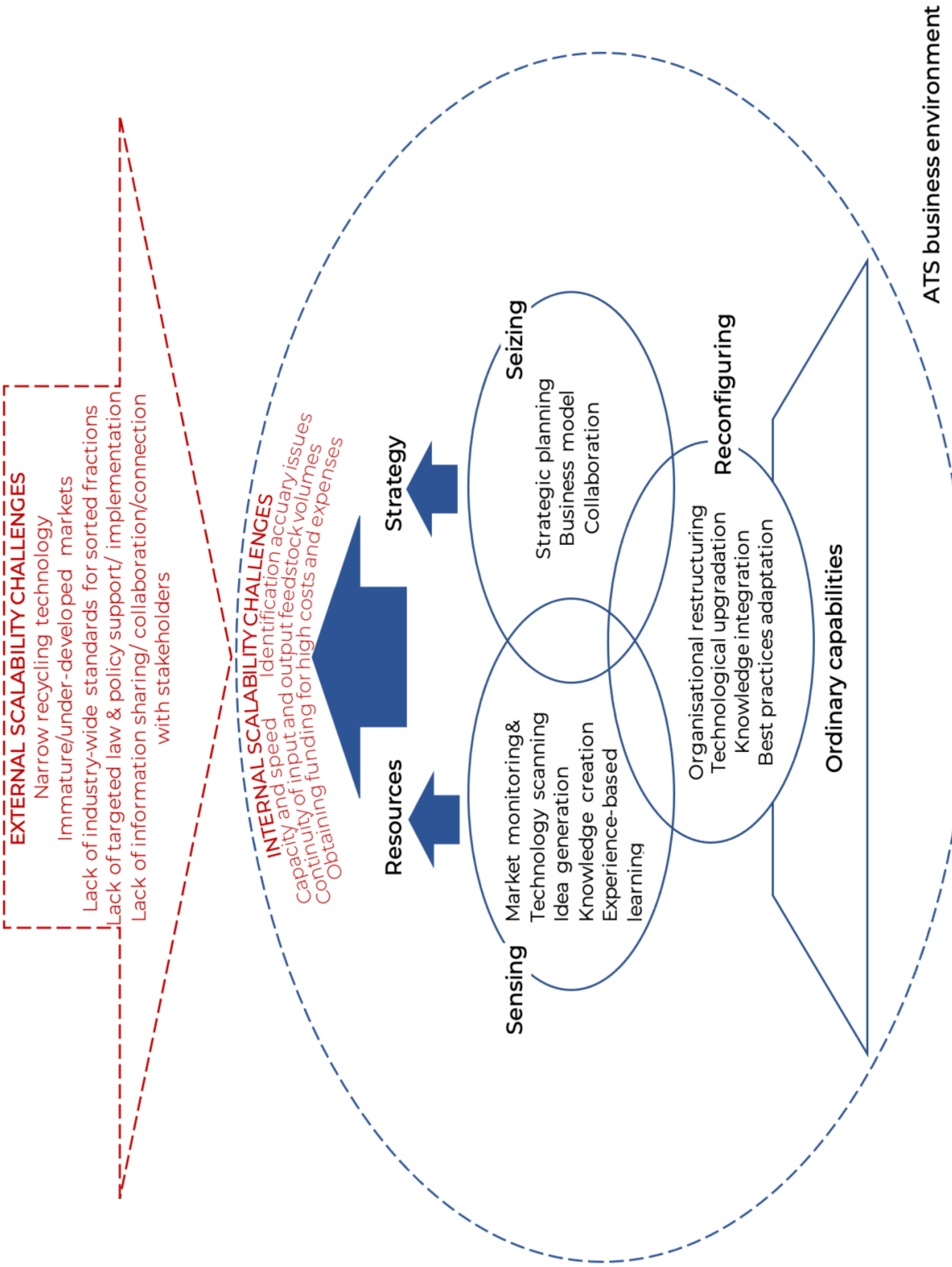
The flexibility offered by being “new” and letting go of severely structured internal business practices provides benefits and opportunities. R07.1 shares this upside:

> *[79] It makes us quicker. If you have a good idea, you can quickly implement it. If somebody in the organisation decides, "Okay, we're going to do that now," then it is set in motion, and it's started. It's not blocked because of procedures. That's also an advantage that we have.*

The conceptual DC framework specifically applied to the ATS environment

Figure 3 illustrates the key components of the emerged conceptual DC framework. The dashed border represents elements external to the organisation, and the blue arrows indicate a combined strong influence. The red text presents key scalability challenges, where the list within the red arrow are external challenges, and the list inside the circle are internal challenges. The overlapping sensing, seizing, and reconfiguring capabilities indicates that the underlying microfoundations are implemented continuously across capabilities and for several purposes. The nested hierarchy within the original DC framework by Teece (2007) is partly adopted as ordinary capabilities are part of the foundation of organisational practices.

Figure 3 Conceptual framework of ATS pilot scalability challenges and novel approach to DC



6 Discussion

This chapter discusses the key findings related to the scalability challenges faced by ATS and the approaches to sensing, seizing, and reconfiguring capabilities to overcome them.

This study aims to narrow the research gap regarding how ATS pilots approach DC to overcome key scalability challenges. Therefore, this study explored the ATS pilot approaches to the sensing, seizing, and reconfiguring capabilities, and how they facilitate the development of commercially viable solutions for ATS in a CE context. Chapter 5 presents multiple examples showing that ATS pilots employ novel approaches to the sensing, seizing, and reconfiguring capability microfoundations to overcome key scalability challenges. Guided by the DC framework, this study reveals an overlapping approach to DC as illustrated in Figure 3.

In contrast to Khan, Daddi and Iraldo (2021), who found that the reconfiguring capability is most important for CE implementation on the micro-level, no prominent role could be awarded to one of the three DC in the context of overcoming scalability challenges by ATS pilots in a CE context. Instead, a prominent role across all capabilities has been found for one of the underlying microfoundations: collaboration. Collaborative practices are employed for all three DC; hence, collaboration has a dominant role for ATS pilots, and, as a result, it can be concluded that collaboration is essential to overcome key scalability challenges. Furthermore, various researchers highlight the importance of collaboration for creating a CE (Palm et al. 2014; Antikainen et al. 2017; Karell and Niinimäki 2019; Sandvik and Stubbs 2019).

6.1 Key scalability challenges

In terms of the internal challenges faced by ATS pilots, the data confirm the literature's concern that capacity and speed remain problematic (Norris 2019). Currently, existing ATS pilots are not able to handle Europe's ATS needs, and more facilities are needed (R02). Mechanical improvement on the ATS line is one solution (R01, quote 1), but the continuity of supply of inbound and outbound feedstocks needs to stabilise, and feedstocks to recyclers must be built up so textile recycling and later production processes can rely on a continuous stream of sorted fractions (R01, quote 2). The data further confirm that today's heterogeneous, complex garments still challenge ATS technology's ability to accurately identify textile items and sort them into pure fractions (R01; R07.1; R10; D16), as stated in the literature (Palm et al. 2014; Antikainen et al. 2017; Watson et al. 2017; Ljungkvist, Watson and Elander 2018; Karell and Niinimäki 2019; Norris 2019; Ki, Chong and Ha-Brookshire 2020; Cura et al. 2021; Islam 2021). Also, identifying chemicals of concern remains an issue, and it is presently impossible to confirm their absence in sorted fractions, which necessarily leaves this challenge in the hands of statistics and probability studies, as well as future legal thresholds for what is accepted as safe (R02, quote 3).

The literature raises the currently high costs and expenses of ATS (Palm et al. 2014; Watson et al. 2017; Ljungkvist, Watson and Elander 2018; Norris 2019), and the data confirm this, often mentioning the chicken and egg strategy problem that exists for the two-sided marketplaces for inbound and outbound sorted fractions. Although CE policy results in some funding support for the initial pioneering efforts of ATS pilots (R01; R02; R07), funding alone does not lessen the challenge. Because the value proposition offered to ATS outbound customers cannot happen without the inbound customers and vice versa, everyone must join in, as R07.1 (quote 13) says. R08 (quote 4) points out there remains a significant opportunity to kick start a virtuous cycle that would provide mutual benefits to all stakeholders. So far, most actors are starting with very small chickens and very small eggs, which is likely to improve with future funding, and supportive tax and EPR policies (R08, quote 4).

ATS pilots' external challenges are often connected to their internal challenges. For example, the textile recycling's narrow specifications identified in the literature (Palm et al. 2014; Antikainen et al. 2017; Ljungkvist, Watson and Elander 2018; Hvass and Pedersen 2019; Karell and Niinimäki 2019; Norris 2019) are confirmed by the data (R01; R02, quote 5). Yet, if textile recycling could advance far enough to accept less strict specifications at scale, then larger, continuous feedstocks for textile recycling would be available and their price would be lower (R02, quote 5). This relates back to the chicken and egg problem, as well.

External challenges are often also connected to each other. For instance, because current CE policy has yet to fully reconcile itself with existing, outdated laws, like content labelling (R02, quote 10), it is difficult to develop standards that can be adopted across all actors in the SC and all markets (R12, quote 12). Further, as textile production is mainly in Asia, it is difficult to move textile waste as a raw material for production across borders and sell products made with recycled materials on diverse markets (R09.2, quote 11).

Moreover, challenges related to the price of outbound sorted fractions were discussed in terms of market disruptions, like the COVID-19 pandemic (R05, quote 17). The COVID-19 pandemic is a significant market disruption with a strong impact across the globe, and the textile industry is no exception (R12, quote 16). This challenge is not mentioned in the literature with respect to ATS yet, because it is too early at the time of this study for articles to have been peer-reviewed and published about the pandemic's effects on the ATS SC. Nevertheless, concerns about increased difficulties competing with virgin fibres in times of crises are apparent.

6.2 Sensing capability

The market monitoring and technology scanning microfoundation is carried out in terms of identifying customer needs, tracking new market trends, and observing technological developments, however, analysing competitors' actions is not observed in the empirical data. This is likely because the ATS pilots view virgin raw material SCs as the competitor and not each other. The secondary data support this and indicate information sharing and networking between ATS pilots (D06; D15).

Further, new indicators emerged, such as tracking new regulatory trends and identifying the needs of all stakeholders. As stated by Teece (2012), top management needs to be aware of market trends, technological developments, and upcoming laws and regulations to decide which technology and market to invest in. Limited financial resources hamper the development of commercially viable solutions; hence, anticipating profitable market opportunities is crucial.

The RSC for end-of-life textiles deals with a lot of different actors and stakeholders that make the process more complex, as stated by Palm et al. (2014); hence, identifying the needs of customers along with all stakeholders plays a crucial role in scaling up the ATS pilots. By identifying the needs of all customers, ATS pilots aim to create a market for the sorted fractions. Complying with the needs of diverse customers and stakeholders requires further adjustments to process and resources. This is supported by Teece (2012, p.1395), who states that "the firm's particular resources can be aligned and realigned to match the requirements and opportunities of the business environment […]". It is important to deal with the needs of all stakeholders to identify and solve the challenges collaboratively (R02; R04), hence overlap with the microfoundation of collaboration is noted.

New market trends around PCT waste have emerged over the years and support CE. Currently, textile recycling is at the forefront to become a core activity in the SC based on advanced technology developments (D15). Textile recycling offers many environmental benefits (Dahlbo et al. 2017). Ljungkvist, Watson, and Elander (2018) also emphasise the importance of textile recycling as it recreates value from used textiles as opposed to incineration or landfill. By using recycled materials in production processes, brands can meet consumers' demands for increased sustainability and transparency. Greenwashing practices are not accepted anymore by the consumers (R12, quote 24). Tracking these market trends supports identifying and addressing increased demand for outbound sorted fractions as input material for textile recycling. Integrating automation in the sorting process is essential to make textile recycling economically viable (R07.1, quote 25). The current non-reusable textile sorting process involves manual labour that is inefficient and time-consuming, while ATS improves operational efficiency and can increase textile recycling rates; thus, it can make textile recycling more profitable (Elander and Ljungkvist 2016).

Similar to tracking new market trends, observing technological developments further supports recognizing market opportunities to scale up. Currently, chemical textile recycling technologies are not fully developed (Palm et al. 2014; Antikainen et al. 2017; Ljungkvist, Watson and Elander 2018; Hvass and Pedersen 2019; Karell and Niinimäki 2019; Norris 2019). It will be a huge breakthrough for the PCT waste industry to chemically recycle poly-cotton (R03, quote 31).

Also, several respondents are certain that the technology for ATS is there to scale up the system (D09), but others mention that it is not quite there in terms of identifying complex garments that have several layers of multiple compositions (R10, quote 29). Technological limitations regarding identification accuracy is a key scalability challenge (Palm et al. 2014; Antikainen et al. 2017; Ljungkvist, Watson and Elander 2018; Karell and Niinimäki 2019; Norris 2019; Ki, Chong and Ha-Brookshire 2020; Cura et al. 2021; Islam 2021); hence, additional developments are needed, for example using hyperspectral cameras (R03, quote 30).

Although the literature (Antikainen et al. 2017; Ljungkvist, Watson and Elander 2018; Hemkhaus et al. 2019; Hole and Hole 2020; Ki, Chong and Ha-Brookshire 2020) and empirical data (R02; R07.1; R09.1; R09.2; D15) mention the lack of targeted law and policy support as a key scalability challenge, new regulatory trends will be more in line with CE principles. Tracking regulatory trends will help to overcome the scalability challenges by supporting the early assessment of the emerging requirements related to handling PCT waste, which benefits the ATS pilots. Tracking upcoming requirements for the separate collection of textile waste by 2025 and textile EPR will shape the handling process of PCT waste and offer a profitable opportunity for ATS and textile recycling (R8, quote 26).

Regarding the microfoundation, idea generation, it is approached in terms of organising brainstorming sessions, involving customers and suppliers in the product development process, and mapping and modelling aspects of the SC. These indicators reveal an active interaction with the market where stakeholders are encouraged to actively participate in idea generation. This is in line with the research by Ma, Zhou, and Fan (2015), who concluded that novel organisations have to learn from practice. Also, during brainstorming sessions, smaller businesses are encouraged to pave their own way by innovating new solutions as pioneers in the used textile SC in their own right (R02, quote 33). By doing this, they will not be solely relegated as followers of the bigger brand's solutions.

A smaller scale implementation before moving to a commercial scale helps to identify shortcomings and challenges to test new ideas and create new knowledge. This is in line with the DC framework, which recommends aligning resources based on the business environment's specific requirements (Teece 2012). Respondents emphasise the same by stating that before using PCT waste as inbound materials for sorting, several trials were executed to understand the scaling challenges (R10, D15). Zahra, Sapienza, and Davidsson (2006) also emphasise that DC are evolved by trial and error rather than planning, and thus supports young organisations to use existing resources in various new ways. Besides, R&D activities in the CE context cannot be carried out alone. Instead, a collaborative effort and engagement are highly beneficial. This overlaps with the seizing capability microfoundations where collaboration among different organisations and actors helps to acquire required knowledge, and it supports Teece (2018b), which finds that the three elements of DC are interconnected.

Lastly, the experience-based learning microfoundation is carried out in terms of assessing potential environmental and social impacts, as well as potential risks and networking with public organizations. Analysing risk scenarios provides insights on potential challenges, which can prevent scaling up the process and hinder the achievement of plan or investment objectives. Before scaling up the ATS pilots, associated risks need to be identified and addressed (D15). Carlsson et al. (2015) also recommend conducting a risk assessment at the early stage of the ATS pilots before going to a massive scale and defining efficient ways to respond to them.

6.3 Seizing capability

The microfoundation of strategic planning is carried out by the organisations involved in the ATS pilot in terms of formulating a strategy, finding strategic partners, planning investments, and capital budgeting. Additionally, the indicators collaboratively seeking funding and grants, evaluating own resources, strengths, weaknesses and opportunities, as well as influencing and proposing new standards, guidelines, laws and/or policies have emerged from the empirical data.

In terms of finding strategic partners, the importance of common values and mindsets runs like a common thread through the findings. According to D14, the ATS pilot is a group of strategic partner pioneers engaged in CE. By viewing themselves as a pioneering, exploring, and experimenting group, they indicate a proactive approach towards strategic management, and DC promote proactivity by constantly anticipating opportunities and threats (Teece 2012; Scarpellini et al. 2020). Teece (2012, p.1396) highlights that "strong dynamic capabilities are critical to success, especially when an innovating firm needs to pioneer a market […]".

Various respondents described the necessity to find strategic partners to tackle the key scalability challenges (R06, quote 46; R09.1; R09.2; R12, quote 47). Strategic partners share common values and a similar mindset, aiming to facilitate CE in the textile industry to reduce the environmental impact. According to Palm et al. (2015), a successful textile waste management strategy needs to be based on common goals, so that commitment and cooperation are high, facilitating open communication, for example, by creating a knowledge-sharing platform for the used textile industry (D14).

The importance of common values is also recognised in the DC of reconfiguring. R12 described that they hire additional employees with expertise in CE development; as a result, a mindset for CE is further introduced within the organisation. Also, a sustainable mindset is promoted within the ATS pilot by organising training to partners via webinars, demonstrations, and workshops (R02; D15). This is in line with Teece's systems approach of DC. The ATS pilots implement an integrated approach by promoting a "unifying strategic vision" towards CE, and, according to Teece (2018b), ultimately encouraging collaboration across all internal partners.

Furthermore, the systems approach of DC encourages to shape the external environment, for instance, by influencing the industry (Teece 2018b). In line with this, the ATS pilots promote CE thinking by investing in the education of a future workforce in the textile industry (D15). The phenomenon of designing garments to be thrown away only after a few wears drastically increases the amount of textile waste, while quality continuously decreases (Birtwistle and Moore 2007), which ultimately diminishes the potential of reuse and recycling of used textiles (Karell and Niinimäki 2019). Creating a CE requires an alignment and synergy of the forward and RSC, which means that reuse and recycling have to be considered already at the design stage (Elander and Ljungkvist 2016); therefore, promoting and supporting CE thinking internally and externally is important to stimulate change within the business environment.

The ATS pilots further initiate change in the industry by proposing new standards, guidelines, and modifications towards laws and policies (R02; R09.1, quote 53; R11; D02; D04; D15). The current business environment is not in favour of CE as many regulations put barriers towards recycled products and sorted textile waste fractions (Antikainen et al. 2017; Ljungkvist, Watson and Elander 2018; Hemkhaus et al. 2019; Hole and Hole 2020; Ki, Chong and Ha-Brookshire 2020), but the identified seizing activities in terms of influencing and proposing new standards, guidelines, laws and/or policies may promote a change in the business environment and help to overcome this scalability challenge.

The indicator for strategic planning in terms of finding strategic partners is directly connected to collaboration, another microfoundation of the seizing DC. Especially smaller brands seek to engage in CE but require strategic partners they can collaborate with to provide them with a "turn-key" solution for recycled textiles in their products. For instance, R09.2 (quote 56) clearly states that they engage in the ATS pilot to gather an understanding of how they can use the sorted fractions. Additionally, R06 (quote 46) collaborates with strategic partners who can provide the necessary infrastructure, while R12 (quote 47) collaborates with strategic partners to gain access to different markets. The focus on collaboration with strategic partners emphasises that the industry and many actors for textile waste are in an early stage. Their resource base and access to resources are limited; hence, they rely on external, complementary resources (Ma, Zhou, and Fan 2015).

The findings showed an immense focus on collaboration within the ATS pilots across the entire SC. Although the literature states that the dialogue between stakeholders is at an early stage and leads to a lack of communication, transparency, and connection (Palm et al. 2014, 2015; Antikainen et al. 2017; Hvass and Pedersen 2019; Karell and Niinimäki 2019; Norris 2019; Sandvik and Stubbs 2019), various respondents describe that they are working with various actors from every step in the SC (R02; R03, quote 58; R09.1, R09.2; R12, quote 57). Teece (2007) highlights that organisations need to embrace the ability to shape the business environment through innovation and collaboration within the industry.

The variety of partners within the ATS pilots, ranging from brands, charities, or waste management organisations, shows that there is a dialogue between actors from the forward and RSC (D04; D06; D07; D08; D09; D12; D14; D15) ultimately facilitating transparency within the used textile industry. According to Palm et al. (2014, 2015), transparency is crucial for circularity, efficiency, and scalability, because it facilitates the potential to increase volumes and profitability. Transparency means to share data, for instance through a digital highway (R01). Especially data regarding the volumes of used textiles are needed to properly plan processes and set quantitative goals, which in turn may attract private investors (Palm et al. 2014, 2015) and support to overcome financial challenges.

Moreover, the participation of charities and other manual textile sorting organisations (D04; D07; D12) confirms that there is no indication of competition within the ATS pilots. Once again, the common goal to support the shift towards CE results in even manual sorters recognising the ATS pilots as a fundamental link in the RSC, because the development of advances in fibre-to-fibre recycling will ultimately create new recycling markets and also benefit manual sorters (Norris 2019; Pal, Sandberg and Paras 2019). It is more of an effort to compete as one collaborative, circular, secondary raw material SC against the well-established, virgin raw material SCs.

Nevertheless, although collaboration is happening, strong negotiation is important, because the efficiency of a textile waste management system highly depends on the creation of a profitable market for textile waste (Palm et al. 2014). The shift of ATS pilots going from waste management to material brokers requires a significant transformation in how the individual actors do business. Especially the power dynamics of western brands as buyers are adjusted for this specific purpose of collaboration with local, textile secondary raw material brokers, like the ATS pilots. During these negotiations, the collaboration with research organisations as project managers and neutral mediators is extremely beneficial (R02, quote 61).

In summary, collaboration within the ATS pilots is strong. They discuss their BMs, margins, and pricing together in a fair and reasonable manner (R02, quote 55; D15), they propose and influence laws and policies collaboratively, and they develop standards together (R02; R09.1, quote 53; R11); yet there are few cross-pilot summits and little opportunity for deep information sharing between the ATS pilots, which remains a drawback (R02, D15). Therefore, cross-pilot collaboration may help to overcome scalability challenges, as well, by creating an understanding of the different paths of the pilots, if they encounter the same or different challenges, and, therefore, they could complement each other and find solutions together (R11, quote 62).

6.4 Reconfiguring capability

Reconfiguration is a key capability for ATS pilots, and they have been transforming both in terms of internal business practices and mindset to overcome scalability challenges (R12, quote 77). Moreover, the data on the ATS pilot approach to reconfiguration have an aspect of flexibility. This is often seen in the way the ATS pilots are constantly quickly improving and learning as one approach to overcoming scalability challenges (R01, quotes 70-71; R02, quote 73; R07.1, quotes 69, 74).

In terms of ATS pilots changing how they are organised to overcome scalability challenges, in contrast to the findings of Khan, Daddi, and Iraldo (2020a, 2020b, 2021), mergers or firm acquisitions are not occurring, at least not yet. Nevertheless, ATS pilots act as if they have gone through a restructuring as new responsibilities and objectives are assigned to existing employees and departments (R05); both internal and external hires are taking place to support CE business development (R04, quote 65; R12, quote 66); and new departments and branches are coming into existence (R12; quote 67). This is required as ATS pilots are taking part in the development of completely new products and services for a previously non-existent, two-sided marketplace for inbound textile waste and outbound sorted textile fractions as feedstocks for textile recycling. Essentially, they are acting as the new raw material brokers. Therefore, it requires significant changes in organisational structure to ensure value capture on both sides and to overcome scalability challenges.

Regarding technological upgradation, the launch of a new plant or line emerged as a major achievement for the ATS pilots (R02, quote 68; R07.1, quote 69). Simultaneously with the new construction, ATS pilots are introducing new technologies (R01, quote 70, 71; R07.1, quote 72) and upgrading and improving their existing technology (R07.1, quote 74). This is a continuous improvement and learning process to overcome scalability challenges. Teece (2007, p.1339) states that learning is critical to success and that organisations should be "designed to enable learning". The data shows that ATS pilots do not find they are offering a fixed product or service, but one that is continually progressing as they learn how to meet the needs of the customer and the SC as a whole. Teece (2018a, p.42) recognises that business "pioneers" need to be "fast learners", and that is precisely the ATS pilots' approach.

Teece (1997, p.515) maintains there are advantages for those who "can demonstrate timely responsiveness and rapid and flexible product innovation". In addition, Teece (2007) notes that organisations cannot be continuously responsive without the flexibility of decentralised decision making, and he encourages the pursuit of that. Later, in *Dynamic Capabilities: Routines versus Entrepreneurial Action*, Teece (2012, p.1399) quotes a Steve Jobs interview excerpt discussing Apple's product development, which Jobs describes "as a mixture of creativity and routines … 'there is no system. That doesn't mean we don't have a process. .... we have great processes. But that's not what it's about.'" Teece (2012) explains that Apple's product development is part routine and part "non-routine strategising". Regarding approaches to DC, Teece (2012) finds that non-routine action by management is an important area of focus. Here, in this study's data, there is a striking parallelism between Teece's and Jobs' perspective and the perspectives given by ATS pilots on how they reconfigure their resources to overcome scalability challenges. The parallel is clear when R07.1 and R07.2 (quote 78) express incredibly similar sentiments regarding how they approach their internal business practices. They say there is a bit of structure, but they are mainly flexible in how they work to quickly create new knowledge and solutions to overcome scalability challenges.

Naturally, without a rigid procedure or structure, there is more flexibility, and adopting less structured internal business practices provides an advantage for the ATS pilots. Teece (2018b) finds flexibility is in line with the DC view and states, "Fostering an organisational culture that favours flexibility and experimentation, while challenging to bring about, can provide a firm foundation for quicker and easier transformations and, therefore, for future advantage". R07.1 (quote 79) shares specifics on why it is advantageous for ATS pilot processes to be flexible, such as it enables a fast-learning response to quickly solve scalability challenges and implementing solutions. In this way, cumbersome or rigid procedures do not bog them down.

Teece (2018a, p.46) explains strong DC include organisations "designed and primed to be innovative and flexible" and that reconfiguration/transformation must be a "semi-continuous activity". Teece (2018a) further notes that future studies on aspects of DC, like flexibility, will illuminate innovation, which can be applied in the ATS and CE context. Flexibility as an aspect of DC supports the ATS pilots' approach to reconfiguration to overcome scalability challenges. In terms of competition, flexibility offers ATS pilots an edge, where it is not a contest of pilot against pilot, but the ATS pilots' circular SC competing against the historically embedded systems of virgin raw material SCs. If this were a David and Goliath narrative, flexibility could be one stone in the sling to combat linear textile SCs.

7 Conclusion

In light of the negative social and environmental impacts of the textile industry, a paradigm shift towards a more CE is inevitable. ATS embodies a crucial but missing link to connect forward and RSCs, however, key scalability challenges hinder the ATS actors in their creation of commercially viable solutions at an industrial scale. Therefore, it is essential to understand how solutions to these challenges are approached. To that end, it is of great interest to explore how current ATS pilots approach the sensing, seizing, and reconfiguring capabilities to overcome their key scalability challenges, and ultimately, support the shift from linear to CE. Because there is little known about how DC can bolster efforts to overcome challenges and attain CE implementation (Kabongo and Boiral 2017; Khan, Daddi and Iraldo 2020a, 2020b, 2021), especially in terms of small organisations and new ventures (Adam, Strähle and Freise 2018), exploring this question contributed to narrowing this research gap.

The findings of this study answered the research question and contributed to the narrowing of the research gap as follows. The data reveal that ATS pilots are still facing the well-known scalability challenges previously identified in the literature, and they are also facing new challenges related to market disruptions, such as the COVID-19 pandemic. Undeterred, the ATS pilots are overcoming scalability challenges through the use of several novel approaches to the microfoundations undergirding the sensing, seizing, and reconfiguring capabilities. Undergirding the sensing capability are novel approaches to market monitoring and technology scanning, idea generation, knowledge creation, and experience-based learning; undergirding the seizing capability are novel approaches to strategic planning, BM, and collaboration; and undergirding the reconfiguring capability are novel approaches to technological upgradation and knowledge integration. The sensing, seizing, and reconfiguring capabilities were found to overlap, and collaboration was found across all DC.

7.1 Theoretical implications

This study provides new insights into the application of the DC framework in a novel context, namely, ATS pilots in Northwestern Europe under the EU's new CE initiatives, and how these pilots overcome key scalability challenges to scale up and support the implementation of CE in the textile industry. In this context, the most relevant findings are that collaboration plays a prominent role and should be integrated into approaches to the sensing, seizing, and reconfiguring capabilities; hence, the ATS pilot approach to DC may be described as a continuous, overlapping process. Furthermore, this study adds to the literature on CE in the textile industry by confirming that known key scalability challenges for ATS actors remain, and new scalability challenges are developing in terms of market disruptions, like the COVID-19 pandemic.

7.2 Practical implications

Based on the novelty and complexity of the used textile industry, actors in the ATS SC can utilise the findings, for example, on the necessity of collaboration across the entire SC. These findings can support efforts to scale up ATS pilots in the EU in anticipation of the separate collection of textile waste by 2025 and EPR for textiles. The findings here can further support the reconfiguration and transformation that will need to take place in the private and public sectors in this regard. For instance, these findings can be used to assess the readiness of organisations and brands to participate in the automated textile sorting supply chains as a collaborative and productive member. For textile industry brands and recyclers, these findings may support their 2030 goals to increase the volumes of sorted textile fractions used as the raw materials for their production processes, and how to be a collaborative member in the ATS SC.

7.3 Research limitations and scope for future research

There are several limitations of this study. In terms of the case study design, even though this research is not testing a general theory, if time would have allowed, the study could have benefitted from additional research in the form of multiple longitudinal case studies, focus groups, and potentially quantitative questionnaires. Including additional methods of data collection and quantitative methods to complement the qualitative data collection and analysis performed here is desirable. In addition, if time allowed, it would have been beneficial to obtain the respondents' review, comments, and perspectives on the final case report as recommended by Yin (2018, p.240) as a "validating procedure" to "boost the overall quality of the study". Doing so would have potentially produced additional data or evidence and could corroborate findings or identify disagreements with findings and conclusions, which would have been valuable to the study.

As to further limitations, a market disruption resulting from the COVID-19 pandemic prevented on-site visits and physical in-person interviews, which otherwise might have provided additional rich data. Also, the research was conducted in English as that was the only language common to all researchers, yet much of the data on ATS pilots in the EU are often published in another language. Although free, basic translation services offered a limited solution to this problem (and 240 pages of secondary data were reviewed), if the authors had the choice, they would have welcomed the ability to access the additional information in documents in another language, which could have provided further insights. Moreover, confidentiality concerns and non-disclosure agreements prevented the analysis and discussion of certain information. Similarly, there is likely a fair amount of non-public information on ATS that the authors are unaware of and that cannot be publicly disclosed at this time due to intellectual property concerns.

Among the other limitations described above, the authors also acknowledge that the CE approach is not without critics or limitations. Researchers note the lack of focus on the social aspects of the CE (Walker et al. 2021) and the lack of focus on other theories related to alternatives to growth (Norris 2019). Moreover, Brydges (2021) finds that the effectiveness of the fashion industry's current CE initiatives are highly contested and warns that circularity in the fashion industry does not seem attainable as it is currently conceptualised and carried out in a compartmentalised manner instead of across the entire SC. Although political agendas and business organisations around the world have included broad CE principles in their initiatives, the academic community has called for more critical analysis and debate on the

CE's effectiveness, its social sustainability potential, and its strong ties to growth (Korhonen, Honkasalo and Seppälä 2018). Unfortunately, a deep and comprehensive critique of the CE approach is outside the scope of this study. Nevertheless, the authors recognise the extreme importance of further critique on how CE is implemented in the textile, apparel, and fashion industry.

The scope for future research is great in terms of how ATS pilots develop DC in the CE context as new ventures (Zahra, Sapienza and Davidsson 2006; Ma, Zhou, and Fan 2015). Multiple case studies could compare aspects of the ATS key scalability challenges and their approaches to solutions throughout Europe. Longitudinal case studies of ATS pilots' approaches to DC over time leading up to and after the implementation of the separate collection of textile waste and textile EPR in the EU would be of interest. Also, an updated mapping of all ATS SCs, both domestic and international, including all production countries, would be valuable, should reliable information be made public in the coming years. Further, exploring solutions to overcome the two-sided marketplace's chicken and egg strategic problem in the context of ATS against the backdrop of EPR and separate collection of textile waste would be worthwhile. A comparison could be potentially made with successful digital two-sided marketplace platforms. The plastic recycling SC could also be inspirational. Additionally, further studies could focus on collaboration, and how to facilitate international trade of sorted textile fractions as secondary raw materials for production. Finally, investigating power dynamics and their impact on negotiating collaborative ATS SCs could be fruitful.

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Appendix 1

RESEARCH/CASE PROTOCOL, INTERVIEW GUIDE, and CODING PROTOCOL

Purpose: *To explore how dynamic capabilities can overcome scalability challenges specific to ATS pilots in Northwestern Europe to create commercially viable solutions.*

Research question: *How can dynamic capabilities overcome scalability challenges faced by ATS pilots in Northwestern Europe to create commercially viable solutions?*

I. RESEARCH/CASE PROTOCOL

1. Identify and confirm the ATS pilots in Northwestern Europe that are active, serving customers, and in the process of scaling up commercially, and identify all their consortia partners via the public information available. Collect secondary data regarding those ATS pilots business activities from reports, news, and their websites and upload to case study database in CAQDAS, Dedoose.

2. Complete purposive sampling from the list of partners of each ATS pilot's consortium to have a good representation of the stakeholders at different roles in the SC. Find persons most knowledgeable at the partner organisations, who are in management/upper management, knowledgeable, have expertise and experience in working with the ATS pilot and that worked recently or currently with the ATS pilot to scale up.

3. Contact the sampled pilot partners to book interviews with those persons most knowledgeable. To meet ethical requirements, attach the one-page summary of the student thesis research work to the initial contact email, so the research purpose and who is completing the research is clear to the potential respondent.

4. Address further ethical issues: although there is no intent to collect or process personal information, out of an abundance of caution, ensure the university GDPR regulations are complied with by providing a notice and consent to the respondent in advance of the interview. Provide this notice and consent, despite not intending to collect personal information, in order to address potential ethical concerns and out of abundance of caution should any personal information be inadvertently collected. Therefore, prepare a notice and consent form and provide it to each respondent.

5. Before the interview, upon confirmation of booking, provide the respondent with a copy of the notice and consent, along with the list of interview questions. In addition, the day before or a few days before the interview, remind the respondent by email of the interview date, time, and meeting link (check the time zone to ensure accuracy), and as a courtesy, re-attach the research summary, and notice and consent, which includes the list of interview questions.

6. At the interview, prior to the interview's start (see orientation phase below), obtain the respondent's consent to record, confirm confidentiality of any personal information/identifiable information, and confirm that proper nouns, such as the names of the pilots, will appear in a generic noun form, which they will approve. Confirm that the respondent, their role, and the ATS pilot will be referred to in the general sense at all times in the paper and any quotes. Confirm the recording will be deleted after transcription approval.

7. Book a test/trial interview with one to two respondents to test the interview questions for clarity and to get any critique on the questions. Revise the interview questions, if necessary, based on the test/trial interview(s).

8. Interview each respondent for approx. 30-45 minutes via Zoom or a similar digital platform with real time audio and video using the interview protocol and interview guide. Be sure to only record the interview with the respondent's consent (see item 6 above).

9. Immediately or as soon as reasonably possible, transcribe the recording via GoTranscript, proofread it, listen to the recording a number of times while reading the transcription to ensure accuracy. Then ensure confidential, personally identifiable information is removed and proper nouns are made generic nouns. As soon as reasonably possible, provide the transcript to the respondent for review, edit, and approval.

10. Once the transcript is approved by the respondent, upload the approved transcript to the case study database in CAQDAS, Dedoose. Then, start reading through an assigned data set of transcripts and secondary data, and begin coding the data with the assistance of the Dedoose software and the thematic analysis procedure identified in the method literature and the coding protocol below. A researcher interview guide, coding protocol, and initial codes/theory framework summary follows. Make analytic memos while you code as instructed by the literature on thematic analysis and coding. Discuss questions with the group.

II. RESEARCHER INTERVIEW GUIDE

A. **Preparation phase** - Ready your room/background, yourself, and check equipment.

B. **Initial phase -** Introduce yourself, your student status, and purpose of the research. Reference the research summary and the interview guide, notice and consent form.

C. **Orientation phase**

- Confirm consent to record the interview
- Confirm confidentiality
- Start the recording (test beforehand to confirm it works)

D. **Substantive/empirical phase**

Private Notes for Interviewer's Guidance (in italics):

- ***Purpose:*** *To explore how dynamic capabilities can overcome scalability challenges specific to ATS pilots in Northwestern Europe to create commercially viable solutions.*
- ***Research question:*** *How can dynamic capabilities overcome scalability challenges faced by ATS pilots in Northwestern Europe to create commercially viable solutions?*
- ***Scalability challenges and Dynamic Capability Microfoundation Indicators*** *applicable to questions below are clustered into key areas for reference of researchers in the last section of the protocol;* **do not disclose these**. *The respondent should come up with their own ideas and not be influenced*
- *Keep in mind that these are scalability challenges that if solved would help to scale up.*

Interview Questions

1. What is your role and what are your activities as an actor in the automated textile sorting (ATS) pilot?
2. From your perspective, what are the key scalability challenges specific to the ATS pilot that are holding the pilot back from scaling up right now and in the near future?
3. Would you explain how you identify and assess these scalability challenges?
4. Would you explain how you plan to address or respond to these scalability challenges?
5. Would you explain how you transform or reconfigure your resources in order to respond to these scalability challenges?
6. Is there anything else that you would like to add or that you believe is important for us to know about this topic, or anything else that we discussed today?

Interviewer Prompts (if needed)

- *Would you tell me more about that?*
- *Would you explain that further?*
- *Would you elaborate on that?*
- *Would you provide an example or examples of that?*

E. Closure Phase

- Thank you for your time today.
- Explain that we are grateful for the respondent’s time in providing knowledge, insight, and contribution to our learning and research.
- May we send you a transcript to review to ensure that we’ve got it right? *Confirm that you will do this.*
- Confirm again that confidential and personally identifiable information will remain confidential.
- Would they like to receive an abstract or copy of the full thesis when it is completed? *If so, make a note of that.*
- Ensure they have our contact information if there are any questions and requests, and we have theirs.

III. RESEARCHER CODING PROTOCOL

1. Familiarizing yourself with your data

- Primary interview data: transcribe data immediately; listen to audio recording to ensure accuracy of transcription; convert proper nouns to common/generic nouns per confidentiality agreement; provide to respondent for review, edit, approval as soon as reasonably possible, and upload respondent's approved transcript to Dedoose.
- Upload secondary documentary data to Dedoose.
- Read and re-read both primary and secondary data, noting down initial ideas in analytic memos.

2. Using initial codes and generating emergent codes

- Guided by existing knowledge and theoretical frameworks from the literature (see below), code the data set using Dedoose in a systematic fashion across the entire data set, collating data relevant to each code.
- When coding, follow the colour-coding scheme in Dedoose and ensure that you distinguish between use of initial code and any emergent codes.
- Discuss initial and emergent coding in analytic memos and with the research team and agree upon the codes.
- NB, each researcher should switch data sets and review the data and other researchers' codes, until all data sets are reviewed and coded.
- Choose best example excerpts/quotes and place them in the designated Excel file in anticipation of the report.

3. Searching for themes for the initial and emergent codes

- Guided by theoretical framework from the literature (see below), use Dedoose to collate codes into potential themes by gathering all data marked relevant to each potential theme.
- Themes are focused on the specific approaches/solutions (skills, processes, activities) underlying the microfoundations found in the theoretical literature.
- NB, each researcher should review themes, write analytic memos, and discuss them with other researchers before agreeing on the theme.

4. Reviewing themes

- Check if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2). Write analytic memos about thoughts on this.
- Discuss and then generate a thematic map (a chart/table/figure) of the analysis together with the other researchers.

5. Defining and naming themes

- Ongoing analysis to refine the specifics of each theme.
- Ongoing analysis to refine the overall picture the analysis shows.
- Generate clear names for each theme.
- Discuss the above with all researchers.

6. Producing the report

- The final opportunity for analysis will take place in the report.
- Select vivid, compelling excerpts makes as best example quotes in Dedoose, and keep track of them in the designated Excel files for the report.
- Choose and place best examples in the designated Excel files for report.
- Complete a final analysis of selected extracts, relating back to the analysis of the research question and literature.
- Producing a scholarly report of the analysis.

IV. EXISTING INITIAL CODES AND FRAMEWORKS FROM THE LITERATURE

Key Scalability Challenges from the reviewed literature

Key Internal Challenges

- Capacity and speed
- Continuity of input and output feedstock volumes
- Identification accuracy issues (e.g., due to complex garment construction; content/garment age or wear on fibres; or the presence of chemicals of concern)
- Obtaining funding for high costs/expenses

Key External Challenges

- Narrow recycling technology
- Immature/under-developed markets (e.g., lack of infrastructure, lack of demand)
- Lack of information sharing/collaboration/connection with stakeholders
- Lack of targeted law and policy support and/or implementation
- Lack of industry-wide standards for sorted fractions

Dynamic Capabilities, Microfoundations, Indicators from the reviewed literature

SENSING CAPABILITY

Market Monitoring and Technology Scanning Indicators

- Identification of customer needs
- Tracking new market trends
- Analysing competitors' actions
- Observing technological developments

Idea Generation Indicators

- Organizing brainstorming sessions
- Involving customers/suppliers in product development process

Knowledge Creation Indicators

- Undertaking R&D to test new ideas and create new knowledge

Experience-based Learning Indicator

- Assessing potential environmental impacts of products/processes/services
- Networking with public organizations/industrial associations/universities/others

SEIZING CAPABILITY

Strategic Planning Indicator

- Formulation of a strategy
- Finding strategic partners
- Planning investments
- Capital budgeting
- Planning requisite human resources

Business Model and Governance Indicator

- Redesigning/transforming business models
- Restructuring of governance structure

Collaboration Indicator

- Collaboration to acquire requisite knowledge/skills
- Collaboration to acquire requisite raw materials/resources
- Interdepartmental cooperation

RECONFIGURING CAPABILITY

Organizational Restructuring Indicator

- Merger with or acquisition of another organization
- Changed organizational structure

Technological Upgradation Indicator

- Made modifications in existing technology/machinery
- Introduced new technology
- Acquisition of a new manufacturing plant

Knowledge Integration Indicator

- Organized training to employees
- Acquisition of existing know-how

Best Practices Adaptation Indicator

- Adopted new internal business practices
- Adopted new methods of managing external relationships
- Adopted new or significantly improved logistics

V. PROTOCOL BIBLIOGRAPHY

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Template Email for Initial Contact with Potential Respondents

Dear [NAME],

We are master's students studying textile value chain management at the Swedish School of Textiles at the University of Borås in Sweden. [We were referred to you by X.]

Your work with the [NAME] automated textile sorting pilot is of interest to us. In light of the EU Waste Directive requiring the separate collection of textile waste by 2025, we are researching how the challenges specific to automated textile sorting pilots in western Europe can be overcome to create commercially viable solutions. Attached is a one-page summary regarding this topic that briefly describes our student research.

Would you be willing to talk with us via Zoom for approximately 30-45 minutes to share your perspectives on this topic? If so, we would be grateful to hear them. Would you be available for an interview during [X date and X time]? If another date and time would work better for your schedule, please let us know.

Thank you for your time, and we look forward to hearing from you.

Kind regards,

Cirrus Alpert
Michaela Turkowski
Tahiya Tasneem

M.Sc. Students
Textile Value Chain Management Programme
Swedish School of Textiles, University of Borås

THE SWEDISH SCHOOL OF TEXTILES
UNIVERSITY OF BORÅS

THE SWEDISH SCHOOL OF TEXTILES
UNIVERSITY OF BORÅS

MASTER'S DEGREE THESIS PROJECT SUMMARY

Research purpose and question: EU commercial-scale automated textile sorting processes can support efficient, circular textile flows for a currently resource-intensive textile industry. Automated textile sorting processes are capable of providing high-quality raw material inputs for recycling, which supports the sustainable management of large volumes of textile waste to be separately collected by 2025 per the EU Waste Directive. As students, we hope to broaden the existing research in this area by asking the following research question:

How can the challenges specific to automated textile sorting pilots in western Europe be overcome to create commercially viable solutions?

Primary data collection method: semi-structured interviews with questions to be provided for review in advance of the interview on the interviewee's perceptions on how the challenges specific to automated textile sorting pilots can be overcome to create commercially viable solutions.

Interview length, dates, and location: 30-45 minutes at a convenient time for the interviewee during weeks 11, 12, 13, or 14 via Zoom or a similar digital platform.

An exploratory research on how the challenges specific to automated textile sorting pilots in western Europe can be overcome to create commercially viable solutions.

STUDENT RESEARCHERS

TAHIYA TASNEEM

M.Sc. Student
Textile Value Chain Mgmt.
Swedish School of Textiles
University of Borås

Background
B.Sc. Textile Engineering
Experienced in sourcing, merchandising, and production

Contact
[redacted]

MICHAELA TURKOWSKI

M.Sc. Student
Textile Value Chain Mgmt.
Swedish School of Textiles
University of Borås

Background
B.A. Int'l. Business Admin.
Experienced in buying, planning, and design for private labels

Contact
[redacted]

CIRRUS ALPERT

M.Sc. Student
Textile Value Chain Mgmt.
Swedish School of Textiles
University of Borås

Background
J.D., US-licensed attorney
Experienced in legal, compliance, and due diligence work for int'l. textile firms

Contact
[redacted]

Required Notification/Consent for Collection/Use of Interview Data and University GDPR Privacy Notice

Regulatory and ethical procedures for academic research undertaken from the Swedish School of Textiles require that interview respondents agree to be interviewed and agree to how the information contained in their interview will be used. This is necessary to ensure that interview respondents understand the purpose of their involvement in the research and are informed about their participation. Therefore, please read the following paragraphs and sign, date, and return this form as indicated below to express your agreement to be interviewed and to how the information contained in the interview will be used.

1. As part of the thesis course within the Textile Value Chain Management Programme of the Swedish School of Textiles at the University of Borås ("University"), student researchers Cirrus Alpert, Michaela Turkowski, and Tahiya Tasneem are conducting a study with the purpose to explore how key capabilities can overcome the scalability challenges faced by automated textile sorting pilots in western Europe to create commercially viable solutions. To conduct this study, you are asked to provide your perspectives on this topic.

2. Personal information is not intended to be collected or processed in this study, and any personal information inadvertently collected during the interview will not be disclosed. Although no personal information is intended to be collected or processed, the University's privacy notice with respect to compliance with the General Data Protection Regulation (GDPR) requirements in the EU or EEA appears on the following page for your review and convenience.

3. You have the right to stop the interview and/or withdraw from this research at any time.

4. You are under no obligation to do so, but if you would be willing to give your permission for the interview to be recorded, this will assist the student researchers in making an accurate data collection. If you grant permission for the recording of the interview, the following shall apply:

> The interview will be recorded only with your permission, and a transcript of the recording will be sent to you for review as soon as reasonably possible. The recording will be deleted after transcription. You will be given the opportunity to correct any errors in the transcript. The transcript of the interview will be analyzed by Cirrus Alpert, Michaela Turkowski, and Tahiya Tasneem as student researchers. Access to the interview transcript will be limited to these student researchers and potentially their thesis supervisor and grader. Any interview summary, content, or direct quotations will not use your name, your title, your organisation's name, or the name of the automated textile sorting pilot. Care will be taken to ensure that information in the interview that could potentially identify you is not revealed.

5. The interview questions you may expect to be asked during the interview are as follows:

a. What is your role and what are your activities as an actor in the automated textile sorting (ATS) pilot?
b. From your perspective, what are the key scalability challenges specific to the ATS pilot that are holding the pilot back from scaling up right now and in the near future?
c. Would you explain how you identify and assess these scalability challenges?
d. Would you explain how you plan to address or respond to these scalability challenges?
e. Would you explain how you transform or reconfigure your resources to respond to these scalability challenges?
f. Is there anything else that you would like to add, or that you believe is important for us to know about this topic or anything else that we discussed today?

6. Please direct any questions on the above to Cirrus Alpert, mobile [redacted] or [redacted] and sign, date, and return this form to this email address.

Interview Respondent: ________________________________ [signature] ______________ [date]

________________________________ [printed name]

University of Borås GDPR Privacy Notice

The University of Borås is the controller of the university's processing of personal data, and the legal basis for the data processing is article 6.1 (a) in the General Data Protection Regulation (GDPR). The personal data will be stored in the EU/EEA, or countries outside the EU/EEA that the EU Commission has determined to have an adequate level of protection, i.e., sufficiently high according to the GDPR. The data will be erased when it is no longer necessary. If you have any questions about how we process your personal data, you are welcome to read more about this on our website, http://www hb.se/privacy, or contact the party responsible.

Your participation in this study is completely voluntary. If you consent to the processing of your personal data, you may withdraw your consent at any time, whereby we will stop using your personal data. Because of legal requirements, however, we may be prevented from immediately erasing your personal data.

Your privacy is important to us at the University of Borås. We are committed to protecting your personal data and only process it according to applicable laws and regulations, including the General Data Protection Regulation (GDPR).

Your Rights

The university is transparent with how we process your personal data. If you want to know what personal data we process about you, you can request a copy of the personal data and information about the processing free of charge once per year. To order a copy of your personal data and information about the processing, you can use the form for this that is available on our website, http://www.hb.se/dataskydd.

If you consent to processing of your personal data, you may withdraw the consent at any time. We will then not continue to process your personal data. Personal data that have been made public, e.g., published on social media, is usually not affected by a withdrawn consent, however. Because of legal provisions, we may also be prevented from immediately erasing your personal data.

- You have a right not to be subject to a decision based solely on automated processing, including profiling, which produces legal, or other significantly effects. The University of Borås does not make such decisions.
- You have a right to have the processing of your personal data restricted.
- You can request rectification or supplementation of personal data that is inaccurate or incomplete.
- You have a right, under certain circumstances, to have your personal data erased.
- You have a right to receive your personal data in a structured, commonly used, and machine-readable format to transmit those data to another controller.
- You have a right to lodge a complaint to the supervisory authority (Datainspektionen).

Contact us with your concerns and questions:

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THE SWEDISH SCHOOL
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