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Secondary Materials in Indian Manufacturing

Factors, barriers and the implications for secondary materials brokers

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Abstract

Consumer manufacturing brands are touting circular business models as the solution to current linear economy production systems that are overburdening the Earth's ecological carrying capacity. Using secondary materials in manufacturing can reduce the waste generation and embedded environmental impacts associated with consuming manufactured goods. Companies such as Karo Sambhav seek to connect manufacturers, who have set secondary materials content targets, with secondary materials suppliers to help attract circular economy minded global manufacturing brands to India. While Karo Sambhav seeks to identify the secondary material needs of manufacturers, the task remains of understanding why consumer goods brands have until now largely avoided producing with secondary materials. This knowledge gap in secondary materials use and procurement practices is the focus of this study. Research in circular economies, supply chain management, industrial ecology and institutional theory provide the theoretical basis for an exploratory multiple case study analysis of consumer goods brands manufacturing in India. Qualitative data collected through structured interviews assesses the factors and barriers associated with secondary materials use and procurement in consumer goods manufacturing. Identified factors and barriers are analysed for their implications on efforts by secondary materials brokers to develop supplies of secondary materials from India's informal waste management sector for global brand manufacturers. Findings from this research can be of value to stakeholder groups involved in promoting secondary materials systems including secondary materials brokers, materials and consumer goods manufacturers, and policy makers. Lastly, while these findings are presented with regards to the Indian manufacturing context, they can also be useful for practitioners and scholars in the field of circular production in other locations seeking to attract global manufacturers to regions where the informal sector plays a large role in regional waste management systems.

Keywords: Secondary materials, circular supply chain management, manufacturing, barriers, factors, India

Executive Summary

Problem Definition

In 2017, resource consumption from cradle to grave is estimated to have emitted 50.9 Gt greenhouse gas emissions (Circle Economy, 2019), or roughly 10.8% of the then remaining total budget of carbon emissions for achieving the Paris Agreement goal of limiting global warming to 1.5°C (MCC, 2019). Along with the range of other environmental impacts, linear take-make-use-dispose economic systems have pushed Earth's ecological and geological systems beyond their capacity to replenish natural resource stocks and absorb emitted substances. Departing from the linear economy practices, and working to unilaterally guide materials back into production after disposal, is therefore seen as an essential component for reversing the trend of rapid environmental degradation resulting from global economic activity. Global manufacturing brands have therefore set goals to only source renewable or recycled materials for their production by 2030.

India is on a trajectory of rapid economic development with an average growth rate of Gross Domestic Product of 6.7% per year between 2008 and 2017 (World Bank, 2019). As a result in India, conservative estimates put the country's generation of municipal solid waste at roughly 62Mt per year (PIB, 2016). India's economic strategy has included expanding the nation's manufacturing base and conducting pro-business reforms under the *Make in India* programme to transform the nation into a major global production hub (PWC, 2019). The fulfilment of these economic ambitions would mean an increased national demand for secondary material inputs to manufacturing given the increasing priority given to circular production by global manufacturers.

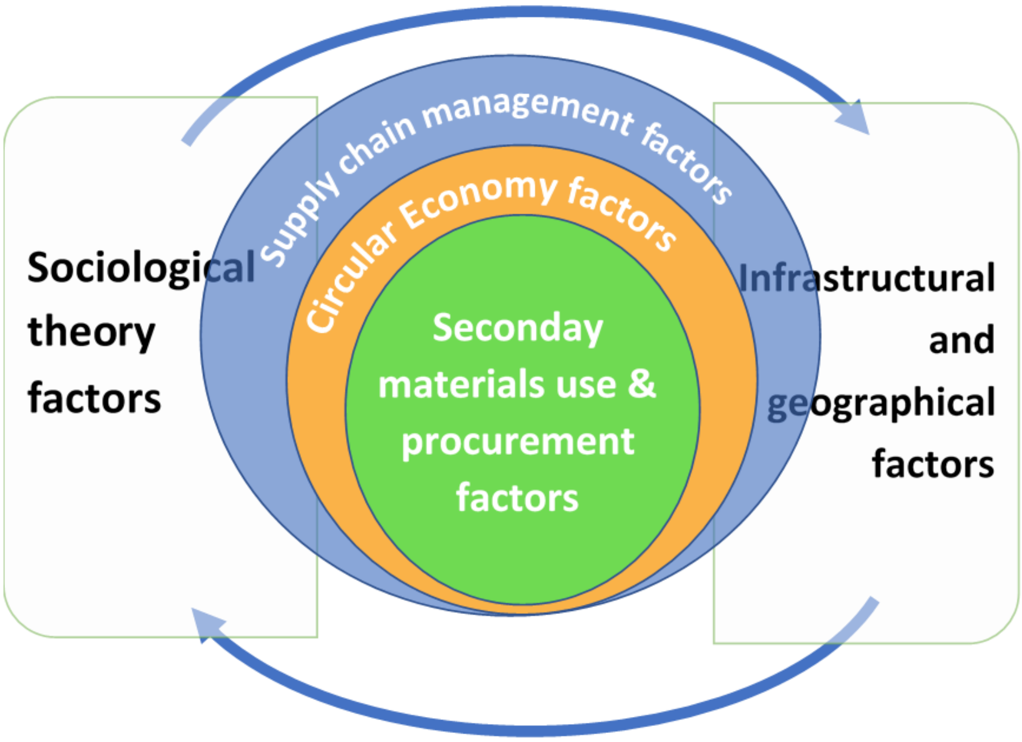
Research aim

There is little published research drawing on empirical data from actors involved with materials use and procurement which assesses, describes and problematises the nature of secondary materials procurement among manufacturer organisations. This research intends to contribute to goals for increasing use of secondary materials in production by improving understandings associated with problem of secondary materials adoption, supply and procurement in manufacturing. As such, this investigation aims to understand the organisational and contextual factors and barriers to manufacturing with secondary materials for production in India or similar contexts. This research is also concerned with the potential implications that these factors and barriers might have for the intermediary actors brokering secondary material supplies. The research questions guiding this enquiry include:

> **RQ 1: What are the key factors of virgin and secondary materials use and procurement for brands and manufactures with operations in India or similar contexts?**
>
> **RQ 2: What barriers can be identified regarding the use and procurement of secondary materials for brands and manufacturers with production operations in India or similar contexts?**
>
> **RQ 3: What are the implications of these barriers on efforts in India to broker and increase secondary materials flows from suppliers to brands and manufacturers?**

Data collection and analysis methodology

The investigation of these research questions was undertaken was through a qualitative exploratory study, based on unstructured interviews (n=11) with consumer brand and manufacturer representatives and Indian industry experts. Given the knowledge gap in research on secondary materials use and procurement, the theoretical underpinnings for this investigation needed to be created and synthesised from research in fields related to secondary materials use and procurement. Theoretical insights from a review of literature (n=38) in the disciplines of supply chain management, circular economies, industrial ecology and sociological theories therefore fed into guiding the data collection and analysis process. Construction of the theoretical framework constituted half the research project and therefore stands as a significant contribution of the investigation output. The overall composition of the theoretical framework is can be seen presented in the illustration below



The application of the theoretical framework through data collection and analysis constituted the second half of the research project. The framework first fed into the data collection process by informing the development of an interview guide. Collected interview data was recorded, reviewed and complied into notated summarises prior to being subject to a coding analysis which was also based on the constructed theoretical framework. The output of the coding analysis produced the identified factors and barriers to secondary materials use and procurement. These resulting barriers were then subject to an analysis for their implications in terms of requirements from and opportunities for secondary materials brokers in further the development of secondary materials systems.

Findings

RQ1: What are the key factors of virgin and secondary materials use and procurement for brands and manufactures with operations in India or similar contexts?

As mentioned at the beginning of the discussion section, technical factors of material properties, material quality and the reliability in consistency of these values all appear paramount for materials use and procurement. These factor holds even more significance for brands and manufacturers producing in India when considering local challenges with MSW collection systems on top of the already significant technical challenges of producing high-quality post-consumer secondary materials. Brand and manufacturer concerns for technical factors of material quality appear rooted primarily in concerns for product safety and legal compliance, product quality and compatibility with production process. Underlying each of these factors is the matter of cost and how much using secondary materials is going to impact a company's bottom line. How much will it cost to develop materials to the standards required by manufacturers? What are the potential costs from product safety related liability claims on companies in terms of legal fees, loss in revenue from drops in business turnover and subsequently in loss in shareholder value? What is the scale of further costs in forgone revenue, supply chain fines and repair costs if technically incompatible materials the damage production equipment? Managerial factors within and between the businesses of a supply chain, pertain the compatibility of the supply chain's structure, knowledge, strategy and culture is with secondary materials use and procurement. Factors of government, markets, society and infrastructure, in all being external to business and supply chains concerned with secondary materials, shape the options available to brands and manufacturers for using secondary materials. These external factors with will subsequently guide the priority placed by brands and manufacturers on secondary materials vs that placed on circularity or sustainability in general. In the Indian context, external factors relate to if the informal waste management infrastructure, evolving government policy and price sensitive market can be conducive for secondary materials use and procurement among brands and manufacturer.

RQ2: What barriers can be identified regarding the use and procurement of secondary materials for brands and manufacturers with production operations in India or similar contexts?

Eight categories of barriers to secondary materials use and procurement in manufacturing were identified based on the factors revealed to answer RQ1 and being invariably closely related to them. Deficiencies in materials technical capabilities, partly down to the lack of needed resources and business autonomy, restrict brands and manufacturers from adopting secondary materials practices. Likewise, the lack of information on the qualities and properties of materials presents sufficient risk to lead manufacturers toward preferences for cheaper and more technically reliable virgin material alternatives. This preference for the more reliable virgin materials alternatives greatly limits the applications for those secondary materials that are already available on the market. Brand and manufacturer decisions to opt for vague, or broad sustainability and circularity strategies limits the degree of support and resources available within organisations for the specific pursue of developing costly and risky secondary materials applications and supplies. When the barriers revealed in this investigation appear present across whole markets, the lack of leadership or even movement by businesses to develop secondary materials develops a herd mentality which in itself becomes a barrier to mangers within organisations. Nobody wants to make the first moves, take the risks and invest the sums needed in hedging their market position on the pursuit of using secondary materials. Government can serve a role in either helping to absorb the risk through financial support or regulation that legally requires all market players to act. Such government intervention would also help to distribute across markets the risks of developing secondary materials supplies and make it more feasible for individual business to engage in the pursuit of this task. However, the absence of such government support and initiatives, or the poor implementation and enforcement of any government initiatives leaves brands and manufacturers with few reassurances and safeguard to pursue secondary materials development.

Barrier category for secondary materials use and procurement	Barrier aspects
Missing information	SM Materials (traceability, quality, properties post production quantity), cost/benefit analysis
Technical capabilities	SM materials quality, design for recycling, segregation, separation and refining technologies, temporal and quality uncertainties in supply
Other sustainability options	Environmental efficiency, feasibility, business fit
Company not structured for SM use	Poor internal communication, insufficient leadership, goals, top down decision making
Supplier market and business environment	Low SM priority, need for SM network leadership, non-SM compatible structure/distribution, need to import quality SMs
Challenging business case for SM	Investment and market risk, SM use expensive (R&D, technologies, administration), insufficient resources for SM transition, competition pressure > SM market pressure, price sensitive market
Social limitations	Perceptions of SM safety & quality, SM ambition and expectations framed by linear economy social standards and norms,
Insufficient state support	Legal, financial, enforcement, policy stability

RQ3: What are the implications of these barriers on efforts in India to broker and increase secondary materials flows from suppliers to brands and manufacturers?

For secondary materials brokers, the implications of the identified barriers can be boiled down to brokers needing to take the initiative in supporting brands, manufacturers, secondary materials industries and government to overcome these challenges. Part of the task for secondary materials brokers is in reflecting on an issues that lies at the heart of their value proposition, to identify and make use of the latent potential in resources that already exist in the surrounding environment. Secondary materials brokers need to work for facilitating trust, co-operation, and information flows to garner finance and drive the emergence of secondary materials production systems in India. With the agenda of secondary materials brokers being per definition based in secondary materials, this is the stakeholder group whose interest it is most in to drive the change to develop supplies. Other stakeholders may express interest in secondary materials, but it is an interest that is subservient to barriers characterised by the conditions of the linear economy within which such ambitions exist. Or to put it another way, developing secondary materials systems is an uphill technical journey. The headwinds of economic norms and government policy making it developing secondary materials systems a hard tasker, and the presence of alternative sustainability options pulling in other directions making it an only harder task further still. If secondary materials brokers do not take the initiative to accelerate change under the current circumstances, it is not clear who might.

Recommendations

1. Strategically develop secondary materials standards system
2. Establish database for the virgin and secondary materials content of products already out on the market or in waste streams
3. Develop R&D services for manufacturers to improve technical secondary material quality
4. Advocate for the climate benefits and the therefore business case of secondary materials use
5. Provide cleaner production technical training to producers which can provide access to post-production waste, and raise awareness for using secondary materials
6. Facilitate product reuse, repair and remanufacture to the levels desired by brands, gaining access to EoL post-consumer waste
7. Develop local level waste exchange and secondary materials networks
8. Develop international secondary materials collaboration networks
9. Become an honest broker for pooling manufacturer competition purchasing power to support secondary materials demand on up-stream supplier producers
10. Conduct research on improving and diversifying the applications secondary materials cleantech investments
11. Unite willing actors to facilitate secondary materials processing and production eco-industrial park

Please see Section 6 for full elaboration of recommendations, and Section 6.1.5 for tabulated summary

Future research

Drawing on the critical reflections of this research in Section 6.2, together with the conclusion presented above, suggestions are made for research that can build on the learnings from this investigation.

This research initiated the investigation into the factors and barriers of secondary material use and procurement in manufacturing systems, drawing on the responses of a limited sample base. It was not the experience of the researcher that data collection from the chosen same base reached a point of data saturation whereby new interviews ceased to reveal new insights. Future research could therefore continue on a similar path of qualitative research to draw in the perspectives of a wider range of brands and manufacturers than those sampled in this research. Such research could subsequently build on and develop the theoretical framework employed in this research. Alternatively, it would be interesting to gain an insight into the same research topic but with a completely separate underlying framework, or even a different research methodology. This second suggestion is with consideration for applying a grounded-theory method (Bryman, 2008) and not limiting the study to any one theoretical disposition but instead having the study be entirely guided by the research objective and the perspectives of research respondents. Other approaches could involve studying specific company case studies to gain in-depth understandings of the factors and barriers to secondary materials use and procurement. To build on this research or any other in-depth studies that pursue the factors and barriers to secondary materials use and procurement, a broad-based quantitative study can help produce generalisable findings on the research topic. Such a study could take the factors and barriers presented in the findings of this study and test them across a much larger respondent base of industries in India.

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Abbreviations

CE – Circular economy

CP – Cleaner production

EoL – End of Life

EEE – Electrical and Electronic Equipment

EPR – Extended Producer Responsibility

FAO – Food and Agricultural Organisation

GHGs – Greenhouse Gases

IPBES - Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

IPCC – International Panel on Climate Change

LID – Landfilling, incineration and discarding

MDGs – Millennium Development Goals

MSW – Municipal solid waste

MSWM – Municipal Solid Waste Management

PACE – Platform for the Acceleration of the Circular Economy

PRO – Producer Responsibility Organisation

RQ – Research questions

RSL – Restricted Substance List

R&D – Research and Development

SC – Supply chain

SCM – Supply chain management

SSCM – Sustainable supply chain management

SM – Secondary material

UN – United Nations

UNEP – United Nations Environment Programme

UNESCO – United Nations educational, Social and Cultural Organisation

VOC – Volatile organic compounds

WEF – World Economic Forum

WEEE – Waste in Electrical and Electronic Equipment

1 Introduction

Current rates of raw material extraction and processing in the global linear economy cause significant global environmental degradation, from climate change, to biodiversity loss, marine pollution and much more. The level of cradle to grave greenhouse gas (GHG) emissions from current material consumption practices, puts into perspective the scale of these environmental impacts, reaching roughly 60 Gt of CO_2e during 2017[1] (Circle Economy, 2019). Municipal solid waste (MSW) generation at current levels of material consumption are posing significant waste management challenges for public authorities around the world. These challenges are particularly acute in large emerging economies with unstructured waste management systems that rely heavily on the informal sector (Wilson et al, 2006). In India it has been stated that roughly 62 Mt of solid waste are generated per year (PIB, 2016)[2]. To reduce the environmental impacts of consumption, numerous global manufacturing brands have set goals to only source renewable or recycled materials for their manufacturing by 2030. The overarching task of this research is to produce findings that assist the development of Indian materials recycling systems, to help manufacturers use secondary materials and therefore reduce the environmental impacts of product consumption.

The large role of the informal sector in Indian waste management centres on the collection and processing of certain material fractions from MSW streams that can then be sold as recycled materials. The informal sector can be summarised typically by low income actors operating outside of the regulation, standards and obligations that govern economic activity. Formal economy actors, either recycling businesses or Producer Responsibility Organisations (PROs) purchase recyclable materials from the informal waste collectors[3]. The heightened demand from manufacturing brands for recycled materials can refine and strengthen signals to the Indian recycling sector, of the value that MSW can have as a production input. When transmitted effectively from manufacturers to Indian recycling actors, these signals can incentivise the Indian recycling sector to reconfigure their processes to produce secondary materials that better meet the needs of brands manufacturing in India.

One formal waste management actor in India, the e-waste PRO Karo Sambhav, is now seeking to expand its role in the wider Indian waste management and recycling sector. Karo Sambhav sees the potential for the 2030 recycling goals of manufacturing brands, to catalyse improvements to waste management in India but claims obstacles remain. According to Karo Sambhav, manufacturing brands lack the knowledge of how to procure secondary materials in a context where there is not yet a formally established system to process and distribute them. Karo Sambhav's ambition has therefore been to assume a broker role in organising the nation's disparate informal recycling systems into a standardised market-platform for secondary materials. By brokering the processing and supply of secondary materials through a market distribution platform, manufacturers would be able to procure secondary materials without themselves needing to navigate materials recycling systems. Such a simplified connection of manufacturers to secondary materials suppliers would ultimately aim to increase the procurement of secondary materials, which in itself could bring down the cost of recycling and increase secondary materials procurement further still (Leire, 2009). Karo Sambhav's desire to

[1] This figure equated to nearly 11% of the then remaining total budget of carbon emissions for achieving the Paris Agreement goal of limiting global warming to 1.5°C (MCC, 2019)

[2] A large degree of uncertainty is associated with this number as official Indian statistics for MSW generation only include those quantities handled by formal waste management systems, and not those openly discarded or handled by the informal sector (Joshi & Ahmed, 2016)

[3] PROs are financed by consumer brands to conduct government regulated obligations of brands for managing in a legally compliant manner, post-consumer products that have become MSW. PROs are further explained in Section 2.3.1.

establish a secondary materials platform is premised on the judgement that lack of knowledge on how to procure secondary materials is the main hindrance to manufacturers actually do so. Under these conditions, research areas of foremost importance become those associated with challenges to establishing the secondary materials platform. With Karo Sambhav viewing its own knowledge deficits on manufacturer needs and expectations relative to secondary materials suppliers as a key hindrance to establishing a secondary materials platform, understanding manufacturer needs has become Karo Sambhav's stated research priority.

1.1 Problem Definition

There is little published research drawing on empirical data from industry actors which assesses, describes and problematises the nature of secondary materials use and procurement among manufacturer organisations. Contributing research, as per the stated priority of Karo Sambhav, on solutions to a problem that is not even yet clearly defined and understood[4], seems premature from the standpoint of following a logical sequence of analysis. Any findings and recommendations provided in such a context would therefore risk being ill suited to the true nature of problem at hand. While Karo Sambhav's research priority may seem premature it nonetheless has flagged up the research gap pertaining the problem description of secondary materials use and procurement in manufacturing. This research therefore intends to contribute to the goal of developing secondary materials supply systems, by improving understandings of the problem itself of low secondary materials procurement among manufacturers and the factors that lead to it. Indian manufacturers are largely procuring virgin materials for manufacturing, that much is clear. However, which factors influence materials use and procurement, and which of those are restraining procurement practices from transitioning toward secondary materials procurement is not yet apparent. A review by Govindan and Hasanagic (2018) of existing research on circular economy supply chain management provides an overview of drivers and barriers to the implementation of circular production that have been identified so far. A compilation of all forms of circular economy case studies (re-use, recycle, recover, redesign, remanufacture) are included in Govindan & Hasanagic's review. The generic review of circular supply chain management drivers and barriers places less emphasis on secondary materials use, on the justification that recycling offers smaller net environmental benefits compared to the other forms of circularity which should be prioritised. The drivers and barriers presented in Govindan & Hasanagic (2018) for circular supply chain management in general can be applied in this study of secondary materials use and procurement in India. Govindan & Hasanagic (2018) may however, not be an exhaustive assessment of all factors influencing secondary materials procurement, and there may be a need to draw on supplementary theoretical perspectives in order to expand understandings of the field. Studies on the enabling or hindering of circular production systems by materials use regulation as in Schreck & Wagner (2017), or business expectations and norms as discussed by Norris (2019), illustrate the value of drawing on institutional theory to study the factors and barriers to secondary material use and procurement.

With little publicised knowledge on manufacturing organisation practices surrounding secondary materials use and procurement, it is difficult to analyse the compatibility of those organisations with initiatives to supply secondary materials. Upon producing such knowledge, a subsequent research problem remains. Identified factors and barriers to secondary materials use

[4] The assessment made by Karo Sambhav of manufacturers not knowing how to procure secondary materials, was obtained by the researcher through informal conversations with Karo Sambav during a student project in India that preceded this research. While the assessment was made by an expert in the field of Indian waste management, an assessment that may well be shared by similar experts, it was not corroborated through further consultations during the research design process of this project. It is therefore only possible to state here the assessment as being Karo Sambhav's own observation of brand and manufacturer behaviour.

and procurement need to be analysed for their implications on efforts by third party actors to establish a secondary materials platform.

1.2 Research Aim

The overarching practical aim of this research is to produce findings that can help efforts to reduce the environmental impacts of consumer manufacturing systems through informing on how to increase the use of secondary materials in production. More specifically, this investigation aims to understand the organisational and contextual factors and barriers to using and procuring secondary materials for production in India or similar contexts. This research is also concerned with the potential implications that these factors and barriers might have for the intermediary actors brokering secondary material supplies. Last, this research also aims to provide recommendation of what secondary materials brokers can do to help manufacturers overcome these challenges. The findings will be relevant for any actor working with secondary material supply chain management but will be made with consideration for Karo Sambhav and other secondary materials brokers in particular. The standpoint of broker actors is taken for two reasons. First, like certain manufacturers, broker actors are seen to take the initiative with developing secondary materials supplies but unlike for manufacturers, this is a source explicit economic interest. Brokers can directly profit from the development of secondary materials supplies. Second, in holding a key position as the enabler of secondary materials flows from the waste management stakeholders to and that are compatible for manufacturers, brokers are of high priority in research about developing secondary materials systems.

In contributing towards addressing a practical problem, this research also aims to contribute to addressing the conceptual problem regarding low levels of research on secondary materials procurement and organisational challenges. The main conceptual aim of this research is to develop a theoretical framework that can be tested to assess the factors of secondary materials use and procurement.

1.3 Research Questions

Based on the research aims stated above, the following research questions have been devised to guide this research in achieving its overarching aim:

> **RQ 1: What are the key factors of virgin and secondary materials use and procurement for brands and manufactures with operations in India or similar contexts?**

The research conducted to answer RQ1 entails describing factors internal and external to brands and manufacturers which bear impact on the use and procurement of production materials. By collecting, describing and analysing qualitative interview data from consumer brand and manufacturing industry representatives, key factors of materials-use and procurement can be explored.

Given the identified gap in research in organisational and contextual challenges related to secondary materials use or procurement, a theoretical framework was constructed from a literature review to answer RQ1. Literature from four theoretical fields contributed to constructing the framework. Supply chain literature provided insight into core factors that guide materials procurement management. With secondary materials use being a type of circularity, circular economies literature was used to gauge theoretical components regarding secondary materials procurement specifically. Industrial ecology literature contributed theoretical components surrounding industrial relations in the context of sustainable materials use. Last, sociological theories were drawn up to include a sensitivity how factors of human interaction may bear influence on secondary materials use and procurement.

RQ 2: What barriers can be identified regarding the use and procurement of secondary materials for brands and manufacturers with production operations in India or similar contexts?

The factors to materials use and procurement described from answering RQ1 will be evaluated to analyse for barriers to secondary materials use and procurement. Factors external and internal to brands and manufacturers will be evaluated for the degree to which they run counter to or appear necessary for the use and procurement of secondary materials in Indian manufacturing.

RQ 3: What are the implications of these barriers on efforts in India to broker and increase secondary materials flows from suppliers to brands and manufacturers?

The implications of barriers to secondary materials use and procurement will be considered from the perspective of the requirements they place on, and opportunities they provide to secondary materials brokers. The requirements are in relation to those which brands and manufacturers have specifically of secondary materials brokers, as well as other requirements not inherently relating to the latter. The direct requirements of secondary materials brokers outline the conditions that are necessary for them to fulfil in order to supply brands and manufacturers with secondary materials in India. Implications relating to general requirements from and of brand and manufacturers pursuing secondary materials use and procurement include opportunities for brokers to facilitate, improve and increase production with secondary materials. The recommendations produced from this research are generally based on the findings from all the research questions, but particularly rooted in those relating to RQ3.

1.4 Definitions

Manufacturers are referenced to throughout this study with consideration for their position and role within product supply chains. ***Brand manufacturers*** will refer to company brand names that features on household recognised products. In instances where certain brands do not conduct any manufacturing under their own operations, they are simply referred to as ***brands***. Manufacturers upstream in a brand's supply chain, but who are not brand manufacturers are referred to as ***product manufacturers***. Lastly, ***materials manufacturers*** will refer to the organisations that themselves process and produce virgin and/or secondary materials for use in product manufacturing. For the purpose of this research, a ***factor*** when considered in relation to secondary materials use and procurement is viewed as a variable that contributes to the outcome of a company's state of material procurement. Likewise, in the context of this research a ***barrier*** is viewed to be a factor with a quality of hindrance to a manufacturing company's capacity to use and/or procure secondary materials. While there has been a preference throughout this research to understand factors and barriers relating to secondary materials from post-consumer waste, the term ***secondary materials*** is used in this study for referring to both pre-consumer and post-consumer material waste. The term ***circular economy*** and its related term ***circularity*** are used to refer to the practice of designing out and minimising resource waste, re-entering used material and energy resources back into human and ecological production systems in a process referred to as ***closing material loops*** (Ellen MacArthur Foundation, 2013). Use of the term ***reverse logistics*** in this report encompasses a wide definition of to include two interpretations. The first interpretation includes informal collection networks of secondary materials from MSW streams, while the second relates to the use of standard logistics infrastructure during the stage of post-shipment delivery on return journeys where no cargo is being transported.

1.5 Limitations & Scope

As the focus of this research is concerned with the little understood research problem area itself of secondary materials use and procurement among manufacturing companies, this study can primarily be considered an exploratory investigation. Within this overall form the research produces three different types of knowledge. The mapping out in this research of trends relating to secondary materials use and procurement in manufacturing brands produces descriptive knowledge. The analysis of these trends to determine factors and barriers to secondary materials use and procurement produces explanatory knowledge. Lastly, the analysis of these factors and barriers for their implications on efforts to establish secondary materials production systems produces evaluative knowledge. Being guided by a theoretical framework of factors and barriers to secondary materials use and procurement, while also remaining open to new perspectives that can emerge from the data collected, this research employs both inductive and deductive analysis. This study does not seek to itself produce findings of causality. Factors presented in this report as being influential to secondary materials use and procurement will be limited to reciting those that are stated by respondents in their testimonies as being so.

The delimitation criteria of this research regarding manufacturing companies is based on the sector and geographical context. Sectoral delimitation is characterised by consumer goods brands and manufacturing companies that have stated an interest for increasing production with secondary materials. This delimitation was chosen instead of one based along the lines of material fractions in order to enable a wider sensitivity to manufacturer perspectives. The geographical delimitation is based along the lines of companies manufacturing in India, or in locations with similar levels of per capita gross domestic product, informal sector presence in municipal solid waste management (MSWM) or as a location for offshored manufacturing. The geographical delimitations were chosen to enable a sensitivity to manufacturer experiences in locations outside but still pertinent to the Indian context. Beyond manufacturing company perspectives, experts of circular production in consumer good organisations and/or in Indian industry were drawn upon to provide outside perspectives.

Being located in Sweden without the possibility to collect data in India was among one of the more significant practical limitations of this research. With a constrained ability to network in person with potential respondents in India, contributions by Indian-based perspectives were fewer than wished for, and fewer than might otherwise have been so had data collection occurred in the field.

As a piece of exploratory research the scope of this study is intentionally wide to assist scouting for potentially unforeseen factors and barriers.

The focus on multiple product and material categories is motivated by a desire to assess for more general underlying factors and barriers that appear to be common to consumer goods manufacturing overall. The wide scope of this study is representative to the intention for its findings not to be taken as generalisable. Instead, findings from this study may provide in-depth perspectives to use and procurement of secondary materials. These perspectives can serve as a tentative guide for evaluating implications for secondary materials supply actors and for constructing further research that seeks to generate generalisable findings.

1.6 Audience

As this research investigates practical problems associated with developing circular production systems, it is intended to hold relevance for practitioners with a stake in this field. The findings from this research are primarily aimed at informing secondary materials brokers in their efforts to build markets for secondary materials. This is applicable to brokers based both in India as well as those that share similar goals and contextual conditions beyond India. Actors in manufacturing organisations that are seeking to increase the use of secondary materials in production may also find useful the snapshot of identified factors and barriers related to secondary materials use and procurement. The external perspective that this study provides can give manufacturers an idea of which challenges and opportunities it has in common with other companies regarding secondary materials use and procurement. Likewise, this research can inform policy actors who are working on the priority issues that companies face when trying to use secondary materials, as well as provide an affirmative signal on company commitments for circular production. This study can therefore help guide policy makers in their own efforts to develop conditions that can support the emergence of secondary materials production systems. Lastly, this study seeks to contribute toward the theoretical discussion on waste management optimisation on the one hand, and circular production on the other, specifically on the utilisation and upcycling of secondary materials in production. This paper is therefore intended to be of interest for scholars in the fields of production with secondary materials, sustainable supply chain management (SSCM), and scholars in waste management.

1.7 Disposition

This chapter presented the conceptual and practical research problems related to limited understandings of secondary materials production systems, and the need to identify factors and barriers to using and procuring secondary materials in consumer goods manufacturers. **Chapter 2** summarises the wider environmental problems associated with linear production systems and proceeds on to present the Indian research context within which efforts occur to develop secondary materials systems. Key contextual elements reviewed include environmental aspects of linear production, societal drivers and environmental benefits to circular production, and the considerations of the informal sector and manufacturing relative to MSW generation and management in India. The research methods and rationale for its selection in this investigation are discussed in **Chapter 3**.

The literature review in **Chapter 4** draws on research in the fields of circular economies, supply chain management, industrial ecology and institutional theory to synthesise the theoretical framework for this investigation of secondary material systems. An overview of the theoretical framework presented at the end of the chapter guides the collection and presentation of primary data from interviews found in **Chapter 5**. Data collected in accordance to the theoretical framework and that which emerged during data collection, are presented in Chapter 5 where each are subject to a coding analysis to identify overarching trends and barriers to secondary materials use and procurement.

The identified factors and barriers resulting from the coding analysis feed into the subsequent analysis found in **Chapter 6** to discuss their implications for actors in the secondary materials value chain or in policy related to developing secondary materials supplies in India. Chapter 6 also includes a critical reflection of the research project with consideration for experiences, challenges encountered, and methodological lessons learned during this project. **Chapter 7** provides a concluding summary of the main findings from this research in relation to the original research questions, serving to highlight opportunities for future research.

2 Research Context of Material Consumption: From Linearity to Circularity

2.1 Environmental Impacts of Linear Material Consumption

Contemporary economies with linear material consumption structures are characterised by virgin resource extraction, use and disposal (Bell, 2012; Ellen MacArthur Foundation, 2017), as well as by economic growth. The associated environmental costs of linear economic activity have generally not been internalised into the price of consumption (Bell, 2012; Sariatli, 2017). Linear production in economic systems of continued growth and externalised costs have pushed resource extraction and environmental pollution beyond Earth's ecological and geological capacity to replenish natural resource stocks and absorb emitted substances (Rockström et al., 2009). These discrepancies between extraction and emissions, and environmental carrying capacities are destabilising eco- and geo-systems from states that human civilisation is critically dependent on (Bell, 2012).

Between 1970 and 2010 the global population doubled whereas the annual rate of materials extraction has roughly quadrupled going from 22 Gt per year in 1970 to 84.4 Gt per year in 2015 (Circle Economy, 2019; Schandl et al., 2018). The increasing material intensity of consumption that these figures represent reflects both a growing global consumer class along with its increasing material consumption. In high-income economies, raw material consumption is estimated to currently stand at around 25t per capita (Krausmann et al., 2016; Schandl et al., 2018). The environmental aspects of consumption occur from raw materials extraction and across a product's lifecycle through to its end-of-life stage. The term linear consumption is applicable to the wide range of industries that collectively encompasses a take-make-dispose economy. Other final demand categories of global material consumption beyond linear consumer goods include material use for other household consumption categories (e.g. transport, housing, energy, health and sanitation), government consumption, exports and capital expenditure (Schandl et al., 2018; UNEP, 2010). In 2015, 9.7 Gt, or 10.5% of global material consumption (virgin and secondary materials) flowed to producing linear consumer goods (Circle Economy, 2019). The lifecycle GHG emissions of these linear consumer goods were calculated to be responsible for 10.7 Gt of CO_2e emissions, or roughly 20% of global carbon emission for 2015 (Circle Economy, 2019). Across all final demand categories (i.e. housing transport, consumables etc) the lifecycle stages of materials extraction and processing were responsible for 35 Gt, or 69% of global CO_2e emissions for 2015[5]. Based on an environmentally extended input-output table analysis, the share of materials requirement and affiliated GHG emissions for household consumption in Finland for example, in 1999 was 21% and 40% respectively (UNEP, 2010). While these figures are nearly 20 years old at the time of writing, they nonetheless give some indication to the comparatively high proportion of household materials and GHG emissions footprint allocable to linear goods consumption. At roughly double the proportion of global levels these figures allude to the global inequalities in consumption as well as the disproportionately higher impacts from households in high-income economies.

With consideration for these limitations in isolating and assessing the environmental impacts of linear consumer goods, the following sections will give a general overview of the environmental aspects and impacts of lifecycle stages of particular significance to linear consumption. The

[5] Figures for the portion of GHG emissions allocable specifically to raw materials extraction and processing were only available at aggregate level of all the final demand categories and not specifically for linear consumer goods

extraction and processing of production of materials as well as product disposal at the end-of-life stage will be discussed through case examples in specific sectors.

2.1.1 Production materials: environmental aspects

Some of the main environmental aspect categories from global materials production include greenhouse gases (GHGs) emissions, eutrophying and acidifying substances emissions, toxic substances emissions as well as , the extraction of abiotic and biotic resources, and the use of land and freshwater resources (UNEP, 2010). Subsequent impacts of these categories include degradation to the health of ecosystems and human health, resource depletion and climate change (UNEP, 2010). The IPCC estimates that between 1970 and 2010, global GHG emissions from industrial processes rose from roughly 15 Gt CO_2e per year to 32Gt Gt CO_2e per year (IPCC, 2014). From 1980 to 2015 roughly 2.9 million km^2 of intact forest has been lost through wood harvesting or land use change to agriculture (including to non-food commodities), brining global forest cover to 68% of pre-industrial levels (IPBES, 2019). Deforestation and non-food agriculture collectively contribute to eutrophic and acidic water pollution. Global eutrophication is estimated to be responsible for '400 ecological dead zones' across 245,000 km^2 of freshwater and ocean bodies in 2011 of which 37% is estimated to come from global non-food agriculture (Hamilton et al., 2018). Together mining and industry account for 18% of global freshwater withdrawals in 2010 (FAO, 2016) and at current rates of water demand increase for industrial production, "the world is projected to face a 40% global water deficit" by 2030 (WWAP, 2015). Further environmental aspects of mining processes can include emissions through mine tailing leachate, erosion and sedimentation that contaminated local groundwater and soil resources with chemical toxins and heavy metals (Ugya et al., 2018).

Taking an industry specific perspective, in 2006 The Carbon Trust estimated the annual emission allocated to the production of linear products for UK household consumption. Collectively the production of furniture, printing equipment emitted 6.2 Mt of CO_2e (The Carbon Trust, 2006). In textile production global consumption of water in the sector reached 93 billion cubic meters in 2017 (Ellen MacArthur Foundation, 2017) and emitted 1.2 Gt of CO_2e in GHGs in 2015, a figure greater than the combined GHG emissions of international aviation and maritime shipping (Ellen MacArthur Foundation, 2017). Cleaner production methods can attenuate the environmental aspects of some linear textiles production, for example a 46% reduction in GHGs per kg of cotton, using organic techniques (Textile Exchange, 2014). However, other aspects remain from production including continued water depletion, land-use for cultivation leading to biodiversity stress, eutrophication and ozone depletion (Östlund et al., 2015; Sandin & Peters, 2018). Consumer electrical and electronic equipment (EEE) was calculated to be responsible for 700 Mt of materials consumption in 2015 (Circle Economy, 2019). In the case of smartphones which were introduced in 2007, 307,000t of minerals and 68,000t of fossil fuels (plastic) have been extracted, processed and used to manufacture 7.1 billion smartphones (Greenpeace, 2017). It has been estimated that the ratio of rock mined to mineral extracted occurs at a ratio of 340:1 (Compareandrecycle.co.uk, 2018) in locations with poor oversight of environmental impacts of mining operations, such as in the Democratic Republic of Congo (Greenpeace, 2017). Calculating from the manufacturing GHG footprint of one Apple iPhone Xs 64GB model smartphone unit, reported at roughly 54kgCO_2e (Apple, 2018), an approximation for the scale of GHG emissions from all smartphone production can be calculated at about 383Mt CO_2e.

2.1.2 End of life: environmental aspects

In the strictest sense, linear consumer goods at their end of life (EoL) stages end their categorisation as products and transition to assume their long-term state as waste. However, in reality a portion of waste consumer goods not being managed at the EoL stage through landfilling, incineration, or discarding (LID) into open land or sea environments, is sent to material recovery. In 2015 the global material flow from short-term consumables' EoL phase, and long-term material stock demolition saw an estimated 1.4 Gt of materials flow toward recycling, representing 1.66% of global materials extraction in 2015 and 2.31% of total global material flows to the material EoL phases in 2015 (Circle Economy, 2019). The EoL destinations of landfilling, incineration or discarding (LID) together represent the second major point of environmental aspects and impact, beyond materials extraction and processing, for linear produced consumer goods. As with materials recovery processes, the methods and degree of environmental impact mitigation for LID can vary widely between locations depending on the stringency of waste management regulation and enforcement, culture, capacity and economic resources (Narain & Swati Singh, 2016). Severity of impacts aside, Table 2-1 summarises some of the major environmental aspects some major aspects of LID processes.

Eol Process	Environmental aspect	Environmental impact
Land Filling	VOC emissions Chemical & heavy metal leachate Odorous emissions GHG emissions (20% of global methane emissions in 2012) Wind-blown litter Land use change	Ozone formation Acid rain Soil acidification Degraded air quality Ground and surface water contamination, Heavy metal soil contamination Eutrophication Climate change Habitat & biodiversity loss Human health ailments
Incineration	Bottom ash Gas emissions: (acidic gases, nitrogen oxides, dioxins, particulates and bound metal vapour condensate) Soot emissions Odorous emissions Contaminated wastewater GHG emissions	Acid rain Soil acidification Degraded air quality Climate change Human health ailments
Discard into environment	Vector for disease and pollutants Accumulation in water ways, marine bodies, land habitats Micro-plastic formation Micro-plastic accumulation in organisms and food webs	Micro-plastics bind pollutants and disease Litter and micro-plastics are poisonous to humans and wildlife (land and marine) Choking, ensnaring and suffocating fauna Litter can aid the spread of disease Fire hazard with land litter accumulation Rupture of sewage systems with ensuring health hazard

Table 2-1 Environmental aspects and impacts from EoL alternatives of LID

Source: (Danthurebandara et al., 2012; Galgani et al., 2019; Williams, 1994)

For some categories of waste, the range and degree of environmental impacts can be extremely severe, with notable reference to marine pollution of discarded consumer waste. The accumulation of MSW in marine environments is fed by a plastics stream of between 4.8Mt to 12.7Mt each year (Galgani et al., 2019). All three forms EoL disposal are characterised by receiving continued and growing streams of waste, global MSW generation at roughly 1.3 Gt in

2012, 2.01 Gt in 2016 and projected to grow to 2.59 Gt by 2030 (Kaza et al., 2018). While even best practices of incineration have significant environmental aspects, such as GHG emissions or the long-term storage of its highly toxic by-product of bottom ash (Andreas, 2017), the rise of which points to an arguably even greater environmental aspect of MSW from consumer goods, it's sheer quantity. The rise of incineration has in part occurred due to a need to manage the growing volumes of MSW generation, even for those waste fractions destined for recycling (DEFRA, 2014; Towie, 2019). The redirection of recycling flows to incineration due to oversupply of waste materials, as demonstrated by China's ban on waste plastic imports (Nee Lee, 2018), testifies to the scale at which consumer waste is overwhelming society's capacity to manage it. The use of incineration in particular, in guarantying low (or no materials recovery in the instance of informal sector from landfill or discard recovery (Wilson et al., 2006)), locks in systems that actively neglect recycling and weaken incentives to transition to circular production (de Bercegol et al., 2017). The handling of MSW by means of LID ensures that the simultaneous growth in consumer goods production occurs using virgin materials and their associated embedded environmental impacts.

2.2 Circularity in Manufacturing

The combined pressures on manufacturers to increase production to meet demand from growing global middle class markets as well as to reduce the environmental impacts of linear consumption (Koszewska, 2018) has lead manufacturers to pursue circular business models. Circular business models fundamentally entail re-using and/or recovering material resources from existing stocks of extracted materials within the economy to fulfil society's economic needs (Circle Economy, 2019). The concept of circularity does not appear to have any inherent connection to limitless economic growth, particularly given its ontological connection to principles of ecology and the limits to growth by virtue of scarcity (Ghisellini et al., 2016; Winans et al., 2017). Despite this, industry and policy makers appear to predominantly refer to circularity in relation to green growth, legitimising approaches of ecological modernisation[6] in response to environmental challenges (Bonciu, 2014; EC, 2008, 2015, 2019; Ellen MacArthur Foundation, 2016, 2017; Govindan & Hasanagic, 2018; Lacy & Rutqvist, 2015) which maintains the dominant paradigm of neo-classical economics and its characteristic of limitless economic growth. Circularity in industry from a neo-classical standpoint therefore maintains focus on the continued expansion of goods and services provision, but in a manner that seeks to reduce the environmental impacts of industrial processes and operations. Isolating this common disposition of circularity sets the perspectives from which business might perceive and interpret the barriers to secondary materials procurement, in this case the business management concepts of neoclassical economics.

The use of secondary materials for production is one form of business circularity. Overall the amount of research specifically on secondary materials procurement is sparse; however, procurement belongs to the wider discipline of supply chain management, one which is not only relevant to but a defining feature of circular business models. Structuring supply chains to recover materials from existing stocks in the economy and enabling the closing of material loops represents an element that fundamentally distinguishes circular business models from their linear counterparts (Sedikova, 2019). In addition to general circular economy literature, circular supply chain management literature can therefore give some indication to where research and practices relevant to secondary materials procurement is at. The origin of circularity which subsequently relates to the different ways in which it has come to manifest in and be practiced

[6] Ecological modernisation maintains that economic growth can be sustained through using technological, political and economic progress to de-couple economic activity from exerting negative environmental impacts (Bell, 2012).

by industries has also been proposed to reveal insight into which areas of circularity can be of interest to review as a proxy to secondary materials procurement.

Some scholars allude to contemporary circularity being rooted in the same cultural origins as modern environmentalism, following the same cultural trajectory, growth and intergenerational shift in significance since their emergence in the 1960s (Crocker, 2018; Winans et al., 2017; Yearley, 1996). Where and how circularity is applied within an industry's operations is in part guided by the preferences of its market segment and potential for value addition (Orsato, 2006). Which markets environmentalism manifests itself in, how, why and at what rate can serve as a proxy to which companies might be sensitive to market pressures for adopting circularity, the extent to which they would do so, and therefore to which companies this study should collect data on.

Another proposed source of business circularity has been through its organic development by virtue of economic necessity in the face of resource scarcity and in pursuit of competition. This form of business circularity can be seen in the field of industrial ecology, whereby industries collaborate through the exchange of waste resources that complement one another's industrial processes and/or through co-developing utilities and infrastructure that serve mutual interests (Chertow, 2000; Korhonen & Snäkin, 2005; Winans et al., 2017). Here, business circularity entails secondary materials procurement and suggests that research on SSCM in industrial ecology can provide insight into practices and theoretical principles of relevance to secondary materials procurement. The topics of pressures on industry to adopt sustainability, and SSCM along with the potential environmental gains from circular production will now be further discussed.

2.2.1 Consumer, market & regulatory pressures

Environmental awareness has become an increasingly important factor of consumer behaviour over generations, gaining significance from the post-war Baby Boomers upwards through Gen X, Millenials and to Gen Z (Nielsen, 2018). The growth in range and market deployment of eco-labels and eco-conscious products (EU Ecolabel, 2019) stands as a testament to consumer expectations of producers to mitigate the environmental impacts of consumer product value chains. The rise of these concerns appears due to the prominence of various environmental causes in public discourse over the course of time. Drivers of the public discourse can include environmental reports, multilateral environmental collaborations and summits as well as focus points by environmental civil society. Environmental issues of high public concern appear to include GHG emissions air, pollution, marine pollution and waste MSW pollution (EC, 2016)

Certain industries have been subject to greater societal and policy pressure than others. At present the industries that experience the most pressure to improve their sustainability performance are those whose value propositions strongly involve environmental aspects that receive the greatest coverage in the public discourse (Siegner, 2019). The leverage these pressures have on companies to pursue sustainability can rely on numerous factors. Fossil energy and mineral extraction companies for example have historically been more resistant to change perhaps due to their lobbying power, extent of growth market potential, lock-in and high costs for substitute. Regulation and enforcement stringency also exert varying degrees of pressure on companies. Early policy responses included the introduction of waste hierarchy policies promoting the re-use and recycling of materials to increase the economic utility gained from a given set of material extraction, processing and disposal processes (EC, 2008). More recent policy developments moved towards closing material loops in production, with the EU circular economy action plan (EC, 2015, 2019) and Sustainable Development Goal 12 for sustainable production and consumption patterns (United nations, 2019). The WEF, UN together with industry have formed the public private partnership PACE to accelerate circular economy practices for plastics, EEE and capital equipment (PACE, 2019).

Consumer trends in support of circularity concentrate most in addressing EoL impacts of plastic pollution from linear plastic consumption, focusing largely on plastics used in non-durable products such as food, beverage and retail packaging (Mintel, 2018). The imperative for companies in these sectors to adopt circular plastics practices may be compounded by further public pressures these industries experience from other, additional environmental and social impacts of their value chains. High embedded GHG emissions (Siegner, 2019) or consumer awareness for the ecosystem & health impacts of industrial agriculture (Nielsen, 2018) may hasten producers into showing they are working with sustainability, even if in ways with low relation to their core environmental impacts.

Textile, apparel and EEE manufacturers each experience public pressure related to a broad range of environmental issues much as with the food, beverage and retail industries. Owing to their large and complex supply chains, production and logistics in each of these industries significantly interacts with multiple different environmental aspects. However, unlike the food, beverage and retail industries, the liability of significant embedded environmental impacts is exacerbated when textile, apparel and EEE products have ever shorter lifespans. Perhaps shortening product lifespans is deemed to be a necessary cost of sustaining demand for new products in highly competitive markets. Nonetheless, shortening the lifespan of high throughput products can contribute to raising public pressure on producers when those products are high in environmental impact and quickly channel material resources through to product EoL. These pressures are leading multinational companies to integrate sustainability into their supply chains with the greater focus on circular business models, in particular setting targets for the quantities of renewable and recycled materials used in production (Stewart & Niero, 2018). In the food, beverage and retail sector 154 companies that have signed up to the UK Plastics Pact by WRAP – The initiative seeks to establish circular plastics use in food, beverage and retail consumption (WRAP UK, 2019). Ikea and H&M have both set the target of using 100% recycled or renewable materials by 2030 (H&M, 2016; IKEA, 2018). Adidas, along with numerous other apparel companies have launched product lines manufactured entirely from recovered marine plastic pollution (Adidas, 2019; Henderson, 2019). In the IT sector Dell and HP (Dell, 2017; HP, 2018) have set targets for the amount of recycled materials used in their products. That these companies to name a few, and many large manufacturers, are seeking to incorporate recycled materials in their products suggests a necessity to include some degree of circular production in order for businesses to remain competitive. Companies are also paying more attention to circularity as a means to "reduce dependence on scarce external resources and maximise profits" (Norris, 2019).

2.2.2 Environmental gains

As demonstrated with consumer goods such as apparel or smartphones, the environmental impacts of the materials used to manufacture these products accumulate through the compiling of a product's constituent parts. For some products a significant portion of the embedded environmental impacts, that is the accumulated impacts from upstream processes, can be attributed to processes related to the manufacturing of production materials. By using recycled materials in product manufacturing the embedded environmental impacts of a new round of virgin materials extraction, processing and LID management are forgone. Meanwhile the embedded environmental impacts of recycled materials from when they were originally extracted and processed are then allocated across all the times the material in used for manufacturing (Bjørn et al., 2018; Curran, 2017).

Material recovery and recycling processes themselves require energy and resources, and using products made from recycled materials still has environmental impacts. The net environmental benefits of recycling are therefore not simply equivalent to those from omitted virgin materials production. The environmental impact of materials recovery processes varies across material fractions and within that, between locations depending on differing energy sources, technology, regulations and so forth. The Swedish Environmental Protection Agency's life cycle assessment of textiles recycling showed that cotton can be recycled to a standard that maintains its material quality. However, the industrial process is an energy-intensive process and yielding the environmental benefits therefore requires the use of sustainable energy supplies, and on chemical processes that at present are not scalable or economically viable (Östlund et al., 2015). Conversely, while the recycling of polyester and nylon perpetuates the micro-fibre pollution from cloths use during laundry routines, the environmental impacts of these aspects are outweighed by the environmental gains from recycling plastic (Ellen Macarthur Foundation, 2017; Östlund et al., 2015). While the extent of reduced environmental impacts varies within and across materials categories depending on material type and recycling methods, closed loop production has the potential to exert a lower environmental impact than that from virgin materials (Östlund et al., 2015; Sandin & Peters, 2018). Some estimates calculate that if circular economy principles are fully deployed across the global economy, production can use up to 32% less materials within 15 years and 53% less by 2050 (Esposito et al, 2018). By 2100 it is estimated that a 36% reduction in cumulative global GHG emissions from 2015 levels can be achieved if circular economy principles are fully implemented for the material fractions of steel, plastics, aluminium and cement alone (Circle Economy, 2019). Manufacturing with secondary materials helps to reduce the environmental impacts from product EoL by redirecting materials from LID at the waste management stage. The demand for secondary materials also places a monetary value on MSW already landfilled and discarded, incentivising the extraction of waste materials from these waste repositories as demonstrated by the range of products manufactured from ocean plastic waste (Henderson, 2019) and examples of landfill mining (Johansson, 2016).

2.3 The Indian Context

2.3.1 MSW generation & management in India

The geographical distribution and composition of India's 62Mt of annually generated MSW varies widely owing to high locational variation in income and associated consumption habits (Sharma & Jain, 2019). Similarly, a high temporal variance in distribution and composition of MSW generation in India as household incomes rise with the growing Indian economy which has seen increasing proportions of plastics and paper recyclables entering MSW streams (Sharma & Jain, 2019). The low allocation of resources by government to MSWM mostly covers transportation costs, reflecting the wider dearth in MSWM infrastructure in India leaving municipal authorities reliant on the low cost treatment option of landfilling (Sharma & Jain, 2019). Deficiencies in MSWM funding result in shortfalls of MSW collection rates (Sharma & Jain, 2019)

The introduction of Extended Producer Responsibility (EPR) rules have placed legal waste management responsibilities on producers or importers of products in lead acid batteries, EEE, plastics packaging and non-biodegradable MSW factions (Sahay & Gupt, 2019). These rules offer a path to managing India's MSW streams avenue in the face on low government financing of waste management. The mix of EPR rules include a range of obligations depending on the waste fraction in question, with some including financing from producers, waste collection targets and channelling of waste to recyclers. The duties can be outsourced to a market of Producer Responsibility Organisations (PROs) (Sahay & Gupt, 2019), alternatively, some companies such as Pepsi Co choose to develop their own reverse logistics and processing network and infrastructure to meet their own EPR obligations (FRPT Research, 2018). While additional resources for MSWM are garnered from manufacturers by the EPR rules, they have been unable to compensate for the shortfalls in public spending with Indian MSWM systems. The India EPR systems still needs to contend with a lack of overall system wide MSWM which, together with vaguely defined rules and insufficient regulatory oversight of PROs has resulted in poor EPR enforcement by authorities (IIIEE, 2019). PROs have subsequently been able to exploit this situation to use very low paid informal sector labour in MSW collection and processing, and offer aggressive pricing to producers for their EPR services. As such, the reliance on the informal sector and price competition has led to a culture of providing PRO services that can fail to meet EPR standards where PROs, producers and importers proceed in a race to the bottom of PRO standards and service fees (IIIEE, 2019). Along with PROs' reliance on the informal sector to lower their EPR costs, the government's default preference for landfilling also places an unofficial dependence on the informal sector for further MSW collection and the implementation of recycling (Gill, 2009; Joshi & Ahmed, 2016).

Official figures on MSW generation do not include the contribution to MSWM made by the informal sector meaning reliance on the latter masks the real scale of MSW generation and collection in India (Joshi & Ahmed, 2016). With default priority given to landfilling of MSW due to economic reasons, there is a low emphasis in MSWM systems on source segregation. Only 5 of India's 29 states work on in promoting source segregation between wet and dry MSW fractions (Sharma & Jain, 2019), providing little reason to develop household behaviours and practices toward waste separation, resulting in the persistence of mixed waste disposal (Pandey et al., 2018). As MSW in India has a high content of wet organic waste (Joshi & Ahmed, 2016; Maletz et al., 2018; Sharma & Jain, 2019), poor source segregation impacts the quality of materials that are recovered by the informal sector from landfilled and discarded waste (Maletz et al., 2018) and raises the cost of segregation at recycling facilities (Shirodkar & Terkar, 2017).

2.3.2 The informal sector & reverse logistics

The contamination of recovered and processed secondary materials due in part by poor source segregation, poses health hazards to the economically and socially vulnerable informal workers handling these materials (Ferri et al., 2015; Joshi & Ahmed, 2016; Kinobe et al., 2015). Secondary material sourced from reverse logistics systems based on the informal sector, will by this virtue come from unethical sources due to the socio-economic inequalities and injustices that are embedded in the material's recovery. Furthermore, the contamination of secondary materials also restricts their range of manufacturing applications due to material quality standards and regulations (de Romph & Van Calster, 2018). From a supply chain perspective, the range of available secondary materials available to procure for manufacturing is limited to those that come to market by means of socially and environmentally unsustainable supply chain practices.

While participation in the informal waste management sector provides a vital source of income for many people in India (Hande, 2019), caution must be taken in considering these economic benefits. That such opportunities are preferable to sources of lower income or no income at all does not make for reasonable justification for the existence of income source contingent on poor working conditions of informal waste management systems (Gill, 2009). Nevertheless, so long as the policy paradigm behind the current MSWM system persists, the limited benefits that marginalised communities etch out from working with informal waste management must be recognised and supplemented with basic social and environmental protections. Under these circumstances, measures to improve reverse logistics working conditions and the quality of recovered secondary materials it produces must include informal sector workers (Gill, 2009). Doing so requires recognising the barriers that hinder improvements to reverse logistics sustainability. The fragmented and disorganised nature of waste collection through independent waste pickers makes it challenging for workers to encourage source segregation practices among waste producers in place of deficiencies in the areas from government. Low informal sector knowledge on materials and recycling processes limit the efficiency of secondary materials recovery by the informal sector from MSW (Pumpinyo & Nitivattananon, 2014). The fragmented structure of informal waste management systems makes it challenging to remedy information asymmetries and disseminate this knowledge through to the waste pickers and collectors on the ground to inform on what to collect and how to handle it (Ferri et al., 2015; Kinobe et al., 2015). Likewise, for similar reasons it is difficult to remedy information asymmetries from waste collectors to manufacturers, with no reliable medium through which to channel information on recovered materials such as collection location/source, method or processing conditions (Hande, 2019; Kinobe et al., 2015). Some initiatives such as Kabadiwalla Connect have gone some way to tackle these information asymmetries by developing a platform accessible by smartphone to communicate all the way upstream to waste collectors the value and quantities of waste demanded by the market (Hande, 2019). However, there remains a need to disseminate technical knowledge upstream on materials qualities and properties to help avoid contamination further still at the source and collection stages.

2.3.3 Manufacturing & circular production in India

India is on a trajectory of rapid economic development with an average growth rate in Gross Domestic Product of 6.7% per year between 2008 and 2017 (World Bank, 2019). India's economic strategy has included expanding the nation's manufacturing base and conducting pro-business reforms under the *Make in India* programme to transform the nation into a major global production hub (PWC, 2019). The fulfilment of these economic ambitions would mean an increased national demand for secondary material inputs to manufacturing given the increasing priority given to circular production by global manufacturers. The increase in household disposable income that comes with the nation's rapid economic development will translate to rising consumer demand (Ellen Macarthur Foundation, 2016). Per capita MSW generation is correspondingly predicted to rise by 50% by 2030 against 2001 levels (Kumar et al., 2017). The growing volumes of generated MSW present a growing base of recoverable materials for manufacturers in India. However, as discussed there remains significant challenges to bringing recovered materials up to the standards required by global manufacturers. In recent years particularly both e-waste and plastics waste have dominated in Indian recycling research due to the growing volume of these waste streams and the challenges associated with thier collection and processing (Sharma et al 2015; Shirodkar & Terkar, 2017). The impacts of materials contamination due to poor source segregation are also illustrated in the frequent application of down-cycling, with recovered plastics used in construction materials (Rajput et al., 2012), and the presence of a large textiles down-cycling industry in India (I10, 2017; Recycling Magazine, 2017). Resolving informational challenges in waste management systems reliant on the informal sector can clarify market signals in reverse logistics chains, potentially incentivising the development of systematic collection and processing of MSW and infrastructure for MSWM (Singh et al., 2017). If Kabadiwalla Connect and similar initiatives can successfully address these challenges and develop India's secondary materials supply, then India could become a preferable location for circular production over more expensive markets with larger supplies of secondary materials like the EU, US and China. By virtue of developing India's secondary materials supply, reverse logistics supply chains can then contribute toward addressing India's broader challenges with MSWM.

3 Research Methodology & Design

This thesis topic evolved from a student field project to India in partnership with the host organisation Karo Sambhav, an Indian E-waste PRO. The project was tasked with investigating the challenges and opportunities faced by Karo Sambhav regarding its operations within the Indian e-waste EPR system. Among the opportunities in Indian waste management facing Karo Sambhav was the option to become more engaged in secondary material flows from the Indian informal waste management sector by facilitating secondary material transfers to the Indian manufacturing sector. Discussions during the field trip with Mr Singhal, the founder of Karo Sambhav, and with a regional director of a multinational beverage company, provided the starting point for the research problem presented in Section 1.1 of this report. These discussions highlighted the interest existing among EPR organisations to facilitate transferring secondary materials from the informal sector toward Indian manufacturers. The discussion also revealed the priority that was being placed on determining standards and specifications that could be applied to secondary materials supplies. A subsequent brief literature review on secondary materials use in manufacturing revealed how little the field of production with secondary materials had already been researched from an organisational perspective. This lack of research pointed to a current poor understanding around why brands and manufacturers in general as well as those in India are not using and procuring more secondary materials. It was from this insight that it became apparent there is a need for developing understandings outlining the nature of problems (Verschuren et al., 2010) surrounding secondary materials use and procurement in manufacturing.

The decision was taken to produce a qualitative exploratory study, based on unstructured interviews with consumer brand and manufacturer representatives as well as with experts on Indian industry. The research was tasked with the aim of establishing a basic understanding for the problems related to secondary materials use and procurement in Indian manufacturing. This understanding would be achieved by describing the factors and barriers to secondary materials procurement, which would then provide the foundation for further research that may be guided by concerns for generalisability and causality (Verschuren et al., 2010). Given that the research would be addressing a knowledge gap in the field of secondary materials use and procurement, its theoretical underpinnings needed to be synthesised from research in fields related to secondary materials use and procurement (Verschuren et al., 2010). As mentioned during the introduction, these theoretical fields included supply chain management, circular economies, industrial ecology and sociological theories. The theoretical framework would then be applied in guiding empirical data collection in the field. Collected data was then analysed, categorised and described to produce the findings found in Table 5-1 and Table 5-2. In order to extract practical use from this research (despite it coming in at the earlier stages of knowledge creation surrounding secondary materials use and procurement) the choice was made apply findings in a broad and hypothetical discussion for their implications on secondary materials brokers. Deduced implications would form the basis of idea generation of actions that secondary materials brokers could take to develop secondary materials systems. While the recommendation would be speculative, they would nonetheless be based on empirical observation and findings.

The following two main sections present the processes and methods applied throughout this research and are broken down into two main stages that this research was composed of, the desk research stage (Section 3.1) and data collection and analysis stage (Section 3.2).

3.1 Desk Research

First detailed is how the evaluation criteria were arrived at, given how they constituted the analytical point of departure for this research. Following on from the methodology of the evaluation criteria is an overview of the methodology for the literature review and theoretical framework section. The methods are presented in this manner in part because the creation of the evaluation criteria, conducting of the literature review and construction of the theoretical framework occurred in unison alongside one another.

3.1.1 Evaluation criteria

The standpoint from which data collection would occur was based in evaluation criteria deduced from the research aim using the process outlined below:

Based on the research aim and questions, the objects of study for this research which were subject to analysis (Verschuren et al., 2010) are:

- Manufacturer procurement and production processes regarding both virgin and secondary production materials
- Factors of materials use and procurement
- Barriers to secondary materials procurement

By studying the research objects of manufacturer procurement and production processes, the relevant underlying factors can be observed. Using the factors of materials use and procurement as a research object, the barriers to secondary materials use and procurement can be deduced. Lastly, the barriers to secondary materials procurement become an object of study to analysing what implications the barriers to secondary materials use and procurement have for secondary materials brokers. Thus, the research perspectives applied to all the research objects (Verschuren et al., 2010) are:

- **Factors** of materials use and procurement in Indian manufacturing
- **Barriers** to secondary materials use and procurement in Indian manufacturing
- **Implications** of barriers for secondary materials brokers in India.

These research objects and perspectives provide the key concepts of this investigation, serving as the basis for conducting the literature review and construction of the theoretical framework that guided the data collection process. The key concepts of this study were therefore:

- Production materials
- Factors of procurement
- Barriers to secondary materials procurement
- Secondary materials broker

To be of practical use for setting the scope of this investigation by guiding the literature review, theoretical framework construction and vis-à-vis, these key concepts were narrowed down, defined and operationalised through the process of unravelling key concepts (Verschuren et al., 2010). This process involved breaking down, with the aid of reviewed literature on supply chain management, industrial ecology, circular economy and sociological theories (Section 3.2.2), the concepts over multiple tier/stages to arrive at ever finer and more precise sub-components. The finest and most precis aspects of key concepts resulting at the end of concept unravelling became the operationalised form of the key concepts, constituting the evaluation criteria that are compiled in the theoretical framework (Appendix F). The method used to conduct the literature review is now presented below in the next section.

3.1.2 Literature sampling

The process of evaluation criteria use and development fed into the literature review by first guiding the types of search terms used to select relevant literature. The literature would then be reviewed for additional elements and aspects that would provide greater detail and more precise perspectives of the key concepts. Where it appeared relevant, additional rounds of literature sampling were conducted based from elements and aspects extracted from the literature. Search terms from the initial key concepts and subsequent elements and aspects are presented in Table 3-1:

Key Concepts	Elements and Aspects
Production materials, procurement, barriers secondary materials broker, India	Circular economy, Circular supply chain, Reverse logistics, India, Supply chain management, Supply chain theory

Table 3-1 Literature search terms based on key concepts and unravelled elements and aspects

Literature sampling was conducted via LUBSearch (Lund University library's electronic catalogue search engine). Searching for literature on LUBSearch was conducted by means of convenience sampling, meaning accessibility to literature samples was a decisive factor in their selection (Bryman, 2008). The convenience sampling search process pursued the following sequence:

1. Enter combinations of search terms found in Tabl 3- into the LUBsearch Boolean search engine, with searches being conducted under all search fields present e.g. *all text*, *author*, *title, subject term* etc
    - Example search term: '*'Production materials OR 'procurement' OR 'India'*'
2. Reduce search results down to peer review academic articles, periodical journals and ebooks
3. Reduce search to results published between 2015 and 2019
4. Browse list of keywords flagged in search result and reduce selection to keywords with clear connection to materials procurement, manufacturing, India, environmental sciences and sociology subjects and lastly in line with the key concepts,
5. Browse the titles of all articles in subsequent search results
6. Browse the abstracts of results with titles that appear to correspond with stated key concepts
7. Archive articles where the abstract subsequently corresponds with the stated research key concepts
8. Continue the title and abstract sample search process for the first three pages of search results (50 results per page)
9. As the search engine revises available options of associated keywords after each keyword selection process, re-select key word search according to stage 3 after browsing three pages of search results
10. Stop searching upon collecting a combined total of 35 samples from across both sampling processes.

Beyond consideration for the number of samples that could be reviewed as part of the narrative review process in the time allocated, the limit of 35 samples was set arbitrarily.

3.1.3 Literature review & theoretical framework

Selected literature was reviewed with the aid of the synthesis matrix tool, which enabled the compiling of key themes central to multiple studies along with a summary of each study and the different perspectives towards the key themes. As the review by Govindan & Hasanagic (2018) provided part of the justification for this study and encompassed a range of other literature in related fields, it was the first article reviewed and therefore shaped the format of the ensuring synthesis matrix. Microsoft Excel was used to construct the synthesis matrix following the sequence outlined below:

1. Identify arguments and findings in reviewed sample that correspond with the key concepts
2. State sample name, authors and publication year in first column of synthesis matrix, with each row representing one sample
3. Compile key arguments and findings of reviewed sample in second column of the synthesis matrix
4. In subsequent columns beyond the right of key arguments and findings, summarise under a narrative theme, data extracted from sample that correspond with key concepts.
5. Columns are limited to one narrative theme but multiple entrants of extracted data can be placed under the same theme when appropriate
6. Multiple narrative themes can be added to subsequent columns when appropriate
7. If the narrative themes of data extracted from a sample is similar to that of a narrative theme already listed in the synthesis matrix, then that data can be added to the existing narrative theme column on the row of the sample in question
8. Extracted data is presented and analysed in the literature review

The output from the literature review and concept unravelling collectively constitute the theoretical framework and the evaluation criteria that guide the data collection and analysis in this study. The narrative themes from the synthesis matrix constituted the main elements of factor categories presented in the theoretical framework (e.g. supply chain factors -supply networks). The different summaries of those themes across different literature constituted the aspects and resulted in presenting the final evaluation criteria for factors of materials use and procurement. The theoretical framework can be found in Appendix F.

3.2 Data Collection & Analysis

3.2.1 Interviews

Unstructured interviews were conducted with two profiles of respondents. The first profile included representatives of manufacturing companies with operations in India or similar locations, and the other profile was with experts on manufacturing industries of Indian industry in general. 11 interviews were conducted in total with durations ranging from 30 minutes to almost 1:40 hours. Eight of the interviews were conducted via online video calls, two in person and one over the phone. All interviews except the one phone interview were recorded. Prior consent was obtained from the respondents to record the interviews and data was also collected in notated form. Respondents were informed that all interview data would be anonymous when presented in the thesis.

As this research is an exploratory descriptive study, it is guided by an interest to be open to avenues of enquiry that emerge throughout the research process. The choice of unstructured, interviews reflects this preference by providing respondents with the opportunity to contribute issues that they perceive to be relevant to the topic of research (Bryman, 2008). Likewise, the interview guide used (Appendix C) was developed along the lines of the theoretical framework, summarising the framework's contents into key talking points and providing a valuable investigative point of departure. Applying the framework through unstructured interviews enabled a balance to be struck between rooting the data collection in a wider body of research, of gauging the relevance of the theories selected, and having an openness for concepts omitted from the framework. An advantage of summarised interview topics is in reducing the chances of asking leading questions and instead enabling the respondents to discuss the topic in question on their terms. The interview guide was emailed in advanced to respondents together with a one-page overview of the research (Appendix B).

3.2.2 Respondent sampling

Interview respondents were primarily obtained through snowball sampling (Bryman, 2008), drawing on contacts available through members of staff and alumni of the educational institution that this research was written at. Within that frame of access, interview respondent selection was guided by seeking out people who work in or with consumer goods brands and manufacturing in several product categories (textiles & garments, furniture, EEE, food and drinks packaging). Roles sought within these organisations include sustainability, supply chain management/procurement, senior management, human resources, finance or product design. This choice of company representative profiles was sought after due to the different professional perspectives that were deemed to be of interest according to factors present in the theoretical framework. Ideally, brand or manufacturer company representatives or at least the company, should have some presence in India or if not then in another country with a similar economic profile. On the other hand, respondents that were not affiliated with a brand or manufacturing company needed to have a professional connection to India. The difference in requirements relates to the type of perspectives that each respondent category was able to provide. Manufacturing company representatives could provide insight on supply chain and sustainability management factors of brand and manufacturer head offices based outside of India but that are relevant for off-shore production in India or similar regions. Non-company affiliated professionals were sought after however, due for the insight that could be provided on the Indian manufacturing environment. A list of the respondent profiles as well as interview data can be found in Appendix D.

All respondents were contacted by email or through LinkedIn, with a request for an interview in which the research and its value potential were introduced. A copy of the interview request text can be found in Appendix A. If the contact replied but was unable to participate in an interview, a follow up email was sent to ask if they knew of anyone who might be able to participate in this research.

3.2.3 Data Analysis

Given that the construction of the theoretical framework constituted a significant component of this research a portion of the data analyse occurred already during the literature review (Verschuren et al., 2010). The perspectives extracted from previous literature and concepts synthesised fed into forming the researcher's ontological disposition prior to conducting any interviews. Despite that unstructured interviews were used to during data collection, the use of an interview guide rooted in the theoretical framework exerted a degree of influence to the type of empirical phenomena that would be observed, sought after and picked up by the researcher. The first case of this was with note taking during the interview, manifesting in which elements of the interview data were notated versus those that were not. When each interview was listed to and reviewed against notes, the same process occurred again, particularly given the practice that was used. Two forms of notes were taken simultaneously on separate documents. One set of notes contained paraphrased summaries of the interview dialogue with efforts made to reduce as much as possible the inclusion of the researchers own analytical interpretations. The other set of notes contained analysis and interpretations of the interview data with a consideration for the research questions. After having reviewed the interview audio recordings, paraphrased interview data was then subject to coding and categorised based on the evaluation criteria in the framework. Data that emerged during interviews generally tended to not conform to the evaluation criteria of the theoretical framework, being instead a slight variation of it but generally still being applicable to the overarching elements and factor categories in the framework. A copy of the coding structure can be found in Appendix F.

The data analysis applied in this research is strictly qualitative and primarily seeks to learn of what type of factors and barriers to secondary materials use may exist. Therefore, any aspects related to the factors and barriers identified and analysed in quantitative terms such as frequency or scale have no relevance here and are not considered. This study does not aim to produce generalisable findings. Beyond the scope of this study such quantitative data certainly holds relevance in general for the field of understanding and overcoming barriers to secondary materials use and procurement in consumer manufacturing. However, first it is important to identifying what types of factors and barriers may exists. Gathering such data can then feed into future studies of a quantitative nature that can then pursue the frequency, depth and potential causes of factors and barriers to secondary materials use and procurement.

4 Theoretical Framework

This section discusses the main theoretical concepts that fed into developing the theoretical framework which guided empirical data collection when conducting this research. The main research gap being pursued in this investigation is primarily in relation to secondary materials use and procurement, literature on this topic is limited, let alone in the Indian context. This review therefore draws on core literature in the fields of supply chain management, circular economies, industrial ecology and institutional theory to guide empirical observations of secondary materials use and procurement among consumer manufacturers in India. Drawing on these concepts to collect and review interview data can provide a close enough glimpse of secondary materials procurement so as to enable factors and barriers per se not covered by the theoretical framework, to emerge from the data and its collection (Bryman, 2008; Punch, 2013). Each of these theoretical disciplines are discussed from the perspective of secondary materials use and procurement in consumer goods manufacturing and summarised in the theoretical framework presented at the end of the chapter.

The research context of the Indian manufacturing sector is an additional differentiator of this investigation, but will not itself explicitly feed into the formation of the theoretical framework. Instead, the Indian contextual factor will feature in the research by applying the devised theoretical framework on cases of companies producing in India, and seeing how this impacts the collected data and concluded-upon findings. However, by heeding calls to consider the role of sociological factors in secondary material procurement (Norris, 2019; Schreck & Wagner, 2017), incorporating into the framework an awareness for theories in institutionalism, social capital and social embeddedness provides an indirect theoretical sensitivity for contextual factors.

4.1 Sociological Theoretical Factors

Factors of sociological theory are integrated into the framework to provide a complementary perspective through which to view and analyse the rest of theoretical components on supply chain, circular economy and industrial ecology, used in this study. As such, the sociological factors employed will be generic and in isolation, bear no relation to supply chains or circularity. A brief overview is provided below of the sociological theoretical factors selected for this study:

4.1.1 Network theory

Network theory seeks to understand society through evaluating the patterns and relationships observed in social interactions between individuals and groups (Ashton, 2008). Identified patterns can help illustrate the overall structure and shape of social ties across a social group which in turn can reveal its internal dynamics and social power distribution.

4.1.2 Social capital

Portes (1998) states that social capital can be considered as 'the ability for actors to secure benefits by virtue of membership in social networks or other social structures' (Portes, 1998). Benefits include privileged access to power, services and the resources of companions by virtue of social ties or position in a relevant social structure (e.g. high-income professionally accomplished family). Benefits are often distributed through gifts and maintained by reciprocity and adherence to group norms (Portes, 1998).

4.1.3 Institutional theory

The "three-pillar's" framework (Palthe, 2014; Scott, 2010, 2014) is a common conceptualisation of institutions:

Regulative institutions: Formalised rules and enforcement mechanisms e.g. laws, contracts, marriage currency etc
Normative institutions: Informal rules and norms characterised by habit and social obligation e.g. manners, family and friendship duties
Cultural-cognitive: Values and belief systems which are 'shared conceptions that constitute the nature of social reality' (Scott, 2014) (e.g. religion, political ideology, language).

4.1.4 Social embeddedness

Social embeddedness stipulates that social context and structure delineate the options available for the development of a social phenomenon, fundamentally shaping its outcome (Portes, 2010). Viewing a given surrounding social context through the lens of social embeddedness enables studying social phenomena by proxy. As a crude example: embedded in surrounding events the room for public debate on climate change may be constrained by the onset of more acute events, such as a financial crisis. Conversely the actions of a resolute teenage activist may help expand the room for debate and the latter's level of ambition.

4.2 Supply Chains: Theoretical Factors

Common to all supply chains are the features of production, inventory, location, transport and information (Hugos, 2006). Based on different configurations of these factors, how a supply chains is structured and managed will vary widely between industries, companies and product lines (Scott et al, 2018). As supply chains are fundamentally about processes of material flows that progressively accumulate value (Hugos, 2006; Scott et al, 2018), they have themselves no inherent disposition in favour of either virgin or secondary materials flows. However, given that production and therefore supply chains currently operate within the dominant economic paradigm of linear production, their structures and management may lean to have a pre-disposition in favour of virgin material flows. Understanding the fundamental theoretical components of supply chains can guide empirical observation that assess if and how a supply chain's configuration is conducive or restrictive towards incorporating secondary material flows, highlighting factors and barriers to secondary materials procurement.

4.2.1 Supply chain structures

Over time, the changes in management of supply chains have seen their structures develop from vertical integration, whereby supply chain stages are in-house, to virtual integration where companies focus on specialisation, trading in providing core competences (Hugos, 2006). In recent years there have been trends observed in a return back to vertical integration of supply chains (Favaro, 2015). Nonetheless, moves towards specialisation that came with outsourcing and offshoring of globalised production systems saw the growth in size and complexity of manufacturer supply chains. Participants in a supply chain will have their own spread of product and service suppliers, each having their own multiple nodes to other suppliers to support their operations (Scott et al., 2018). In this configuration, systems resemble networks more than linear chains (Jain et al., 2018). Actors within a supply network can be referred to in terms of being 1st tier, 2nd tier etc, communicating the degree of separation to a manufacturer in question by either being direct suppliers, a supplier's supplier and so on (Scott et al., 2018). This attention to network distance between manufacturers and suppliers can communicate the complexity of relations between supply chain actors and the ensuing practical implications on the level and quality of information exchange and interaction that can be expected between actors.

Network complexity in terms of the number, size and depth of collaborative partnerships can impact the degree of risk within the supply network. The number of exchanges present across a network to facilitate a unit of production can also be taken to represent the number of opportunities for network error between participating actors (Jain et al., 2018). When considering the pursuit of secondary materials, this type of supply network risk could manifest in a network's capacity to communicate upstream detailed signals from end manufacturers on the quantity and quality of secondary materials demanded (Hart et al., 2019; Hugos, 2006; Ivanov et al., 2019; Jain et al., 2018). Supplier collaboration can serve to reduce risk relating to issues of trust and certainty between supply network actors but is not without its own risk factors. As companies become more committed to the capital and trust invested into a collaboration, the social capital garnered from it, and are brought closer to one another, each participating stakeholder becomes susceptible to the general risks associated with the other stakeholder's respective sectors (Ashton, 2008; Behera et al, 2012; Manavalan & Jayakrishna, 2019). Buyers collaborating with India's secondary materials suppliers for example, may assume some of the risk of material supply uncertainty and information asymmetries that are related to the informal sector's role in the nations secondary materials systems (Kumar et al, 2019).

4.2.2 Supply chain management & governance

However a supply chain is structured, its operation will be managed and governed by direct and indirect forces. Formal governance mechanisms contribute reliable accountability mechanisms to the management of supply chains in being often underwritten by legal backing. Examples include regulatory standards set by governments (de Romph & Van Calster, 2018) and third-party organisations, or legally binding buyer/supplier contractual agreements for product and service standards, such as the restricted substance lists and buyer code of conduct lists (Ivanov et al., 2019). The norms, habits, routines, culture and values present which develop through the nature of social interactions and practices across a supply chain network provides informal governance mechanisms for supply chains (Cardoso de Oliveira et al., 2019; Singh & Giacosa, 2019). These elements of informal governance foster trust, predictability and expectations based on experience and precedent. Both formal and informal governance and management mechanisms contribute assurances and degrees of certainty in the face of supply network uncertainty (Cardoso de Oliveira et al., 2019). The level of certainty could enable risk taking among supply network actors toward collaboration and expand into handling flows of secondary materials. When governance mechanisms are low or non-conducive to secondary materials flows, they could produce lock-in and inertia in virgin materials systems, serving as a barrier to developing secondary materials systems (Cardoso de Oliveira et al., 2019).

Beyond the impact of who and what a supply chain will manufacture, product type will also influence supply chain management based on the nature market demand for it. Demand driven supply chains - those sensitive to product demand and that are managed with a priority for responsiveness - require reliable and efficient information flows and short lead times which can enable manufacturers to produce in batches while holding a low inventory of stock (Ivanov et al., 2019). Alternatively, supply driven supply chains - those experiencing consistent and reliable demand - are characterised by continuous production and economies of scale with a primary focus on efficiency and cost reductions (Ivanov et al., 2019). In reality, the nature and extent of demand can best be considered from the perspective of a scale, where manufacturers are in a balancing act between a supply chain efficiency and its responsiveness (Hugos, 2006; Ivanov et al., 2019; Scott et al., 2018).

Geographical structural factors of supply networks can feed into the latter's management. The viability of a resource (e.g. secondary materials), to a supply network actor's needs of network responsiveness versus efficiency, can be based on its relative proximity (how far away it is), dispersal (its concentration), impacting transportation costs and delivery times (Hugos, 2006; C. Scott et al., 2018). Resource proximity and dispersal also impact the responsiveness and efficiency of supply chain management regarding information flows on sought-after materials. For manufacturers with needs of secondary materials traceability and quality assurances (Agrawal & Pal, 2019), proximity, dispersal and therefore information flows can be of particular importance. Supply network structural factors of positional and bargaining power present in buyer/supplier relations can steer the nature of network collaborations between these actor groups (Cox, 2004). Viewed at the network level, power dynamics of supplier/buyer relations can reveal if and where actors exist with strategic positions over material flows, dubbed structural agents for their capacity to exert influence over the structure of a supply network (Binder, 2007; Laurenti et al., 2018). Structural agents, and their enabling conditions can be important to identify given their effective position as gatekeepers to efforts for regulating how a supply network might operate (e.g. for or against secondary material flows, relative to their own interests) (Binder, 2007; Jain et al., 2018; Laurenti et al., 2018).

4.3 Circular Economy: Theoretical Factors

Govindan and Hasanagic (2018) reviewed of 173 academic journal articles on circular economy in supply chains that were published between the years 2000 and 2016 (including 5 other review articles in similar fields) to synthesise the drivers, practices and barriers to circular supply chains. Due to the study's broad coverage of circular economy literature, and its close alignment to this research, Govindan & Hasanagic (2018) provide a basis to review literature on circular economy, industrial ecology and institutional theory. Categories of barriers to circular production present in Govindan & Hasanagic (2018) are extracted and used in this study's literature review to identify factors and barriers to the use and procurement of secondary materials in consumer manufacturing.

4.3.1 Technical & knowledge

When organisation and individual practices are geared to deliver linear production, many actors find themselves in positions of not having the necessary knowledge for circular production. Knowledge deficiencies in companies can include how to use and procure secondary material (Agyemang et al., 2019; Benton, Hazell, & Hill, 2015; Liakos et al., 2019) or uncertainty in how circular business models relate to linear business models (Agyemang et al., 2019; Hart et al., 2019). More severe knowledge deficiencies relate to low knowledge on circular economy principles overall, conflating circularity with environmental sustainability in general (Liakos et al., 2019). The allocation of resource can impact manufacturer's capacity to implement secondary materials production. Manufacturers may require R&D capabilities and in-house laboratories to secure compatibility of secondary materials with products performance, quality, manufacturing and regulatory requirements (Agyemang et al., 2019; de Mattos et al., 2018). Part of the requirement for manufacturers to ensure materials compatibility lies in that regulatory standards, both governmental and third party, for secondary materials are under-developed. The lack of standards mean that materials procurement departments have no information, let alone assurances, of material quality and performance (Govindan & Hasanagic, 2018; Hart et al., 2019; Kumar et al., 2019), with the securing of such information through the supply chain being too costly (de Romph & Van Calster, 2018; Govindan & Hasanagic, 2018).

However, work on material compatibility would still be required even if a standards systems were established. The degradation of material properties following use and re-processing limit in some instances the degree to which secondary materials can be applied in place of virgin materials. Alterations in product design, potentially towards material substitutes or the informed compromising of product quality may be required (Benton et al., 2015; de Mattos et al., 2018; Esposito et al., 2018; Govindan & Hasanagic, 2018; Jain et al., 2018; Koszewska, 2018), Such requirements may prompt a re-evaluation of whether secondary materials use is the most appropriate circularity principle for the company (Koszewska, 2018). Manufacturers seeking to recover materials from their own retrieved products will need to design products with a compatibility for recycling, potentially by drawing on the knowledge and insight of recyclers (de

Romph & Van Calster, 2018) and/ or by reducing the content of hazardous materials (Bozena, 2018; de Romph & Van Calster, 2018; Govindan & Hasanagic, 2018).

4.3.2 Managerial

When an organisation seeks to change strategy and re-orient its operations, the initiatives will bear costs on those tasked with implementing the transition (de Mattos et al., 2018). Transition costs that garner enough resistance among staff can potentially impede an organisation's ability to implement a transition at all. Barriers related to the technical knowledge and resource deficiencies discussed, including the need to learn new skills and time costs associated with acquiring them can weaken the legitimacy and support that staff reserve for circular economy initiatives (Agyemang et al., 2019). Strategic misalignment between senior management policy relative to supply chain operation structure may place high costs on staff to pursue production with secondary materials. When this pressure occurs in a supply chain structured for linear production it may weaken staff support for using secondary materials (Govindan & Hasanagic, 2018; Ivanov et al., 2019). Ignorance or opposition rooted in perceived risk from change which may entail a threat to the status quo of vested interests represent some of the more ideological sources of resistance to pursing circular manufacturing systems (Agyemang et al., 2019; Benton et al., 2015; de Mattos et al., 2018; Ivanov et al., 2019; Kumar et al., 2019; Prendeville et al., 2018). Management in manufacturing organisations can potentially be the source or solution to these forms of staff resistance in transitioning to circular production.

Moving from linear production to circular production entails a significant departure from incumbent operations, practices, culture and knowledge. Senior-, middle- and factory-level management need to recognise and mitigate the discrepancies in these areas that staff will be expected to handle, which are associated with transitioning from linear and circular production systems (Agyemang et al., 2019; de Mattos et al., 2018). Senior management will need to allocate resources to strategic visioning and generate guiding principles for a business's operations and value proposition that are centred on the closing of material loops (Agyemang et al., 2019; de Mattos et al., 2018). Strategic re-alignment, together with training for middle and lower level management to addresses circular economy knowledge deficiencies, can help align a company's circularity objectives with the supply chain implementation of those objectives (Ivanov et al., 2019). Beyond providing the support and conditions necessary to foster buy-in from management across a supply chain (Prendeville et al., 2018), the business benefits of a secondary material transition need to be clearly established and stated (Agyemang et al., 2019). A compelling business case for secondary materials use can help to counter production manager aversion to both risk associated with departing from linear production systems (de Mattos et al., 2018) and to large long-term investments that are dis-incentivised by short managerial term limits (Kumar et al., 2019).

A supply chain's management structure should be evaluated for its conduciveness to disseminating knowledge and practices in secondary materials use and procurement (Govindan & Hasanagic, 2018). Business unit autonomy can provide the flexibility that production facility level management may need in order to be responsive to local level challenges and needs (Benton et al., 2015; de Mattos et al., 2018; Hugos, 2006), helping to foster ownership across management in the supply chain for transitioning to circular production. Factory level attention of management can include training on secondary materials use in production (Govindan & Hasanagic, 2018; Kumar et al., 2019) and changing habits set by and for production with virgin materials (Cardoso de Oliveira et al., 2019). For production within company cultures and/or surrounding societies where the power distance believe[7] is prevalent, incentives for management may be characterised by the desire to acquire status and patronage from their senior peers (Singh & Giacosa, 2019). Power distance incentives may steer management action through desires to curry favour on the terms of their superiors, circumstances in which the need for strategic visioning and leadership towards circular production can clearly state the terms upon which status might be acquired (Singh & Giacosa, 2019)

4.3.3 Economics & markets

While the means of income generation for manufacturing companies will transition to circular production models, these organisations and their management will continue to be steered by neo-classical business principles of the economies within which they are embedded (Govindan & Hasanagic, 2018; Laurenti et al., 2018). The costs of restructuring toward circular production can require high upfront investments (Govindan & Hasanagic, 2018) that have long payback periods (Benton et al., 2015), requiring compelling risks and costs of inaction to motivate such investments (Agyemang et al., 2019; Benton et al., 2015; de Mattos et al., 2018; Hart et al., 2019). Secondary material production investments will need to be strategically timed to coincide with the end of or following payback periods for the significant capital investments that manufacturers can have in linear production systems (Benton et al., 2015; Hart et al., 2019).

Consumer and market pressure to persuade manufacturers to transition toward production with secondary materials (Agyemang et al., 2019; Esposito et al., 2018; Govindan & Hasanagic, 2018) will contend with company priorities for profit growth and meeting market demand (Hugos, 2006; Koszewska, 2018). Calls for manufacturers to transition towards circular production must therefore factor in the need to maintain market standards, the costs of reverse logistics as well as continuing to meet consumer expectations relating to product innovation cycles, quality, quantity and price (Hugos, 2006; Koszewska, 2018). Should using secondary materials negatively impact consumer relationships with products due to a perceived or actual lowering of product quality (Singh & Giacosa, 2019), circular products will need to demonstrate benefits in other forms that outweigh these cost. Sources of profit in production with secondary materials can include market growth (Agyemang et al., 2019) for circular products, or in costs savings from using cheaper options of secondary materials once logistics and technical challenges are overcome (Liakos et al., 2019). Cleaner production methods that use recovered post-industrial waste can also improve material use efficiency can also yield cost saving (Esposito et al., 2018).

While opportunities for cost savings exist when using certain secondary materials, certain virgin material fractions such as plastics or textiles remain cheap and in abundant supply (Govindan & Hasanagic, 2018; Hart et al., 2019; Kumar et al., 2019), meaning the cost of materials will likely need to supplement other economic arguments in favour of using secondary materials. Uncertainty in supply of virgin materials or their potential subjugation to regulation that could risks price increases exemplify some of the arguments in favour of using secondary materials on the grounds of production and investment certainty (Govindan & Hasanagic, 2018).

4.3.4 Government policy

A manufacturers' ability to transition to using and procuring secondary materials while operating in competitive markets will be influenced by the business environment conditions formed by government policy. Laws and regulation supporting industrial growth in its linear economy form may be prohibitive, even punitive towards transitions to circular production, with financial

[7] In the power distance belief, inequality is viewed by individuals to be justified on the grounds that an individual's power and status is rightfully held by them owing to their earning of it through merit and endeavour (Singh & Giacosa, 2019).

incentives to develop sources of virgin materials, or regulations on materials quality and use (Agyemang et al., 2019; Govindan & Hasanagic, 2018; Kumar et al., 2019). Conversely, governments with ambition to develop economic circularity, attract business or address waste management problems may support the development and use of secondary materials supplies by providing economic incentives (Agyemang et al., 2019) or through direct government investment in building secondary materials systems (Bozena, 2018). Where government regulation directly or indirectly relating to the use and development of secondary materials systems is missing, actors pursuing circular production are left to operate in an uneven playing field that is skewed in favour of linear production systems (de Mattos et al., 2018; Govindan & Hasanagic, 2018; Kumar et al., 2019). Regulation and standards on the properties (Govindan & Hasanagic, 2018) or hazardous substance content (de Romph & Van Calster, 2018) of virgin materials provides buyer manufacturers with the assurances of material quality. The playing field is therefore levelled between all virgin material producers but not secondary materials producers, owing to the latter's omission from such rules. Secondary materials are therefore missing the regulative push needed to unilaterally bring their quality to parity with virgin materials. Subjecting all secondary materials producers to the same standard can enable the sector to compete within itself, consolidate and then be in a position where it can compete externally with the virgin materials (de Mattos et al., 2018; Govindan & Hasanagic, 2018; Kumar et al., 2019).

The stability of politics or government itself can impact the degree to which policy and regulation developments will occur towards secondary materials systems. Irregular and weak policy developments will in themselves be a barrier but also place further barriers in the form of weakening business confidence for investing in and pursuing production with secondary materials (Benton et al., 2015). Where policy and laws are in place to support secondary materials systems, deficiencies in enforcement and implementation can be equally hindering as political instability, weakening business confidence and deterring the investments needed for companies to transition to circular production (Agyemang et al., 2019; Govindan & Hasanagic, 2018; Hart et al., 2019; Kumar et al., 2019). Government support in the form of knowledge, technical assistance or finance may be more reliable and forthcoming from local and regional governments when municipal and county authorities compete to attract skills and investment through pursuing sustainable urban development (Prendeville et al., 2018). With a closer administrative proximity to industrial and waste management systems than national governments, local authorities are better positioned to tailor their support and responsiveness to the needs of actors working to develop secondary materials production systems (Prendeville et al., 2018).

4.3.5 Infrastructural & geographical: theoretical factors

Along with and at times, a result of the policy and regulative environment, geographical and infrastructural factors can substantially impact manufacturer capacity to procure and use secondary materials in production. Being derived from waste material flows, the quantity and quality of secondary materials collection and processing from MSW can be highly impacted by the extent and quality of MSWM infrastructure (Bozena, 2018; Govindan & Hasanagic, 2018). Direct investments by governments in secondary material systems can provide resources such as pilot projects, R&D facilities, materials processing infrastructure and other technical support to the benefit of manufacturers and users of secondary materials (Ashton, 2008; Govindan & Hasanagic, 2018; Paquin & Howard-Grenville, 2012; Prendeville et al., 2018; Wolf et al., 2007). Government investments can play an important role in providing access to the necessary infrastructure and knowledge to catalyse secondary materials system growth. Government investments can do this by taking the associated investment risk on behalf of reluctant companies that might otherwise not make the investments themselves. Secondary materials systems centred on extensive MSW systems are able to provide detailed information tracking systems that can disseminate material data from disposal to manufacturing use (Govindan &

Hasanagic, 2018). As discussed above, secondary materials systems that rely on the informal sector are currently still grappling with establishing viable information tracking systems, with the private sector stepping in to experiment solutions such as with Kabadiwalla Connect (Hande, 2019).

The state of private sector infrastructure through local industry networks, can be relevant for secondary materials systems when considering the use of post-industrial waste. Material waste flows from industrial parks as well as stand-alone industrial facilities can provide valuable sources of reliably high-quality secondary materials. For industrial waste flows to become a viable procurement option for manufacturers, assessments need to be made on their technical and logistical compatibility in type, quality, quantity and proximity/transport times, for use in circular production (Ashton, 2009; Behera et al., 2012; Chertow, 2000; Jain et al., 2018). For the technical compatibility of waste material flows in industrial networks to be of any use, the adequate social, collaborative and administrative infrastructure needs to be in place within the network to realise the transfer of waste materials. Knowledge exchange, network dialogue and trust are examples of factors that help forge the relationships necessary to persuade industries to integrate their operations with one another in pursuit of production with secondary materials (Chertow, 2000; de Mattos et al., 2018; Wolf et al., 2007). Similarly, the social infrastructure of industrial networks can enable industries to collaborate when in need of a partner with whom to source secondary materials together with in order to make the procurement economically viable (Burström & Korhonen, 2001; Chertow, 2000). The social infrastructure underpinning industrial collaborations can develop organically between actors or be actively facilitated. Industrial clusters may contain one or two dominant facilities that serve as a primary- or anchor-supply of secondary material flows to tenant industries (Chertow, 2000) and coordinate collaborations. With anchor actors whose size may gain dominant political and societal influence locally, there is a reliance that the organisation's interests and agendas do not run counter to the development of further secondary material infrastructure, for example by such developments undermining the anchor's revenue from supplying secondary materials (Prendeville et al., 2018). Aside from anchor actors, local intermediary and network actors, government bodies or trade associations can also potentially coordinate collaborations (Boons & Spekkink, 2012; Chertow, 2000; Howard-Grenville & Paquin, 2009).

4.4 Theoretical Framework Summary

Reviewing the three disciplines included in this literature produced the concepts that can be used to build a theoretical framework. The diagram presented in Figure 4-1 conveys how each of the reviewed disciplines are used relative to each other. Factors of secondary materials use and procurement are located at the centre of all the reviewed theoretical concepts, sitting immediately within those of circular economy theory and then within those of supply chain management further still. These three fields of conceptual factors are placed on a backdrop of the wider societal and physical environment which consist of sociological, geographical and infrastructural factors. In Figure 4-1 these last theoretical concepts are presented outside of the concepts displayed within the diagram as they interact with each other as well as directly with each of the concepts represented in the diagram. Lastly, while infrastructural and geographical factors are discussed in the literature review under Circular Economy: Theoretical Factors, Section 4.3, they are presented separately in Figure 4-1 as they both contribute to, while also at times stemming from, Circular Economy factors.

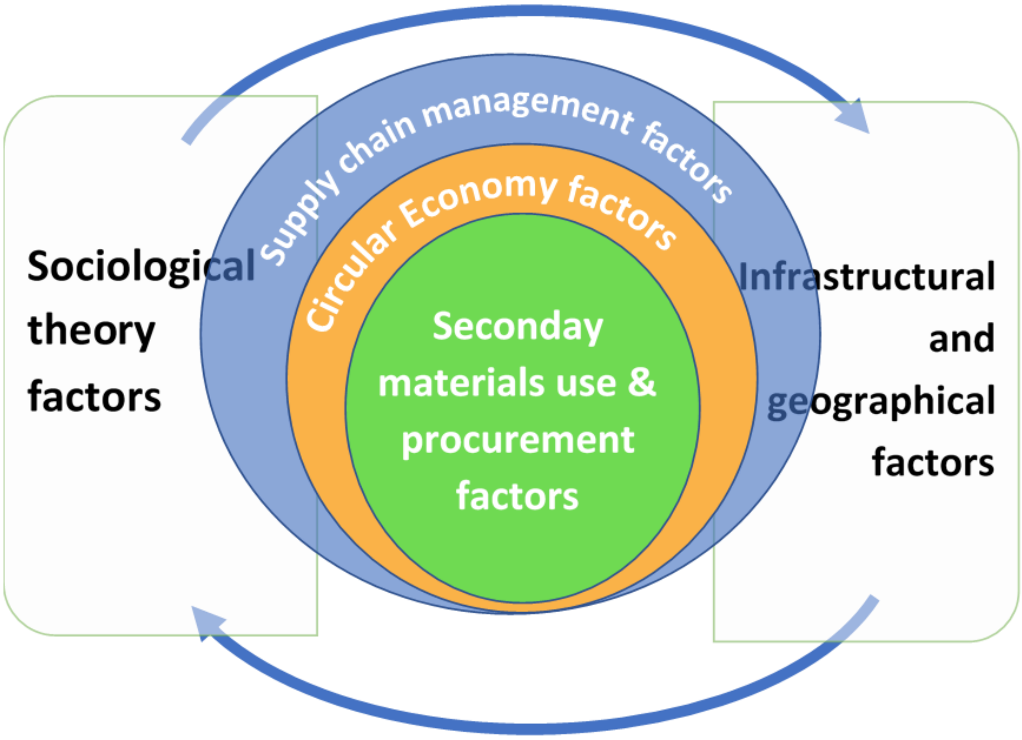

Figure 4-1. Diagrammatic representation of theoretical framework

Source: Authors own elaboration derived from the literature review in Section 4

The key theoretical points extracted from the literature are summarised in **Table 4-1**. Concepts are presented under the main theoretical categories reviewed according to the literature review in the rest of Section 4. Within each theoretical category, concepts and aspects of those concepts are presented. A more extensive version of the theoretical framework can be found in Appendix E, containing descriptions of all the evaluation criteria together with references.

Supply Chain Factors	
Supply Networks	**Supply chain management & governance**
Structural and indirect agents and hold levers to change of material flows Network structure impacts - Complexity - Composition of structural and indirect agents: - Depth of integration - Level of meta-network management Network risk: - IS partner industry risk - Information and quality from informal sector	Supply or demand driven? Formal Governance mechanisms: - Contracts, standards, CoC Informal Governance mechanisms: - Trust, habits, norms, values, belief systems Governance: balancing order and structure with inertia Reconciling core SCM needs with SMs procurement: - Costs, information, inventory, logistics, production stability, product quality

Circular Economy Factors		
Government Policy	**Technical & knowledge**	**Economics & markets**
Laws, regulation and policy: - Restraining/enabling - Financial implications - Level of gov that is intervening - Establish industry standards Political and policy stability: - Consistency – application & enforcement - Business certainty SMs hazardous substances rules - Substance declaration - Information transfer	Knowledge capacities: - Use SMs - On CE principles (conflate with sustainability) - Levels and consequences on business behaviour Resource allocation: - R&D on SMs - Necessary facilities e.g. in-house lab Material - Standards, consistency, quality, different properties Verification costs Product design - Product and process compatible with SM - Substitute with SMs available - High impact materials - Product quality vs material efficiency - Other CE options may be more appropriate - For recycling, involve recyclers	Profit & growth opportunities: - Consumer & market pressure - Mitigate against resource scarcity Transition costs: - Investment & payback period - Brand quality and image - vs inaction costs Opportunity costs of transition - Investments in linear capital - Customer product relationship - Cheaper virgin materials

Circular Economy Factors		
Managerial	Infrastructural & location	Sociological
Resistance to change - Lack of knowledge - Lack of resources - Ignorance of risks (of inaction) and benefits - SCM/business strategy misalignment Leadership & support - Training - Strategic visioning & planning - SMs procurement risk management - Disruptive business models - Business case for SMs Maintain product standards & quality Business unit autonomy Company & Management structure - Incentivise long term CE investments? - Configured for CE dissemination? - Logistics geared for SMs procurement?	Local Industry networks: - Trust - Collaboration & IS exchange - Compatible resource flows - SMs broker - Proximity correlates with depth and extent Dominant actors: - Potential IS anchor - Pro/anti SMs infrastructure agendas State & CE infrastructure: - Recycling collection and processing - Knowledge & pilot projects - Information tracking systems	CE socially embedded in Linear economy -Norms, habits, values, beliefs -Fast turnover, risk aversion, limited materials recover, new product thrill -Reveals structural agents and leverage points for change Individual, societal and cultural barriers - Power distance belief Secondary materials awareness education SMs supplier development - Build Trust - conducive/non-conducive habits & behaviours for SMs procurement - Cleaner production

Table 4-1 Theoretical framework for assessing factors and barriers to secondary materials use and procurement in consumer brands and manufacturers

Source: Author's construction using theoretical insights from literature on supply chain management, circular economies, industrial ecology and sociological theories - see Appendix E for referenced threoretical framework with expanded evaluation criteria

5 Results & Analysis

This section presents the empirical data collected from interviews conducted with manufacturing industry experts and representatives. The format for presenting interview data employed in this section is a descriptive analysis which elevates factors and, where stated by respondents, barriers to secondary materials use and procurement. As stated in Section 3, these data are categorised and interpreted through the perspective provided by the theoretical framework developed from the literature review. This results section therefore follows a structure broadly similar to that represented in Section 4. First interview data is reviewed from the perspective of supply chain management factors (Section 5.1) before moving on to micro level circular economy factors (e.g. 5.2 Technical Issues). The interview data presentation and analysis subsequently proceeds to take a progressively wider scope of circular economy factors moving through Company Managerial Issues (Section 5.3) and out to the macro-level factors of Government and Policy (Section 5.4), Economics and Markets (Section 5.5) and concluding with Infrastructure & Geography (Section 5.6). The data are then summarised and presented in Table 5-1, within which there are two types of presented barriers to secondary materials use and procurement. The barriers explicitly stated by respondents during interviews are presented alongside those that are derived from analysing the identified factor to secondary materials use and procurement. In accordance with ensuring the anonymity of all respondents who participated in the data collection process, all interviewees will be referenced according to their associated Interviewee Number (See Appendix D). For example, data collected from an interview with interviewee number 2 will be referenced in parenthesis as such: (I2).

5.1 Supply Chain Structure, Management & Governance

5.1.1 Supply chain management fundamentals & secondary materials procurement

Total cost of ownership, the sum of all supply chain costs incurred to bring a product to market, was consistently cited as one of the more important standard supply chain management factors that secondary materials procurement needs to reconcile with. The extent to which total cost of ownership impacts the brand/manufacturer choice of secondary materials varied from one company to the next. Brands with explicit secondary or circular materials targets appeared more prepared to absorb higher secondary materials costs (I10, I9) compared to those with weaker and vague circularity ambitions (I1). Some of the larger brands/manufacturers interviewed reported taking advantage of their size and offering to their suppliers, partnerships in multiple locations when there was a 'geographical fit' e.g. colocation of manufacturers and suppliers (I1). For brands placing a higher priority on secondary materials, deepened partnerships could translate to leveraging suppliers to develop access to secondary materials (I10).

The larger size of certain brands also enabled them to set stronger sustainability criteria to include procuring secondary materials (I1, I10). For the smaller brands, managing secondary materials use within the supply chain was communicated to be more difficult. Some brands would experience resistance from 2nd and even 1st tier suppliers for requests of data on resource consumption and emission from production (I4, I7). The availability of supply chain data impacted decisions to select secondary materials suppliers due to buyer needs for data on material quality and on consistency in supply (I2, I10, I1, I9). While physical distances between brands and sourcing manufacturers hampered efforts for the former to obtain requested data on production processes (I7), brands with in-house manufacturing nonetheless still struggled to utilise post-production material waste flows in a structured and systematic way. The time limited and batch nature of product development and manufacturing processes mean production waste flows arrive when the need for them been fulfilled, with demand instead being for subsequent product ranges (I7). In store collection systems have been used to intervene in local material flows (I10), however these seem to be limited to the larger brands in India due to their ability to use their existing logistics infrastructure. The absence of reliable and established third party reverse logistics networks in India limits the quality of recovered products for smaller brands (I3).

5.1.2 Network Structure

Within the total-cost-of-ownership approach to supply chain management, transportation costs for materials and components were stated by multiple respondents as being of increasing importance (I1, I2) due to rising costs of transportation. *Local for local* procurement and production (I1), which locates production as close to target markets as possible and has the additional benefits of reducing supply chain carbon emissions from transportations (I1) are therefore increasingly preferred procurement strategies (I1, I2, I4, I7). Beyond factors of costs and delivery times, risk mitigation against regional political, economic or social disturbances forms the geographical structure of supply chains, with production dispersed across multiple locations (I1). Where manufacturing with secondary materials is prioritised by brands also practicing local for local production, manufacturers can source secondary materials from its production sites where material quality is reliable, and then ship the materials to other production sites (I1, I9). Household waste in the EU is one such source, particularly food and beverage packaging given the level of regulation and enforcement it is subject to during production, and then the level of source segregation upon disposal (I9). Non-EU secondary materials were reported to vary in material quality, with Chinese secondary materials stated as being of reasonable quality (I9). That being said, two of the manufacturers interviewed reported of efforts within their companies to look at options for producing outside of China due to the country's ongoing trade war with the USA at the time of writing (I4, I7). Manufacturers looking at developing secondary materials suppliers outside of China expressed interest in Thailand and Taiwan (I10), alluding to potential for Indian materials producers to catch some of the secondary materials demand moving away from China. In India, efforts to increase the reliability in quality of secondary material sources need to be considered against the significant role played by the informal sector in Indian secondary materials systems, and the need to integrate them into such efforts (I6).

One respondent working in Indian circular materials systems (I8), reported organisations such as Shakti Plastics (Shakti Plastics, 2019), that have inserted themselves as an intermediary between informal material collection networks and formal production systems. The significance of organisations such as Shakti was stated to be their ability to work with informal actors to improve materials collection and segregation practices to an extent that enabled more technically sophisticated methods of materials recovery (I8). Shakti and similar organisations therefore offer avenues to reconcile the quality and reliability concerns of brand manufacturers, with the stake that the informal sector has in Indian waste management. Through maintaining their investments predominantly in the production and supply of virgin materials, larger actors within materials supply networks serve as stop gaps to actors such as Shakti stepping up their operations to increase the supply of secondary materials (I8, I10). Respondents representing smaller brands in the textiles and outdoor apparel sector cited manufacturers presenting barriers to improving materials use efficiency (I7, I4). The supply chains for these actors are characterised by sourced manufacturers simultaneously supplying brands that were competing with one another (I7, I4). In such an advantageous bargaining position (I4), manufacturers require minimum purchase orders from each buyer, where the manufactures themselves procure and own the materials used (I7). The outcome can be over production and difficulty in using surplus materials due to reasons of access discussed in Section 5.1.1 (I7). While the smaller brands could in some instances source materials directly themselves, larger brands with stronger bargaining positions relative to the manufacturers could directly source materials themselves when desired (I10, I9).

5.1.3 Supply chain governance & management mechanisms

Most of the organisations interviewed did not own in-house production facilities, and for those that did, manufacturing tended to be reserved for specialised production where it was difficult to find suitable external manufacturers (I1). Formal mechanisms to manage supply chains were frequently reported during data collection. Purchasing guides were often cited to play a role in steering manufacturer supplier assessment and selection (I1, I2, I4, I7, I10, I9). In certain instances, purchasing guides would contain sustainability compliance criteria with some limited measures for secondary materials content in packaging (I1). Purchasing guides were stated to often be applied together with rigorous materials and product testing prior to confirming the selecting of a supplier and use of contracted purchase orders (I1, I4, I10, I7). Maintaining sourcing quality and subsequently supplier contracts, is contingent on due diligence audits that assess supplier adherence to buyer materials specifications (I7). Notably, for one large garment manufacture, the third party Global Recycling Standards certification system by Control Union (Control Union, 2019), which is limited to secondary textiles materials, was used to certify the quality of secondary materials procured by the brand (I10).

In a number of instances, supplier collaboration is employed for innovating to resolve certain secondary materials challenges (I1). Conditions for doing so can include supplier willingness (I7) the right price (I9) or a shared need among brands to to exert greater pressure on upstream materials suppliers when manufacturers in between may have less influence (I10). However, the extent of R&D collaboration for materials development is limited by the range and complexity of components used in brand product design (I1, I2), at which point greater reliance will be placed on tender processes to see if secondary material solutions are available in the market (I9). To overcome challenges of supplier manufacturer dominance, some of the smaller brands reported collaborating with competitors who sourced from the same manufacturers to pool their purchasing power and collectively assert social sustainability requirements on suppliers (I7). Though textiles and garment brands communicated experiencing supply chain resistance to sustainability requirements, buyers nonetheless reported a perceived norm of overall increasing readiness among suppliers for meeting such criteria (I7). These norms seemed to be developing in the instances where manufacturers had already implemented sustainability practices for certain customers. Manufacturers seemingly seek to capitalise with other buyers on sustainability services once the associated investments have been made (I7), going so far as to reach out to brands to promote their supply of reliably high quality secondary materials (I10). Market impacts on supply chain governance of secondary materials could also be seen with rare earth minerals, when virgin supplies are per definition scarce and therefore expensive. Market actors were stated to be incentivised to provide rare earth mineral recovery services (I1). Interviewee 6 stated there was a need to find a way of integrating this same supply chain governance factor into the informal Indian MSW collection networks to improve recovered material quality (I6).

The presence of supplier/buyer trust was reported as both a boon but also a constraining factor to searching for secondary materials supplies. The development of long robust buyer/supplier relationships provides assurances that reduce the need for costly formal supply chain governance mechanisms of contracts, audits and monitoring relating to an array of factors beyond considerations for secondary materials. Where deep relations have emerged, brands and brand manufacturers stated a greater confidence in the results of collaboration for secondary materials R&D (I1, I9). Some supplier/buyer relationships were stated to be characterised by strong levels of overall trust but lacked opportunities for collaboration on secondary materials development (I4). Relationships such as these risk buyer inertia for pursuing production with secondary materials. The potential costs of switching from a trusted partner to a new, less well-known supplier that offers collaboration on secondary materials development may be too great and lead buyers to forego the pursuit of secondary materials options (I4)

5.2 Technical issues

5.2.1 Secondary materials quality, standards & knowledge

Technical issues related to secondary materials featured significantly in data collection, underlying the responses of every respondent interviewed for this research. An issue unique to secondary materials procurement relative to virgin materials procurement, the salience of material quality is rooted in three issues. First, the need to have detailed knowledge of procured secondary materials content was relevant when dealing with post-consumer material flows. Poor source segregation of MSW as well as the use of mixed material products e.g. polyester-cotton, lead to uncertainties in material quality and its consistency in processed secondary materials (I1, I9, I3, I10, I4). Second, issues of material quality degradation over successive rounds of material recycling would limit the range of applications that secondary materials could be used in (I8, I3, I10, I2, I5). The issue of material quality degradation can interact with uncertainties of processed secondary material quality. When the number of use-dispose-recycle rounds that secondary materials have been subject to is unknown, there is risk of using secondary materials that incorporate multiple rounds of material quality degradation (I8). Beyond the level of materials testing that would be required for procuring products made from virgin materials, procurement of secondary materials requires additional quality testing in the absence of better supply chain information systems.

Issues of material quality were often mentioned in close connection to the absence of comprehensive secondary materials standards systems. The need for standards systems regarding secondary materials specifically, was essentially stated to be due to an inability for certain waste material fractions such as plastics, to be reduced back down to their primary materials (I5). The quality of material fractions that can be reduced to their primary material (such as certain metals), are simply able to use the material standards applicable for virgin materials (I5). Aside from monitoring costs, brands and manufacturers are reluctant to use post-consumer secondary materials in the absence of appropriate standards for fear of compromising product quality and function (I1, I2, I10) and for liability concerns. Without the assurances for secondary materials that standards would provide, the warranties on manufacturer plant equipment using secondary materials as inputs, will be compromised (I5). Brands and manufacturers will also be adopting risk in product performance and compliance with restricted substances regulation (I9). Unfortunately, it was not until the penultimate interview that Control Union's Global Recycling Standards were learned of (I10), coming too late to enquire with the other respondents about their knowledge of this system.

The respondent who cited challenges with using post-production waste (I7) also referred to the need for developing technical knowledge on production processes in order to be better positioned to collaborate with suppliers on cleaner production. For the larger brands working with secondary materials procurement, more long-term challenges were raised with setting up textile to textile circular production systems (I10). Specifically, as textile to textile systems have not been tested yet, there is a large degree of uncertainty on the type of challenges that exist, let alone the scale of those challenges (I10). At a more general level, respondents communicated displayed issues of conflating circular production (including secondary materials use) with sustainability (I4). When discussing the use of secondary materials, respondents either chose to discuss options of materials downcycling or discussed where manufacturing actors equate materials downcycling with materials recycling where material quality is maintained (I5, I3). Waste as a construction aggregate (I1, I5), and waste to energy were the downcycling options raised by respondents (I8, I6).

5.2.2 Resource allocation

The priority areas for resource allocation that were stated by interviewees, largely centred on developing capabilities in two areas, those of waste stream segregation, and of R&D to effectively utilise secondary materials that are characterised by quality uncertainties. Resource allocation priorities for developing waste stream segregation included working with informal waste collection networks. Preferences for collaborating with informal networks were based in working to achieve a set level of initial waste segregation that would be suitable for actors such as Shakti Plastics to undertake more advanced levels of segregations (I3, I8). Focusing on segregation systems would also include prioritising the uptake and further development of advanced material segregation and separation technologies[8] (I8, I10, I3, I5). Some of the larger brands and manufacturers interviewed reported themselves allocating seed money to the development of these technologies (I1, I9, I10). Ultimately though, the resources needed to scale up the segregation and separation and technologies were anticipated to come from the large virgin materials manufacturers (I10, I3, I8, I1).

Brands viewing post-production waste as the optimal source of secondary materials voiced preference for allocating resources to developing the administrative infrastructure needed to facilitate the retrieval of production waste and subsequent distribution to other manufacturers (I7). Third-party bodies financed by industry association groups (I10) were also suggested to provide training for brand staff on assessing the quality of secondary material supplies and cleaner production opportunities among prospective materials suppliers (I7). Two manufacturers stated that an early priority for resource allocation was in evaluating the suitability of using secondary materials on the grounds of potential environmental lifecycle benefits (I10, I11), technical feasibility (I10) and the value user product experience (I11).

5.2.3 Product design

The lack of standardised quality assurance systems for currently available secondary materials were stated to be a limiting factor for brands and manufacturers to pursue production with secondary materials (I2). Secondary material use tended to therefore be product specific (I4), potentially coming as a trade-off against product function, being restricted to products with simple designs or product low in quality or value (I1, I2, I8). In instances of higher quality product manufacturing, the use of secondary materials tended to be restricted to simple components within the product design which would be manufactured further down the supply chain (I9). Such use of secondary materials in stages closer to product assembly, such as in the manufacturing of product casing, would occur to enable closer brand and manufacturer oversight and control of secondary material sources and quality (I9, I1). Decisions for secondary material use based on product design and function could also be made in relation to the lifecycle impact of the product (I2, I3). The environmental impact of incorporating secondary materials use in a product's design would be compared to those of alternatives in materials categories where secondary material options may not exist, but where the lifecycle environmental impact is concluded to nonetheless be lower (I2, I3).

For product categories that can be manufactured using secondary materials while maintaining product quality, respondents stated the importance of designing products for recycling (I3, I8, I10). Restricting where possible the use of mixed strands of materials (e.g. polyester-cotton or fire retardants in EEE plastics) (I9, I1), and designing for disassembly (I3, I10, I7) were needed to enable logistically feasible waste collection streams and product material separation.

[8] From here onward, the term segregation and separation technologies refers to processes and technologies that isolate whole and unprocessed products from one another (segregation) and processes and technologies that take whole isolated products and breaks them down into their constituent components, materials and chemicals (separation).

Designing products with data on material content embedded into them and specifically the number of recycling rounds that the secondary materials content had been subject to, would address challenges of accumulating material quality degradation (I8).

5.3 Managerial

5.3.1 Resistance to change

Beyond technical barriers, poor knowledge on- and ignorance of the topic of secondary materials, or structural resistance to producing with secondary materials was seen to deprioritise their use. The priorities within the sustainability strategies of respondent companies were often referred to on the grounds of their business case (I1, I2, I4, I7, I9, I11). One garment brand representative suggested the lack of initiative within the company to manufacture with post-consumer secondary materials may be owing to the associated potential economic benefits and risks[9] being little explored by the company (I4). Where there is dedicated interest within a company to produce using secondary materials, poor communication within the company appeared to undermine how the policy would be implemented. Poor communication appeared to manifest itself between marketing and product design departments. In one instance, the former would publicly declare a company policy on secondary materials use without consulting product designers on such a policy's feasibility (I9). In another instance, the marketing strategy would work to promote linear economy products to be released and consumed at one-year intervals, while the product design department in the same company would be tasked with designing circular products with secondary materials with an intended lifetime of 3 years (I3). Some companies avoided this type of communications problems by having sustainability staff integrated throughout all parts of the company (I11). Though a similar practice were stated by respondents to take place in other companies (I1, I9, I4), those practices would be limited to integrating sustainability staff into the purchasing departments.

For some organisations, the dominance of standardised (environmental, social and governance) criteria for sustainable business management in purchasing guides was stated to present a structural barrier when the criteria did not incorporate secondary material criteria (I3, I4, I7). Garment brands and manufacturers operating in highly competitive sectors pointed to both large production workloads and pressures for short lead times leaving little time to learn how to valorise and integrate production waste into their design and manufacturing processes (I7). Likewise, multinational brands producing in India faced a highly fragmented local secondary materials market accused of being ignorant to buyer brands' needs to comply with export market materials regulations (I5). Large Indian corporate brands are apparently reluctant to remedy the issues through themselves developing the necessary supply chain infrastructure to ensure compliant and reliable material quality. The reluctance was stated to be for fear of free riding from competitors on the supply chain infrastructure once it had been developed, leaving the company with the financial burden while and only a portion of the commercial benefits (I5).

5.3.2 Leadership, support & sustainability strategy

The need for brands and manufacturers to see a business case for using secondary materials featured strongly amongst the interview data. For some, an already effectively presented business case has enabled production using secondary materials, with the clearest case being the utilisation of production waste from in-house manufacturing processes (I4). Science Based

[9] Data relating to economic factors of secondary materials use and procurement are discussed in greater detail in Section 5.4

Targets[10] are used by some manufacturers as a tool for informing sustainability strategies overall (I4). One representative believed applying this method to embedded, indirect GHG emissions from upstream production may help illustrate to senior management the contribution to reducing a company's carbon footprint that secondary materials use can make (I4). With the high cost of fledgling segregation and separation technologies, compelling business cases for secondary materials employed long-term strategic visioning (I10, I8) to incorporate the dividends from reaching economies of scale in secondary materials processing. Though a clear business case is a necessary factor for adopting the use of secondary materials, it does not appear to be sufficient. Brands and manufacturers also need to pay consideration for how such manufacturing practices would be perceived publicly. Manufacturers may experience reputational damage through public perceptions of undermined consumer safety due to using perceived sub-standard materials, despite evidence to the contrary. Any subsequent loss of shareholder value can in turn compromise the business case for secondary materials use (I5). In the absence of comprehensive third-party standards on secondary materials quality and properties, business cases for production with secondary materials need to contend with providing assurances that manage the risks of uncertain materials supplies (I5).

Manufacturers that were working towards or already producing with secondary materials demonstrated leadership through training initiatives. Continuing the topic of presenting a clear business case, brands stated efforts to establish channels of training with 1st tier manufacturers, advocating to supply manufacturers on how they could benefit commercially from manufacturing with secondary materials (I7, I9). The allocation of resources to companywide internal training and integration of sustainability practices (I11, I7, I4, I1) doubles up to clearly communicate to the respective company's staff, customer segment, competition and supply chain partners of their commitment to using secondary materials. Indian manufacturers were stated to demonstrate weak senior management leadership toward using secondary materials through ignorance and a lack of interest for the public health, sustainability and litigation risks of poorly implemented downcycling (I5, I6, I8). Beyond the scope of secondary materials, the form of leadership that appeared to stand out were company commitments and strategies relating to becoming a circular business or towards sustainability in general. Overall, production specifically with secondary materials seems to be a lower priority for manufacturers when compared to these other two issues (I3, I1, I4, I2). The seeming preference among brands and manufacturers for circular business models regarded affording a wider range of options for how to structure supply chains, including product repair, take back (I3, I1) and the use of renewable materials (I3, I11). Public and media attention of plastics pollution enables initiatives such as using organic cotton (I3) or bio-based plastics (I10) to dominate measures, or attention on climate breakdown to provide a company the social license to focus its sustainability efforts on reducing supply chain GHG emissions (I4). The decision for a company to implement Science Based Targets stemmed from a resolution at a board meeting of directors in part due to public and market pressure felt by the company in this area (I4). The central tenant of outdoor adventure companies' value proposition, to promote healthy lifestyles through activities in natural environments, was stated to drive the sector's focus on mitigating the environmental health impacts of its outdoor products (I7, I3, I4). This tailoring of sustainability strategies based on the association of product categories with the natural environment was also communicated to occur in other product ranges (I11, I4). The adoption of wider circularity strategies which include renewable or more sustainable material sources instead of materials recycling, was justified in one case as being an intermediary solution. Various circularity solutions would be

[10] Science Based Targets is a corporate environmental management system that measures and evaluates company and/or industry GHG emissions and subsequently devises a GHG emissions reduction plan with targets that conform to "what the latest climate science say is necessary to meet the goals of the Paris Agreement – to limit global warming to well-below 2°C above pre-industrial levels and pursue efforts to limit warming to 1.5°C" (Science Based Targets, 2019).

used to help reduce the environmental impacts of production (I10) while significant technical challenges to using post-consumer secondary materials would be addressed and ideally overcome through R&D (I10). Strategies focused on developing segregation and separation technologies focused on achieving economies of scale to reduce the unit cost of production for high-quality post-consumer production materials (I10). Any company successfully pursuing this strategy would become a market leader, while also increasing the economic feasibility for smaller market actors to use the technology that might otherwise be unable to invest in it themselves (I10). This prospect of seeing sustainability practices achieve a level of deep market penetration across all industries, be it through secondary or organic materials, product re-use or repair, was expressed to be the most important element of circularity to focus on (I3). This opinion was stated on the justification that environmental impacts from various product categories constitute a fraction of a person's total environmental footprint and circular production improvements would have a limited positive direct environmental impact. The greater impact of integrating circularity principles into products was stated to be in the educational value that would encourage individual lifestyle and consumption changes corresponding to lower environmental impacts (I3). To that end, some respondents went as far as to advocate for other elements of circularity leadership that continue to be widely practiced throughout Indian society by virtue of high rates of product re-use, repair and re-manufacture (I5, I8, I10). Such Indian circularity practices in certain instances limit access to supplies of secondary materials by wearing products out to a state where its materials are unrecoverable. The development of these practices was nonetheless advocated to be prioritised over developing secondary materials production systems due to the comparatively higher environmental gains they offered (I5, I8, I10).

5.3.3 Company & management structure

The larger brands interviewed were generally subject to sustainability policies that were administered top down from head office, limiting the extent to which decisions could be made to expand production using secondary materials (I1, I9, I2, I10, I11). In contrast, smaller companies were afforded more freedom to decide if, how and where production with secondary materials would be pursued (I4, I7). Despite the differences in levels of autonomy afforded by brands and manufacturers of different sizes, the larger brands were provided with the technical resources needed for materials R&D and testing to actually enable the realisation of production with secondary materials (I1, I9, I2, I10, I11). Correspondingly, the smaller brands interviewed had little resources to exclusively dedicate to determine how they could produce using secondary materials, expressing instead a greater reliance on external resources through collaborations to explore secondary materials opportunities (I8, I4, I7).

5.4 Government & Policy

5.4.1 Law, regulation & policy

Regulative issues were largely discussed by respondents representing the larger brands or by the Indian industry experts interviewed. The interest of the larger brands and manufacturers interviewed either had in-house production facilities, or significant and close collaboration with manufacturers located outside of the EU in emerging economy markets (I1, I9, I10, I11). The smaller brands interviewed stated that by not having a production presence in emerging economies, nor a substantial enough collaboration with manufacturers in such locations, they are unable to comment on governmental issues surrounding secondary materials systems (I4, I7). Brands' and manufacturers' expressed interest regarding regulation mostly concerned the previously discussed issues of materials quality assurances and subsequent brand liabilities. Respondents from large brands called for regulatory measures to be deployed in order to leverage collective resources from the private sector, either directly through EPR regulation, or indirectly through tax breaks for actors working to develop secondary materials standards (I1, I9, I10). Stringent enforcement of hazardous substances laws in high-income markets places a high level of risk for manufacturers importing into these markets when using secondary materials in production. Manufacturers therefore preferred to source materials and components, subject to stringent materials regulation, from locations with more reliable production standards as well as in regulatory enforcement on the upstream suppliers (I2, I9). When manufacturers do source secondary materials from emerging markets with low reliability of material quality, it is done conservatively with a very limited range of products that are not subject to strict materials standards (I5)

Regulative issues discussed by industry experts focused on matters relating to the shortcomings of informal markets for secondary materials. Government policy support was stated to be needed in order to counter the underutilisation of waste materials that resulted from materials recovery systems characterised by cherry-picking of the most valuable waste streams (I6, I8). Markets alone were stated to not have enough influence to make the most of waste resources available, even when there is a high level of co-operation on secondary materials in those markets (I8).

Public pressure was stated to be having a marked impact in driving the development of Indian policy on waste management (I8), moving the latter in the direction for setting legislation that can facilitate closing material loops. The implementation of various EPR and waste management rules have help to increase the sources of waste management revenues from the private sector while also incentivising manufacturers to pursue circular production (I8, I6). The less waste that is produced from manufactured products, the lower manufacturer's PRO fees become (in instances of EPR systems that require producers to pay PRO fees) (I8). However, one respondent drew attention to the discrepancies between the depth of Indian E-waste EPR rules compared to those for multilayer plastics (I6). The much greater stringency of the former was suggested to reveal the low priority and subsequent lack of resources allocated to the latter (I6). Though beyond the geographical context of India, one respondent also raised the role that international trade agreements and trading bloc membership can have in guiding the continued development of a nation's circular economy legislation (I6).

When asked about the relation to one another of two flagship policies in India, *Make in India*, and the *Clean India Mission*, multiple respondents stated that there appears to be little policy coordination between the two (I5, I6, I8). Despite this, one respondent argued that the *Clean India Mission* is to some extent inherently compatible with *Make in India* (I8), giving reference to a paradigm shift in Indian waste management policy that views the matter as a sustainability issue instead of a sanitary one (I8). Efforts to promote the *Clean India Mission* as a matter of industrial policy and foreign direct investment were recommended to learn from the EU legislative processes that lead to the implementation of the Circular Economy Package. In the EU, interest in the policy increased significantly when it was framed on the grounds of economic benefits, compared to previous efforts to gain support that promoted the policy on the basis of its sustainability potential (I6).

5.4.2 Political & policy stability

Political stability was only minorly discussed during data collection. The most notable political factor pertained the ongoing trade dispute between the USA and China at the time of writing (I7). The significance of these events in international trade politics was mostly considered from the perspective of its potential to guide offshore production to India and any subsequent demand in secondary materials along with it. Not surprisingly, one manufacturer stated a desire for policy certainty regarding issues related to waste management and circular economy systems (I1), one which is likely shared by other brands and manufacturers, particularly those weighing up investment decisions in material recovery infrastructure (I10, I8). The need for policy stipulating requirements for production with secondary materials was singled out in particular for the impact of certainty it could inject into manufacturing markets (I8). The Paris Climate Agreement (I8) and the 2030 Sustainable Development Goals have both provided a general degree of certainty in the direction of consumer and manufacturing markets moving to integrate circular economy principles.

5.5 Economics & Markets

5.5.1 Growth opportunities & market pressures

As stated above, the level of market pressure that brands and manufacturers experience to pursue some form of circular production varies between product categories (I4). Where general market pressure for circular production has been reported, brands and manufacturers need to balance costs of integrating secondary materials use and procurement with those of consumer demand for low product prices. Brands sourcing production in India will be faced with manufacturing companies also serving a highly price sensitive domestic market (I10). Pressure from Indian consumers for high-end consumer goods manufactured using secondary materials will be much lower than such pressures from Indian export market consumers. Any investment and growth opportunities in Indian manufacturing with secondary materials will therefore need to be driven by certainty in both demand and revenue from high-income export markets (I8). In addition, one respondent lamented over the degree to which Indian sourcing manufacturers for garments and apparel often displayed a poor understanding for the sustainability concerns of high-income market consumers (I10). The respondent's perspective reinforce the belief that moves to production with secondary materials will not originate from garment and apparel sourcing manufacturers in India.

Among the industries reviewed during data collection, pressure for circular production appeared upon interpretation to be strongest in the garments and apparel sectors. Brands and manufacturers in this sector appeared to already be exploiting the economic opportunities, where possible, that could be had from valorising post-production waste (I7, I4). Even though development of secondary material production systems in the garment sector was stated by respondents to be resource intensive and risky (I8, I10, I3), the high degree of market saturation was reported to nonetheless compel international brand manufacturers to pursue the option in the name of brand differentiation (I10, I3). Conversely, in the home furnishing and appliance sector, the same factor was reported to be approaching the level of consumer expectation toward the brand. During a home furnishing and appliance consumer survey conducted by an interviewed brand, the brand respondent summarised the surprised customer responses as "What? Are you not doing that already…?", upon customers being informed of the brand's plans to increase secondary materials use (I11). When secondary materials use is pursued by brands and manufacturers, it was stated to also be done due to the strong consumer pressure the garment and apparel industry experiences in relation to its significant environmental footprint (I3). Where such market pressure has been sufficiently significant, such as with social sustainability pressures, it has led brands and manufacturers to see it in their commercial interest to enter into pre-competition collaboration with competitors to address the source problem of criticism (I7, I10, I3).

One industry expert respondent (I8) raised the topic of waste to energy as an option for circular production. Waste to energy was being discussed for its benefits in utilising MSW streams that were otherwise already depleted of any waste fractions that could be recovered and processed into production materials. MSW was being sent, at a profit, to incineration as a fuel for cement production processes. The respondent was questioned about the risk of profitable incineration operations in India, incentivising the diversion of potentially recyclable MSW materials away from secondary materials processing and instead being sent to waste to energy in cement production. Such incentives were assured by the respondent to not occur so long as the current prices paid for waste to energy MSW streams, remained 1/10th of those for material recovery at the same time as being cheaper than the fossil energy source that waste to energy streams are replacing (I8). The higher price paid for secondary material MSW fractions ensued its recovery by the informal waste management sector while the higher cost of fossil fuels relative to waste to energy streams, ensured that cement producers would opt for the latter.

5.5.2 Transition & opportunity costs

In line with the key factors that emerged from the data, cost issues related primarily to issues of verifying and achieving acceptable levels of secondary material quality. Secondary materials use with the current low levels of quality assurances in supply systems would require increasing the applied rate (I4) and duration (I1, I9) of already expensive product testing processes to ensure consistency in material and product quality. Where materials testing is outsourced to third-party auditors or supply chain partners, the associated costs would manifest more in administering supplier compliance with desired material quality standards (I1). Alternatively, where testing costs would be lower, transition costs may be rooted in establishing reverse logistics and materials processing infrastructure that provide quality assurances to brands through close monitoring of material production processes (I3, I10, I8). For some respondents such costs were excessively high and warrant brands to not opt for undertaking the task of developing secondary material supplies (I1, I8). The earlier stated concern among Indian corporates for competitors free riding on company infrastructure investments (I5) pointed to the need for the transition costs of developing secondary materials supplies to be borne collectively. Brands that need to base their business case for post-consumer secondary materials on long-term strategic visioning essentially do so due to virgin material alternatives being cheaper (I1), even in cases for desires to maintain low but consistent levels of material quality (I1). Secondary materials tended to only be cheaper when downcycling, where maintaining material quality is a low priority, in material categories where virgin alternatives are already extremely cheap, with waste to energy or in applications as aggregates (I1, I5, I8). In the cases of long-term business plans for producing high quality post-consumer secondary materials, manufacturers communicated a reluctance to pass on to consumers the short-term price increases coming from transition costs (I11, I10). The same consumer perceptions of secondary material quality and safety that risk a brand's social licence to operate (Section 5.3.2) also risk having negative impacts on the level of emotional attachment that consumers place on the product at the expense of lower product demand for those products (I3, I11).

Seasonal fluctuations in the supply of waste material feedstock factor into brand and manufacturer decisions to invest in developing secondary materials supplies, with a concern for capital investment under-utilisation compromising brand investment payback periods (I5, I2). Processing certain post-consumer waste fractions to high material standards and at economies of scale in India will likely rely on expensive imported technologies (I10). The primary cost advantages of producing in India are based in the cheap price of production labour (I5). Using expensive materials processing technologies will undermine that cost advantage of basing production in India (I10). This will come at the risk of production of and with high quality secondary materials moving to markets with more reliable MSW segregation systems (I10). As such technologies may be of decisive importance to the production of certain secondary materials, Indian materials producers would need to find economically viable means for adopting the technologies. Financial support from a third-party actor such as the government might enable the costs of processing to be reduced and the costs of materials to become economically competitive.

5.5.3 Social embeddedness in the linear economy

The brand and manufacturer approach to using secondary materials that were communicated by respondents displayed how actions toward circular production remain significantly shaped by the linear economy in which those actions are socially embedded. The most overt cases of this related to respondents reaffirming their opinions' that the most environmentally sustainable company is a profitable company (I1, I9, I3), on the basis that if a company is not in business, it is unable to work to make industry sustainable. This rationale extended to suggesting that production with secondary materials needed to find a way of co-existing with instead of seeking to replace, hyper-consumption and the fast turnover traits of the linear economy (I10, I3). Highly responsive product leasing business models and the deep application of cleaner production methods were claimed to be necessary for the success of production with secondary materials (I3). Two respondents recognised that while brands claim to equally prioritise social, economic and environmental value, particularly those basing their value proposition on maintaining access to a clean environment (I3), user experience and therefore the saleability of a product remain the dominant priorities (I3, I11). Consequently, respondent testimonies on the challenges faced by brands and manufacturers to develop secondary material supplies contained much reference to risk aversion, with the need to choose secondary material or even just circular options that would provide a reliable sales and economic return (I1, I2, I3, I4, I7, I5, I9, I10, I8 I11, I6). The current main sources of reliable secondary materials supplies that were communicated to be available were those from post production waste which itself would be based on the throughput of virgin materials (I10, I7, I3, I4). The raising in this subsection of these factors may appear to the reader be almost self-evident, something that itself could be the product of embeddedness in linear economy thinking. However, the choice has been made to elevate these factors primarily for the way in which they set the terms under which efforts to develop production with secondary materials will occur. At the very least, a reminder of these boundaries and the constraints they exert, can be of value when seeking to devise solutions for developing secondary materials production systems. Beyond practical considerations, an awareness for factors of embeddedness in the linear economy can perhaps encourage reflection on the extent to which such circular economy measures are really circular.

5.6 Infrastructure & Location: Local Industry Networks

Few examples of local industry networks were presented by the respondents interviewed. The most explicit examples presented related either to clusters of garments and apparel manufacturers (I4, I7), or to formal processing facilities of waste collected and sourced from informal waste management networks in India (I8). The local for local structure of manufacturing systems result in supply chains being spread across multiple countries surrounding key markets to create regional clusters (I1, I9). Within these clusters the strategy to pursue a geographical fit with its suppliers see one electronics manufacturer (I1) likewise one garment brand (I7) being engaged in industry networks with suppliers distributed within these regional clusters. Engagement by these brands with domestic local networks mostly revolved around drawing on local production infrastructure (e.g. utilities providers), an area within which one manufacturer expressed an interest for better connections with other local industries that may be able to valorise its production waste (I1). However, the same electronics manufacturer stated that having a geographical fit with a regional supplier offered the economies of scale that could make production with secondary materials economically viable (I1). Where localised industrial clusters existed in India, but are characterised by low levels of integration, respondents pointed to the need for collaborative forums that can organise these clusters into becoming secondary materials-oriented networks (I10, I8). The Intellecap platform the Circular Apparel Innovation Forum (Intellecap, 2018) was referenced to be in the process of conducting such network developments (I10). The primary interest of respondents in galvanising industrial clusters was expressed for recruiting the necessary production capacities to form a viable industrial ecosystem for supplying high quality post-consumer secondary materials (I8, I10). The network would work to establish sufficient levels of trust and buy-in among member industries to develop and adopt in unison the range of fledgling technologies and production processes needed to valorise currently difficult to recycle MSW fractions (I8, I10).

For small and medium sized garment and apparel brands, industry networks appeared to manifest more between the brands themselves (once the brands overcame their competitive differences). Networks came in the form of pooling purchasing power to set demands on sourcing manufacturers, exchange knowledge on sustainability topics and disclose supply chain sustainability data (I7, I3). Industry network emergence was stated by one respondent to occur once brands and manufacturers realised that the challenge of linear production is too big a problem for individual organisations to solve themselves (I3). Brands and manufacturers then would understand the need to find ways of collaborating without compromising company secrets and non-disclosure obligations (I3). Despite these initiatives, there was a call by one respondent for a business-to business platform similar to the one envisaged by Karo Sambhav, to facilitate the exchanges of secondary materials (I7, I10). Another respondent informed of how the Stepwise initiative in India - Industrial Symbiosis for Circular Economy – was already seeking to build a network of actors with surplus material flows (I8). In addition to connecting sources of secondary materials with prospective users, such network platforms were praised for the potential to reduce the costs of secondary materials procurement through bypassing middlemen that act mostly as rentiers in secondary materials systems (I6). Proponents of such systems were said to be faced with the challenge of building sufficient legitimacy in the network so as to both achieve buy-in from interested participants (I10) as well as achieve a critical mass of users to enable the network to serve as a reliable platform (I6). One respondent raised the issue of how to overcome ownership issues of production waste that could be exchanged on the network (I7). Can buyer companies demand that sourcing companies place surplus material on the platform in instances when the material is owned by the sourcing manufacturer (I7)? Likewise, how can buyer companies ensure that sourcing manufacturers register and send surplus production materials through an exchange network when the materials are owned by the buyer brand, and the manufacturer holds no responsibility for the materials (I7)?

5.7 Summary of Results & Analysis

5.7.1 Factors & barriers to secondary materials procurement

Factor category	Factors to secondary materials use and procurement	Barriers to secondary materials use and procurement
Technical issues	Production waste: type source, quantity, quality Material quality: properties, degradation, recycled content (accumulation), high tolerances, limiting factor for use, simple applications Collection infrastructure SM standards: legal assurances, material verification, limited existence Environmental suitability: lifecycle environmental footprint, environmental efficiency, user interest, logistics Design for recycling	Difficult to valorise own post-production waste from non-in-house manufacturing when missing information from it SM cannot yet fulfil function needed for product and/or its production, insufficient material tolerance, may require setting up in-house reverse logistics network Need to review product design to be recycling compatible for SM recovery from own products Need to conduct extra testing to compensate for lack of SMs standards SMs may not provide optimal lifecycle footprint relative to other SMs
Managerial	Structural barrier: purchasing guides without SMs criteria Risk mitigation for free riding on SM investments Lack of knowledge: risks and benefits Senior Management: market sensitive, social licence, SM ignorance Business case: strong for post-production materials, slow returns, needs long term strategic visioning Communication & training: internal, partners, consumer sustainability education Strategy focus: often on sustainability or circularity in general, GHG emissions focused, open for flexibility in choosing options Leadership: SMs system development (larger brands), market differentiator Indian waste hierarchy as role model Management of sustainability and SMs: internally, horizontally, vertically Company size: variance in levels of ambition vs levels of resources committed	Un-unified organisation management, structure and goals may lead to contradictory priorities for SM use and procurement e.g. purchasing guides prioritising virgin materials over SM Companies reluctant to be first to develop SMs infrastructure, want others to move first Unable to make informed business decision for/against SMs use without conducting proper cost/benefit analysis Public perception of SM quality, safety and reliability Small businesses may struggle to put resources into long term SM strategic visioning Other sustainability and/circularity strategies may be more appropriate Indian consumption and user practices of re-use, repair, re-manufacture may reduce sources and present more environmentally efficient option of consumption circularity Business units may not have authority to use, adapt to and develop SMs, or if authority has been delegated, then business units may not have the resources to use SMs
Government & policy	Supportive/prohibitive SM policy: relevant for larger brands and manufacturers with own production facilities in India Production and material quality standards: export market legal compliance Government support: level playing field, resource provision, resource use efficiency incentives Policy support when supported by strong economic case Market direction: certainty, trade disputes, international sustainability agreements	SMs policy aimed at larger brands and manufacturers, small brands highly committed to SMs reliant on sourcing manufacturers to take advantage of any national SMs policy Legal risk from material quality standards of export market Lack of government assurances/support risks companies becoming uncompetitive when individually bearing costs of SM supply chain development Government support may disappear upon change in leadership Risk of stranding SM investments if manufacturing relocates because of trade disputes

Economics & markets	Market pressure: sustainability pressure (particularly garment sector), saturation, intense price competition, can force pre-competition collaboration Indian SMs use driven by high-income export markets (not domestic Indian market) Waste segregation and material separation technologies for market differentiation SMs largely outcompete waste to energy Risk mitigation costs: developing and monitoring material quality, prohibitively high Transition costs: larger companies absorb the costs, reduced margin Investments in SM capital equipment: certainty of SM supply impacts payback period Sustainable company must be profitable: consumer experience, business case for SMs, follow markets Circular business occurs within paradigm of linear business models	Non-disclosure policies, low trust and strong rivalry might block move for pre-competition collaboration Indian manufacturing facilities investment priorities more Indian market driven, not western market driven Segregation and separation technologies unattainable: too expensive, technically unfeasible Cannot absorb costs increases from SM usage Insufficient SM supply reliability to ensure viable payback plan for SM capital investments Too demanding to live up to linear economy terms of business on using SMs
Infrastructure & networks	Industrial clusters: networks for developing SM eco-industrial parks Industry networks and associations - pre-competition SM collaboration SM exchange platform	Insufficient resources and/or local leadership to galvanise local industrial clusters to becoming SMs eco-industrial parks SM use and circular production may be one of the few avenues available for gaining a competitive advantage, making pre-competition collaboration difficult to commit to Unreliable flow, user mass as well as lack of material standards to make SM platform a viable procurement option
Supply chain structure, management & governance	Total cost of ownership Local for local production: proximity to market, geographical fit Buyer power: ambitions to develop it, size dependent, can enable SM connections Supply certainty: reverse logistics, consistency Information transfers Production standards: supplier compliance, monitoring, purchasing guides Procurement process: tendering, collaboration & trust Supplier anticipation of market demand Risk mitigation: disperse production, EU SM Supplier power: minimum purchase orders/same producer for competing buyers Informal sector: reliance on it, interface with formal sector Material quality: import SMs from reliable sources	Low tolerance for cost increase, or requirement for increases elsewhere in supply chain Preference for virgin material suppliers with better geographical fit Need to ensure supply certainty with uncertain materials sources Difficult for small buyers to obtain information on production waste High bar of entry for suppliers regarding buyer material procurement standards Low trust in buyers leads to low trust in SMs quality High buyer trust in suppliers is opportunity cost when switching suppliers to meet SM needs Good supplier SM co-operation partly reliant on norm of SM demand in market sector Poor traceability of material source, content and quality through informal sector collection systems Need to import processed post-consumer SMs from locations with good product safety regulations and MSW recycling infrastructure

Table 5-1 Table of results for factors and barriers to secondary materials use and procurement in manufacturing

Source: Author's construction based on the analyses of interview data presented throughout Section 5

5.8 Overview of Key Barriers

Table 5-1 summarises all the key elements of data and analysis from Section 5 up to this point. The listed factors serve to answer Research Questions 1, and subsequently reveal the barriers to secondary materials use and procurement in manufacturing. Reviewing the summarised data reveals the presence of groupings across factor categories, in the types of barriers that have been deduced and interpreted. Table 5-2 presents an attempt to broadly structure the barriers into categories with greater detail and types of specific barriers found under the aspects column. The findings presented in Table 5-2 answer Research Question 2 on the barriers to secondary materials use and procurement in Indian manufacturing. The identified barriers are then used in Section 6 to answer Research Question 3, by analysing what implications these barriers might have for actors who broker the supply of secondary materials in India to consumer manufactures. Findings from the subsequent analysis will then feed into presenting a summary of recommendations that may inform how secondary material brokers can mitigate the barriers presented in Table 5-2 in the pursuit of increasing secondary materials supplies for consumer goods manufacturing in India.

Barrier category for secondary materials use and procurement	**Barrier aspects**
Missing information	SMs (traceability, quality, properties post-production quantity), cost/benefit analysis
Technical capabilities	SMs quality, design for recycling, segregation, separation and refining technologies, temporal and quality uncertainties in supply
Alternative sustainability options	Environmental efficiency, feasibility, business fit
Company not structured for SM use	Poor internal communication, insufficient leadership, goals, top down decision making
Supplier market and business environment	Low SM priority, need for SM network leadership, non-SM compatible structure/distribution, need to import quality SMs
Challenging business case for SM use	Investment and market risk, SM use expensive (R&D, technologies, administration), insufficient resources for SM transition, competition pressure > market pressure for SMs, price sensitive market
Social limitations	Perceptions of SM safety & quality, SM ambition and expectations framed by linear economy social standards and norms,
Insufficient state support	Legal, financial, enforcement, policy stability

Table 5-2 Summary of key barriers to secondary materials use and procurement in manufacturing

Source: Author's construction based on results presented in table 5-1

6 Discussion & Recommendations

This section is composed of two subsections, beginning with reflections on the results presented in Tables 5-1 and 5-2 to discuss what implications the identified factors and barriers have on secondary material brokers. Discussion of the implications for secondary materials brokers is roughly framed around the identified barriers in accordance to the categories presented in Table 5-2, but it also draws at times on various factors presented in Table 5-1. This first section of the discussion concludes with a summary of recommendations on what actions this stakeholder group can take to address challenges and seize opportunities around developing secondary materials systems in India. The second section of the discussion critically assesses the processes of undertaking this research to reflect on challenges experienced throughout the investigation, and the shortcomings that came as a result. As with during the results section, all references to interview data made during the discussion are presented according to the interviewee number, for example Interviewee 1 is presented as follows: (I1).

6.1 Implications of Findings for Secondary Materials Brokers

6.1.1 Technical capabilities & missing information

Underlying many of the analysed barriers were factors relating to technical challenges of producing, using and procuring secondary materials for manufacturing. As is raised throughout the rest of the discussion section, nearly all other derived barriers are in some way contingent on technical challenges. Preceding elements of choice regarding whether secondary materials use should be pursued or not is the matter of ability. Does the technical capacity to use secondary materials exists and importantly, under the terms and conditions required by society, markets and government regulation (I1, I2, I3, I8, I9, I10). As presented in Section 5.3.3, these conditions are largely set at the level of those required by the linear economy (I3, I10, I11) within which secondary materials use and procurement needs to exist (Laurenti et al., 2018). One condition that featured prominently during data collection was for consistency in desired levels of material quality and properties, due to reasons of legal compliance (I1, I3, I9)(de Romph & Van Calster, 2018), product quality and compatibility with production processes (I5). Interest among respondents for knowledge on the condition of incoming streams of recovered waste and processed secondary materials (I3, I8, I9) sees technical related barriers to secondary materials use interact with those of missing information (Kumar et al., 2019). The dominance of these two barrier categories place a strong impetus on broker actors to work with remedying information asymmetries in secondary materials systems and support efforts to overcome some of the technical challenges to secondary materials recovery and processing (I5, I8).

For some brands and manufacturers, the uncertainties in material quality and product compatibility were sufficiently prohibitive to render secondary materials as an unviable sourcing option (I1, I5 & I10). Other brands and manufacturers engage in limited secondary materials R&D to overcome such uncertainties. The unknown unknowns of if and how secondary materials can be refined to desired specifications makes the costs of R&D sufficiently high (I10), particularly when needing to be conducted on a product-by-product basis (I4, I9, I10), to deter manufacturers from engaging in R&D (Agyemang et al., 2019; Benton et al., 2015; Kumar et al., 2019). If broker actors set up secondary materials R&D operations, they could help distribute some of the costs and risks across participating brands and manufacturers, making secondary materials R&D more viable, particularly for smaller more resource constrained actors (I4 & I6). Broker actors that are already involved in regional MSW sectors could use their insight into local waste production patterns to access information that could be used to inform secondary materials R&D (I8)(IIIEE, 2019). Brokers could develop geographical intelligence on variations and patterns in material consumption and waste generation patterns (I1 & I2) (Hugos, 2006; Scott, 2014). Drawing on such MSW intelligence to inform secondary materials R&D conducted in collaboration with brands and manufacturers, would serve to increase manufacturer trust in the quality and reliability of both the secondary materials and findings about it (I1, I9). R&D efforts could be conducted with greater certainty on the quality of secondary materials and therefore efforts to tailor materials to the requirements of a production process would be facilitated (Benton et al., 2015; de Mattos et al., 2018; Esposito et al., 2018; Govindan & Hasanagic, 2018; Jain et al., 2018; Koszewska, 2018). Lastly, benefits of geographical based data can better feed into brands and manufacturers Local-for-Local procurement decision making when applicable, on which regions to source production from when using secondary materials (I1 & I2).

Brands and manufacturers seeking to produce with secondary material but that are not prepared to engage in materials R&D remain restricted by the absence of secondary material standards systems. In line with by Karo Sambhav's assessment, brands and manufacturers stated a clear need for material standards (I1, I2, I4, I5, I7 & I9). Secondary materials brokers can take on the task themselves of developing standards systems (I6), but to do so would likely be costly (I5 & I8), meaning efforts would need to be strategic. As stated above, manufacturer concerns with using secondary materials are primarily relate to issues of regulatory compliance, product quality and production process compatibility (I1, I3, I9 & I5). Efforts to develop secondary materials standards could therefore be based on brand and manufacturer priorities in these areas for product categories where there is likely to be demand (I3, I10). Brokers could conduct market research focused on which companies appear most committed to secondary materials usage, the products and respective virgin material categories that would be most feasible to replace with secondary materials and then initially focus standards development on these fractions (I8). The development of standards could then be conducted in accordance with brand and manufacture concerns and priorities relating to secondary material use, focusing first on product safety standards and restricted substance lists (de Romph & Van Calster, 2018). Work on non-legal compliance related standards could focus on bringing together the small disparate range of recycled materials standards systems to build a more widely recognised set of recycled materials standards (I7 & II10). For material fractions that can be processed to standards of quality close to those of the virgin material equivalent, the same standards used for virgin materials can be drawn into the standards guide (I5)

Where viable technical options are available for segregating and separating recovered materials, those materials' use may be restricted by insufficient levels of segregation in waste collection networks or in inabilities to know of the contained levels of accumulated recycled materials (I8). Formal recyclers like Shakti Plastics (Shakti Plastics, 2019) source recovered MSW from informal collection networks and then apply advanced levels of waste material processing. High levels of MSW segregation down to the product category level are required from informal waste collection networks (I8) to reduce material verification costs (Bozena, 2018; Govindan & Hasanagic, 2018). Such formal recyclers can then themselves apply sophisticated levels of material segregation that can enable the application of materials separation processes to produce high quality secondary materials from informal sector collected post-consumer waste (Östlund et al., 2015). To assist recyclers like Shakti Plastics, secondary materials brokers could develop in collaboration with brands and manufacturers, additional materials database operations to determine the likely product and specific material composition of MSW streams (I9). Secondary materials brokers such as Kabadiwalla Connect (Hande, 2019) can facilitate improved levels of secondary materials segregation within informal networks by using data on product types that are likely in MSW. These data could be used together with reverse logistics information systems aimed at informal collection networks (Hande, 2019) to put out tenders for specific material categories as stated by the formal materials processing actors (I7). Tenders put out by recycling actors can be made on the basis of assessing what secondary materials are being sought by brands and manufacturers, and then reviewing the databases to assess which product waste streams would need to be collected by the informal sector in order to meet this demand.

To avoid secondary material degradation through accumulating in product content successive rounds of material recycling brands and manufacturers have been stated to be developing systems that embed production batch information into the product (I8). When brands recover their product waste, they read the embedded batch information, refer to internal databases on product recycled material content and then apply the necessary recycling process accordingly. The system relies on a high level of coordination in reverse logistics system to bring waste products back to the original manufacturer. To avoid the reliance of this system on a highly coordinated reverse logistics system, secondary materials brokers can work with manufacturers to administer a database that contains production batch recycled content information. Multiple recycling actors would have access to the database and could therefore recycle any other brand's product waste so long as those products were in the broker database. Furthermore, recycling brokers could coordinate the standardisation of recycled content information to avoid the development of disparate embedded information systems between brands and manufacturers, which may not be readable to other manufacturers.

6.1.2 Other sustainability options

For various reasons discussed in Section 5.3.2 brands and manufacturers prioritise secondary materials use to varying degrees, with only one explicitly stating a strategy to become a fully circular company in providing cradle to cradle products (I10). Another manufacturer stated that as a second-tier producer, the company experienced low pressure to use secondary materials, and more pressure to become a sustainable company in general (I2). The level of public pressure each of these two companies are exposed to appears to differ significantly, with the former coming under heavy public scrutiny and the latter not so. For the brands and manufacturers exposed to high public pressure, moves appeared to be made for at least committing to some form of circularity strategy (I1, I4, I6, I9 & I10), though there appears reluctance to commit specifically to secondary materials targets. Second-tier industries seemed to engage with more general sustainable measures (I2, I4 & I6) unless there was very high pressure on their buyers or if brands and manufacturers directly contacted suppliers at this level (I10 & I11). For secondary materials brokers, these patterns in public pressure mean that the manufacturers higher up in the supply chain who are likely to be the actors actually procuring production materials, are the ones with less focus on circularity or sustainability. Actors higher in the supply chain that showed interest in sustainability were stated to be focused more on the climate impacts of production or the cost benefits that could be achieved from sustainability measures (I2, I5 & I6). Secondary materials brokers will need to make the case to such manufacturers for the contribution that production with secondary materials can make to the topics of interest to them (e.g. reducing carbon emission or cost savings) (I4) (Koszewska, 2018). The provision by secondary materials brokers of cleaner production technical services can both provide manufacturers with costs savings and technical knowledge on how to improve resource use efficiency (I6) as well as increase awareness among manufacturers for circular production (Liakos et al., 2019).

Despite efforts that brokers can make to increase interest among manufacturers for secondary materials, it seems fair to assume that the capacity for brokers to significantly realign the sustainability strategy of such companies is limited. Preferences among larger brands and manufacturers seem to be for open sustainability strategies (I1, I3, I9, I10 & I11) which risks secondary materials brokers competing with circular materials options which have greater lifecycle footprints but fewer technical challenges (e.g. bio-plastics) (I3). Beyond using other forms of circular materials, brands and manufacturers may also increasingly explore re-use, repair and re-manufacture options as a means to pursue production circularity (I10 & I11). As these latter options are higher in the waste hierarchy with a lower environmental impact than using secondary materials, these strategies are to be encouraged (I3) (Govindan & Hasanagic, 2018). Secondary material brokers need to identify how their operations can complement, instead of run counter to, wide circularity strategies among brands and manufacturers. On numerous occasions throughout the data collection process, respondents informed of how the long-held household economic culture of re-use, repair and remanufacture remains strong in Indian consumption culture (I5, I7, I8 & I10)(Pandey et al., 2018). While Western moves towards circular economies are challenged by being deeply embedded within cultures of linear economic consumption (I3), Indian consumption culture retains some degree of circularity practices. There may be value for consumer goods brands and manufacturers entering the Indian market to find ways to adapt the market delivery of products to these circular practices of consumption. Indian secondary materials brokers with knowledge on local infrastructure surrounding reverse logistics networks, repair shops and resale platforms can facilitate in partnerships with brands, the flow of products through stages of reuse, repair and remanufacture (Boons & Spekkink, 2012; Chertow, 2000; Paquin & Howard-Grenville, 2012). With brands and manufactures being involved along the circularity value chain, they would be able to maintain some degree of product quality. In administering the flow of products through the circular infrastructure, brokers would be waiting at the product's absolute EoL stage, gaining access to recoverable secondary materials (I8).

From a broader perspective, this circularity approach for brands and manufacturers could serve as a compelling attempt to redefine what high-income consumption should consist of. Indian examples of product consumption would move away from the unsustainably idealised role-model of consumption practised in high-income countries (I3), and toward the circular consumption patterns long practiced in emerging and low-income markets. Not only would this serve to challenge the culturally hegemonic Western definition a high-income lifestyle (Laurenti et al., 2018). This approach to circularity also has the strength of using the valuable cultural-cognitive institutions that already align with circularity, which still exist in India and that otherwise appear difficult to develop once lost if Western experiences are anything to go by. Potentially, the role could be reversed where, as a young rising and dynamic economy, India and its consumption patterns can learn from the mistakes of the West's consumption behaviour. Circular consumption in India can lead the way in re-defining what the high-income lifestyles of vibrant emerging and modern economies wish to aspire to, leaving behind resource inefficient, highly wasteful and destructive Western consumption patterns.

6.1.3 Supplier market & business environment

With some of the larger manufacturers communicating a preference for suppliers that offer a geographical fit with buyer production operations and locations (I1, I2 & I3), secondary materials brokers will need to compete with virgin material suppliers on an international level. The importance of reliability in material supply has also led manufacturers to source when necessary, secondary materials from their own international supply networks and import these materials to production locations (I9). These two hindering factors demonstrate the barriers that stem from under-developed materials supply networks and point to the need for secondary material brokers to build up the networks themselves. To meet the international materials supply competition, Indian secondary materials brokers need to follow suit and reach out to international initiatives and platforms such as the Textile Exchange (Textile Exchange, 2019). By establishing and co-ordinating international material supply networks, secondary materials brokers can match the geographical fit requirements of multinational brands and manufacturers (Boons & Spekkink, 2012; Chertow, 2000; Paquin & Howard-Grenville, 2012).

To contribute from the Indian perspective to such an international network, regional Indian materials exchange networks need to be developed as stated by one respondent (I6). To establish such exchange platforms, materials brokers need to address the barriers that have made exchanges difficult to conduct on a one to one basis so far. Ownership issues of waste material streams have made it difficult to allocate responsibility for the collection and delivery of exchanges between manufacturers (I6). Limitations on available resources among manufacturers for allocating to implement materials movement, storage and administration of materials exchanges has also hampered efforts to valorise post-production waste between manufacturers(I6). In developing an exchange platform, secondary materials brokers may need to assume the responsibility of a third party administrator to exchanges (Howard-Grenville & Paquin, 2009). Such a role might involve absorbing the risk within such exchanges, actively reaching out to manufacturers and informal secondary material networks to source materials for the platform and reviewing their compatibility for the match-making of registered secondary materials with member production processes (Behera et al., 2012; Howard-Grenville & Paquin, 2009). The role for brokers as an administrator would be particularly important in making the business case of the exchange platform to supplier manufacturers that have otherwise proved resistant to collaboration on materials exchanges (Koszewska, 2018). Developing a compelling case for buyer participation in the exchange platform is also important for secondary materials brokers to achieve sufficient user volume to make the forum self-sustaining (I7). With user critical mass in mind, brokers could focus on targeting the exchange platform to material fractions and buyer industries where there are reliable sources and high demand secondary materials such as PET bottles (I1 & I8). To that end, exchange platform administrators could expand to incorporate the registering of renewable materials suppliers to increase platform usage and subsequently increase market exposure to the provision of secondary materials by those coming to the platform to source renewable materials. As administrators of the platform, brokers would be in the advantageous position of being able to monitor and measure the levels of secondary materials commerce. Secondary materials market data generated through usage of the platform could be used to inform materials manufacturers on the level of market demand for secondary materials, helping to build a business case to compel industry investments in secondary materials production systems.

6.1.4 Challenging business case for secondary materials use

The role of risk aversion for brands and manufacturers has been discussed from the perspective of restraining investment in efforts to overcome technical challenges of material quality (Section 6.1.1). Risk aversion also appeared to be a barrier to manufacturers using and procuring secondary materials, coming in the form of seeking to maintain a competitive edge, making the necessary investments to develop secondary materials infrastructure, and concern for public perceptions of using secondary materials. Smaller companies communicated how their buyer power was limited (Cox, 2004) regarding secondary material requests to sourcing manufacturers, particularly when competitors source from the same manufacturers (I3, I4 & I6). The possibility for buyer brands to overcome this barrier by pooling purchasing power specifically around secondary materials requests was said to be undermined by brands that are competing in saturated markets seeking to maintain the competitive edge (I3, I4, I6 & I10). Circular materials use was communicated to be one of the few product features that brands could use to differentiate themselves. There appeared a discomfort with the idea of disclosing such information to competitors (I3, I4, I6 & I10). Secondary materials brokers could step in to be an honest third-party mediator (Boons & Spekkink, 2012; Howard-Grenville & Paquin, 2009) that can yield collective buying power without disclosing producer trade secrets. Secondary materials brokers could pool brands' purchasing orders, achieving collective buying power on the brand's behalf and finding a way to collaborate with competitors on procure secondary materials while being compliant with non-disclosure duties (I3).

Brand and manufacturer risk aversion regarding investments in developing secondary materials infrastructure and supply chains was stated to be rooted in several concerns. Temporal uncertainties in the supply of waste material feed stocks (I5) pose risks for undermining the ability of manufacturer investments in secondary materials technology to have a sufficiently robust repayment periods (I5) considering that there can be high-upfront costs (Benton et al., 2015; Govindan & Hasanagic, 2018). Secondary materials brokers can perform a couple of measures to try and address the investment risk and improve the business case for such investments. First, in line with the suggestions proposed above of providing research and technical support, secondary materials brokers can investigate options to increase the range of applications for such technology and use their connections with waste collection networks to identify other feedstock sources. As part of this approach, brokers could register the availability and provision of secondary materials processing capacity on such exchange platforms, as well as incorporating on the exchange platform collections and stream of segregated unprocessed waste (I8). Second, brokers can work to reinforce the market signals that manufacturers would need for committing to invest in secondary materials infrastructure (Govindan & Hasanagic, 2018). Here, brokers can engage with multiple buyer brands to establish specific purchasing commitments on the levels of secondary material that would be demanded by them in production, co-ordinating buyers and suppliers collectively as a network (Cardoso de Oliveira et al., 2019). Similarly, secondary materials brokers could co-ordinate between multiple brands and manufacturers, financing the development of secondary materials infrastructure. Involving more actors in the investment process would spreading the risk of investments to help increase the chances of state support (Boons & Spekkink, 2012; Howard-Grenville & Paquin, 2009) and reduce the manufacturer concern for free riding (I5).

The aversion of materials manufacturers to investing in secondary materials infrastructure can also stem from having capital investments in virgin materials infrastructure, or because the companies sufficiently benefit from the linear economy status quo (Benton et al., 2015; Hart et al., 2019). Cases of such materials manufacturers were claimed to exist among Indian materials industries (I5, I8 & I10), with the effect of defining market trends, and due to the companies' size and market share, stifling the transition of materials markets towards secondary materials production (Cox, 2004; Laurenti et al., 2018). Secondary materials brokers can address these structural market barriers by working to co-ordinate coalitions of willing partners that seek to transition to production with secondary materials. Brokers can draw on international networks to identify multinational materials manufacturers that are looking to grow in India, and present those manufacturers with strategies for doing so which involve producing secondary materials in India. Strategies can include facilitating access to local networks of materials industries that are looking for investment to expand their secondary materials processing operations (I8), and with whom multinational companies can partner with. Such partnerships could also facilitate access, through the connections of local industry, to informal waste material collection systems (I8). Another strategy could involve working with buyer brands to map out the potential level of market demand for secondary materials, and the willingness of buyers to pay should supplies be developed. For strategies to develop secondary materials supplies, co-ordination with local partner industries would need to include efforts that develop buy-in from manufacturers across the secondary materials processing value chain (I10). Gauging the demand potential for secondary materials can provide the necessary signals to foster buy-in from materials manufacturers by underwriting proposals for investment in materials production with clear destinations for any subsequent secondary materials output. For example, in the case of post-consumer plastics-based textiles, secondary materials brokers would need to co-ordinate among industries working with PET fibre separation, PET de-polymerisation to basic chemical, repolymerisation, fibre production and yarn production (10). Success in such co-ordination would result in developing eco-industrial parks that are geared towards secondary materials production (Howard-Grenville & Paquin, 2009). The successful emergence of such an industrial eco-system would be the development of market pressure on the incumbent materials manufacturers to begin transitioning toward secondary materials production themselves (I3) (Agyemang et al., 2019; Esposito et al., 2018; Govindan & Hasanagic, 2018; Hugos, 2006; Jain et al., 2018; Koszewska, 2018).

The development of industrial ecosystems can produce market actors that could begin to exert pressure on policy makers for improved policy and enforcement in support of secondary materials systems (Binder, 2007; Chertow, 2000; Prendeville et al., 2018). Developing eco-industrial systems for producing secondary materials helps demonstrate to potential opponents that a) viable alternatives to virgin materials systems has been developed, tested and demonstrated to work b) the costs and risks of developing those systems have already been taken and overcome. Policy makers would therefore have industry actors that would stand to benefit from policy in favour of secondary materials systems development. These industry actors would subsequently provide the support needed from the business community to reinforce public support and together meet resistance from incumbent business interests (I7) (Binder, 2007). The policy developments to be advocated for by subsequent pressure groups, such as secondary materials brokers, could include tax incentives for the environmental services provided or regulatory requirements for secondary materials content in manufacturing (I8).

6.1.5 Summary of discussion & recommendations

The discussion up until this point of Section 6 has reviewed the barriers to secondary materials use and procurement, from the perspective of implications for secondary materials brokers. Of the eight barrier categories presented in Table 5-2, five of them were analysed to an extent to be able to produce recommendations and are summarised in Table 6-1. As can be seen in the summary, the barriers that were analyses to have implications for secondary material brokers were *missing information, technical capabilities, other sustainability options, supplier market and business environment,* and *challenging business case for secondary materials*. This assessment of the barriers with implications on secondary materials brokers is not exhaustive. The implications presented in Table 6-1 are those arsing from the data collection and analysis process in seeking to understandings the needs and challenges faced by brands and manufacturers relative to the evaluation criteria. To some extent the implications of the remaining three barrier categories (*company not structured for SM use, social limitations, insufficient state support*) are addressed by some of the recommendations. In reality, many of the barriers are multifaceted and overlap, for example a recommendation aimed at addressing challenging business case for secondary materials can also challenges barriers related to insufficient state support, as discussed in Section 6.1.4.

Barrier category	Recommendation	Details
Missing information	Strategic development of materials standards system	Research product and material categories for likely demand in secondary materials, begin working first on RSL standards, material properties & quality, bring together disparate standards Use virgin material standards for SMs: can be processed near to virgin materials standards
	Product virgin and secondary materials content database	Facilitate tenders to informal sector for demanded streams of waste materials Standardise the embedded recycled material content information
Technical capabilities	Develop R&D services for improving secondary material quality	Distribute risk of R&D investments for individual brand and manufacturer buyers Brokers will have access to waste stream and collection network information Inform local-for-local production strategies Collaborative R&D will Increase buyer trust in supplied secondary materials
Other sustainability options	Advocate for climate benefits and therefore business case of secondary materials use	
	Provide technical training for cleaner production methods	Access to post-production secondary materials Methods can help increase manufacturer interest in secondary materials use
	Facilitate product reuse, repair and remanufacture to the levels desired by brands using those circularity strategies	Use broker knowledge to access local informal repair and reverse logistics networks Gain access to secondary materials at the ultimate product EoL
Supplier market and business environment	Develop international secondary materials collaboration networks	Can produce business fit for manufacturers with local-for-local procurement strategies
	Develop local waste exchange networks	Assume third party administrative role Waste and secondary materials matchmaking Make compelling case for platform participation in order to achieve critical mass usership Incorporate renewable materials providers Provide platform access for segregated but unprocessed collected waste Source of secondary materials market data to make business case investments to grow secondary materials systems

Challenging business case for SM	Honest broker for pooling purchasing power of competitors	Facilitate pre-competition collaboration
	Research to improve and widen SMs cleantech applications	Will help hedge cleanteach investments against feedstock supply insecurity Include option to register idle SM processing capacity on SM exchange platform Broker SM commitments from buyer brands to provide certainty Broker infrastructure financing from across multiple brands to pool investment risk and reduce risk of free riding
	Unite willing actors in facilitating the development of eco-industrial park to process SMs	Draw on international network of secondary materials brokers and suppliers, offer to facilitate access to Indian recovery materials markets Develop market pressure on virgin materials Build business community support for government to increase financial and regulatory government support

Table 6-1. Summary of recommendations for secondary material brokers

Source: Author's construction based on the discussed implications for secondary materials brokers, of the barriers to secondary material use and procurement for consumer brands and manufacturers

6.2 Evaluation & Reflection of Research

Central to a critical reflection of this research are considerations for if the task of answering the research questions was achieved. To recap, the research questions were:

RQ1: What key are the key factors of virgin and secondary materials use and procurement for brands and manufactures with operations in India or similar contexts?

RQ2: What barriers can be identified regarding the use and procurement of secondary materials for brands and manufacturers with production operations in India or similar contexts?

RQ3: What are the implications of these barriers on efforts in India to broker and increase secondary materials flows from suppliers to brands and manufacturers?

Key factors and barriers of materials use and procurement were presented in Table 5-1, with the barriers being further refined and categorised in Table 5-2. The discussion presented in Section 6.1 and summarised in Table 6-1, reviewed the barriers to secondary materials use and procurement for their implications regarding the requirements they place on, and opportunities that it would be present to brokers. As far as the main components of each of these research questions are concerned, it would therefore be fair to state that all the research questions were answered. The next consideration pertains the quality of the answers presented. Section 6.2.1. and Section 6.2.2 reflect on the theoretical framing and methodological approaches employed in evaluating the quality of the results presented in this study.

6.2.1 Theoretical framing

Focus is here paid to reflect on the theoretical framing of this study because this investigation was rooted in, and the direction therefore significantly influenced by, the framework constructed to carry it out. The selection of theories used to guide this research were able to provide perspectives that yielded results in terms of the investigated factors, barriers and implications. Upon closer review the theoretical framework appeared to be effective in guiding the collection and analysis of interview data under all of the factor categories include within it. At the level of evaluation criteria certain elements of the theoretical categories began to show signs of weak or no applicability at all to interviewed company cases. At this stage of research problem analysis, the lack of theoretical applicability is not considered a shortcoming of the framework. The research purpose was to scout among respondent cases for factors to secondary materials use and procurement and is therefore a process that inherently involves prioritising certain theoretical categories over others in accordance with collected data. That being said, as this research did not employ methods that seek to produce generalisable results, the low or absent relevance of some evaluation criteria to the research topics may not be representative of the research object studied. The selected evaluation criteria may appear more relevant if applied differently during data collection and analysis. For example, different applications could occur along the lines of specific categories of respondent or manufacturing industries, through framing during interviews, or through choosing other data analysis methods, to name a few.

As data was produced for many of the categories, those categories included could be considered a relevant but by no means exclusive account of the variables to incorporate in a framework for analysing secondary materials use and procurement. The selection of input literature for the framework in terms of theoretical disciplines as well as the specific articles, was based on the author's own interpretations of how to implement the research perspective of factors to secondary materials use and procurement. The framework could be enhanced by drawing on different theoretical perspectives of the research topic, even just by using the collected data to incorporate additional evaluation criteria that emerged from respondent data. While the theoretical framework was a significant output from this research, it was nonetheless a means to an end of understanding the factors and barriers to secondary materials use and production systems. Expansion of the framework based on the data and analysis from this study was therefore beyond the scope of this investigation. Options for framework development are discussed more in depth under Further Research the Section (7.2).

Of the four main disciplines drawn on to construct the theoretical framework, theories on supply chain management, and those on sociological factors were the most difficult to systematically review and integrate into the framework, data collection and analysis. With the author's higher educational background in sociology, this research was undertaken with a reasonable insight into some of the fundamentals of the discipline, which in some ways provided valuable contribution the research process. This same level of background knowledge was also the source of difficulties, as the framework development, data collection and analysis were to some extent influenced by a desire to incorporate a range of sociological factors that in hindsight were unfeasibly wide. The vague and unsystematic incorporation of sociological theories came to the detriment of the contribution that perspectives from this field could have made to investigating and understanding the research topic. Narrowing the sociological framing of the theoretical framework to a more targeted application would enable the disciple to be used to much greater effect. To some extent the same challenges characterised the use and application of supply chain management theory regarding its breadth, though this latter discipline was integrated into the theoretical frame with more precision. Whereas challenges with integrating sociological theory in a structured way were rooted in the author's previous insight to the discipline, challenges to do so with supply chain management occurred precisely because of the author lacking previous knowledge of such a wide discipline. Particular efforts were made to be more meticulous in the detailing of supply chain management evaluation criteria due this lack of previous knowledge. Despite these efforts, the inclusion of supply chain management theory felt uncoordinated, guided more by the respective theoretical factors that the author stumbled upon by chance more than those that appeared most relevance to the aims of this study.

6.2.2 Methodological reflections

This research was conducted with an intentionally wide focus for the stated reasons of trying to get a general sense for factors that feature across a range of industries. This approach yielded a correspondingly wide range of perspectives to the benefit of providing a broader picture of the factors facing industry regarding materials procurement. The research challenges that were experienced in connection to the broad research perspective related to the preparation and carrying out of data collection, particularly given the use of unstructured interviews. During the process of sampling, individuals contacted for an interview request would often state and interest in participating but hesitated to do an interview owing to uncertainties to the relevance of their professional insights. It is worth restating here that interview requests were only sent out to contacts, known by reliable means (e.g. LinkedIn profile or through professional contacts), to have experience and/or job titles in positions that were of relevance to this research. Usually the stated uncertainties of individuals were with regard to not working in a specific role, usually procurement, but also in relation to sustainability or to India. When some contacts were reminded of the breadth of the research, some agreed to an interview, the data from which made valuable contributions to this research. Of course, declines for interviews may have been for reasons of simply not wanting to participate in the research. However, experience of the contacts ultimately interviewed corroborated with uncertainties expressed during interviews. Only once interviews were underway and respondents were able to frame their responses in relation to a specific theme, usually their respective position, did they begin to connect with the research topics.

Aside from methodological shortcomings regarding how the research was conveyed to prospective respondents, the broad focus on any position within entire product sectors was challenging for respondents to engage with. In addition, the focus could have been narrowed from the focus on product ranges (EEE, textiles, packaging, furniture) instead down to specific materials fractions (e.g. plastics, textiles, paper, rare earth minerals). The focus on product categories was too vague and included material fractions in which there are fewer technical for materials segregation and collection and therefore in maintaining material quality. Notably this included metals used in large quantities such as steel, copper, aluminium or materials where there are not yet established systems for recycling that maintain material quality, such as wood. This point is raised because during data collection, the focus of respondents tended to gravitate towards plastics in particular and is here interpreted as indicative of the significant challenges associated with the use of this secondary materials fraction. Despite these shortcomings, have product categories did assist identifying potential respondents to reach out to.

It became apparent during research that the structure of supply chains was still much less integrated than assumed at the outset of the research. Many manufacturer representatives who were interviewed and located either in head offices or regional offices, did not have much oversight on matters of logistics relating to themselves acquiring secondary materials specifically. Representatives therefore did not tend to have much oversight on the sociological perspectives associated with sourcing and using of secondary materials within components sourced for assembly. As secondary materials criteria featured low or not at all in the purchasing guides of end product manufacturing companies, secondary materials procuremetn would be the prerogative of the sourcing department of 1st and 2nd tier manufacturers. This structure of supply chains points to the need for greater data collection from production facility representatives.

Unfortunately, consideration was not given at the planning stage to the value that could have come from conducting a second round of interviews following analysis of the interviews. The first round of interviews enabled the possibility to scout for key topics that were mentioned across multiple interviews for example, themes of collaboration through industry association networks was raised by multiple respondents. At the time of receiving data on these topics during interviews, it was often difficult to see the pattern and significance of this topic. Only upon conducting the analysis would the significance become more apparent, at which point it would have been good to focus in on asking questions about this topic. A final methodological reflection, this time in relation to Research Question 3 is that one of the key concepts, *implicateion for secondary materials brokers* was insufficiently defined. As a result, the discussion tended to focus more on the barrier and then what actions broker actors could take in response to the barrier. The starkest illustration of this is that while the implications were discussed and addressed by virtue of the recommendations, they were not explicitly stated, with the outcome of not being able to present in a tabular form, the implications for secondary materials brokers.

7 Conclusion

7.1 Summary & Significance of Findings

RQ1: What are the key factors of virgin and secondary materials use and procurement for brands and manufactures with operations in India or similar contexts?

As mentioned at the beginning of the discussion section, technical factors of material properties, material quality and the reliability in consistency of these values all appear paramount for materials use and procurement. These factor holds even more significance for brands and manufacturers producing in India when considering local challenges with MSW collection systems on top of the already significant technical challenges of producing high-quality post-consumer secondary materials. Brand and manufacturer concerns for technical factors of material quality appear rooted primarily in concerns for product safety and legal compliance, product quality and compatibility with production process. Underlying each of these factors is the matter of cost and how much using secondary materials is going to impact a company's bottom line. How much will it cost to develop materials to the standards required by manufacturers? What are the potential costs from product safety related liability claims on companies in terms of legal fees, loss in revenue from drops in business turnover and subsequently in loss in shareholder value? What is the scale of further costs in forgone revenue, supply chain fines and repair costs if technically incompatible materials the damage production equipment? Managerial factors within and between the businesses of a supply chain, pertain the compatibility of the supply chain's structure, knowledge, strategy and culture is with secondary materials use and procurement. Factors of government, markets, society and infrastructure, in all being external to business and supply chains concerned with secondary materials, shape the options available to brands and manufacturers for using secondary materials. These external factors with will subsequently guide the priority placed by brands and manufacturers on secondary materials vs that placed on circularity or sustainability in general. In the Indian context, external factors relate to if the informal waste management infrastructure, evolving government policy and price sensitive market can be conducive for secondary materials use and procurement among brands and manufacturer.

RQ2: What barriers can be identified regarding the use and procurement of secondary materials for brands and manufacturers with production operations in India or similar contexts?

Eight categories of barriers to secondary materials use and procurement in manufacturing were identified based on the factors revealed to answer RQ1 and being invariably closely related to them. Deficiencies in materials technical capabilities, partly down to the lack of needed resources and business autonomy, restrict brands and manufacturers from adopting secondary materials practices. Likewise, the lack of information on the qualities and properties of materials presents sufficient risk to lead manufacturers toward preferences for cheaper and more technically reliable virgin material alternatives. This preference for the more reliable virgin materials alternatives greatly limits the applications for those secondary materials that are already available on the market. Brand and manufacturer decisions to opt for vague, or broad sustainability and circularity strategies limits the degree of support and resources available within organisations for the specific pursue of developing costly and risky secondary materials applications and supplies. When the barriers revealed in this investigation appear present across whole markets, the lack of leadership or even movement by businesses to develop secondary materials develops a herd mentality which in itself becomes a barrier to mangers within organisations. Nobody wants to make the first moves, take the risks and invest the sums needed in hedging their market position on the pursuit of using secondary materials. Government can serve a role in either helping to absorb the risk through financial support or regulation that legally requires all market players to act. Such government intervention would also help to distribute across markets the risks of developing secondary materials supplies and make it more feasible for individual business to engage in the pursuit of this task. However, the absence of such government support and initiatives, or the poor implementation and enforcement of any government initiatives leaves brands and manufacturers with few reassurances and safeguard to pursue secondary materials development.

RQ3: What are the implications of these barriers on efforts in India to broker and increase secondary materials flows from suppliers to brands and manufacturers?

For secondary materials brokers, the implications of the identified barriers can be boiled down to brokers needing to take the initiative in supporting brands, manufacturers, secondary materials industries and government to overcome these challenges. Part of the task for secondary materials brokers is in reflecting on an issues that lies at the heart of their value proposition, to identify and make use of the latent potential in resources that already exist in the surrounding environment. Secondary materials brokers need to work for facilitating trust, co-operation, and information flows to garner finance and drive the emergence of secondary materials production systems in India. With the agenda of secondary materials brokers being per definition based in secondary materials, this is the stakeholder group whose interest it is most in to drive the change to develop supplies. Other stakeholders may express interest in secondary materials, but it is an interest that is subservient to barriers characterised by the conditions of the linear economy within which such ambitions exist. Or to put it another way, developing secondary materials systems is an uphill technical journey. The headwinds of economic norms and government policy making it developing secondary materials systems a hard tasker, and the presence of alternative sustainability options pulling in other directions making it an only harder task further still. If secondary materials brokers do not take the initiative to accelerate change under the current circumstances, it is not clear who might.

7.2 Future Research

Drawing on the critical reflections of this research in Section 6.2, together with the conclusion presented above, suggestions are made for research that can build on the learnings from this investigation.

This research initiated the investigation into the factors and barriers of secondary material use and procurement in manufacturing systems, drawing on the responses of a limited sample base. It was not the experience of the researcher that data collection from the chosen same base reached a point of data saturation whereby new interviews ceased to reveal new insights. Future research could therefore continue on a similar path of qualitative research to draw in the perspectives of a wider range of brands and manufacturers than those sampled in this research. Such research could subsequently build on and develop the theoretical framework employed in this research. Alternatively, it would be interesting to gain an insight into the same research topic but with a completely separate underlying framework, or even a different research methodology. This second suggestion is with consideration for applying a grounded-theory method (Bryman, 2008) and not limiting the study to any one theoretical disposition but instead having the study be entirely guided by the research objective and the perspectives of research respondents. Other approaches could involve studying specific company case studies to gain in-depth understandings of the factors and barriers to secondary materials use and procurement. To build on this research or any other in-depth studies that pursue the factors and barriers to secondary materials use and procurement, a broad-based quantitative study can help produce generalisable findings on the research topic. Such a study could take the factors and barriers presented in the findings of this study and test them across a much larger respondent base of industries in India.

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Appendix A - Interview Respondent Request Email

Dear …

I saw on the IIIEE alumni platform that you work at **XYZ** and thought you might be good to contact to request assistance for my research.

I am an EMP MSc student at IIIEE and am writing my thesis on factors and barriers that manufacturers might experience when seeking to use and procure secondary materials for their production in countries such as India.

My findings aim to help develop the supply of secondary materials by informing secondary materials suppliers and brokers on the needs and challenges faced by manufactures in their efforts to develop circular production

I am currently searching for representatives of consumer goods manufacturing companies to interview for my research and would highly value **XYZ's** perspective. Some examples of respondent profiles of interest include staff working with senior management, procurement, product design, HR, sustainability/environment, finance or consultants and researchers

Would you be willing and able to spare some time for an interview or know anybody who might be good for me to contact?

I have attached two PDFs, one providing a one page summary of my research, and another summarising the topics I wish to focus on during interviews

If you have any questions or would like to know more, please do no hesitate to get in touch.

Thank you for your time and I am grateful for any assistance you may be able to provide.

Kind Regards,

Ben Donovan

Appendix B - Research Summary Overview

MSc Circular Production Research Summary – Lund University, Sweden

Research Problem:

- Unique challenges come with procuring secondary materials for production in emerging economies
- Materials suppliers and brokers in emerging economies need to understand manufacturer needs and barriers to secondary materials procurement in order to meet the increased demand

Research aims and value for respondents:

- Investigate priorities and barriers to secondary materials procurement faced by manufacturers
- Produce findings for secondary materials suppliers and brokers on challenges manufacturers face with procurement of secondary materials in India and other emerging economies.
- Findings aim to help develop secondary materials suppliers in India and emerging economies
    - Help increase manufacturer supply chain access to secondary materials
    - Explore options for multi-stakeholder collaboration towards secondary materials systems
- Identify organisation priority areas for improvement in pursuit of circular production
- Provide an external perspective on organisation materials procurement activities

Background to research problem:

- Global manufacturers have 2030 goals for levels of secondary material usage in their production
- Meanwhile, India has the ambition to become a global manufacturing hub
- As a high growth economy, India is a potentially large source of secondary materials
- To attract globalised production India needs to develop its secondary materials suppliers

Interviews: Who, how and key talking points:

- Consumer goods and materials manufacturing company representatives and industry experts with insight on the factors influencing virgin and secondary materials use and procurement
- Remotely via telephone or video call
- **Supply chain overview** - structure, dynamics, governance, risk etc
- **Circular production at company** - Politics & governance factors, social issues, technical issues, economics & markets, management perspective, infrastructure & surrounding environment,

About the Researcher - Ben Donovan

I am a MSc student in Environmental Management and Policy at the International Institute of Industrial and Environmental Economics, Lund University, Sweden. I have an interdisciplinary background in Development Cooperation, Environmental Sciences and experience with project management in waste management systems, social integration initiatives and events management. As a sustainability consultant at Lunicore Consultancy as well as through academic projects, I have delivered sustainability services in Sweden and India in the fields of life cycle assessments, cleantech industry research, and sustainability strategy formation.

Appendix C - Interview Guide Summary: Respondent Copy

Summary of interview discussion topics

Ben Donovan: Master's thesis, Lund University, Sweden

Factors and barriers to secondary materials use and procurement for consumer goods manufacturing in India: Implications for secondary materials brokers

Introduction:

Interviews will be recorded, and all data obtained during interviews will only be used for the purpose of this research.

All respondents and citations will remain anonymous when presented in the final research report unless prior consent has been given by the respondent to do otherwise.

Please find below a summary of all the key discussion topics that will be covered in my research. The questions have been written with the aim of subjecting them to a range of different staffing positions in the organisations I interview. I therefore do not expect every respondent to answer every question. Instead I would say please respond to as many or few of the topics that you feel you have time for and are most relevant.

All the question topics will be asked from the perspective of one or more of the following points:

- Gaining an overview of materials procurement in the respondent company
- Identifying factors that have led to the current state of materials procurement
- Identifying barriers that are experienced and/or have been overcome by the company in using and procuring secondary materials

1. Opening questions:

- Company strategy regarding recycled materials
- Progress made
- Push/pull factors toward circular production

2. Supply chain overview

a. Supply chain networks

- Structure
- Actors and their significance in SC
- Informal sector
- SC risk factors

b. Supply chain network management

- Types of buyer/supplier relationships
    - Benefits and disadvantages
- Key areas of SC challenges and success

3. Circular economy factors

a. Government policy in location of production

- Legal and regulatory impacts
  - Supportive/prohibitive
  - Incentives & disincentives
  - Health and safety
- Political stability, governance & business environment

b. Infrastructure & location of production

- Location types of production
  - Relative to other businesses
- Resource and waste flow collaborations with nearby businesses
  - Potential
  - Collaboration extent
  - Supporting factors
- Collaboration network features
- Local recycling infrastructure
- Supporting resources and infrastructure

c. Economics & markets factors

- Business case of circular production
- Transition costs
- Recycled materials markets

d. Managerial factors

- Head office/off-shore management relations
- Receptiveness of off-shore management & staff to circular production
- Requirements from management to successfully drive circular production
- Level of business unit autonomy & impact on integrating circular production

e. Technical factors

- SC actor knowledge of circular production
  - Deficiencies & requirements
- R&D in recycled materials
  - Quality
  - Properties
  - Product design
- Implications for production processes

f. Social factors

- Social sources of resistance in SC to circular production
  - Cultural
  - Ideological
  - Habits and routines

Appendix D - Interview Respondent List

Interviewee Number	Interview date	Interview medium	Duration	Position	Organisation type	Respondent sector
I1	22nd August 2019	Online video call - Recorded	1 hour	Supply Account Manager	Brand & Manufacturing	EEE
I2	22nd August 2019	Telephone call - Unrecorded	0:40 hour	Quality & Environmental Director	Manufacturing	Paper
I3	27th August 2019	Online video call - Recorded	1:45 hours	Circular Economy Researcher & Consultant	University & Policy Analysis	Outdoor Adventure Gear
I4	27th August 2019	In person – Recorded	1 hour	GRI & Sustainability Analyst	Brand & Manufacturing	Outdoor Adventure Gear
I5	29th August 2019	Online video call - Recorded	1:20 hour	Senior Civil Servant	Multilateral Governance	Sustainable Industry
I6	2nd September 2019	Online video call - Recorded	0:40 hour	Project Manager	Consultancy	Waste Management Policy Research
I7	2nd September 2019	Online video call - Recorded	0:50	Sustainability Specialist	Brand & Retail	Outdoor Adventure Gear
I8	4th September 2019	Online video call - Recorded	1 hour	Circular Economy Researcher & Consultant	Freelance Consultant	Circular Economy & Waste Management
I9	5th September 2019	Online video call - Recorded	0:40	Environmental Director	Brand & Manufacturing	EEE
I10	6th September 2019	Online video call - Recorded	1:10 hour	Sustainable Materials Analyst	Brand & Retail	Garments & Apparel
I11	12th September 2019	In person – Recorded	1 hour	Circular Business Design	Brand, Retail & Manufacturing	Home & Furnishing

Appendix E - Theoretical Framework: Expanded & Referenced

Supply chain factors – supply networks		
Theoretical Factor	**Description/evaluation criteria**	**Source**
Structural and Indirect Agents hold levers to change of material flows	Material flows in network nodes controlled by key actors (structural agents) among producers and distributors that hold levers to changes in material flows,	(Binder, 2007; Hugos, 2006)
	Indirect agents support structural agents i.e. service providers or supplier's suppliers, can therefore impact change to CE	(Binder, 2007; Hugos, 2006)
	Work with structural agents to transition of SMS supplies	(Cox, 2004; Laurenti et al., 2018)
Network structure impacts Complexity Composition of structural and indirect agents: Depth of integration Level of meta-network management	Network structure and dynamic guides how these agents act regarding material flows and is itself guided by nature of product supply, customer demand and actor power relations	(Binder, 2007; Cox, 2004)
	Number, depth and complexity (connections per node) of network partnerships impacts SC risk and capacity to establish CE	(Hugos, 2006; Jain et al., 2018; Kumar et al., 2019; Tse et al., 2018)
	Deeper and larger network partnerships increasingly work as meta-entity being managed at the network level instead of in dyadic partnerships	(Agyemang et al., 2019; Cardoso de Oliveira et al., 2019; Cox, 2004; Govindan & Hasanagic, 2018; Ivanov et al., 2019; Jain et al., 2018; Kumar et al., 2019)
Network risk: IS partner industry risk Information and quality from informal sector	Unreliable quality and information from informal sector actors in supply networks	(Kumar et al., 2019)
	Identify locations or actors in existing locations with waste streams compatible to SMS procurement	(Jain et al., 2018; Manavalan & Jayakrishna, 2019)
	Consider risk of in industry of symbiosis partner	(Ashton, 2008; Behera et al., 2012; Manavalan & Jayakrishna, 2019)
Supply chain factors – Supply chain management & governance		
Theoretical Factor	**Description/evaluation criteria**	**Source**
Governance and Management mechanisms Formal mechanisms: Contracts, standards, CoC Informal mechanisms Balance structure with order	Network governance guided by formal (regulative institutions e.g. contracts and standards, CoC for virtual SC integration) and informal factors (normative and cultural e.g. trust, habits, values. cooperation)	(Cardoso de Oliveira et al., 2019; Ivanov et al., 2019; Singh & Giacosa, 2019)
	Supplier selection and management dependent of supplier/buyer power relations	(Cox, 2004; Scott et al, 2018)
	Pursuit of collaboration with network actors enables potential to develop SMs supplies	(Jain et al., 2018)

	Governance can manage risk and provide guarantees across network but subsequently facilitate inertia and lock-in	(Cardoso de Oliveira et al., 2019)
	Possible resistance from structural agents to implementing SMs procurement due to subjective norms despite own wishes to do so	(Singh & Giacosa, 2019)
Reconciling core SCM needs with SMs procurement: Costs Information Inventory Logistics Production stability Product quality	Logistics requirements and solutions can impact cost and viability of SMs procurement	(Hugos, 2006)
	Standard inventory management practices (cost management, manufacturing stability and mitigation against uncertainty) may conflict with SMs procurement	(C. Scott et al., 2018)
	Information quality impacts levels of SC traceability needed for managing risk, logistics, product quality, property rights, product maintenance	(Agrawal & Pal, 2019; Hugos, 2006)
	Can logistics options economically recover own products at sufficient rate to recover SMs?	(Kumar et al., 2019)
Supply or demand driven?	Driven by customer demand and product supply	(Ivanov et al., 2019)
	Balancing of production responsiveness & efficiency impacts scale of purchasing, degree of outsourcing, locating of production	(Hugos, 2006; Ivanov et al., 2019; C. Scott et al., 2018)
Circular Economy Factors – Technical and Knowledge		
Theoretical Factor	Description/evaluation criteria	Source
Knowledge capacities: Use SMs On CE principles (conflate with sustainability) Levels and consequences on business behaviour	Knowledge deficiencies (how to use SMs, procure them) hold back but development of CSCM but can also motivate actors to learn	(Agyemang et al., 2019; Benton et al., 2015; Hart et al., 2019; Liakos et al., 2019)
	Conflation of CE with sustainability – over focus on Cleaner production	(Liakos et al., 2019)
Resource allocation: R&D on Secondary materials Necessary facilities e.g. in house lab	Company resource allocation to pursue CSCM, lab access for materials R&D,	(Agyemang et al., 2019; de Mattos et al., 2018)
Material Standards: Consistency, Quality, Different properties, Verification costs	Insufficient standardisation of SMs quality and performance	(Govindan & Hasanagic, 2018; Hart et al., 2019; Kumar et al., 2019)
	Costly verification of material quality and chemical composition	(Bozena, 2018; Govindan & Hasanagic, 2018)

Product design: Product and process compatible with SM Substitute with SMs available High impact materials Product quality vs material efficiency Other CE options may be more appropriate For recycling, involve recyclers	Review product design to accommodate SMs usage: compatibility with other materials and existing processes, substitute out materials with high environmental impact and to those available for secondary production, compromise on product quality, improve material efficiency	(Benton et al., 2015; de Mattos et al., 2018; Esposito et al., 2018; Govindan & Hasanagic, 2018; Jain et al., 2018; Koszewska, 2018)
	Required compromises may elevate suitability of other CE alternatives instead of SMs	(Koszewska, 2018)
	Involve recyclers in materials designing for recycling	(de Romph & Van Calster, 2018)
	Design products with reduced chemical composition to help recycling	(Bozena, 2018; Govindan & Hasanagic, 2018)
Circular Economy Factors – Managerial		
Theoretical Factor	Description/evaluation criteria	Source
Resistance to change Lack of knowledge Lack of resources Ignorance of risks (of inaction) and benefits SCM/business strategy misalignment	Resistance to change due to lack of resources, knowledge or data, of risks and benefits and/or lack of strategic fit between SCM and business strategy	(Agyemang et al., 2019; Benton et al., 2015; de Mattos et al., 2018; Ivanov et al., 2019; Kumar et al., 2019; Prendeville et al., 2018)
Leadership & support Training Strategic visioning & planning SMs procurement risk management Disruptive business models Business case for SMs	Training, senior management visioning and strategic planning needed to integrate CE into company and to manage challenges and risks (e.g. quality, hazardous materials, reliability) of SMs procurement	(Agyemang et al., 2019; de Mattos et al., 2018; de Romph & Van Calster, 2018; Govindan & Hasanagic, 2018; Liakos et al., 2019; Prendeville et al., 2018)
	Developing CE in company requires disruptive business model to challenge systems lock-in and increased company collaboration	(Esposito et al., 2018; Hart et al., 2019)
	Make a business case and secondary material potential of supply chain	(Koszewska, 2018; Liakos et al., 2019)
Company & Management structure Incentivise long term CE investments?	Manager term limits can hinder managers from maing necessary long term investments for transitioning to SMs procurement	(Kumar et al., 2019)

Configured for CE dissemination? Logistics geared for SMs procurement?	Re-evaluate logistics systems to manage procurement of SMs	(Govindan & Hasanagic, 2018)
	Unconducive managerial structure for disseminating SMs procurement	(Govindan & Hasanagic, 2018)
Maintain product standards & quality	Demonstrate that product standards and quality are not compromised	(Koszewska, 2018)
Business unit autonomy	Degree of autonomy in business units helps them integrate CE principles in a way that best suits them	(Benton et al., 2015; de Mattos et al., 2018; Hugos, 2006)
Circular Economy Factors – Economics and Markets		
Theoretical Factor	Description/evaluation criteria	Source
Profit & growth opportunities: Consumer & market pressure Mitigate against resource scarcity	CE source of profits (market growth, cost savings, productivity & efficiency)	(Agyemang et al., 2019; Esposito et al., 2018; Govindan & Hasanagic, 2018; Liakos et al., 2019)
	Consumer and market sustainability pressures need to be balanced with other pressures e.g. cost, quality, quantity, taste, lead times, fast product innovation otherwise associated with virgin materials	(Agyemang et al., 2019; Esposito et al., 2018; Govindan & Hasanagic, 2018; Hugos, 2006; Jain et al., 2018; Koszewska, 2018)
	Secure resources in face of scarcity and population growth	(Govindan & Hasanagic, 2018)
Transition costs: Investment & payback period Brand quality and image vs inaction costs	Does the costly restructuring outweigh the risk associated with continued virgin materials use?, and is it supported by sufficient economic incentives?	(Agyemang et al., 2019; Benton et al., 2015; de Mattos et al., 2018; Hart et al., 2019; Kumar et al., 2019)
	Transition can have long payback period and high upfront costs	(Benton et al., 2015; Govindan & Hasanagic, 2018)
Opportunity costs of transition Investments in linear capital Customer product relationship Cheaper virgin materials	Too much capital invested in linear economy	(Benton et al., 2015; Hart et al., 2019)
	Reduced consumer product relationship with use of SMs	(Singh & Giacosa, 2019)
	Virgin materials still cheaper	(Govindan & Hasanagic, 2018; Hart et al., 2019; Kumar et al., 2019)

Circular Economy Factors – Government and Policy		
Theoretical Factor	Description/evaluation criteria	Source
Laws, regulation and policy: Restraining/enabling Financial implications Level of gov that is intervening Establish industry standards	Laws and MBIs: punitive/supportive as well as investment in CE system	(Agyemang et al., 2019; Bozena, 2018; Govindan & Hasanagic, 2018; Hart et al., 2019; Kumar et al., 2019)
	Local government policy can be more effective in supporting manufacturers with CE – more responsive to company specific needs	(Prendeville et al., 2018)
	Legislate for standards and specifications for secondary material performance and quality	(Govindan & Hasanagic, 2018)
	Legislation for CE/secondary materials procurement helps level the playing field as companies need to comply with new CE laws	(de Mattos et al., 2018; Govindan & Hasanagic, 2018; Kumar et al., 2019)
Political and policy stability: Consistency – application & enforcement Business certainty	In/-stability and in/-consistency in politics and of policies and enforcement that impact CSCM can impact rate of secondary material uptake	(Agyemang et al., 2019; Benton et al., 2015; Govindan & Hasanagic, 2018; Hart et al., 2019; Kumar et al., 2019)
SMs hazardous substances rules Substance declaration Information transfer	Restricted chemical rules have different requirements for information transfer of SMs, post consumer waste materials potential source of chemical risk	(de Romph & Van Calster, 2018)
Infrastructural and Location Factors		
Theoretical Factor	Description/evaluation criteria	Source
Local Industry networks: Trust Collaboration & IS exchange Compatible resource flows SMs broker Proximity correlates with depth and extent	Local industry networks high in trust and collaboration – exchanging knowledge and resources may have compatible resource flows for industrial symbiosis and SMs provision, flows which need to be identified	(Behera et al., 2012; Chertow, 2000; de Mattos et al., 2018; Jain et al., 2018; Wolf et al., 2007)
	Presence of local broker actors with other manufacturers (to collaborate on waste flows) and waste management actors (to source SMs	(Boons & Spekkink, 2012; Chertow, 2000; Howard-Grenville & Paquin, 2009)
	Presence of other businesses pursuing CE to share associated utilities and resources with to make SMs production and procurement economically feasible	(Burström & Korhonen, 2001; Chertow, 2000)
	Extent of proximity to CE collaboration partners will impact depth and responsiveness of CE collaboration	(Ashton, 2009)

Dominant actors: Potential IS anchor Pro/anti SMs infrastructure agendas	Regional dominant actors may have agendas that support/resist development of recycling infrastructure and can play a key role in supporting a CE network as anchor	(Chertow, 2000; Prendeville et al., 2018)
State & CE infrastructure: Recycling collection and processing Knowledge & pilot projects Information tracking systems	Presence and extent of recycling infrastructure across national economy to enable collection and processing of SMs	(Bozena, 2018; Govindan & Hasanagic, 2018)
	Local government policy can provide, pilot projects technical and knowledge support Information tracking systems to verify secondary material data	(Govindan & Hasanagic, 2018; Prendeville et al., 2018)
Sociological Factors		
Theoretical Factor	Description/evaluation criteria	Source
CE socially embedded in Linear economy Norms, habits, values, beliefs Fast turnover, risk aversion, limited materials recover, new product thrill Reveals structural agents and leverage points for change	CE efforts embedded in formal and informal rules and standards, norms, habits, values and beliefs of linear economy e.g. market competition, fast turnover, corporate risk aversion, recover only select materials, customer thrill for new product)	(Govindan & Hasanagic, 2018; Laurenti et al., 2018)
	Structure of norms, rules, power, reveal structural agents, and leverage points/barriers to systems change for SMs procurement (14)	(Binder, 2007)
Individual, societal and cultural barriers Power distance belief	Individual, societal and cultural barriers	(Singh & Giacosa, 2019)
	Presence of power distance belief among SC actors, which supports inequalities, may see SC actors prioritise status quo in pursuit of personal status and power	(Singh & Giacosa, 2019)
Secondary materials awareness education	Education need to address general low level of awareness in society for CE impacting recycling behaviour and purchasing of secondary material products	(Govindan & Hasanagic, 2018; Kumar et al., 2019)
SMs supplier development	Supplier/buyer Trust important for collaboration on developing SMs supplies	(Cardoso de Oliveira et al., 2019)

Build Trust conducive/non-conducive habits & behaviours for SMs procurement Cleaner production	Need to identify and work with habits and behaviours along value chain that are not conducive to SMs procurement	(Singh & Giacosa, 2019)
	Cleaner production helps facilitate mentality shift in company	(Liakos et al., 2019)

Appendix F - Interview Coding Chart Example

Supply Chain Structure, management governance		
Category	Aspect/evaluation criteria	Example Factor
SCM	Supply chain costs, supplier selection, delivery times and costs, logistics, strategic fit between business strategy and supply chain management, product recovery challenges, information flows	Total cost of ownership High baseline for procurement Local production for Local market strategy
Governance & management mechanism	Formal governance - Contracts, standards, CoC, audits, incentives Informal governance - Trust, habits, norms, values, belief systems - Balancing structure with order	Use of Sustainability compliance guide and collaboration for innovation to overcome materials challenges,
Network Structure	Dispersal of production, risk management, network actor power, agendas in network, Structural agents, Reliable/low risk secondary material sources	EU post-consumer household MSW used, food packaging reliable in quality, lower risk Non-EU secondary materials source of risk Structural agent role of larger brands facilitates material-manufacture connection
Supply or demand driven	Level of materials and/or product supply/demand.	Level of supply influence varies between product category ranges and their demand
Technical and Knowledge		
Category	Aspect/evaluation criteria	Example Factor
Knowledge Capacities	Use of Secondary materials, CE principles (conflate with sustainability), knowledge levels and consequences on business behaviour	Company culture focus more on sustainability than circularity room for improvement. Need know on why post-production waste occurs, production efficiency, cleaner production
Resource allocation	R&D on Secondary materials, Necessary facilities e.g. lab	Secondary material suppliers supply engineering support and R&D collaboration generate trust for material quality, and to learn about cleaner production Informal sector does not have recycled material validation technology
Material	Standards, quality, properties, verification costs	Quality of secondary materials degrades every round of recycling
Product design	Product and process compatibility with SM, Substitute with secondary materials, involve recyclers, Other CE options may be more suitable	Material properties provide limited function, design trade-off between function and secondary materials content
Management (Within organisation)		
Category	Aspect/evaluation criteria	Example Factor
Resistance to change	Lack of knowledge, lack of resources, ignorance of benefits or inaction risks, SCM business strategy misalignment	Indian consumption values conducive to using secondary materials No economic assessment on risks and benefits of using secondary materials
Leadership and support	Training, Strategic visioning & planning, SM procurement & risk management, disruptive business models, business case	Secondary materials use needs to have consideration for maintaining social licence, which can impact access to business

Maintain product standards and quality	Management practices to ensure material quality	Close 1st tier supplier dialogue for maintaining material quality partly to ensue regulatory compliance
Business Unit autonomy	Degree and nature of autonomy to pursue sustainability	Low autonomy of SM strategy, can only focus on business unit sustainability
Company and Management Structure	Configured for CE dissemination? Logistics geared for secondary materials procurement? Incentives long term CE investments?	While culture is in favour of secondary materials, business cultural priorities override individual decisions but not overall strategy
Economics and Markets		
Category	Aspect/evaluation criteria	Example Factor
Profit & growth opportunities	Consumer market pressure, mitigate against resource scarcity	Renewed pressure for low product price
Transition Costs	Investment and payback period, brand quality and image, inaction costs	First movers worried about shouldering the most risk and investments for infrastructure leading the market toward PSS business model which for garments companies
Opportunity costs	Investment in linear capital, customer product relationship, cheaper virgin materials	Recycled materials can be cheaper the virgin materials
CE socially embedded in Linear economy	Cultural cognitive institutions, fast turnover, risk aversion, low material recovery, reveals structural agents and leverage points	Secondary materials business models need to integrate with fast fashion
Government and Policy		
Category	Aspect/evaluation criteria	Example Factor
Laws, Regulation and Policy	Restrain/enabling, financial implications, level of gov that is intervening, establish industry standards	Brands and category ranges subject to strict material and quality regulation are very conservative in exploring secondary materials options
Political and policy stability	consistency in application and enforcement, business certainty	Policy on requirement for secondary materials content needed to provide certainty on recycling tech investments
SM hazardous substances rules	Substances declaration, information transfer	Difficult to import chemicals from production chemicals from china or India due to REACH
Infrastructure and Location		
Category	Aspect/evaluation criteria	Example Factor
Local Industry Networks	Trust, collaboration & industrial symbiosis exchange, compatible resource flows, secondary materials broker, Proximity correlates with depth and extent	Middle men in network can undermine its effectiveness
Dominant Actors	Potential industrial symbiosis actor, Pro/anti SMs infrastructure agendas	However, some of the larger chemical companies may agree to develop these networks to gain a competitive edge in a saturated market
State &CE infrastructure	Recycling collection and processing, knowledge & pilot projects, information tracking systems	Governments need to invest in improved secondary materials collection processing infrastructure with simplicity and user interaction