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Consumer Behaviour, Rebound Effects, and LCA-research: Analysing Environmental Benefits of Reuse of Denim Jeans and Button Shirts in the Netherlands

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Abstract

The textile industry is among Earth's most polluting industries, that – among other issues – leads to large amounts of CO_2-emissions and creation of wastes. Previous studies concluded that reuse of clothing can bring benefits to combat issues of the textile industry. *Life Cycle Assessment* [LCA] is a commonly used method to assess such benefits. The role of consumer behaviour is however commonly overlooked in LCA-research, while this heavily influences the use phase which constitutes between 50% and 80% of a product's overall lifecycle impacts. *Rebound effects* [REs] can furthermore occur, further increasing impacts, but yet are often excluded from analysis. Constructing robust methods to include consumer behaviour and REs into LCA-research is called upon. This study contributed to bridging this knowledge gap by conducting a comparative environmental assessment based on the ISO 14040 standards, whereby linear use (representing fast fashion) and reuse of clothing are analysed using a multimethod approach in the Netherlands. A literature research was conducted to determine relevant concepts after which ten store manager interviews and ten consumer interviews were conducted. The store manager interviews concluded that denim jeans and button shirts are the most relevant garments to analyse for this LCA-research. Theory explored in literature research was checked using consumer interviews, which allowed construction of a survey. A functional unit [FU] was based on survey result: "Covering up the upper body of 1 person with a cotton garment weighing 616 g for 514 wears in the Netherlands, while providing sufficiently perceived performance, quality, and fit" for the denim jeans. The FU for the button shirt concerns a cotton- and polyester blend, weight of 425 g, and 273 wears. Survey data furthermore enabled using the quantitative methods descriptive- and inferential statistics to analyse Es. The LCA concluded that reusing 1 FU denim jeans could result in resource and environmental savings of 156.35 MJ energy, 6.53 m³ water and 12.14 kg CO2-eq emissions, compared to the fast fashion scenario. Similarly, reusing a button shirt results in savings of 6.67 kg CO_2-equivalent emissions, 98.09 MJ energy, and 1.73 m³ water. The sample was of insufficient size (n=104) to formulate generalising statements regarding the occurrence of REs. The REs Price, Motivational (direct), and –(indirect) did not occur within the sample, while Re-spending – buying, and Re-spending – selling did occur. The extent of these impacts could not be calculated, but it is understood that these reduce the environmental benefits calculated from the LCA.

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1 Introduction

The textile industry is among Earth's most polluting industries (Hole & Hole, 2019; Siderius & Poldner, 2021). Specifically, it is responsible for about 10% of global *carbon dioxide* [CO_2] emissions, 20% of global clean water pollution (European Parliament, 2023a), and the disposal of garments alone results in 92Mt landfilled waste annually (Campione, 2017). This industry will be responsible for using over 26% of the global carbon budget by 2050, if linear fast fashion continuous (Ellen MacArthur Foundation [EMF], 2017; Hole & Hole, 2019; Niinimäki et al., 2020; European Parliament, 2023a). Fast fashion is a commonly practiced *business model* [BM] in the fashion industry (EMF, 2017; Bick et al., 2018). This BM is characterised by cheap availability of clothing with fast-changing styles, made possible by cheap labour from international supply chains. Fast fashion is characterised by mass production and high stock turnover rates which encourages overconsumption (Bick et al., 2018; Hole & Hole, 2019; Niinimäki et al., 2020; European Parliament, 2023a). Hence, the fast fashion BM belongs to the currently dominant linear economic model of "take-make-consume-dispose", in which resources are extracted, products are produced, consumed, and disposed (Reike et al., 2018, p.246; European Parliament, 2023a). Repetition of this linear production cycle requires continuous extraction of primary resources and produces increasing amounts of waste (European Commission [EC], 2020), resulting in associated detrimental impacts of high resource consumption, landscape reduction, habitat disruption, and biodiversity loss. Long-term solutions to the fashion industry's sustainability problems therefore require a sustainable alternative to the dominant fast fashion BM, and abandoning of fast fashion (Niinimäki et al., 2020). The *Circular Economy* [CE] model is a proposed alternative for the fashion industry, aimed at retaining and maximising the value of a product throughout the entire lifecycle.

Circular Business Models [CBMs] are BMs that result from *circular thinking* (Castro et al., 2022), as practiced in the CE. CBMs aim to prolong the practical lifecycle of products or their parts, or close material loops, by implementing R-imperatives (Nußholz, 2017; Reike et al., 2018). Transitioning to CBMs is assumed to bring environmental benefits when compared to their linear, non-circular, counterparts. Therefore, CBMs can provide sustainable alternatives to fast fashion. Reuse, repair, and recycle are promising R-imperatives for the fashion industry (Bick et al., 2018; European Parliament, 2023b). Examples of CBMs that follow these R-imperatives are reselling of second-hand clothing, clothing repair services, and recycling of clothes into new fibres. Generally, reuse results in the greatest environmental benefits out of these three R-imperatives (Reike et al., 2018), mainly because this avoids the manufacturing of new products (Sandin & Peters, 2018). Transitioning from linear fast fashion towards a CE-model however requires shifts in both *business practices* and *consumer behaviour* (European Parliament, 2016; Camacho-Otero et al., 2020).

The *Life Cycle* Assessment [LCA] tool is widely used to evaluate environmental impacts throughout a product's lifecycle (Shaked & Jolliet, 2011). Comparative LCAs allow comparison between alternative lifecycle pathways, and are thus often used to analyse potential environmental benefits of transitioning from a linear- to a circular setting (Sandin & Peters, 2018; André & Björklund, 2022), such as transitioning from fast fashion to reselling second-hand clothes. However, methodological implications in LCAs still exist and have largely remained scientifically unexplored to date (Korhonen et al., 2018). One of LCA's main limitations is its inability to systematically include primary empirical data on

consumer's behavioural aspects into the analysis. This implication is mostly dealt with by relying on assumptions to model behavioural aspects (Polizzi di Sorrentino et al., 2016). However, assumptions can greatly influence the outcome of an LCA and lead to differing or even contradictory outcomes (Huppes & Ishikawa, 2009). This is problematic, since behavioural aspects heavily influence the 'use phase' of a lifecycle, which constitutes between 50% and 80% of a product's overall lifecycle impacts (Polizzi di Sorrentino et al., 2016). Additionally can transitioning with a poor understanding of behavioural aspects may lead to *Circular Rebound Effects* [CERs], which refer to situations whereby unwanted consequences of CE-measures outweigh- or even terminate expected benefits (Polizzi di Sorrentino et al., 2016; Castro et al., 2022; Metic & Pigosso, 2022). Thus, including behavioural aspects into LCA-analysis could enhance the robustness and reliability of LCA-studies in the fashion industry.

1.1 Relevance

Literature on the relation between the consumer and CER currently lacking, yet called upon (Siderius & Poldner, 2021; Castro et al., 2022; Metic & Pigosso, 2022). It is further called upon to mapping user characteristics in relation to certain behaviour to develop policies in support of the CE-transition (Castro et al., 2022; Koch & Vringer, 2023). To the author's knowledge, is the only framework proposed to incorporate consumer behaviour into LCA-research and quantify the occurrence of CER by André and Björklund (2022; 2023). The authors have however called for further expansion and validation of this framework. The scientific relevance of this to bridge the knowledge gap by constructing robust methods on incorporating behavioural aspects and CER into LCA-research.

The societal relevance of this study is that it provides a more complete re-assessment of the environmental benefits of clothing reuse, which may be lower than consumers presume it to be due to REs. This study could thus raise awareness on REs among consumers. This study furthermore contributes to the transitioning into a CE, which is presumed to bring benefits to society as a whole.

1.2 Research questions

This study aims to contribute to the transition of the fashion industry into the CE, by analysing the impacts of clothing consumption in a circular setting versus a linear setting. Hereby, the environmental potentials of the linear BM 'fast fashion', and CBM 'second-hand clothes' are analysed using an LCA approach that includes consumer behavioural aspects and deals with CER by building on the framework proposed by André and Björklund (2022; 2023). The Netherlands was chosen as a case study because the government's ambition to transition into a CE before the year 2050 (Ministry of Infrastructure and Water Management [IenW], 2023a). The Dutch fashion industry furthermore shows a large and realistic potential for environmental benefits, because Dutch citizens state to be willing to buy more sustainable clothing or reduce consumption, yet not act upon these intentions. Reaching and convincing this group requires further research (Koch & Vringer, 2023). Along with the knowledge that income is linked to consumption (EMF, 2017; Deckers et al., 2023) and the Netherlands is a high-income country, is this country an excellent location for this case study. This research is done with the following research question and sub questions:

"*To what extent do environmental benefits occur when consuming second-hand clothing compared to consuming new clothing bought from fast fashion stores, when also considering rebound effects?*"

Sub questions:

1. "*What is the environmental impact of consumption of second-hand clothing and consumption of clothing bought from fast fashion stores?*"
2. "*To what extent have rebound effects occurred when consuming second-hand clothes, and how does this affect the environmental impacts of clothing consumption?*"

Sub question 1 aims to assess the environmental impacts of clothing consumption in a setting of reuse versus new-use. This allows to make a comparison between clothing consumption in the context of fast fashion versus second-hand, based on actual use phase data. The second sub question aims to map- and quantify the REs during the use phase. This quantification allows insights into additional environmental impacts which are normally left outside of the scope of LCA-analysis, providing additional depth.

2 Theory

This section lays the theoretical foundation for this research, through a literature study. The topics discussed are: consumption (2.1), business models (2.2), Life Cycle Assessment (2.3), and CER (2.4). A brief explanation of the CE is provided in Appendix 1 as background information.

2.1 Consumption and consumer behaviour

Consumption has been defined as "*the acts and processes of acquisition and (or) use of goods and services*" (Poças Ribeiro et al., 2019, p.202). This definition is further explained by distinguishing six stages within consumption (Table 1): (1) acquisition, (2) appropriation, (3) appreciation, (4) devaluation, (5) divestment, and (6) disposition. All stages as a collective represent the 'use phase'. Stages 2, 3, 4, and 5 constitute the 'use stage', which refers to the "*physical deterioration of products…* [and] *…the creation of meaning*" (Comacho-Otero et al., 2020, p.75).

Consumption starts when the consumer gets hold of the object to be consumed (Comacho-Otero et al., 2020). Manufacturing of this object requires energy and raw materials, which have both resulted in environmental impacts. Impacts are thus embodied in the product. Consumption determines how these embodied impacts are used. Consumption can therefore determine the effectiveness of a CBM in terms of environmental benefits to a large extent (Camacho-Otero et al., 2020; Castro et al., 2022; Koch & Vringer, 2023). Polizzi di Sorrentino et al. (2016) indicate that this can constitute between 50% and 80% of a product's lifecycle impacts, which highlights the importance of consumer behaviour in LCA-research.

Related to consumption, is *consumer behaviour*. Consumer behaviour is relevant because transitioning into a CE requires shifts in consumer behaviour (European Parliament, 2016; Camacho-Otero et al., 2020). This concept is defined as "*how a consumer consumes*" (Polizzi di Sorrentino et al., 2016). Combined with the theory by Camacho-Otero et al. (2020), this means that consumer behaviour refers to how an individual acquires-, appropriates-, appreciates-, devaluates-, divests-, and disposes a product or service.

Table 1: Stages of consumption (derived from Camacho-Otero et al., 2020, p.75)

Stages of consumption (use phase)		
Number	Name	Description
1	Acquisition-stage	The process in which consumers get hold of the objects to be consumed.
2	Use stage: Appropriation	The means by which consumers embed acquired objects in their daily life.
3	Use stage: Appreciation	Occurs when individuals value the acquired objects in their domestic environment.
4	Use stage: Devaluation	Occurs when the acquired objects lose their meaning and therefore importance for the consumer.
5	Use stage: Divestment	Occurs when the individual distances themselves from the object, because the object is considered irrelevant or not useful anymore to the consumer.
6	Disposition-stage	Disposal of a product, which could mean disposal in a waste bin but also storage in (for example) a room.

2.2 (Circular) Business Models

A *business model* [BM] describes how a company creates value for the customer, and captures value for the company (Pal & Gander, 2018; Rosa et al., 2021). Businesses that follow a *Circular Business Model* [CBM] aim to contribute to resource efficiency by extending usefulness of products or their parts throughout the lifecycle, and by closing material loops (Nußholz, 2017). This means that their value creation revolves around keeping economic value embedded in the product for as long as possible (Rosa et al., 2021). Linear BMs rely on selling as many products as possible, thus the value creation revolves around customers disposing the created value in order to purchase new products. Many BMs and CBMs exists. For the sake of relevancy are only (C)BMs within the scope this research discussed, which are fast fashion, second-hand clothing stores, and kringloopwinkels.

Fast fashion is a relevant BM to discuss because this BM is commonly practiced in the fashion industry (EMF, 2017; Bick et al., 2018). This BM furthermore results in many unstainable practices, which include overproduction, overconsumption, and careless disposal of garments (EMF, 2017; Bick et al., 2018). Long-term solutions for the fashion industry's sustainability problems require the abandonment of fast fashion (Niinimäki et al., 2020; European Parliament, 2023b). These factors make fast fashion a useful reference scenario to use when conducting the LCA. Buying second-hand clothing is a feasible alternative to fast fashion (Bick et al., 2018). Second-hand clothing stores and *kringloopwinkels* are the most commonly found type of Dutch second-hand clothing stores (Allekringloopwinkels.nl, 2023). Therefore are these CBMs selected as an alternative to fast fashion when conducting the LCA, rendering them relevant in this case study. Subsequent paragraphs describe what each BM entails.

2.2.1 Fast fashion

Fast fashion often requires international supply chains, with production located in China or Bangladesh (Bick et al., 2018). Fast fashion pushes new styles, resulting in overproduction and planned obsolescence (Hole & Hole, 2019). Fast fashion encourages the idea that clothing is disposable, encouraging consumption (Bick et al., 2018; Hole & Hole, 2019; Niinimäki et al., 2020; European Parliament, 2023a), resulting in a short use span. The EMF (2017) estimates that over half of fast fashion-clothing items are disposed within a year after purchase.

2.2.2 Second-hand stores

Second-hand stores, informally also referred to as *vintage clothing stores*, are private-owned stores that sell second-hand goods, online and/or from a physical store. Goods are donated to- or bought by the store (Allekringloopwinkels.nl, n.d.a). Differences within this CBM exist. Some stores for example offer resellers a portion of the profits after selling the product. Most second-hand stores however function like traditional stores whereby the store itself buys the garments, sell them, and receives all profits.

2.2.3 Kringloopwinkels

Kringloopwinkels (Dutch for '[life]cycle-stores'), also called *kringloopcentrum* ('[life]cycle-centre'), second-hand goods, online, physically, or a combination of both. Their goods usually range from clothing, furniture, books, home appliances, and toys, among other products. Kringloopwinkels are non-profit organisations with the aim to facilitate jobs for people with a labour market disadvantage, and to support sustainable initiatives such as transitioning to the CE through enabling local reuse (Allekringloopwinkels.nl, n.d.b; 100procentkringloop.nl, 2022). Kringloopwinkels rely on donations of goods, which are checked, cleaned, repaired, priced and before reselling (Allekringloopwinkels.nl, n.d.b).

2.3 Life Cycle Assessment

Life Cycle Assessment [LCA] is a useful tool for quantifying the environmental impacts of a product or service over its lifecycle. The results of LCA are presented based on the function of the product or service, which enables comparison between different user-scenarios of the products or services (Shaked & Jolliet, 2011). Therefore is LCA adopted for the comparative environmental assessments of the fast fashion- and circular BM in this study. The following paragraphs discuss standardised LCA (2.3.1), and enhanced LCA (2.3.2).

2.3.1 Standardised Life Cycle Assessment

LCA-analysis consists of an iterative process of four stages; goal definition, inventory of extractions and emissions, impact assessment, and interpretation of results, as demonstrated in Figure 1 (ISO 14044, 2006; Shaked & Jolliet, 2011).

The goal definition stage involves defining the *functional unit* [FU] and reference flows, and the *system boundaries* (Jolliet at al., 2015). The FU is defined as the "*quantified performance of a product system for use as a reference unit*" (ISO 14044, 2006). This implies quantification of the function that is offered by the product or service, which can be used as a basis to compare different scenarios of this respective product or service. The FU is additive, meaning that two FUs equal double the impact of one FU (Jolliet at al., 2015). The reference flows represent the required products or services to achieve 1 FU, and may differ among scenarios (Jolliet at al., 2015). The system boundaries are a "*set of criteria specifying which unit processes are part of a product system*" (ISO 14044, 2006). The system boundaries typically include all economic processes involved to deliver the system function; extraction of energy and raw materials, manufacturing, use phase, and waste treatment (Shaked & Jolliet, 2011). These processes together constitute the lifecycle of the product (ISO 14044, 2006). Assumptions are formulated for parameters such as use rates, lifetime, and use efficiency (Jolliet at al., 2015).

The inventory analysis stage examines the inventory of resource inputs and pollutants emitted throughout the product's life cycle. Primary inventory data can

be collected from existing production facilities, while missing data could be sourced from secondary sources such as inventory databases like Ecoinvent (Shaked & Jolliet, 2011).

Impact assessment is the third step, in which the environmental impacts of the resources and emissions identified in the preceding step are estimated. (Shaked & Jolliet, 2011).

The interpretation stage is the final step. In this step are the results analysed, which is important to, for example, identify hotspots where can be intervened for improvements (Shaked & Jolliet, 2011).

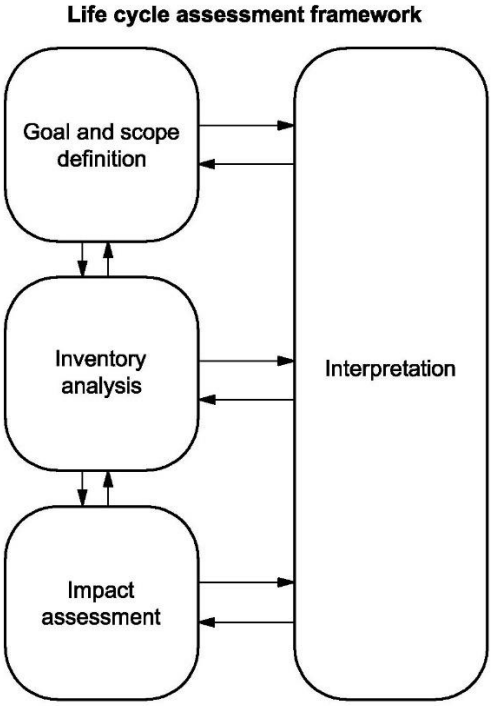


Figure 1: Life cycle assessment framework (from ISO 14040, 2006)

2.3.2 Enhanced Life Cycle Assessment

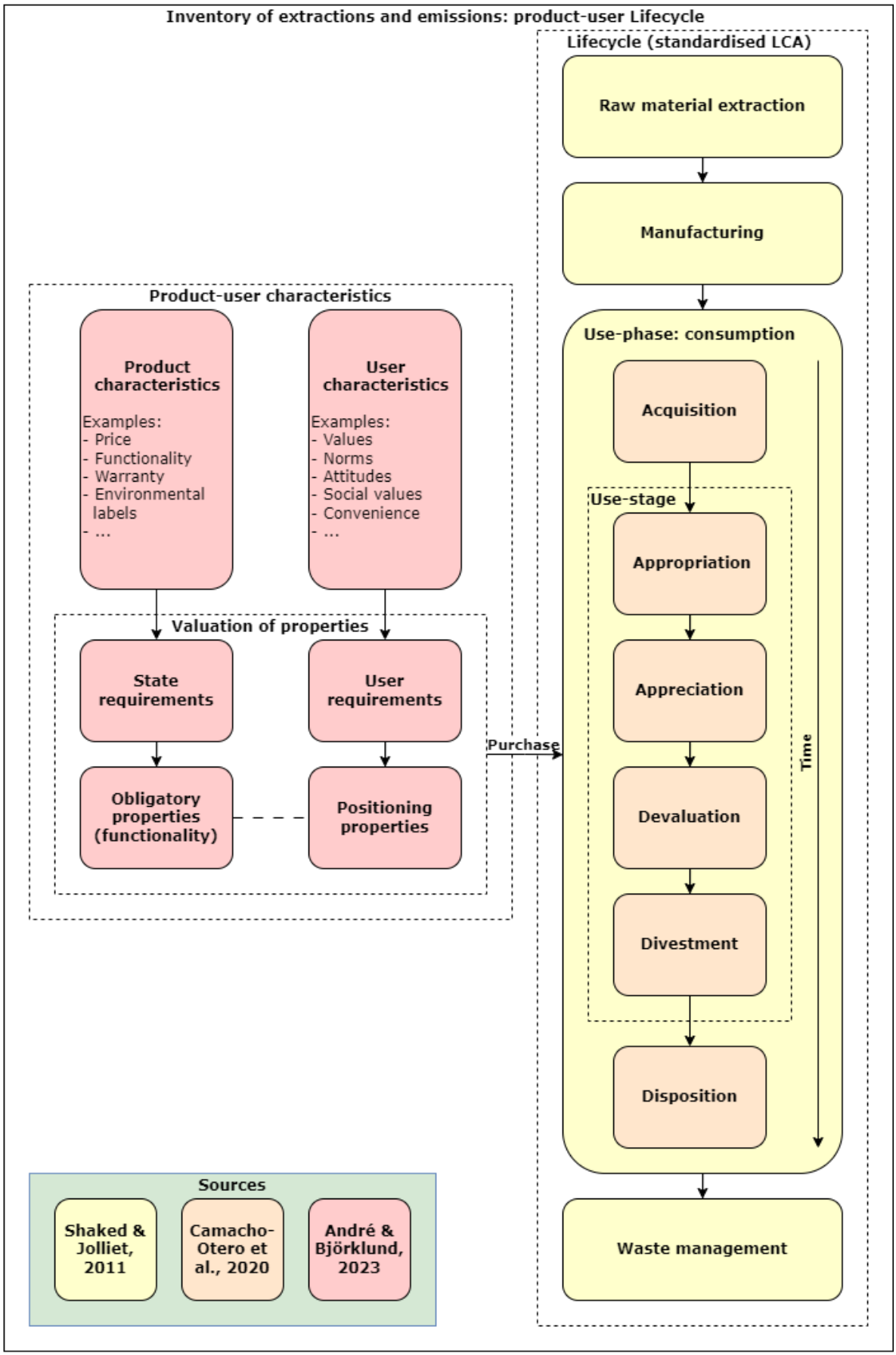
One main limitation of conventional LCA is its inability to systematically include primary empirical data on consumers' behavioural aspects into the analysis (Polizzi di Sorrentino et al., 2016; André & Björklund, 2023). As a result is the use phase of the lifecycle often modelled based on secondary data and assumptions, which can greatly influence its outcome (Huppes & Ishikawa, 2009; Polizzi di Sorrentino et al., 2016; André & Björklund, 2023). Method development to include consumer behaviour into LCAs has remained scarce. Polizzi di Sorrentino and colleagues (2016) state that methods must address (1) realistic user scenarios, (2) defined correlations between shared user characteristics and behavioural patterns, and (3) improved behaviour over time.

Another determinant of the LCA outcome is the displacement rate assumed. Displacement rates refer to the extent to which products are equal to one other, and the product displaces another product, as exemplified by a fast fashion clothing being replaced by a reused alternative. A 1:1 ratio implies a perfect displacement in which the need to produce a new good is displaced and thus a sustainable scenario (Zink & Geyer, 2017). Displacement rates may influence the FU.

Rebound effects (section 2.4) are equally important when conducting an LCA on clothing. André and Björklund (2022) proposed a framework to include these

into LCA-analysis. The authors introduced the concept of *product-user lifecycles*, which reflects to the interplay between the product and its user in the lifecycle (Figure 1). Mapping of product-user lifecycles starts with mapping *product-user characteristics*, which refer to key product factors such as function, lifespan, and energy efficiency. These are called product-user characteristics, because these factors are relative to the user; it is the user who determines how a product is ultimately used. *Product properties* are found at the intersection of product-user lifecycles and product-user characteristics, and consist of both product characteristics (such as performance, appearance, and pace of change) and aspects of how a product functions (product functionality). Product properties can be described in terms of *state requirements* and *user requirements*. State requirements refer to the extent to which a product is able to perform a certain function, while user requirements refers to the extent an user wants a product to function. Interplay between state- and user requirements is called *user valuation of product properties*, which determines the obtainment motivation (acquisition). Both state- and user requirements develop over each use span, starting at the acquisition phase (see section 2.1) and ending at the disposition phase. User valuation of product properties can be plotted over time, which provides insights into the extent to which a product is used. Decreasing valuations of product properties are either the result of a decreased state of performance or service, or an increased state of user requirements. Lower valuations result in lower use rates, and eventually a *riddance decision* in which one disposes off the product. This theory is conceptually visualised in Figure 2.

Figure 2: Conceptual visualisation of including consumer behaviour into LCAs



2.4 Circular Economy Rebound

The concept of *rebound effects* [REs] originates from energy economic, in which it refers to situations where expected energy savings from efficiency increases are reduced by changes in consumption patterns (Metic & Pigosso, 2022). Three types of REs are generally distinguished; direct-, indirect- (also called secondary), and economy-wide RE. Direct RE refer to situations in which improvements result in increases in production or consumption of the same good/service. Indirect RE occurs when these increases happen in production or consumption of other goods/services. An aggregation of both types is called an economy-wide RE (Metic & Pigosso, 2022). This results in a relationship between the REs response time, whereby direct RE has the fastest- and economy-wide RE has the slowest response time (Castro et al., 2022), which means that direct RE is measurable within a relatively short period of time. REs can occur on three levels; micro, meso, and macro. The micro-level refers to individual consumers, producers, companies, or households in relation to a single good or service. The meso-level encompasses whole markets or sectors that entail multiple of micro-level actors, with a focus on the relationships between them. The macro-level refers to interactions that occur on the level of whole cities, regions or nations (Metic & Pigosso, 2022). REs can also be distinguished based on the actors involved, for example consumer(s), producer(s), or both (Castro et al., 2022; Metic & Pigosso, 2022).

Circular Economy Rebounds [CERs] are REs in the context of the CE. These occur when increases in eco-performance from implementation of a CE-measure are lower than expected due to absolute increases in production or consumption (Zink & Geyer, 2017; André & Björklund, 2022; Castro et al., 2022; Metic & Pigosso, 2022). CER has the potential to undermine the benefits of the CE, thus must be included into CE-research (Siderius & Poldner, 2021). Literature on CER is scarce (Siderius & Poldner, 2021), although two influential systematic literature reviews on CER have been conducted (Castro et al., 2022; Metic & Pigosso, 2022). A consensus on terminology surrounding CER concepts, causes of CER, CER-indicators, and how these relate is however still lacking (Castro et al., 2022; Metic & Pigosso, 2022). This research mainly uses Metic and Pigosso (2022) to explain CER, because these authors provide a more detailed categorisation of different types of CER than Castro et al. (2022). Metic and Pigosso (2022) conceptually explain that CER is caused by a trigger, which effect is reinforced by a *driver*[1]. Triggers and drivers are defined as "a set of interdependent elements that cause an activity or process to occur" (Castro et al., 2022, p.4). Together, the trigger(s) and driver(s) initiate one or more mechanism(s). Over time, these mechanisms result in CER (Metic & Pigosso, 2022). Figure 3 visually displays this relationship. Exact causal mechanisms for CER are hard to determine, and mechanisms might be synergistic (Metic & Pigosso, 2022; André & Björklund, 2023).

[1] The terms 'trigger' and 'driver' correspond with what Castro et al. (2022, p.4) call "initiator mechanism" and "developer mechanism", respectively.

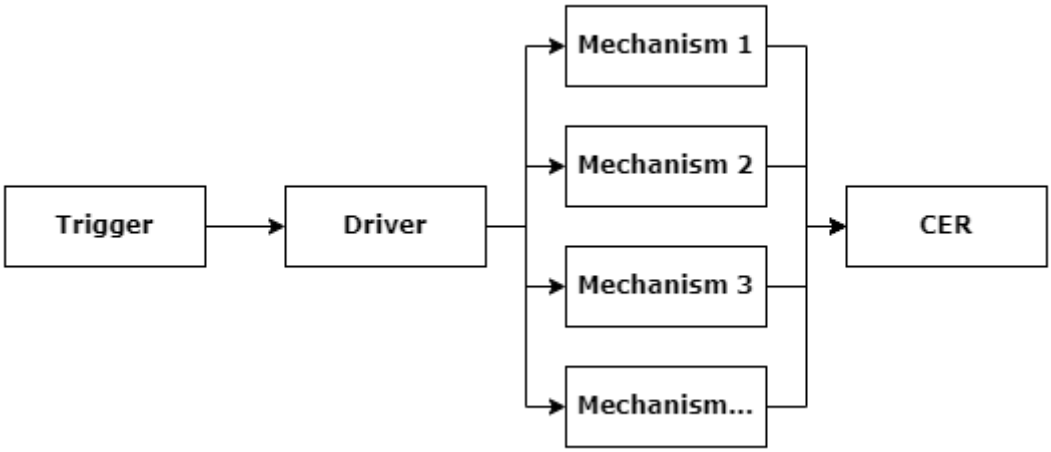


Figure 3: Conceptual visualisation of the occurrence of CER (based on Metic & Pigosso, 2022)

2.4.1 Relevant mechanisms

This research is a case study on clothing consumption by individuals, in the context of a linear- and a circular setting. Mechanisms that occur on the micro-level and relate to the consumer are therefore potentially relevant for this research. These are the direct mechanisms 'Price', 'Income', 'Motivational (direct)', and 'Time', and the indirect mechanisms of 'Re-spending', 'Consumption accumulation', and 'Motivational (indirect)', as defined by Metic and Pigosso (2022).

The definitions for these mechanisms provided by Metic and Pigosso (2022) often include the term 'efficiency improvements'. This results in narrow definitions which are hardly applicable to the case of clothing consumption, since clothing consumption from the consumer's viewpoint rarely includes 'efficiency'. The use of this terminology is likely the result of the novelty of the CER-concept, and its roots in energy economics. The definitions are converted into more general definitions to enable applicability in this case study. In these definitions is strived to preserve the main essence of the original definitions. Subsequent paragraphs argue how this is done for each respective mechanism. Additionally is argued how each relevant CER-mechanism conceptually relates to this case study, in terms of main driver(s) as defined by Metic and Pigosso (2023). The triggers are left outside of this explanation, since all triggers take place on a macro-level. This means that the triggers are relevant to explain *why* CER occurs, but not relevant when quantifying the effects of CER. Table 2 displays all relevant drivers for this research, and Table 3 shows all relevant mechanisms alongside their original- and the interpretation of their essence. Numbers for the drivers are directly adapted from Metic & Pigosso (2022). Figure 4 visually displays the conceptual relations of each relevant CER-mechanism.

Table 2: Relevant drivers (adapted from Metic & Pigosso, 2022, p.5)

Relevant drivers		
D1	Economic factors	Economic factors such as price, cost, and wealth influenced by triggers acts as RE drivers by decreasing the products/service price or increasing the disposable income
D2	Consumer/producer behaviour	Consumer and/or producer behaviour changes (e.g. change in consumption/production patterns) as drivers of RE due to implementation of certain improvement initiatives
D7	Information accessibility/knowledge	Information accessibility, knowledge difference, and lifestyle choices influencing decision making and further drive RE if not having a complete picture of a problem/solution

Table 3: Relevant direct- and indirect rebound effect mechanisms, micro-level, consumer-related (adapted from Metic & Pigosso, 2022)

DIRECT		
Mechanism	Original definition	Interpretation of essence
Price	Efficiency improvements reduce the production costs of a product/service, resulting in lower costs and higher demand for the product/service, which in turn results in higher resource demand for production	Cheaper availability of a good or service attracts new consumers thus increasing total demand for this respective good or service
Motivational (direct)	As a product/service gets more efficient, consumers' preferences, perceptions and behaviour change leading to an increase in the consumption of that product/service	When a good or service is perceived as a sustainable choice, consumption of this good or service increases
INDIRECT		
Re-spending	Efficiency improvements can reduce the cost of a product/service, increasing disposable income which can be spent on other products/services	Cheaper availability of a good or service results in monetary savings, which are then spend on other forms of consumption, increasing total consumption
Consumption accumulation	The demand/supply of more efficient product/services often does not replace but instead supplements conventional products	Situations in which sustainable options do not replace existing demand, but supplement it, increasing total consumption
Motivational (indirect)	As product/service gets more efficient, consumers' preferences, perception and behavioural change leading to an increase in consumption of other products/services	A change in consumer's behavioural patterns, because the consumer considers the sustainability performance of a product/service important, resulting in increased consumption of resources

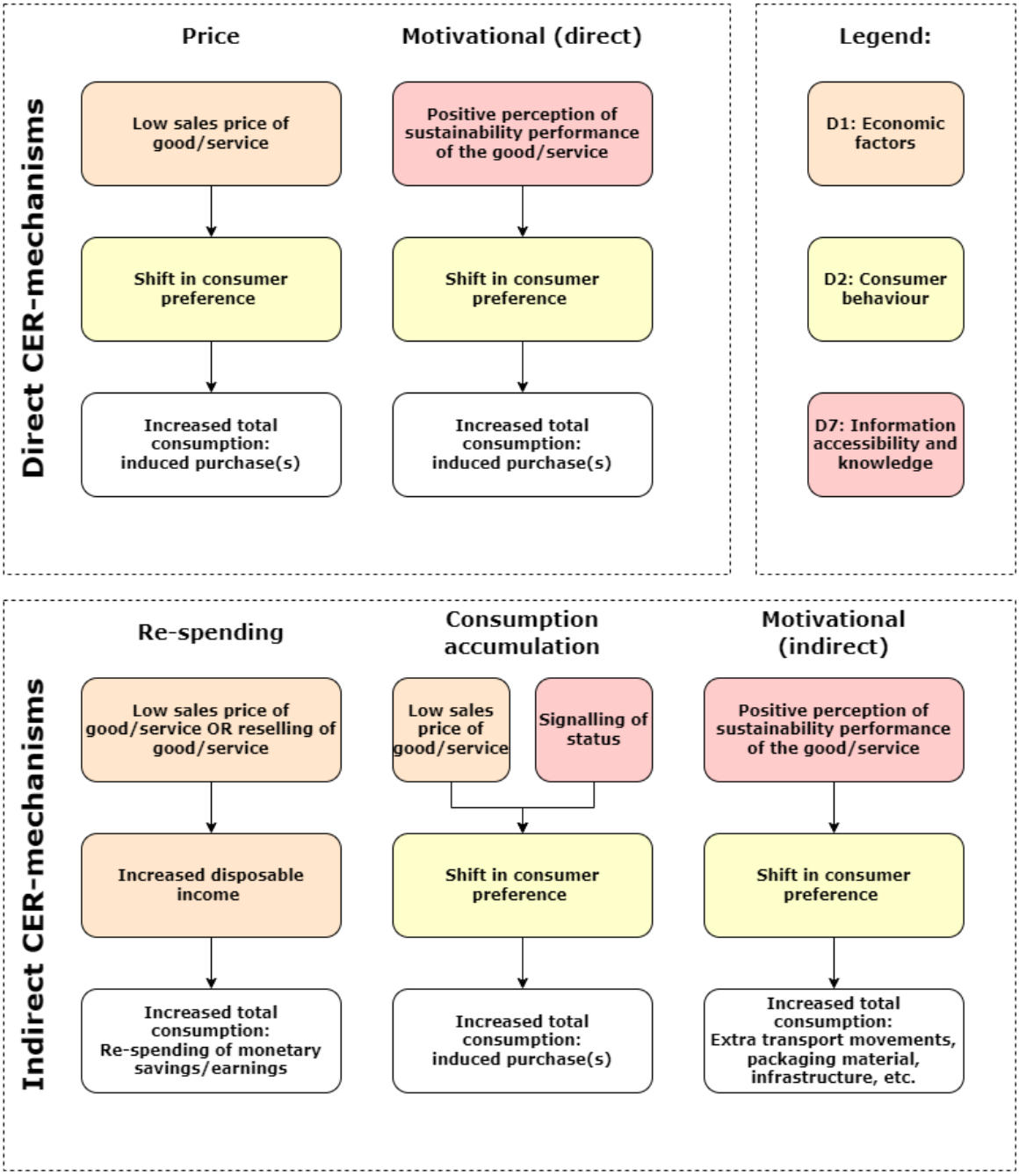


Figure 4: Conceptual visualisation of relevant CER-mechanisms in this case study

2.4.1.1 Price

Metic and Pigosso (2022) define this mechanism as increased demand for a product or service, as a result of a lower sales price, enabled by reduced production cost due to a more efficient manufacturing process. D1 is the main driver of this CER-mechanism, with D2 as a secondary driver (Table 2).

The main essence of this CER-mechanism is induced demand as a result of cheaper availability of the good or service. The following definition can be formulated in more general terms: "the price-mechanism refers to a situation in which cheaper availability of a good or service motivates the user to obtain this respective good or service, increasing total demand for this respective good or

service". In the case of clothing consumption can 'Price' refer to cheap availability of clothing which in turn induces consumption of clothing.

2.4.1.2 Income

Metic and Pigosso (2022) define this mechanism as reduced cost of ownership of a good or service due to efficiency improvements, resulting in increased disposable income of the consumer. In turn, this results in increased consumption of the respective good or service.

The essence of this mechanism is interpreted as reduced cost during the use stage. In the case of clothing consumption, the use stage consists of wearing, washing, storing, maintaining, and drying the clothes (Sohn et al., 2021). Direct cost are only involved during maintaining, washing and drying (if done by machine). It is unlikely that individuals wash and dry their second-hand clothing differently than newly bought garments, thus it is assumed that income does not relate to those practices of clothing consumption. It can be argued that used clothing, such second-hand clothing, requires more maintenance than newly bought garments due to the higher number of use cycles. However, in the Netherlands, clothing is rarely repaired; Koch and Vringer (2023) state that merely 48% of the Dutch population is willing to repair clothes – and only if repairing is cheaper than the purchase of a new garment. The authors did not ask about actual clothing repair rates, since they argued that Dutch respondents would not be able to remember the last time they had their clothing repaired. It can furthermore be argued that the actual repair rates are well below 48%, since perceived behaviour is consistently lower than willingness for behavioural change in the report by Koch and Vringer (2023). The CER-mechanism 'Income' therefore barely applies to clothing consumption in general, and does not apply to a case study in the Netherlands. Thus is this CER-mechanism considered irrelevant for this research.

2.4.1.3 Motivational (direct)

Metic and Pigosso (2023) state that this mechanism refers to situations in which efficiency improvements of a good or service result in a more favourable perception of the good or service. This influences consumer preferences and thus -behaviour, leading to an increase of consumption of the good or service. This means that D7 is the main driver of this CER-mechanism, with D2 as a secondary driver.

The essence of this definition is interpreted as when a good or service is perceived as a sustainable choice, consumption of this good or service increases. In the case of clothing consumption, Motivational (direct) can be defined as situations in which a garment is perceived to be more sustainable, which results in increased consumption of this garment because the consumer considers this important. This could mean that second-hand clothing induces consumption of clothing, since second-hand clothing is often considered a more sustainable option than new clothing.

2.4.1.4 Time

Metic and Pigosso (2022) refer to Time as situations where individuals can consume a good or service in less time, which makes them likely to consume more of that good or service, resulting in increased total consumption. Castro et al. (2022) describe a similar RE in which innovation leads to reduced time of consumption, increasing total consumption. The essence of this CER-mechanism is interpreted as temporal savings due to using the respective good or service, which result in time spend on consumption of the same good or service. An

example is transportation; faster modes of transportation increase the total travel distance within a set time frame.

This mechanism refers to goods or service with a temporal dimension during usage. Clothing consumption does not include a temporal dimension, thus is this mechanism considered irrelevant for this research.

2.4.1.5 Re-spending

Metic and Pigosso (2022) define this mechanism as situations in which efficiency improvements result in the lowering of the cost of the good or service, which results in a lower sales price, and thus an increased disposable income of the consumer after purchasing the good or service. The consumer then spends this increased income on other goods, which increases total consumption. D1 is the only driver associated with this CER-mechanism, since all relates to economic factors.

The essence of this mechanism is interpreted as monetary savings as a result of choosing one good or service over another, which enables the consumer to re-spend the money on other goods or services, increasing total consumption. André and Björklund (2023) discuss a closely related CER-mechanism whereby the good is resold after using it, which allows the reseller to re-spend that money on other goods or services. This CER-mechanism is unnamed by André and Björklund (2023) and undefined by Metic & Pigosso (2022), although the essence of this CER-mechanism is the same as Re-spending. Therefore are two types of Re-spending distinguished in this study, in which the prior described is referred to as 'Re-spending – buying' and the latter as 'Re-spending – selling'.

In the case of clothing consumption can Re-spending – buying refer to cheap availability of clothing due to availability of second-hand clothing, resulting in monetary savings by the individual that purchases it, which then can be spend on other types of consumption. Re-spending – selling refers to situations in which an individual sells an used garment, which results in the seller gaining money, which then can be spend on other forms of consumption.

2.4.1.6 Substitution

This mechanism refers to efficiency improvements and reduced costs of a good or service, which results in substitution of other goods or services by the (now) cheaper available good or service (Metic & Pigosso, 2022). Castro et al. (2022) emphasize that similar situations may occur when implementing R-imperatives. The authors state that reuse-, remanufacturing, and recycling may result in a secondary market which does not proportionally replace primary production, resulting in reduced environmental benefits or even increased -impacts. Zink and Geyer (2017) discuss a case in which refurbished smartphones attract consumers who would not have been able to afford a new smartphone. Thus in that case, the R-imperative 'refurbish' attracts new clientele, which increases total consumption. This means that D1 is the main driver, with D2 as a secondary driver.

The essence of this CER-mechanism is interpreted as cheaper availability of a good or service, that attracts consumers that initially would not have consumed that respective good or service, which increases total consumption. For the case of clothing consumption, it is assumed that everyone wears clothing. This means that there is no new clientele to attract, rendering this CER-mechanism irrelevant for the case of clothing consumption.

2.4.1.7 Consumption accumulation

Metic and Pigosso (2022) define this mechanism as situations wherein more efficient – and thus cheaper – goods or services do not replace existing demand but supplement it. Castro et al. (2022) describe a similar mechanism in which circular goods are acquired in addition to non-circular goods, as a result of cheap availability. Consumption with the aim to signal status furthermore influences the obtainment decision in this CER-mechanism. This means that D1 and D7 are the main drivers of this CER-mechanism, with D2 as a secondary driver.

The essence of this CER-mechanism is interpreted as situations in which sustainable options are acquired due to economic factors, or to signal social status. However, the sustainable options do not displace existing demand, but supplement it. This increases total consumption. Both Metic and Pigosso (2022) and Castro et al. (2022) use second-hand clothing consumption as an example of consumption accumulation. The authors state that second-hand clothing is often acquired in addition to-, rather than in substitution of new clothes.

2.4.1.8 Motivational (indirect)

This mechanism refers to situations in which efficiency improvements of a good or service result in a more favourable perception of the good or service. This influences consumer preferences and thus -behaviour, increasing other forms of consumption (Metic & Pigosso, 2023). The authors provide an example whereby individuals are attracted towards this good or service, and might go out of their way to acquire this specific good or service, resulting in increased fuel consumption. D7 is the main driver and D2 is a secondary driver.

The essence of this CER-mechanism is interpreted as a higher attraction to a good that is considered sustainable, which leads to a change in consumers' behavioural patterns, which in turn results in increased consumption of resources. This could go beyond fuel consumption; another example could be online shopping for goods that are perceived to be sustainable, but require additional packaging materials for delivery. Another example could be the development of infrastructure required to create or facilitate the goods. In the case of clothing consumption, Motivational (indirect) can be defined as situations whereby a garment is perceived to be sustainable, which results in increased attraction of customers towards stores that sell this garment.

3 Research Design

This research takes place in the Netherlands, using the city of Utrecht as a case study. The research question of this research consists of two components; (1) analysing the environmental impact of clothing consumption in a setting of reuse versus new-use, and (2) quantifying the impact of rebound effects that have occurred during the product-user lifecycles in both contexts. Both components are reflected in sub question 1 and 2, respectively. In this section is discussed why the research location was chosen (3.1), which methods are used to answer each sub question and why (3.2), the data collection process (3.3), ethical issues related to data collection (3.4), operationalisation of the interview- and survey concepts (3.5), and the LCA (3.6).

3.1 Location case study

The Netherlands is chosen for this case study, because this country has formulated the aim to have transitioned into a CE by 2050 (IenW, 2023a). Research on second-hand clothing in the Netherlands is was feasible, because the majority of Dutch second-hand transactions involve clothing items (Thuiswinkel.org, 2022; Kunst, 2023), and clothing stores are most prominently found out of all specialised physical second-hand stores (Allekringloopwinkels.nl, 2023). Shifting away from fast fashion is recognised as one of the most promising ways towards environmental benefits in the Netherlands. This is because Dutch consumers state to be willing to reduce consumption and consume more sustainably, yet do not act upon these intentions (Koch & Vringer, 2023); merely 12.7% of the Dutch population regularly wears second-hand clothing (Kloosterman et al., 2021). Dutch citizens are however willing to consume 'more sustainably' (Koch & Vringer, 2023). But greater environmental benefits can be achieved by reusing goods, since reuse extends the use cycle of goods that are already in existence, which potentially prevents the production new goods (Reike et al., 2018). Therefore great opportunities for environmental benefits exist in the Netherlands. The inverse is also true; not acting upon these opportunities will result in increased environmental impacts by the fashion industry. Reasons for this include trends that are expected to continue, such as the growth of the fashion industry in general (EMF, 2017; European Parliament, 2023b) and increased consumption due to population growth (Deckers et al., 2023; Centraal Bureau voor de Statistiek, [CBS] 2023a).

The city of Utrecht was chosen as the main location for this study. Utrecht is considered suitable for this research, because it is among the largest cities of the Netherlands in terms of population size (CBS, 2024a), increasing the chance on a representative sample. Additionally, there are at least 28 physical second-hand stores located in Utrecht (Allekringloopwinkels.nl, 2023), which contributes to research feasibility in the city of Utrecht.

3.2 Methods used

This research uses a multimethod approach to incorporate behavioural aspects into LCA-research. Figure 5 provides an overview of how the methods used and how they relate. Subsequent paragraphs explain per sub question why these methods are used.

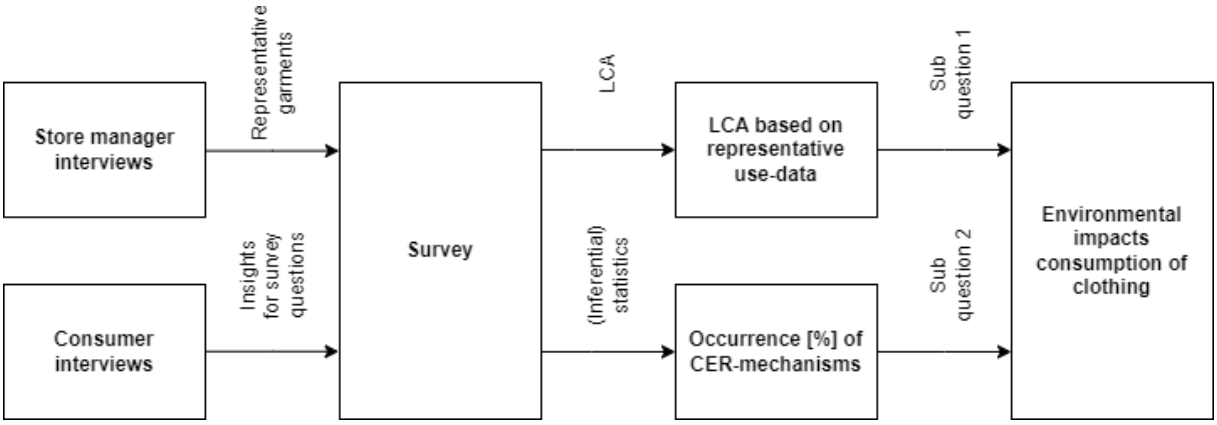


Figure 5: Visualisation of methods used per sub question

3.2.1 Methods used in sub question 1

The first sub question, "*What is the environmental impact of consumption of second-hand clothing and consumption of clothing bought from fast fashion stores?*", aims to assess the environmental impact of clothing consumption in a setting of reuse versus new-use.

The main goal of this sub question is to compare the environmental impact of both settings. This comparison is made by using the quantitative method LCA. This method was chosen because LCAs enable the quantification of occurred environmental impacts of a good, in relation to the function of this good (Shaked & Jolliet, 2011). This allows a comparison between consumption of newly bought fast fashion clothing items and the reuse of second-hand clothing. The LCA is constructed using SimaPro software.

The LCA is based on input-data gathered through conducting semi-structured interviews with store manages of second-hand stores. Conducting these interviews allows the determination of often sold garment types, which ensures relevancy of the LCA-analysis. Semi-structured interviews were chosen over structured interviews, because semi-structured interviews provide a guideline through predetermined topics, while maintaining flexibility (Dunn, 2016). This flexibility allows a clear interview structure on the one hand, and a natural conversation on the other.

Semi-structured consumer interviews were conducted in order to gain additional insights into differences in consumption of second-hand- and new clothing. These additional insights were used to explore if the theory discussed in section 2 holds true for the Netherlands, or if there were important factors that were not considered. Semi-structured interviews were chosen because of flexibility.

Use phase data for the inventory phase of the LCA was gathered through surveys. Surveys enable large scale data collection through standardised questions. Large scale data collection in turn allows to formulate generalising statements about the use phase the Dutch population as a whole, on the precondition that the sample is of sufficient size and the user characteristics are representative. This method is therefore highly suitable for this research. The specific sampling method 'cluster sampling' was used, which means that a specific cluster of individuals is targeted (Schaap et al., 2016). This cluster consists of individuals that consume both second-hand- and new clothing. This method is used because this cluster is relatively small in the Netherlands: only 3% of the Dutch population states to buy second-hand clothing (Koch & Vringer, 2023). Using cluster sampling therefore increases the chance to find compatible respondents, which in turn increases the chance on a sufficiently large sample size. The collected sample will be tested on representativeness in relation to the Dutch population, using a Chi^2-tests on key user characteristics (see 4.3.2.1) with the program SPSS.

3.2.2 Methods used in sub question 2

The second sub question, "*To what extent have rebound effects occurred when consuming second-hand clothes, and how does this affect the environmental impacts of clothing consumption?*", aims to map the occurrence of REs and to quantify its impact(s). Answering this sub question in conjunction with sub question 1 will result in a more robust analysis.

Mapping the occurrence of REs is done by gathering data using surveys. The surveys in turn are based on insights gathered during consumer interviews, in addition to theory as discussed in section 2. Surveys suit this research question

well, because these allow large-scale data collection, which can provide insights into the extent of occurrence of REs.

Survey data is analysed using inferential statistics in the programme SPSS. Specifically were two correlation analyses and 1 independent samples t-test planned. In section 3.5.3 is further explained why and how these tests were conducted.

3.3 Data collection process

Subsequent paragraphs explain the data collection processes.

3.3.1 Data collection: store manager interviews

Store manager interviews were conducted with both specialised second-hand stores and kringloopwinkels. The stores were found through an initial Google-search, followed by selection based on criteria as shown in Table 4. A selection between those stores was made, following the process as described in section 3.3.1.1 and 3.3.1.2, for the specialised stores and the kringloopwinkels respectively. The process is summarised in Figure 6.

It is assumed that conducting five store manager interviews for both types of circular stores provides sufficient information to determine relevant garments for the determination of the FU. All interviews were conducted in-person. The interviews took place between the 25th and 30th of January, 2024.

Table 4: Selection criteria store manager interviews

Selection criteria store manager interviews		
Number	Criteria	Reason for criteria
1	The store must sell second-hand clothing	Basing the functional unit on second-hand clothing which is often sold allows the construction of a relevant LCA.
2	The store must have a physical location in the city of Utrecht	Utrecht is the location of the case study of this research.
3	The clothing sold must be marketed to all genders	This allows to determine a representative garment that is unisex, which allows the inclusion of all genders in the survey, which in turn is a prerequisite for representativeness of the sample.
4	The store must only sell second-hand garments	Determining a representative garment from a store which only sells second-hand garments means that the functional unit is a more truthful reflection of reality, since the stores of which the data originates offer a more complete arrange of garments.

Figure 6: Overview selection process second-hand stores[2]

3.3.1.1 Selection for second-hand clothing store manager interviews

Seven out of the seventeen specialised second-hand clothing stores resulting from the initial Google-search were non-profit organisations. The non-profit stores were excluded from the selection because kringloopwinkels are already non-profit organisations, to allow a more balanced selection process. Five out of these ten stores have multiple physical locations, which implies high stock turnover. These five stores were thus visited to conduct store manager interviews.

3.3.1.2 Selection for kringloopwinkel store manager interviews

The twelve different kringloopwinkels found through the Google-search are ran by eight different organisations. It was assumed that selecting stores that are ran by different organisations would result in the most accurate depiction for the representative garments. A selection of five stores all ran by a different organisation was therefore made, of which the five largest stores were visited for an interview.

3.3.2 Data collection: consumer interviews

The target group for the consumer interviews are individuals whom shop at physical clothing stores in the Netherlands and consume clothing, aged 18 years or older. This minimum age was included to ensure consistency with the survey (see section 3.3.3).

Consumer interviews were conducted on Saturday the 16th of March, 2024. Participants were randomly approached on a central square nearby the railway station *Utrecht Centraal* [UC]. This central location was chosen because UC is the largest and busiest railway station of the Netherlands. It was therefore assumed that conducting interviews in the vicinity of UC inclusion of participants from

[2] Sources icons in figure: Google LLC, n.d.; Freepik, n.d.; Surang, n.d.; Dwi ridwanto, n.d.; Juicy_fish, n.d.; Good Ware, n.d.

diverse backgrounds, and that participants hanging around the square had time to participate in an interview. Ten interviews were conducted.

3.3.3 Data collection: surveys

Formulating generalising statements for the Dutch population as a whole requires a representative sample of sufficient size. For the Netherlands, this entails of a minimum of 384 respondents (Voorbij, 2015), with matching user characteristics compared to the Dutch population. The target group of this research consists of individuals whom shop at physical clothing stores in the Netherlands and consume clothing. The cluster analysed in this case consists of individuals that live in the Netherlands and have purchased second-hand clothing. The minimum age to participate in the survey is 18 years old. This age was chosen because laundry practices are important for the use-stage, and it is assumed that individuals aged 18 years or older are knowledgeable on how the laundry is done in their household. The target group thus consists of individuals aged 18 or above. Data collection took place between the 25th of March and the 5th of June, 2024.

Invites to the survey were distributed through social media. Flyers were also printed, of which one side was in English (Appendix 2) and the other in Dutch. The flyers were distributed to 12 second-hand stores and hang on notice boards in libraries, bars, supermarkets, and community centres in the Utrecht-area.

3.4 Ethical issues

In this paragraph is discussed how this research deals with ethical issues.

3.4.1 Informed consent and withdrawal of consent

Respondents are informed about the research aim and way of data handling prior to participating in the interview(s) or survey, after which the respondent is asked for consent. The respondent is then handed a printed paper with a QR-code and link, which lead to an online summary of section 3.4 (attached in Appendix 3). This enables respondents to reread the information explained, and withdraw consent afterwards if they change their mind.

Withdrawal of consent can only occur on the preconditions that the withdrawal request happens before the deadline of this research (the 10th of July, 2024), and that the respondent's dataset can be identified. Withdrawal results in exclusion of the respondent's answers from the collected data, and is possible by emailing the researcher. Withdrawal requires the respondent to share additional data, because data is collected anonymously and therefore may be hard to identify. For interview-datasets, this means that respondents are required to state the date and time on which the interview started, which can be found on the paper with the QR-code that the researcher handed over at the start of the interview. If the respondent does not know the starting date and time of the interview, additional information may be requested (for example the types of garments that the respondent has purchased in the past, as stated in the interview). Additional data that may be requested for withdrawal of survey-datasets especially relates to answers regarding the respondent's user age, gender, completed level of education, and the respondent's level of income. Even after providing additional data it could however be possible that an exact dataset cannot be identified. In such a case consent cannot be withdrawn. Respondents have the right to deny the request for additional data, after requestion their consent to be withdrawn. In such a case consent cannot be withdrawn.

3.4.2 Data minimisation, pseudonymisation, and anonymisation
Personal data collection is minimised to only collect data which is strictly necessary. Gathered interview data is de-identified using interview numbers (pseudonyms), rather than collecting respondent's or store (manager's) names. Complete anonymisation is unlikely to be achieved because data could be cross-referenced with additional datasets.

3.4.3 (Personal) data handling
Personal data is defined as "any information relating to an identified or identifiable natural person" (Utrecht University [UU], 2024a, p.43). All data involved in this research is treated as personal data, because cross-referencing may be possible.

3.4.3.1 Data storage location
UU guidelines on data storage prescribe researchers to use the Data Storage Tool to determine a proper storage medium to store gathered respondent-data (UU, 2024a). Appendix 4 provides an overview of the answers on the Data Storage Tool's questions. Office 365 SharePoint was chosen to store the gathered data.

3.4.3.2 Data storage practices
Answers from interviews are stored in anonymised form. Contact information, such as is gathered to participate in the raffle, is stored encrypted.

3.4.3.3 Data expiration and deletion
Data of the store manager interviews and survey (except contact information for participation in the raffle) will be archived for at least 10 years on an UU-dedicated server, following UU policy (UU, 2024a). Consumer interviews and contact information was destroyed upon completion of this research using Eraser software (Eraser, n.d.; UU, 2024a).

3.4.3.4 Data sharing, publishing, and reuse
Contact information will never be shared. Remaining gathered data may be shared for research purposes. Data shared for research purposes will always be minimised so that only relevant data for a specific research will be shared. Primary data, which refers to raw, unprocessed data (UU, 2016), will not be published. Data in processed form may be shared or published.

3.5 Operationalisation
In this paragraph is discussed how each concept discussed in section 2 is measured in this research, and why this is done in this way.

3.5.1 Topic list store manager interviews
The purpose of the store manager interviews is to determine a representative garment and to discuss future support of the research. This is achieved by using to the topic list as displayed in Table 5. An interview sheet (Appendix 5) is based on this topic list. Subsequent paragraphs explain why each topic is relevant.

Table 5: Topic list store manager interviews

Topic list store manager interviews		
Topic number	Topic	Example question(s)
1	Representative garments	What are the top five types of garments that are mostly sold in your store? Is the supply and demand for these garments balanced throughout the year?
2	Material composition	What is the material composition of each of the garments?
3	Production location	In what country are the garments produced?
4	Support research	Are you willing to help the research in the future, for example by distributing a survey through your social media channels?

3.5.1.1 Representative garments

Representative garments are based on the store manager interviews. Garments with a balanced supply and demand throughout the year are preferred, hence is this asked during the interview.

3.5.1.2 Material composition

The material composition of the garments is relevant, because different types of materials go through different production phases, resulting in different types of environmental impacts. For this reason is the material composition an important LCA-parameter.

3.5.1.3 Production location

The production location is an important parameter to determine the travel distances of the garments, which are a relevant LCA-parameter.

3.5.2 Topic list store consumer interviews

The topic list (Table 6) served as the foundation for the interview sheet (Appendix 6), which was used during the interviews. Topics are grouped together to create a logical flow during the interview.

Table 6: Topic list consumer interviews

Topic list consumer interviews		
Topic number	Topic	Example question(s)
1	Introduction	- Informed consent; explain aim and background of the research. Provide paper with link to privacy- and data handling statement. - Determine if the respondent has purchased second-hand clothing, what type of garment this was, and if this was at a physical store or a web shop.

2	Obtainment motivation	- What are reasons for you to buy second-hand? Do these reasons differ from buying new clothing? - If insinuated that the purchase was induced: how often do you wear the garment(s) you did not plan to buy beforehand?
3	Displacement rates	- Does buying second-hand clothing replace your need to buy new clothing? Why does(n't) this replace your need to buy new clothing?
4	User valuation of product properties, Consumption accumulation, Re-spending, and Motivational (direct)	- What product-related factors do you consider important when buying a second-hand garment? - Would this list of factors change when buying new clothing? - If something relating to social affiliation is mentioned, follow-up questions regarding how second-hand/new clothing contributes to image to be signalled are asked. - Do you usually have concrete plans on how to spend money you saved from buying second-hand clothing? - You state that buying (second-hand) clothing brings joy/feels good/feels like the right thing to do. Do you think this may result in you buying more garments?
5	Price	- To what extent do low prices play a role in buying second-hand clothing? Is there a difference between how often you wear garments you have bought because they were a bargain? - Does this occur when you are out to buy clothing or also when you are just browsing? Where does it occur more often?
6	Motivational (indirect)	- How far do you usually travel to the store? - What method of transportation do you generally use to make these trips? - When you go to a second-hand store, do you usually combine this trip with other business en-route or not?
7	Use-phase	- Do you wear second-hand clothing more often or less than new clothing? - Do you have different washing/drying habits with second-hand clothing compared to new clothing? - Do you ever repair your clothing? Is this more often second-hand- or new clothing?

8	Disposition	- Do you dispose second-hand clothing sooner than new clothing? Could you estimate how long you wear clothing before disposing it? - When you dispose of a garment, what do you do with it? - Are there differences between the way you dispose second-hand clothing and new clothing?
9	Closing	- Thank for participation. - Promote survey. - Gather email address to participate in raffle.

3.5.2.1 Introduction

The purpose of this research is explained so that the respondent can give consent (see section 3.4.1). The respondent is asked if they have ever purchased second-hand clothing, what type of garment this was, and if this happened in a physical store or a web shop. This allows to determine if the respondent is part of the target group.

3.5.2.2 Obtainment motivation

The obtainment motivation is relevant to measure the occurrence of all CER-mechanisms in the survey (see 3.5.3.3). The goal of asking about the obtainment motivation in the consumer interviews is to explore why respondents themselves state to purchase second-hand clothing, and if these reasons differ from purchasing new clothing. If the interviewee gives the impression that a purchase is induced, then the interviewer can ask follow-up questions about the use of the specific garments to gain insights into the occurrence of CER-mechanisms.

3.5.2.3 User valuation of product properties, Consumption accumulation, Re-spending, and Motivational (direct)

The user valuation of product properties is relevant because this valuation determines whether or not a purchase action takes place (André & Björklund, 2023). André and Björklund (2023) provided a list of nine product properties which are relevant for the consumption of clothing. The interviews are used to check how important Dutch consumers consider the properties. This is done by asking what product properties the respondent considers important when buying a second-hand garment. The interview sheet includes a checklist of the product properties. All product properties that are not mentioned are deemed to be of neglectable importance, which is useful as survey-input. All product properties that are not on the list but are repeatedly mentioned by the respondents are considered to be added to the survey. The respondents are also asked if this list of product properties changes when consuming new clothing.

Consumption accumulation is a CER-mechanism and is thus relevant to discuss. This mechanism relates to second-hand purchases that are made in addition to-, instead of replacing new purchases, because the price is perceived as cheap and/or to signal status (Castro et al., 2022; Metic & Pigosso, 2022). Discussing consumption accumulation thus concerns three topics. Disscussing if the acquired second-hand garments (1) replaced the need to purchase a new

garment, (2) -were perceived as cheap, and (3) are part of the perceived image that the respondent desires to signal.

Re-spending is a CER-mechanism that relates to monetary savings from purchasing second-hand products. These savings are then re-spent on other forms of consumption, increasing environmental impacts. If the respondent has stated that price is an important factor a follow-up question is asked if the respondent thinks that buying second-hand clothing is cheaper, and what the respondent plans to do with the money saved.

Motivational (direct) is a CER-mechanism and is thus relevant to discuss. This mechanism occurs when an individual perceives a product to be sustainable, thus acquires it, resulting in increased consumption (Metic & Pigosso, 2022). If the respondent states that buying second-hand clothing feels good or like the right thing to do, a follow-up question is asked with the aim to determine if this may have led to increased levels of consumption.

3.5.2.4 Displacement rates

Displacement refers to the extent to which a second-hand garment replaces a new garment (Zink & Geyer, 2017). Asking about displacement in the interviews allows to ask about the reasons to why second-hand clothing does (not) displace new clothing. This in turn provides insights into (1) which indicators are useful for the survey, and (2) as policy recommendations.

3.5.2.5 Price

Price is a CER-mechanism and is thus relevant to discuss. The respondent is asked if they have ever purchased a second-hand garment because it was perceived as cheap, and how often the respondent wears this garment.

3.5.2.6 Motivational (indirect)

Motivational (indirect) refers to the priority that the respondent ascribed to sustainability in clothing, which induces consumption of extra resources to acquire second-hand products (Metic & Pigosso, 2022). Therefore is discussed how far the respondent usually travels to the store, by what method of transportation, and if this trip is usually combined with other business en-route. This is preferably expressed in kilometres, but may also be answered in minutes travelled.

3.5.2.7 Use phase

The use phase is relevant because the use phase largely determines the extent to which environmental impacts occur during a product’s lifecycle (Polizzi di Sorrentino et al., 2016). Usage of clothing consists of the practices of storing, wearing, washing, drying, and maintaining (Sohn et al., 2021), of which storing is irrelevant for this research as it does not consume any energy.

3.5.2.8 Disposition

Disposition is the final phase of consumption (Camacho-Otero et al., 2020), thus is relevant to discuss. The way that an individual disposes a garment determines the end-of-life [EoL]-scenario of the garment, which is relevant as LCA-input. Therefore is discussed after how long the respondent disposes the garment, how the garment is disposed of, and if this differs between second-hand- and new clothing.

3.5.2.9 Closing
The respondent is thanked for their time, the survey is promoted, and the respondent is asked to leave their email address if they wish to participate in the raffle. Gathering the respondent's contact information happens on a piece of paper separate from the interview sheet, so that the answers are not linked to the answers of the interview.

3.5.3 Operationalisation survey questions
The survey questions are structured to follow a logical flow from the respondent's perspective. The survey starts with general questions and leads up to more specific questions. Appendix 7 provides an in-depth explanation of each question formulations. Table 7 and subsequent paragraphs explain how each survey question contributes to answering the sub questions, and which method of analysis will be used. Appendix 8 displays an empty survey.

Table 7: Goals of survey questions

Goals of survey questions			
Section	Title	Question(s) involved	Goal of questions
3.5.3.1	General user characteristics	Q1-Q6	Check if the respondent is part of the target audience and check on representativeness
3.5.3.2	Restock rates	Q7 and Q13	LCA-input: expected garment lifetimes CER-mechanisms: Price
3.5.3.3	Acquisition-stage and Obtainment motivation	Q8-Q11 + Q13	CER-mechanisms: Motivational (indirect), –(direct), and Consumption accumulation LCA-input: method of transport
3.5.3.4	User valuation of product properties	Q12	LCA-input: Displacement rate
3.5.3.5	Re-spending – buying	Q14	CER-mechanism: Re-spending – buying
3.5.3.6	Use-stage, Disposition, and Re-spending – selling	Q15-Q16	LCA-input: Use rates and EoL scenario CER-mechanism: Re-spending – selling

3.5.3.1 General user characteristics
Question [Q] 1-3 are used to check if the respondent is part of the target audience. Q1, Q4, Q5, and Q6 are used to check the sample on representativeness compared to the Dutch population as a whole. This check on representativeness is done by conducting a Chi^2-test using the programme SPSS, in which the sample is compared with the most recent Dutch census data downloaded from CBS. Q1 and Q4 are compared with CBS (2024a), Q5 with CBS (2024b), and Q6 with CBS (2023b).

Table 8: Operationalisation General user characteristics ([1]Fraser, 2018; [2]CBS, 2024a; Nuffic, n.d.; [3]Duurkoop et al., 2021; CPB, 2023; UWV, 2023)

Operationalisation General user characteristics		
Indicator	Question	Number
Age	How old are you? … years	Q1
Geographical location	Do you live in the Netherlands? o Yes o No	Q2
Purchased second-hand clothing	Have you ever purchased second-hand clothing? o Yes o No	Q3
Gender[1]	With what gender do you identify the most? Please also select "other" when you identify with both male and female equally. o Male o Female o Other o I'd rather not say	Q4
Level of education[2]	What is the highest level of education you have completed? o Primary education/*Basisschool* o Secondary education/*VMBO, HAVO onderbouw, VWO onderbouw, MBO1* o Vocational education/*HAVO, VWO, MBO2, MBO3, MBO4* o Higher education (bachelor)/*HBO-bachelor, WO-bachelor* o Higher education (master)/*HBO-master, WO-master, doctor* o Don't know/unknown/not available	Q5
Income[3]	Please select your average monthly gross income level. o Below €1,408 o Between €1,407 and €3,291 o Between €3,292 and €3,625 o Between €3,626 and €6,958 o Between €6,959 and €10,375 o Over €10,375 o I'd rather not say	Q6

3.5.3.2 Restock rates, Lifetimes, and the CER-mechanism Price

The aim of Q7 is to determine how many garments the respondent purchases per year, and the expected lifetime of these garments. This data is used to determine a restock rate which is used to determine if the CER-mechanism Price has occurred. The garment lifetimes are also used as LCA-input.

The restock rate (Formula 1; Table 9) represents the normalised number of purchases that the respondent makes for the respective garment. A restock rate of 1.00 means that consumption of the purchased garments is perfectly spread out throughout a year and stock does not grow. A rate >1.00 represents a growth in the respondent's stock of the respective garment, in which a higher number

represents a faster growth. The normalised number is used instead of the absolute number of purchases because the normalised number includes the lifetime of each garment, thus provides a more accurate reflection of the restock rate.

The restock rate is used to test if the CER-mechanism Price has occurred. This is done by using the restock rate in a correlation analysis, along with the respondent's answer on statement Q13.3: "I bought this garment because it was a bargain" (see 3.5.3.3.2). Using these indicators allows to determine if respondents that purchase garments because they are cheap also purchase more garments in general, testing the hypothesis "*Respondents that have purchased second-hand denim jeans/button shirts because it was a bargain or cheap purchase more second-hand denim jeans/button shirts per year*". A tested p-value of <0.05 means that there is a significant correlation between both indicators.

Price has taken place among respondents that have agreed with statement Q13.3 and have a restock rate >1.00, and if a significant correlation is found. The percentage of respondents that meet these criteria are the extent to which the mechanism has taken place. No direct environmental impacts can be quantified for this CER-mechanism, because this concerns a correlation and not a causal relation.

$$\text{Restock rate} = \frac{Garments\ purchased\ in\ a\ year * Expected\ lifetime\ in\ months}{12\ months}$$

Formula 1: Restock rate

Table 9: Operationalisation Restock rates

Operationalisation Restock rates		
Q7: Please fill in the table. If you do not own-, buy-, or discard any of the garments, please fill in 0 in the respective field.		
Garment type	Please estimate how many of each garment type you usually buy per year:	After how many months do you usually stop using each garment:
Denim jeans, **second-hand**	… months	… months
Denim jeans, **new**	… months	… months
Button shirt, **second-hand**	… months	… months
Button shirt, **new**	… months	… months

3.5.3.3 Acquisition, Obtainment motivation and the CER-mechanisms Motivational (indirect), -(direct), and Consumption accumulation

Q8 enables measuring of the CER-mechanisms 'Motivational (indirect)' and 'Motivational (direct)' (Table 10). A score is calculated that represents the extent to which the respondent ascribes priority to the sustainability performance of clothing. This score is based on the extent that the respondent agrees with each statement. Answering to a statement grants the respondent between -2 and +2 points, in which "Completely disagree" grants the respondent -2 points, and "Completely agree" +2 points. Further use of this score is described in each CER-mechanism's respective paragraph (3.5.3.3.1 and 3.5.3.3.2).

The goal of Q9 (Table 10) is to determine if the respondent has purchased a pair of (second-hand) denim jeans or -button shirt in the past, which checks if the respondent fits the audience for the LCA-analysis. Q9 furthermore enables logic branching so that respondents that have not purchased a specific garment type skip all questions associated with that type of garment.

Table 10: Operationalisation Ascribed priority to sustainability performance of clothing and Acquisition (Leclercq-Machado et al., 2022)

Operationalisation Ascribed priority to sustainability performance of clothing and Acquisition		
Q8: Please state the extent to which you agree with each of the statements		
Indicator	Statement	Number
Subjective norms on sustainable clothing	- SN1: My friends expect me to buy sustainable clothes - SN2: My family expects me to buy sustainable clothes - SN3: The community I live in expects me to buy sustainable clothes	Q8.1 – Q8.3
Attitude on sustainable clothing	- ATT1: It is good when clothing becomes more sustainable - ATT2: Buying second-hand clothes is good - ATT3: Buying second-hand clothing instead of new clothing is good for the environment	Q8.4 – Q8.6

Q9: Have you ever bought a pair of denim jeans or a button shirt/blouse in the past, either second-hand and/or new, and was this at a physical store, a web shop, or somewhere else? Please tick all boxes that apply. Multiple answers are possible.				
Garment	Second-hand	Type of store second-hand	New	Type of store new
Denim jeans	○ Yes ○ No	□ Physical store □ Web shop □ Other	○ Yes ○ No	□ Physical store □ Web shop □ Other
Button shirt	○ Yes ○ No	□ Physical store □ Web shop □ Other	○ Yes ○ No	□ Physical store □ Web shop □ Other

3.5.3.3.1 Motivational (indirect)

Q10 concerns asking the method of transportation and transport distance to the store (Table 11). Logic branching is used to skip Q11 if the respondent states to have used a non-emitting method of transportation (walking, bicycle, public transport). Both Qs serve as LCA-input for the use-, reuse-, and both disposition-stages, and to calculate the occurrence of Motivational (indirect). Q11's aim is to specifically allocate the impacts of the trip.

Motivational (indirect) may have occurred among respondents whom have agreed with Q11's statements and state to have visited the second-hand store as a primary reason (statement 1 or 2), and did not state to have combined the trip with other business en-route (statement 3, 4, 5, and 6). A binary variable is constructed based on these criteria, on which the sample is split. A t-test is conducted based on this split, based on the respondents' scores calculated form Q8 (3.5.3.3.). This allows to determine if respondents that go to the second-hand store without combining this trip with business en-route significantly ascribe more priority to sustainability of clothing than respondents that do combine business en-

route. Occurrence of Motivational (indirect) is considered proven if there is a significant difference between both groups. A significant difference between both groups means that transport emissions for the respondents whom have displayed Motivational (indirect) can be calculated in the LCA, which then can be ascribed to this CER-mechanism.

Table 11: Operationalisation Motivational (indirect) ([1]André & Björklund, 2023)

Operationalisation Motivational (indirect)		
Indicator	Statement	Number
Method of transportation	Please select the main method of transportation you used, and the distance travelled to the store for the trip(s) you made to buy your second-hand garment(s). o Walking o Bicycle o Scooter o E-bike or e-scooter o Public transport o Car o Other o I don't remember	Q10.1
Distance (km)	Can you state the distance (in km) travelled to the store? … km	Q10.2
Reason of store visit[1]	Please tick a maximum of three boxes that apply to the last trip you have made to buy a (pair of) second-hand denim jeans/button shirt at the physical store. □ 1: Buying a pair of denim jeans/button shirt was the primary reason for me to make this trip that day □ 2: Visiting the store I bought this pair of denim jeans/button shirt at was the primary reason for me to make this trip that day □ 3: Buying a pair of denim jeans/button shirt was a secondary reason for me to make this trip that day □ 4: Visiting the store I bought this pair of denim jeans/button shirt at was a secondary reason for me to make this trip that day □ 5: I combined this trip with other business I had on-route □ 6: I don't remember anything about the trip I made to buy this pair of denim jeans/button shirt	Q11.1 – Q11.6

3.5.3.3.2 Motivational (direct)

A score which represents the extent to which the purchase was induced is calculated using the respondents' answers to Q13's statements (Table 12). Answering "Completely agree" on statement 1-4 grants the respondent +2 points, while answering "Completely disagree" grants -2 points. "Somewhat agree" and "Somewhat disagree" grant the respondent +1 and -1 point respectively. This distribution of points is flipped for statements 5, 6, and 7. Statement 5's score is also divided by 2 because it represents a semi-induced purchase.

A correlation analysis between the score calculated from Q8 (ascribed priority to the sustainability performance of clothing, section 3.5.3.3) and the score calculated from Q13 (induced purchase) is conducted. This analysis allows to determine if there is a significant association between ascribing priority to the sustainability performance of clothing and making an induced purchase of second-hand clothing, following the hypothesis: "*Ascribing higher levels of priority to the sustainability performance of clothing correlations with making induced purchases of second-hand denim jeans/button shirts*". A proven significant relation between both scores proves to that the CER-mechanism 'Motivational (direct)' took place. A percentage of respondents that both ascribed high levels of priority to the sustainability performance of clothing and made an induced purchase will be calculated, which represents the extent to which Motivational (direct) occurred. No impacts can be attributed to this CER-mechanism because this mechanism is not causal.

Table 12: Operationalisation Obtainment motivation ([1]André & Björklund, 2023)

Operationalisation Obtainment motivation					
Q13: Please fill in the extent to which you agree with each of the following statements					
Statement number and indicator		Denim jeans, **second hand**	Denim jeans, **new**	Button shirt, **second hand**	Button shirt, **new**
1: Induced purchase; appearance	I bought this garment because a garment that looks like this one is hard to come by	4-point rating	4-point rating	4-point rating	4-point rating
2: Induced purchase; social affiliation	I bought this garment because of other people that wear this style	4-point rating	4-point rating	4-point rating	4-point rating

3 Induced purchase; value for money	I bought this garment because it was a bargain or it was cheap[1]	4-point rating	4-point rating	4-point rating	4-point rating
4 Induced purchase; discounts, promotions, and store loyalty	I bought this garment because the store promoted this specific garment[1]	4-point rating	4-point rating	4-point rating	4-point rating
5 Semi-induced purchase; back-up	I bought this garment to have as a backup[1]	4-point rating	4-point rating	4-point rating	4-point rating
6 Non-induced purchase; needed purchase	I bought this garment because I needed it[1]	4-point rating	4-point rating	4-point rating	4-point rating
7.1 Non-induced purchase; displacement	If I had not found this garment I would have bought a new garment of this type instead[1]	4-point rating	Not applicable	4-point rating	Not applicable
7.2 Non-induced purchase; displacement	If I had not found this garment I would have bought a second-hand garment of this type instead[1]	Not applicable	4-point rating	Not applicable	4-point rating

3.5.3.3.3 Consumption accumulation

Q13's statements are used to determine the occurrence of Consumption accumulation. Consumption accumulation is considered to have taken place among respondents that agree with the statements relating to purchases that signal a

social image (statement 2), or because of economic stimuli (statement 3 or 4), and disagreed with statements relating to purchasing the garment as a replacement (statement 6 or 7). This allows to determine the extent to which this CER-mechanism has occurred, expressed in a percentage.

3.5.3.4 User valuation of product properties

Q12 allows to determine the extent to which second-hand garments displace new garments, which is used as LCA-input in the form of the FU. First is asked how the respondent would rate the new garment upon purchase, followed by rating the second-hand garment of the same type upon purchase (Table 13). Garments are rated in terms of three technical indicators; performance, quality, and fit. Rating takes place on a scale of equal steps which ranges from "Very poor" to "Very good". The prior corresponds with +1 and the latter with +5. A rating is calculated for each indicator, after which an average is taken (Formula 2). This average represents the extent (in percentages) to which a second-hand garment displaces a new garment, which is used check if the FU is applicable to both garment conditions.

Table 13: Operationalisation of user valuation of product properties of purchased garments

Operationalisation of user valuation of product properties of purchased garments	
Q12: Please state how you would have rated your garments **at the moment you bought them**, in terms of each of the following product properties.	
Product property	Examples
Performance	For example, that the garment is waterproof, windproof, lightweight, ventilate body heat, etc.
Quality	For example that the garment does not easily break/wear down, has good warranty, is dependable, etc.
Fit	For example that the garment fits your body type well

$$\text{Displacement rate } [\%] = \frac{\frac{Performance_{second-hand}}{Performance_{new}} + \frac{Quality_{second-hand}}{Quality_{new}} + \frac{Fit_{second-hand}}{Fit_{new}}}{3}$$

Formula 2: Displacement rate

3.5.3.5 CER-mechanism: Re-spending – buying

Q14 enables to check if the CER-mechanism Re-spending - buying took place. First is asked if the respondent has saved any money by purchasing a second-hand garment compared to purchasing a new garment of the same type (Table 14). Then is asked if the respondent already has any plans on what to do with the money. Quantifying environmental impacts resulting from the plans stated by the respondents goes beyond the scope of this research. Plans for money to be re-spend will be summarised and listed as a direct result.

Table 14: Operationalisation Re-spending – buying

<table>
<tr><td colspan="3">Operationalisation Re-spending – buying</td></tr>
<tr><td colspan="3">Q14.1: How costly/expensive was the second-hand garment you have bought compared to a new garment of that same type?</td></tr>
<tr><td>Indicator</td><td>Denim jeans, second-hand</td><td>Button shirt, second-hand</td></tr>
<tr><td>Price</td><td>The price was…
○ Lower than new
○ The same as new
○ Higher than new
○ I don’t remember</td><td>The price was…
○ Lower than new
○ The same as new
○ Higher than new
○ I don’t remember</td></tr>
<tr><td colspan="3">Q14.2: You have stated to have saved money by buying a second-hand garment instead of a new garment. How much money do you think you approximately saved compared to a new garment of the same type, and what do you think you will do with the money you saved?</td></tr>
<tr><td>Denim jeans, second-hand</td><td colspan="2" rowspan="2">I have saved… [insert numeric value]

I will do the following with the money saved:
○ Nothing in particular
○ Save
○ Spend on…</td></tr>
<tr><td>Button shirt, second-hand</td></tr>
<tr><td colspan="3">Q14.3: Could you explain on what you plan to spend the money you have saved?</td></tr>
<tr><td>Denim jeans, second-hand</td><td colspan="2" rowspan="2">I plan on spending the money saved by buying a (pair of) second-hand denim jeans/buttons shirt instead of new denim jeans/button shirt on the following: [insert text]</td></tr>
<tr><td>Button shirt, second-hand</td></tr>
</table>

3.5.3.6 Use-stage, Disposition and the CER-mechanism Re-spending – selling:
Q15 concerns wear-, wash-, and dry rates, which are used as direct input for the use-phase of the LCA. Q17 concerns the method of disposal, which allows to determine the EoL-scenario for the garments, which is relevant as LCA-input because it allows to determine accurate lifecycles (Table 15). Q17 also allows to map the percentage of respondents that plan on reselling the garment after using it, for how much they think they can resell it, and if they have plans to re-spend the money. Mapping this allows to determine the occurrence of the CER-mechanism Re-spending – selling.

Table 15: Operationalisation disposition ([1]André & Björklund, 2023; [2]Sohn et al., 2021)

<table>
<tr><td colspan="3">Operationalisation Use-stage</td></tr>
<tr><td colspan="3">Q15.1: Please state for how many months you think you will use each garment, and how often. This time period starts when you have bought it, and ends when you actively stop using the garment. If the purchase happened recently, please provide an indication of what you think applies. If you do not think you will use the garment at all, please fill in 0.</td></tr>
<tr><td>Indicator</td><td>Question</td><td>Number</td></tr>
<tr><td rowspan="2">Wearing[1]</td><td>How long do you think you will use the garment?
… months</td><td>Q15.1.1</td></tr>
<tr><td>How often do you think you will use the garment?
… times per month</td><td>Q15.1.2</td></tr>
</table>

Q15.2: Please state your washing habits for each garment.		
Washing method[2]	How do you wash your garment? ○ By hand ○ Machine ○ Other…	Q15.2.1
	You selected "other" as a washing method, can you explain what other method you use? …	Q15.2.2
Washing practice[2]	Do you use detergent while washing the garment? ○ Yes ○ No	Q15.3.1
	Do you use fabric softener while washing the garment? ○ Yes ○ No	Q15.3.2
	At what temperature do you wash the garment? ○ 20°C ○ 30°C ○ 40°C ○ 50°C ○ 60°C ○ Tap water temperature	Q15.3.3
Drying method[2]	Do you use a clothes dryer after washing the garment? ○ Yes ○ No	Q15.4
Operationalisation Disposition/Re-spending – selling		
Indicator	Question	Number
Method of disposal[1; 2]	What will you most likely do with the garment when you don't (want to) use it anymore? ○ Sell ○ Throw away ○ Donate/give away ○ Repurpose (for example as rags) ○ Recycle/hand in for recycling ○ Keep in storage indefinitely	Q16.1
Re-spending – selling[1]	For how much do you think you could sell the garment upon disposal, and what do you expect to do with the money earned from selling? €… [insert numeric value]	Q16.2
	I will do the following with the money: ○ Nothing in particular ○ Save ○ Spend on [insert text]	Q16.3

3.6 Life Cycle Assessment approach

In this section is explained how the LCA is conducted, and for what reasons.

3.6.1 Goal and scope definition

The LCA in this study is based on the ISO 14040 standard (2006) to ensure comparability with other conducted LCAs. The goal of the LCA is defined in paragraph 3.6.1.1, and the scope in 3.6.1.2.

3.6.1.1 Goal definition

The aim of this LCA is to compare the environmental impacts of consumption of second-hand- and -newly bought clothing. The main reason to conduct this LCA is to expand on the scientific knowledge of how environmental impacts occur within the fashion industry. This LCA is intended to be disclosed to the public, as it is accessible in the thesis repository of Utrecht University and may possibly be published in a journal. Other scientific researchers are the main target audience of this LCA, as this study aims to expand on the scientific knowledge base. Consumers of second-hand clothing are a secondary target audience, because this study checks if consuming second-hand clothing is more sustainable than consuming new clothing.

The decision context of this study is "Situation C1 (Accounting)", because the function of LCA is to map and analyse current practice, without having direct influence on the product system. This consequentially means that no direct structural changes are expected as a result of this study. Furthermore are interactions with other systems (for example waste incineration for energy recovery) also included.

The LCA conducted in this study has an emphasis on primary data collection for the use-phase of clothing. This emphasis is the result of the aim to tackle one of LCA's main limitations, as discussed in section 2.3.2. Tackling this limitation has however led to a disbalance relative to the other phases in the LCA, which have not been researched as in-depth as the use-phase. This disbalance is the main limitation as a result of the methodological choices made in this study.

3.6.1.2 Scope definition

The scope definition consists of the definition of the FU, definition of the unit processes, and the Life Cycle Inventory.

3.6.1.2.1 Functional unit definition

Table 16 provides the list of product properties associated with clothing, on which the FU is based. The list in Table 16 is based on- and categorised accordingly to André and Björklund (2023). Both garment types have a separate FU, which is "*Covering up the upper body of 1 person with a cotton garment weighing 616 g for 514 wears in the Netherlands, while providing sufficiently perceived performance, quality, and fit*" for the denim jeans, and "*Covering up the upper body of 1 person with a cotton- and polyester blended garment weighing 425 g for 273 wears in the Netherlands, while providing sufficiently perceived performance, quality, and fit*" for the button shirt. Garment weights are explained in section 3.6.1.2.2. The number of wears (see 4.3.2.4.2) and perceived performance, quality, and fit (see 4.3.2.3) are survey results.

Table 16: Product properties clothing (based on André & Björklund, 2023: [1]Performance; [2]Fit; [3]Appearance; [4]Price; [5]Environment; [6]Quality; [7]Social affiliation)

Product properties clothing	
Obligatory properties	Positional properties
Covering up a wearer's body[1]	Fits the wearer's body well (complements/accentuates described parts of the wearer's body)[2]
Protecting the wearer's body from outdoor climate (either preserve or ventilate body heat)[1]	Is fashionable/stylish[3]
Fits a human body[2]	Sold for the right price (is expensive/cheap/affordable)[4]
	Made out of sustainably sourced materials[5]
-	Made out of recycled materials[5]
-	Can easily be recycled[5]
-	Has a certain material density[6]
-	Is made by using durable techniques[6]
-	Fulfils social image[7]

3.6.1.2.2 Properties representative garments

Table 17 displays an overview of properties of the denim jeans and button shirt analysed in this study. The denim jeans analysed in this LCA are assumed to be made out of cotton. Cotton has been – and still is – the dominant material used for denim jeans manufacturing (McLoughlin et al., 2015), and is thus likely to reflect both denim jeans being reused and sold. The pair of denim jeans analysed in the LCA is calculated to have a total weight of 617 grams, which is based on denim fabric weighing 14.5 oz/yd² (Raina et al., 2015), made by weaving approximately 2 yd² of denim fabric (Denimhunters, n.d.; Kan, 2015)[3].

The fabric of the button shirts analysed in the LCA is assumed to be made out of a blend of 50% cotton, and 50% polyester, because blending cotton with synthetic material such as polyester is common practice (Hsu et al., 2024), especially in Europe (McLoughlin et al., 2015, p.34), and such a blend is commonly used for shirts (Fashion Encyclopedia, n.d.). Buttons for shirts are commonly made out of hard plastic (Costa & Broega, 2023), such as polyester (Discovery Channel, 2005; Gam, 2011; Cotton Incorporated, 2017). Hence are the buttons of the button shirt analysed in the LCA assumed to be made of polyester. The total weight of the button shirt is calculated to be 425g[4]. This weight is based on a material density of 7.0 oz/yd² (Raina et al., 2015), and material requirements stated by Maresh (2010). The fabric is assumed to be woven by using the plain weave method, because this is the most basic weave method (Raina et al., 2015).

[3] 14.5 oz/yd² * 1.5 yards = 21.75 oz = 616.60 gram. This is in line with Pal et al. (2017, p.111), who state that an average pair of denim jeans weighs 600 grams.

[4] One long-sleeve button shirt requires 2-½ yards (90 inch) of fabric, with a width of 36 inch (Maresh, 2010). Material weight of fabric for shirts ranges between 3.5 – 8.0 oz/yd² (Raina et al., 2015). A material weight of 6.0 oz/yd² is assumed. 90 * 36 = 3240 inch² = 2.5 yard². 6.0 oz/yd² * 2.5 yard² = 15 oz = 425.24 gram. This is in line with Ahsmann et al. (2020), who assumed that an average garment weighs 375g, and Cotton Incorporated (2017), who state that an average knit collared shirt weighs 305g. Woven fabrics are denser and thus heavier than knit fabrics.

Table 17: Overview of properties representative garments

Overview of properties representative garments		
	Denim jeans	Button shirt
Material composition	100% cotton (fabric); 100% brass (rivets, zipper, and button)	50% cotton & 50% polyester (fabric); 100% polyester buttons
Total weight	617g	425g
Fabric weight	14.5 oz/yd²	6.0 oz/yd²
Yarn production method	Woven	Woven

3.6.1.2.3 System boundaries

This LCA aims to compare consumption of reused clothing to a linear reference scenario of clothing consumption. Therefore is a cradle-to-grave approach taken in this study. Figure 7 displays the system boundaries of this study, which consist of raw material extraction, raw material processing, product manufacturing, distribution and retail, use, and disposition which leads to either repurposing, waste incineration, recycling or reuse of the garment. Transport between each step is excluded from the analysis, because the reuse scenario results in analysed garments which very heterogeneous – thus a large variety of potential sites for each step exists. Assuming transport distances may distort the analyses and does not contribute to further answering the research question.

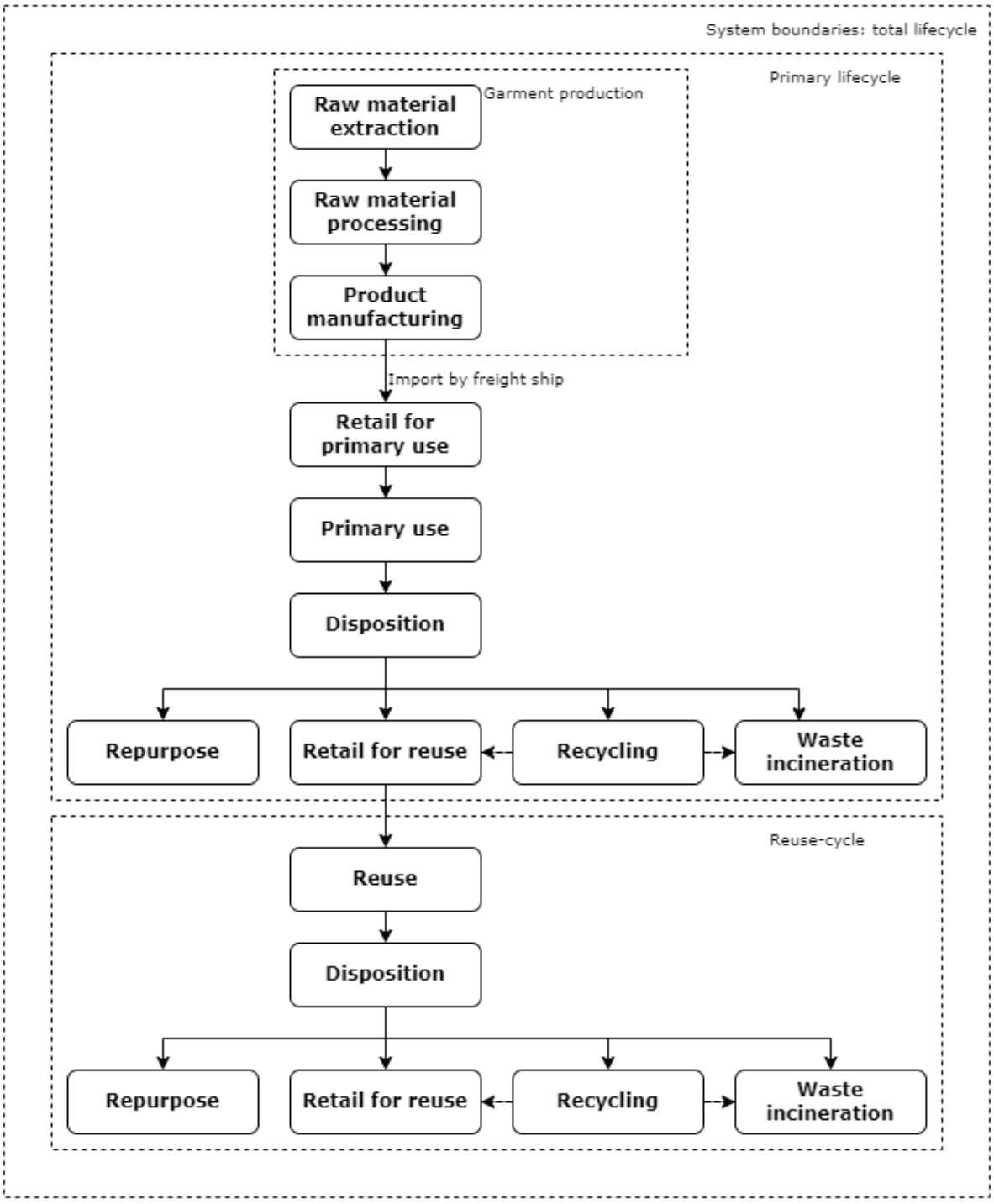


Figure 7: System boundaries LCA

3.6.1.2.4 Impact assessment categories

A systematic literature review concluded that the most relevant assessment categories for an LCA on clothing are *green house gas* [GHG]-emissions, energy use, and water consumption (Manusinghe et al., 2021). This research analyses these impact categories to ensure relevancy and comparability with other research. Table 18 displays the units of measurement for each assessment category, and the characterisation method used. Each method was chosen to ensure comparability, and due to relevancy regarding the assessed impact category.

Table 18: Impact assessment categories analysed

Impact assessment categories analysed		
Impact assessment category	Unit	Characterisation method
GHG-emissions	kg CO_2-eq	IPCC 2021 GWP_{100}
Energy use	MJ	Cumulative Energy Demand (LHV)
Water consumption	m^3	ReCiPe 2016, midpoint (H)

3.6.1.2.5 Allocation

Allocation refers to the way that the input- and output flows are divided over the studied product system (Williams & Eikenaar, 2022). This research follows a method described by Farrant et al. (2010) whom refer to a 'replacement rate', which refers to the portion of uses within the reuse-cycle compared to the total lifecycle. The authors provide an example of a replacement rate of 50.0%, which means that reusing a second-hand item replaces production of two new items. The replacement rate in this research is based on survey data (see 4.3.2.4.2), and are 43.19% for denim jeans and 45.8% for button shirts (Formula 3).

$$Replacement\ rate = \frac{Number\ of\ wears\ in\ reuse\ stage}{Number\ of\ lifetime\ wears}$$

Formula 3: Replacement rate

3.6.2 Life Cycle Inventory

Figure 8 provides a visualisation of the product system required to fulfil the FU for both garments. The phases coloured in yellow constitute the foreground system for which primary data is gathered through the survey. All other phases constitute the background system and only rely on data gathered from secondary sources.

Subsequent paragraphs explain what each step entails, what assumptions are made, and which datasets or -sources are used. This analysis relies on predefined datasets from the Ecoinvent 3.0 *Cut-Off* library, unless otherwise specified in the respective paragraph. Infrastructure and transport for staff is excluded from the analysis.

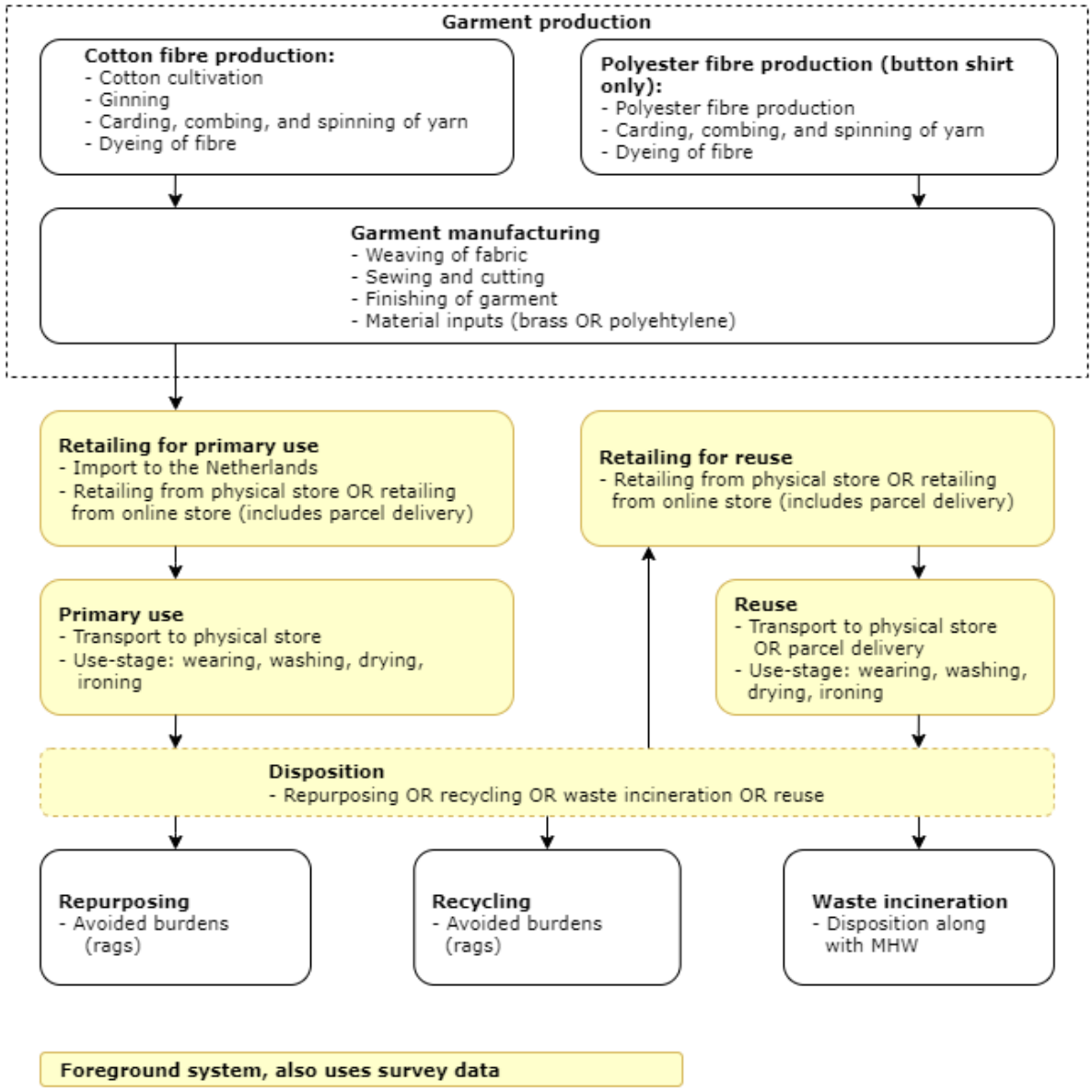


Figure 8: Product system

3.6.2.1 Cotton fibre production

It is assumed that all steps upstream of 'retailing for primary use' take place in Bangladesh, because clothing imported into the Netherlands often originates from Bangladesh (CBS, 2021a; OECD, 2024). Cotton is a natural textile fibre which is harvested by hand in Bangladesh. Harvested cotton is *ginned*, referring to a process in which the seeds are removed from the fibres (McLoughlin et al., 2015), resulting in a mass loss of 0.70% (Khalifa et al., 2009). Ginned fibres are then *carded* and *combed*, referring to processes in which the fibres are prepared to be spun into yarn (McLoughlin et al., 2015). These processes collectively result in a mass loss of 1.50% (Sandin et al., 2019, p.42). The prepared fibres are dominantly spun into yarn using the ring spinning method (Yin et al. 2021), thus the assumed method. Ring spinning results in a mass loss of 11.00% (Sandin et al., 2019, p.42). Spun yarn is dyed before weaving (Kan, 2015), using the batch dye method (EC, 2022, p.63). Batch dyeing results in a mass loss of 9.17% (Ecoinvent, 2019). Table 19 summarises all assumptions and datasets used.

Figure 9 summarises the material weight for each step, based on the loss factors discussed. One pair of denim jeans requires cultivation of 876.78g of cotton, and one button shirt requires cultivation of 325.41g of cotton (Figure 9 & 11). Only warp yarns for denim fabric are dyed, which have a relative share of 62.7% of the denim fabric (Kan, 2015). This means that there are no losses for 37.3% of the yarn for denim fabric.

Table 19: Overview cotton fibre production

Overview cotton fibre production			
Description step	Assumption(s)	Data source	Dataset
Cotton cultivation	- Cultivation occurs in Bangladesh	Ecoinvent 3	Seed-cotton {BD}| seed-cotton production, conventional | Cut-off, U
Ginning	- Ginning occurs in Bangladesh - Mass loss of 0.7% as a result of ginning	Ecoinvent 3	Fibre, cotton {BD}| fibre production, cotton, ginning | CUT-OFF, U
Carding, combing of cotton, and yarn spinning	- Carding and yarn spinning occur in Bangladesh - Ring spinning method is used - Mass loss of 1.5% as a result of carding and combing - Mass loss of 11% as a result of yarn spinning	Ecoinvent 3	Yarn, cotton {BD}| yarn production, cotton, ring spinning | Cut-off, U
Dyeing of fibre	- Dyeing happens in Bangladesh - Batch dyeing method is used - Mass loss of 9.17% as a result of batch dyeing - Only 62.7% of the spun yarn used for denim fabric is dyed	Ecoinvent 3	Batch dyeing, fibre, cotton {RoW}| batch dyeing, fibre, cotton | Cut-off, U

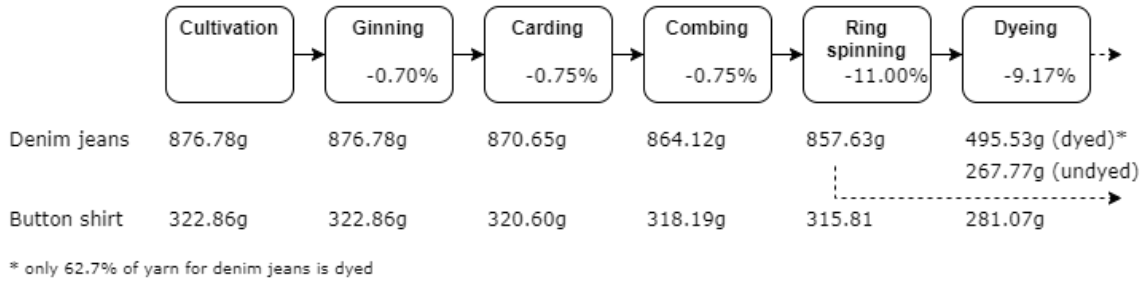


Figure 9: Weights of cotton inputs, cotton fibre production for one garment

3.6.2.2 Polyester fibre production

Polyester fibre is a synthetic fibre made from *polyethylene* [PET], using the *melt spinning* method. Polyester fibres are almost exclusively dyed using the batch dyeing method at temperatures between 125°C and 135°C. Fibres which are dyed in a light shade do not need any further processing besides rinsing after dyeing before usage. The fibres are spun into yarn in preparation of the weaving process, in a process comparable to that of cotton yarn production (EC, 2022, p.23; 75).

It is assumed that one button shirt requires production of 291.07g of polyester fibres (Figure 9, 10 & 12). Bangladesh is not among the top producers of polyester fibre (Statista Research Department, 2023). Therefore, the *Rest of World* [RoW] dataset was adopted. The fibres are carded and combed in a manner similar as the cotton fibres and dyed using the batch dyeing method. No specific data regarding the 'spinning of polyester fibres into yarn' was found, thus the dataset for 'spinning of cotton into yarn' was assumed due to the similar process operations (EC, 2022, p.23). A loss factor of 0.5% is assumed during this step, based on Sandin et al. (2019). Table 20 summarises the assumptions, data sources and datasets applied. Figure 10 visualises all weights and loss factors.

Table 20: Overview polyester fibre production

Overview polyester fibre production			
Description step	Assumption(s)	Data source	Dataset
Polyester fibre production	- Rest of World dataset is used	Ecoinvent 3	Fibre, polyester {RoW}| Polyester fibre production, finished | Cut-off, U
Carding, combing of cotton, and yarn spinning	- Carding and yarn spinning occur in Bangladesh - Ring spinning method is used - Mass loss of 1.5% as a result of carding and combing - Mass loss of 0.5% as a result of yarn spinning	Ecoinvent 3	Yarn, cotton {BD}| yarn production, cotton, ring spinning | Cut-off, U
Dyeing of fibre	- Dyeing happens in Bangladesh - Batch dyeing method is used - Mass loss of 9.17% as a result of batch dyeing	Ecoinvent 3	Batch dyeing, fibre, cotton {RoW}| batch dyeing, fibre, cotton | Cut-off, U

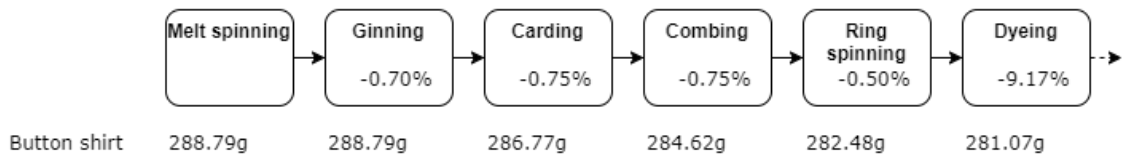


Figure 10: Weights of polyester inputs, polyester fibre production for one button shirt

3.6.2.3 Garment manufacturing: denim jeans

Cotton yarn for denim fabric is woven using either rapier- or air jet weave technology (Raina et al., 2015), which results in a material loss of 3.6% (Cotton Incorporated, 2017, p.51; 131). The fabric is then cut and sewn into a pair of denim jeans using manually operated machines. The Ecoinvent library does not provide a dataset for sewing and cutting, nor for Bangladesh's electricity mix, thus these were modelled based on literature. Sewing and cutting consumes 84.720 kWh/1000 kg of fabric (Cotton Incorporated, 2017, p.137), 185.50 L_{water}/1000 kg of fabric (Sandin et al., 2019, p.51), and results in a mass loss of 15% (Hayes & McLoughlin, 2015; Cotton Incorporated, 2017, p.137). Bangladesh's 2021 electricity mix is presented in Table 21 (International Energy Agency [IEA], n.d.a). The corresponding RoW data from Ecoinvent 3 database were applied to model the electricity mix.

Zippers, rivets, buttons, and a care label are added during sewing and cutting (Hayes & McLoughlin, 2015). The care label, made of cotton, is already factored into the total mass of the clothing (see section 3.6.1.2.2). the other referred components are commonly made of brass (Sarkar, 2015), and are assumed to have a total weight of 27.77g (Table 22)[5]. Steps required to transform brass into these components are omitted form the analyses because the energy consumption of these steps is negligible, as well as those of the care label (Farrant et al., 2010). Denim jeans manufacturing concludes with finishing of the garment, which entails washing, desizing, and softening of the garment (Kan, 2015). This process does not result in any mass losses (Cotton Incorporated, 2017, p.51; 135). All assumptions and data sources are summarised in Table 23. Figure 11 displays the weight of the cotton for each step.

Table 21: Electricity output (GWh), Bangladesh, 2021 (IEA, n.d.a)

Electricity output (GWh), Bangladesh, 2021		
Source	GWh	Relative (%)
Natural gas	69813	73.12%
Oil products	19192	20.10%
Coal and coal product	5297	5.54%
Hydro	694	0.73%
Solar	477	0.50%
Wind	6	0.01%
Total	95479	100.00%

Table 22: Weight of brass components in one pair of denim jeans (Boomsma, n.d.; Walker, 2011; Amazon, 2016; Cotton Incorporated, 2017).

Weight of brass components in one pair of denim jeans		
Component	Weight	Unit
Rivet (x5)	13.27	g
Zipper	13.20	g
Button	1.30	g
Total	27.77	g

[5] This weight is based on components described in Boomsma (n.d.), Walker (2011), Amazon (2016), and Cotton Incorporated (2017).

Table 23: Overview garment production: denim jeans

Overview garment manufacturing: denim jeans			
Description step	Assumption(s)	Data source	Dataset
Weaving of denim fabric	- Weaving occurs in Bangladesh - Mass loss during weaving is 3.6%	Ecoinvent 3	Textile, woven cotton {BD}| textile production, cotton, weaving | Cut-off, U
Sewing and cutting of denim jeans	- Sewing and cutting occurs in Bangladesh - Rivets, zipper, and button are made of brass and have a total weight of 27.77g. Steps required to produce said components are excluded from analysis - Consumes 84.720 kWh/1000 kg of fabric, - Consumes 185.50 L_{water}/1000 kg of fabric	IEA, n.d.a Ecoinvent 3 Boomsma (n.d.); Walker (2011); Amazon (2016); Cotton Incorporated (2017) Ecoinvent 3	Energy mix electricity generation Bangladesh RoW data for each respective method of electricity generation Waste yarn and waste textile {GLO}| market for waste yarn and waste textile | Cut-off, U Brass {RoW}| production | Cut-off, U
Finishing of denim jeans	- Finishing happens in Bangladesh - No mass loss during finishing	Ecoinvent 3	Finishing, textile, woven cotton {GLO}| finishing, textile, woven cotton | Cut-off, U

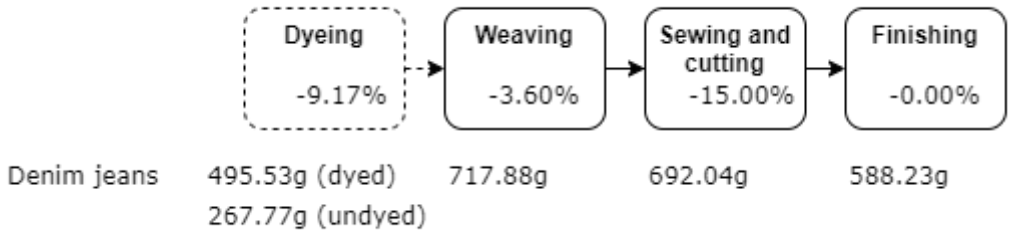


Figure 11: Weights of cotton inputs, production of one pair of denim jeans

3.6.2.4 Garment production: button shirt

The cotton- and polyester yarn are woven into a textile fabric on a 1:1 basis. The garment is then cut and sewn, using manually operated sewing machines. Sewing and cutting consumes 84.720 kWh/1000 kg of fabric (Cotton Incorporated, 2017, p.137), 185.50 L_{water}/1000 kg of fabric (Sandin et al., 2019, p.51), and results in

a mass loss of 15% (Hayes & McLoughlin, 2015; Cotton Incorporated, 2017, p.137). Bangladesh's 2021 electricity mix (Table 21) is assumed. The buttons are then attached to the sewn garment. These concern a total of twelve polyester buttons with a total weight of 6.6g[6] (Cotton Incorporated, 2017). The button shirts are finished after cutting and sewing, which does not result in any mass losses (Cotton Incorporated, 2017, p.51; 135). Table 24 summarises all assumptions, sources- and datasets used. Figure 12 visualises the fabric weights and losses.

Table 24: Overview garment production: button shirt

Overview garment production: button shirt			
Description step	Assumption(s)	Data source	Dataset
Weaving of fabric	- Weaving occurs in Bangladesh - An equal material input of 257.32g of cotton and polyester is fed into the weaving machine	Ecoinvent 3	Textile, woven cotton {BD}| textile production, cotton, weaving | Cut-off, U
Sewing and cutting of button shirt	- Sewing and cutting occurs in Bangladesh - A button shirt has twelve buttons made of polyester with a total weight of 6.6 grams. Steps required to produce the buttons are excluded from analysis - Consumes 84.720 kWh/1000 kg of fabric, - Consumes 185.50 L_{water}/1000 kg of fabric - Mass loss during sewing and cutting is 15%	Ecoinvent 3	Polyethylene, high density, granulate {GLO}| market for | Cut-off, U
Finishing of button shirt	- Finishing happens in Bangladesh - No mass loss during finishing	Ecoinvent 3	Finishing, textile, woven cotton {GLO}| finishing, textile, woven cotton | Cut-off, U

[6] Buttons for collared shirts have an average weight of 0.55 grams each (Cotton Incorporated, 2017, p.52).

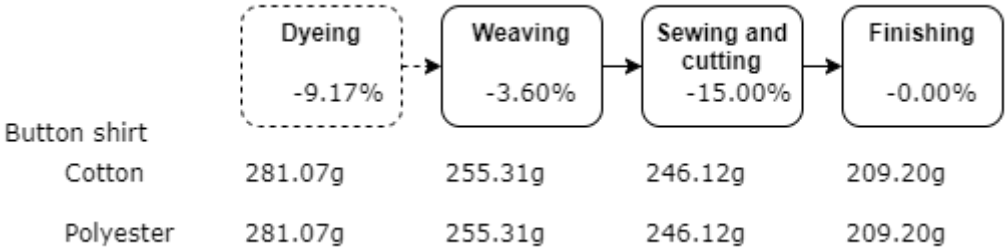


Figure 12: Cotton and polyester weights and losses when manufacturing one button shirt

3.6.2.5 Retailing for primary use

Transport from Bangladesh to the Netherlands is included in the analysis because of the long travel distance and there is a clear point of departure and arrival. Garments imported from Bangladesh to the Netherlands for domestic consumption are mainly transported by freight ship (CBS, 2023c), and the main ports for both countries are Chittagong (also known as *Chattogram*) and Rotterdam, respectively (Port of Rotterdam, n.d.; Saha, 2023). It is assumed that the only direct trading route used for trade between Chittagong and Rotterdam is used in this scenario. This route has a total travel distance of 27,242 km (Routescanner, n.d.) and uses freight ships with a capacity of 1,500 TEU (Maritime Gateway, n.d.), which is assumed to be fully loaded. Furthermore is assumed that 1 standard freight container measuring 2 TEU is fully filled with garments, delivering either 20,500 pairs of denim jeans (Jeans Info, n.d.; CBS, n.d.) or 28,700 button shirts. This amount of button shirts is based on the mass difference of a button shirt compared to a pair of denim jeans, which is 1.4 (see section 3.6.1.2.2). Transport to- and from the ports to the warehouses and retail locations is excluded from the analysis, because these locations are diverse thus cannot be accurately assumed.

A dataset was constructed for both in-store retailing and online retailing in the Netherlands. It is assumed that in-store retail consumes 111.557 Wh/kg, and 200.803 KJ_{NG}/kg sold (Manusinghe et al., 2016). Garments purchased online are assumed to be directly delivered from a distribution centre to the costumer. It is calculated that online retail in the Netherlands consumes 3.244 Wh/kg and 11.373 KJ_{NG}/kg sold (Klimaatakkoord, n.d.; Jeans Info, n.d.; CBS, n.d.; 2021b). This calculated consumption corresponds with 1.998 Wh/garment, which is in line with UK data which reported 2.100 Wh/garment (Klooster, 2022).

Home delivery is the dominant method of parcel deliver in the Netherlands (Autoriteit Consument & Markt [ACM], 2020), thus is this method assumed for all online orders. Online orders require a HDPE transport bag weighing 62.9g, and an A4 paper invoice weighing 5g (Klooster, 2022) of which 39.53% is attributed to each garment[7] (Kunst, 2020). 65.1% of 2023's business-to-consumer parcel deliveries were made by using vehicles with an *internal combustion engine* [ICE], and an electric vehicle in 34.9% of the cases (ACM, 2024). The average distance travelled for a delivery in the Benelux is 1 km per parcel (PostNL, 2024, p.3), hence is this travel distance assumed in the analysis. Table 25 summarises all assumptions, sources- and datasets used.

[7] This is based on an average sized US (2018) order of 2.53 garments (Kunst, 2020), because data for the Netherlands and the EU are unavailable.

Table 25: Overview retailing for primary use

Overview retailing for primary use			
Description step	Assumption(s)	Data source	Dataset
Importing of garments	- Import occurs from the port of Chittagong to the port of Rotterdam - Transport to- and from the ports is excluded from the analysis - Transport occurs by freight ship, through an indirect route with a total distance of 27,242km - One freight container contains 20,500 pairs of denim jeans, or 28,700 button shirts	Ecoinvent unit processes Jeans Info, n.d.; CBS, n.d.	Operation, transoceanic freight ship, OCE U
Retail from physical store	- Supplying the store is excluded from the analysis - Consumes 111.557 Wh/kg, and 200.803 KJ_{NG}/kg sold	Sandin et al., 2019	Electricity, low voltage, production NL, at grid/NL U
Retail from online store	- Supplying the distribution centre is excluded from the analysis - Garments are stored for 31 days - Consumes 3.244 Wh/kg and 11.373 KJ_{NG}/kg sold - Requires 39.53% of an A4 paper invoice weighing 5g - Requires 39.53% of a HDPE bag weighing 62.9g - Deliveries are made by travelling 1km with a EURO6 diesel vans in 65.1% of the cases, and electric vans in 34.9% of the cases	Jeans Info, (n.d.); CBS, (2021b; 2022a); Klooster, (2022); Klimaatakkoord (n.d.); ACM (2024); PostNL (2024)	Electricity, low voltage, production NL, at grid/NL U Operation, van < 3,5t/RER U Operation, passenger car, electric, LiMn2O4, CH U

3.6.2.6 Primary use: purchase

Survey data was used as LCA-input regarding purchasing of garments for primary use. The survey reported that 65.6% of the purchases for new denim jeans occurred in a physical store, and 33.4% online. This was 61.4% and 38.6% for new button shirts respectively[8]. The survey furthermore reported average travel distances of 9.43 km for new denim jeans and 8.11 km for new button shirts to the physical store. Trips to purchases a new pair of denim jeans were made by car (18.6%), e-bike/e-scooter (1.2%), or by non-emitting methods of transportation (80.2%)[9]. The distribution for purchases of new button shirts was 11.5%, 1.3%, and 87.2%, respectively (Table 26).

No survey question regarding the specific car engine was included, thus were impacts from car transport calculated by constructing a dataset which reflects the average 2024 Dutch car fleet (ANWB, n.d.a; CBS, 2024c). Environmental impacts resulting from trips made on e-bike or e-scooter were based on their respective datasets from the Ecoinvent database, while modifying the electricity mix for the e-bike and e-scooter to reflect the Netherlands. An equal share for e-bike and e-scooter was assumed within the dataset. The survey stated that almost all (>95.0%) of the new purchases were combined with other business en-route, hence is 39.53% of each trip's impacts attributed to the purchased garment (Kunst, 2020).

Table 26: Overview consumption: purchase

Overview Primary use: purchase			
Description step	Assumption(s)	Data source	Dataset
In-store purchase: transport by car	- 65.6% of the purchases of new denim jeans, and 61.4% for new button shirts were made at a physical store - The average travel distance to the store was 9.43 km to purchase a new pair of denim jeans, and 8.11 km for a new button shirt - 18.6% of the store visits for new denim jeans, and 11.5% for new button shirts were made by car - 39.53% of each trip's impacts are attributed to the purchased garment - Average car fleet of the Netherlands in 2021 is	Ecoinvent unit processes ANWB (n.d.); CBS (2024b) Kunst (2020)	Operation, passenger car, petrol, 15% vol. ETBE with ethanol from biomass, EURO4/CH U Operation, passenger car, petrol, 4% vol. ETBE with ethanol from biomass, EURO4/CH U Operation, passenger car, petrol, EURO5/CH U Operation, passenger car, electric, LiMn2O4, certified electricity/CH U

[8] These percentages slightly differ from the percentages shown in paragraph 4.3.2.2 because the category "other" is excluded.

[9] Non-emitting forms of transportation: on foot, by bicycle, or by public transport.

	assumed for each km travelled. This includes the following percentages: - Petrol E10: 69.0% - Petrol E5: 7.7% - Electricity: 13.8% - Diesel: 13.8% - LPG & CNG: 1.1%		Electricity, low voltage, production NL, at grid/NL U Operation, passenger car, diesel, EURO5, city car/CH U Operation, passenger car, natural gas/CH U
In-store purchase: transport by e-bike or e-scooter	- 65.6% of the purchases of new denim jeans, and 61.4% for new button shirts were made at a physical store - The average travel distance to the store was 9.43 km to purchase a new pair of denim jeans, and 8.11 km for a new button shirt - 1.2% of the store visits for new denim jeans, and 1.3% for new button shirts were made by an e-bike/e-scooter - 39.53% of each trip's impacts are attributed to the purchased garment - Equal share of operating e-bike and e-scooter is assumed per kilometre	Ecoinvent unit processes Kunst (2020)	Operation, electric bicycle, certified electricity/CH U Operation, electric scooter, certified electricity/CH U Electricity, low voltage, production NL, at grid/NL U
In-store purchase: transport by public transport, bike, or on foot	- 80.2% of the store visits for new denim jeans, and 87.2% for new button shirt were made by public transport, bike, or on foot - No impacts are assumed	-	-

3.6.2.7 Primary use: use-stage

The average expected uses before discarding a garment were determined from survey data. These were 292 wears for new denim jeans, and 148 wears for new button shirts. It is assumed that wearing itself does not result in any impacts or mass loss of the garment.

It is assumed that a garment is worn twice before washing it (Daystar et al., 2019; Traa, 2021). New denim jeans are washed 146 times, and new button shirts 74 times before discarding it. Washing in the Netherlands is calculated to consume an average of 0.479 kWh/wash cycle (Bakker et al., 2022; Compendium voor de Leefomgeving [CLO], 2023; CBS, 2024a). This level of consumption corresponds with using a washing machine with energy label A at 40 ºC or 60 ºC (EC, n.d.), which is realistic because this type has been dominantly sold in the Netherlands since 2017 (CLO, 2023). Washing at 20 °C consumes 30.0% of the electricity of washing at 60 °C (Alborzi et al., 2017), and washing at 30 °C 33.6% (Milani et al., 2015). Therefore is assumed that washing at 20 ºC consumes 0.144 kWh/wash cycle, and washing at 30 ºC consumes 0.161kWh/wash cycle. It is assumed that each cycle consumes 49 L of water, which is the Dutch average (Bakker et al., 2022), and that the water- and electricity consumption of the washing machine remains constant throughout the years. All information is summarised in Table 27.

It is assumed that a front loading washing machine with a maximum capacity of 8kg is used, because this type is most commonly sold in the Netherlands (Milani et al., 2015; La Faille, 2024). The filled loads of each cycle are assumed according to average European washing loads, which are 100% in 46.8% of the cases, 80% in 25.8% of the cases, 50% in 16.1% of the cases, and "*just a few items*" in 11.3% of the cases (WRAP, 2017, p.32). These numbers are used to calculate the share of impacts attributed to each respective garment, using Formula 4. Washing by hand is assumed to consume 0.144 kWh and 12.4 L_{water}, based Laitala et al. (2020).

$$\text{Share of impacts due to washing garment [\%]} = \frac{Garment\ weight\ [g]}{Maximum\ capacity\ [g] * filled\ load\ [\%]}$$

Formula 4: Share of impacts due to washing garment [%]

The distribution of washing temperatures within the sample is discussed in section 4.3.2.4.3, and summarised in Table 27. Survey data showed that 98.9% of the respondents use detergent when washing new denim jeans, and 95.2% when washing new button shirts. Fabric softener is used in 19.6% of the cases for new denim jeans, and 22.0% for new button shirts. It is assumed that liquid detergent is used, because this is more commonly used in the Netherlands than powdered detergent (Radar, 2019; BNNVARA, 2022; Van Rijn, 2023). It is further assumed that one wash requires a normal dosage detergent or fabric softener if applicable, which are 75 ml or 28 ml respectively. LCI data regarding both detergent and fabric softener are derived from Sandin et al. (2019, p.130;157). The share of impacts from using detergent and fabric softener attributed to each respective garment are based on Formula 4.

Survey data showed that 18.5% of the respondents use a clothes dryer after washing new denim jeans, and 13.4% for new button shirts. Drying in the Netherlands is calculated to consume 0.524 kWh/cycle (CLO, 2023; CBS, 2024c; EC, 2024). It is assumed that the dryer has a capacity of 8 kg – as is common in the Netherlands (Joris, n.d.) – and is loaded at equal capacities as the washing

machine. The share of impacts from using a clothes dryer attributed to each respective garment are based on Formula 4.

It is assumed that 23.0% of all denim jeans, and 76% of all button shirts are ironed (Van der Plaat, 1998), and that ironing takes place after washing. The number of ironing actions is thus equal to the number of wash cycles for each respective garment. It is assumed that ironing consumes 0.0417 kWh/minute (ANWB, n.d.b), and ironing a garment takes five minutes (Dobbi, n.d.); consuming 0.208 kWh.

Table 27: Overview Primary use: use-stage

Overview Primary use: use-stage			
Description step	Assumption(s)	Data source	Dataset
Wearing	- A pair of new denim jeans is worn 292 times, and a new button shirt is worn 148 times - Wearing does not result in impacts or mass losses	Survey	-
Washing	- A pair of second-hand denim jeans is washed 146 times, and a second-hand button shirt is washed 74 times - Washing at 20 °C consumes 0.144 kWh/wash cycle 2.1% of the new denim jeans, and 2.4% of the new button shirts are washed at this temperature - Washing at 30 °C consumes 0.161 kWh/wash cycle. 53.3% of the new denim jeans, and 64.4% of the new button shirts are washed at this temperature - Washing at either 40 °C or 60 °C consumes 0.479 kWh/wash cycle. 42.4% of the new denim jeans, and 30.5% of the new	Traa (2021); CLO (2023); CBS (2024c); EC (n.d.); La Faille (2024); Bakker et al. (2022); WRAP (2017); Radar (2019); BNNVARA (2022); Van Rijn (2023); Sandin et al. (2019); Milani et al. (2015); Alborzi et al. (2017) Ecoinvent unit processes	Electricity, low voltage, production NL, at grid/NL U Tap water {Europe without Switzerland}| market for | Cut-off, U Treatment, sewage, to wastewater treatment, class 3/m3 Ingredients detergent (listed in Appendix 10) Ingredients fabric softener (listed in Appendix 10)

	button shirts are washed at this temperature - Each washing cycle consumes 49 L of water - Washing by hand consumes 12.4L_{water} and 0.144 kWh. 2.2% of the new denim jeans are washed by hand, and 2.4% of the new button shirts. - Washing efficiency does not change throughout the years - Washing does not result in mass losses - Washing machine is a front-loading machine with a maximum load of 8 kg - Washing loads are distributed according to European average: 100% full in 46.8%, 80% full in 25.8%, 50% in 16.1%, and 'just a few items' in 11.3% of the cases - Detergent is used in 98.9% of cases for new denim jeans, and 95.2% of new button shirts - Fabric softener is used in 19.6% of the cases for new denim jeans, and 22.0% of new button shirts - Share of impacts resulting from washing attributed to the garment are calculated according to Formula 4		
Drying	- Clothes dryer is used in 18.5% of the cases for new denim	CLO (2023); CBS (2024c); EC	Electricity, low voltage,

	jeans, and 13.4% of new button shirts - Drying consumes 0.524kWh/cycle - Share of impacts resulting from washing attributed to the garment are calculated according to Formula 4	(2024); Joris (n.d.) Ecoinvent unit processes	production NL, at grid/NL U
Ironing	- 23.0% of all denim jeans-, and 76.0% of all button shirts are ironed - Ironing takes five minutes thus consumes 0.208 kWh	Dobbi (n.d.); Van der Plaat (1998); Sandin et al. (2019)	Electricity, low voltage, production NL, at grid/NL U

3.6.2.8 Primary use: disposition

No mass losses were assumed during use. The mass discarded during disposition is thus equal to that of a retailed pair of denim jeans (616g), or -button shirt (425g).

Survey data showed that 4.3% of the respondents plan to repurpose their new denim jeans upon discarding it, which was 10.8% for new button shirts ("A%" in Figure 13). It is assumed that all repurposed garments are repurposed as rags, as discussed in the survey. The repurposed material weight is considered as avoided production for textile fabric.

Survey data showed that 5.4% of the respondents plan to store their new denim jeans indefinitely upon discarding it, which was 8.4% for new button shirts ("B%" in Figure 13). This does not result in any impacts or credits.

Survey data showed that 29.3% of the respondents plan to recycle their new denim jeans, and 20.5% their new button shirt upon discarding it ("D%" in Figure 13). It is assumed that 8.0% of the portion to be recycled is incinerated, and 55.0% is reused, based on Ahsmann et al. (2020). The remaining 37.0% is assumed to be downcycled into rags (Sympany, n.d.), in the form of avoided production of textile fabric (Table 28).

Textiles are incinerated along with the *municipal household waste* [MHW] if the consumer disposes them in the general waste bin (Ahsmann et al., 2020). Survey data showed that 1.1% of the respondents plan to dispose their new denim jeans, and 2.4% of their new button shirts along with the MHW upon discarding it ("C%" in Figure 13). The mass not suited for recycling (8.0%) is added to this mass. Impacts originating from incineration are assumed according to the datasets displayed in Table 28.

Survey data showed that 59.8% of the respondents plan to donate or resell their new denim jeans for reuse upon discarding it, which was true for 57.8% of the new button shirts ("E%" in Figure 13). It is assumed that respondents hand these garments in at a second-hand store which sells them for reuse. A travel distance of 10.58 km for new denim jeans, and 8.76 km for new button shirts is assumed, based on survey data for the respondents that have stated to either donate or resell for reuse upon discarding. Transport methods during these trips are based on this same group (Figure 14). Environmental impacts resulting from

these trips were based on their respective datasets from the Ecoinvent database, while modifying the electricity mix for the e-bike/e-scooter to reflect the Netherlands. Trips made by public transport, on foot, or by bike are assumed to not result in any impacts and are thus excluded from the analysis.

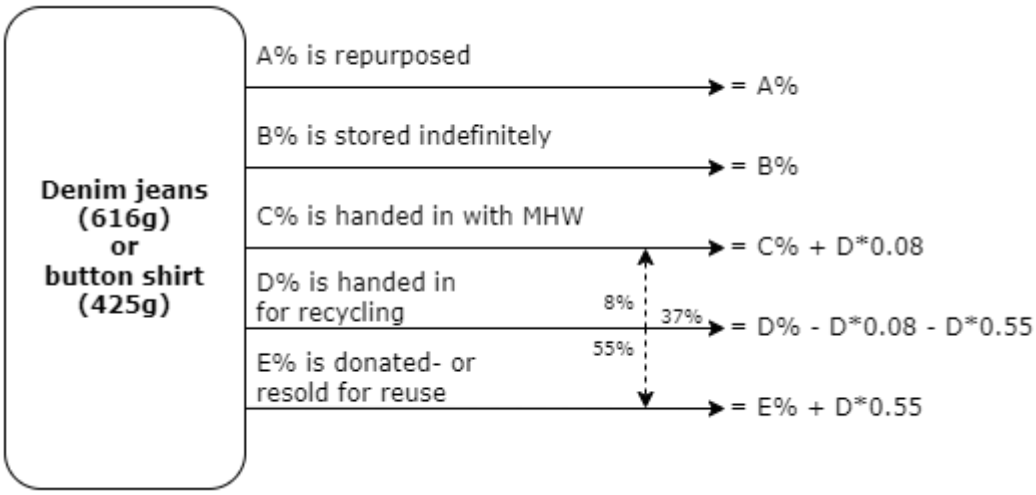


Figure 13: Disposal scenario of one garment

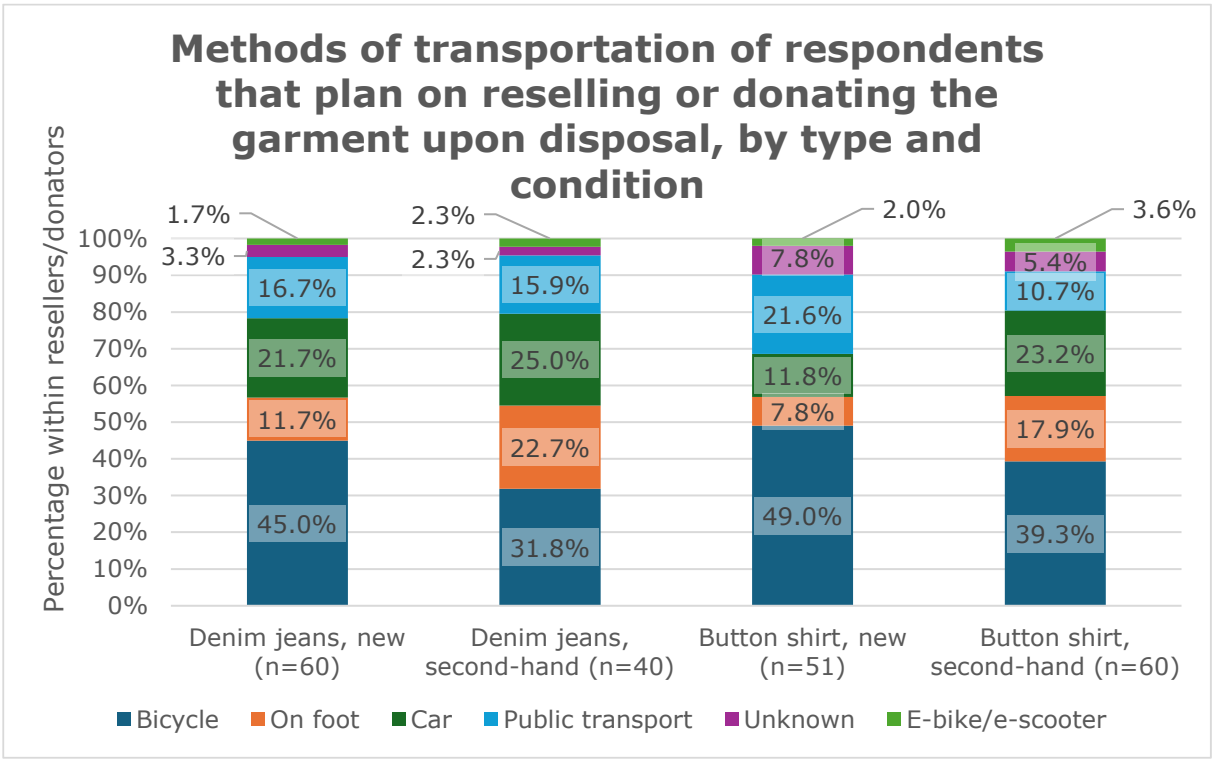


Figure 14: Methods of transportation of respondents that plan to resell or donate the garment upon disposal, by type and condition

Table 28: Overview Primary use: disposition

Overview Primary use: disposition			
Description step	Assumption(s)	Data source	Dataset
Repurposing [A%]	- A total of 15.2% a pair of new denim jeans is repurposed - A total of 18.4% of a new button shirt is repurposed - All material repurposed avoids the production of textiles for rags	-	Textile, woven cotton {GLO}| market for | Cut-off, U
Stored indefinitely [B%]	- A total of 5.4% of a pair of new denim jeans is stored indefinitely - A total of 8.4% of a new button shirt is stored indefinitely - No impacts nor credits from storing indefinitely	-	-
Recycling [D%]	- All recycled clothing avoids the production of rags	Ecoinvent unit processes; Ahsmann et al. (2020)	-
Waste incineration [C%]	- A total of 3.4% of a new pair of denim jeans is incinerated along with MHW - A total of 4.0% of a new button shirt is incinerated along with MHW - Incineration occurs in the Netherlands	IenW (2023c) Ecoinvent unit processes	Disposal, textiles, soiled, 25% water, to municipal incineration/kg/CH
Reuse [E%]	- Garments are dropped of at the store that sells them, using transport methods as displayed at Figure 14 and a travel distance of 10.58 km for new denim jeans, and 8.76 km for new button shirts - A total of 75.9% of a new pair of denim jeans is reused - A total of 69.1% of a new button shirt is reused	IenW (2023c) Ecoinvent unit processes	Operation, passenger car, petrol, 15% vol. ETBE with ethanol from biomass, EURO4/CH U Operation, passenger car, petrol, 4% vol. ETBE with ethanol from biomass, EURO4/CH U

			Operation, passenger car, petrol, EURO5/CH U Operation, passenger car, electric, LiMn2O4, certified electricity/CH U Operation, passenger car, diesel, EURO5, city car/CH U Operation, passenger car, natural gas/CH U Operation, electric bicycle, certified electricity/CH U Operation, electric scooter, certified electricity/CH U Electricity, low voltage, production NL, at grid/NL U

3.6.2.9 Reuse: retailing for reuse

Survey data showed that 73.6% of the second-hand denim jeans were purchased from a physical store, and 26.4% online. This was 76.0% and 24.0% for second-hand button shirts respectively. Impacts for retailing of these garments is followings the same assumptions as retailing for primary use (3.6.2.5), which are summarised in Table 29.

Table 29: Overview retailing for reuse

Overview Reuse: retailing for reuse			
Description step	Assumption(s)	Data source	Dataset
Retail from physical store	- 73.6% of the second-hang denim jeans are purchased at a physical store - 76.0% of the second-hand button shirts are purchased at a physical store	Sandin et al., 2019	Electricity, low voltage, production NL, at grid/NL U

	- Supplying the store is excluded from the analysis - Consumes 119.73 Wh/kg sold		
Retail from online store	- 26.4% of the second-hand denim jeans are purchased at an online store - 24.0% of the second-hand button shirts are purchased at an online store - Supplying the distribution centre is excluded from the analysis - Garments are stored for 31 days - Consumes 1.998 Wh/garment sold and 0.195 dm^3 natural gas per garment sold - Requires 39.53% of an A4 paper invoice weighing 5g - Transported in 39.53% of a HDPE bag weighing 62.9g	Jeans Info, (n.d.); CBS, (2021b; 2022a); Klooster, (2022)	Electricity, low voltage, production NL, at grid/NL U

3.6.2.10 Reuse: purchase

Survey data was used as LCA-input regarding purchasing of garments for primary use. The survey reported that 73.6% of the purchases for second-hand denim jeans occurred at a physical store, and 26.4% online. This was 76.0% and 24.0% for new button shirts respectively[10]. The survey furthermore reported average travel distances of 6.70 km for new denim jeans and 6.68 km for new button shirts to the physical store. Trips to purchase a new pair of denim jeans were made by car (20.3%), e-bike/e-scooter (1.6%), or by non-emitting methods of transportation (78.1%). This distribution for purchases of new button shirts was 20.3%, 2.5%, and 77.2%, respectively. Impacts relating to purchasing these garments follows the same assumptions as Primary use: purchase (3.6.2.6), which are summarised in Table 30.

[10] These percentages slightly differ from the percentages shown in paragraph 4.3.2.2 because the category "other" is excluded.

Table 30: Overview Reuse: purchase

Overview Reuse: purchase			
Description step	Assumption(s)	Data source	Dataset
In-store purchase: transport by car	- 73.6% of the purchases of second-hand denim jeans, and 76.0% for second-hand button shirts were made at a physical store - The average travel distance to the store was 6.70 km to purchase a second-hand pair of denim jeans, and 6.68 km for a second-hand button shirt - 20.3% of the store visits for second-hand denim jeans, and 20.3% for second-hand button shirts were made by car - 39.53% of each trip's impacts are attributed to the purchased garment - Average car fleet of the Netherlands in 2021 is assumed for each km travelled. This includes the following percentages: - Petrol E10: 69.0% - Petrol E5: 7.7% - Electricity: 13.8% - Diesel: 13.8% - LPG & CNG: 1.1%	Ecoinvent unit processes ANWB (n.d.); CBS (2024b) Kunst (2020)	Operation, passenger car, petrol, 15% vol. ETBE with ethanol from biomass, EURO4/CH U Operation, passenger car, petrol, 4% vol. ETBE with ethanol from biomass, EURO4/CH U Operation, passenger car, petrol, EURO5/CH U Operation, passenger car, electric, LiMn2O4, certified electricity/CH U Electricity, low voltage, production NL, at grid/NL U Operation, passenger car, diesel, EURO5, city car/CH U Operation, passenger car, natural gas/CH U
In-store purchase: transport by e-bike or e-scooter	- 73.6% of the purchases of second-hand denim jeans, and 76.0% for second-hand button shirts were made at a physical store - The average travel distance to the store was 6.70 km to	Ecoinvent unit processes	Operation, electric bicycle, certified electricity/CH U Operation, electric scooter, certified electricity/CH U Electricity, low voltage,

	purchase a second-hand pair of denim jeans, and 6.68 km for a second-hand button shirt - 1.6% of the store visits for second-hand denim jeans, and 2.5 % for second-hand button shirts were made by an e-bike/e-scooter - 39.53% of each trip's impacts are attributed to the purchased garment - Equal share of operating e-bike and e-scooter is assumed per kilometre	Kunst (2020)	production NL, at grid/NL U
In-store purchase: transport by public transport, bike, or on foot	- 78.1% of the store visits for second-hand denim jeans, and 77.2% for second-hand button shirt were made by public transport, bike, or on foot - No impacts are assumed	-	-

3.6.2.11 Reuse: reuse-stage

The average expected uses before discarding a garment were determined from survey data, and were 222 wears for second-hand denim jeans and 125 for second-hand button shirts. Second-hand denim jeans are washed 111 times, and second-hand button shirts 63 times before discarding it. 98.6% of the respondents used detergent when washing second-hand denim jeans, which was 96.7% for second-hand button shirts. Fabric softener is used in 23.0% of the cases for second-hand denim jeans, and 25.6% for second-hand button shirts. Survey data showed that 13.5% of the respondents use a clothes dryer after washing new denim jeans, and 11.1% for second-hand button shirts. Impacts relating to using these garments furthermore follow the same assumptions as Primary use: use-stage (3.6.2.7), which are summarised in Table 31.

Table 31: Overview Reuse: Reuse-stage

Overview Reuse: reuse-stage			
Description step	Assumption(s)	Data source	Dataset
Wearing	- A pair of second-hand denim jeans is worn 222 times, and a second-hand button shirt is worn 125 times	Survey	-

	- Wearing does not result in impacts or mass losses		
Washing	- A pair of second-hand denim jeans is washed 111 times, and a second-hand button shirt is washed 63 times - Washing at 20 °C consumes 0.144 kWh/wash cycle 1.4% of the second-hand denim jeans, and 2.2% of the second-hand button shirts are washed at this temperature - Washing at 30 °C consumes 0.161 kWh/wash cycle. 55.4% of the second-hand denim jeans, and 64.4% of the second-hand button shirts are washed at this temperature - Washing at either 40 °C or 60 °C consumes 0.479 kWh/wash cycle. 40.5% of the second-hand denim jeans, and 31.1% of the second-hand button shirts are washed at this temperature - Each washing cycle consumes 49 L of water - Washing by hand consumes 12.4L_{water} and 0.144 kWh. 2.7% of the second-hand denim jeans are washed by hand, and 2.2% of the second-hand button shirts.	Traa (2021); CLO (2023); CBS (2024c); EC (n.d.); La Faille (2024); Bakker et al. (2022); WRAP (2017); Radar (2019); BNNVARA (2022); Van Rijn (2023); Sandin et al. (2019); Milani et al. (2015); Alborzi et al. (2017) Ecoinvent unit processes	Electricity, low voltage, production NL, at grid/NL U Tap water {Europe without Switzerland}| market for | Cut-off, U Treatment, sewage, to wastewater treatment, class 3/m3 Ingredients detergent (listed in Appendix 10) Ingredients fabric softener (listed in Appendix 10)

	- Washing efficiency does not change throughout the years - Washing does not result in mass losses - Washing machine is a front-loading machine with a maximum load of 8 kg - Washing loads are distributed according to European average: 100% full in 46.8%, 80% full in 25.8%, 50% in 16.1%, and 'just a few items' in 11.3% of the cases - Detergent is used in 98.6% of cases for second-hand denim jeans, and 96.7% of second-hand button shirts - Fabric softener is used in 23.0% of the cases for second-hand denim jeans, and 25.6% of second-hand button shirts - Share of impacts resulting from washing attributed to the garment are calculated according to Formula 4		
Drying	- Clothes dryer is used in 13.5% of the cases for second-hand denim jeans, and 11.1% of second-hand button shirts - Drying consumes 0.524kWh/cycle - Share of impacts resulting from washing attributed to the garment are	CLO (2023); CBS (2024c); EC (2024); Joris (n.d.) Ecoinvent unit processes	Electricity, low voltage, production NL, at grid/NL U

	calculated according to Formula 4		
Ironing	- 23.0% of all denim jeans-, and 76.0% of all button shirts are ironed - Ironing takes five minutes thus consumes 0.208 kWh	Dobbi (n.d.); Van der Plaat (1998); Sandin et al. (2019)	Electricity, low voltage, production NL, at grid/NL U

3.6.2.12 Reuse: disposition

The same assumptions as discussed in section 3.6.2.8 apply for Reuse: disposition, and are summarised in Table 32. Survey data showed that 10.8% of the respondents plan to repurpose their second-hand denim jeans upon discarding it, which was 13.3% for second-hand button shirts ("A%" in Figure 13). 1.4% of the respondents plan to store their second-hand denim jeans indefinitely upon discarding it, which was 5.6% for second-hand button shirts ("B%" in Figure 13). The data furthermore reported that 25.7% of the respondents plan to recycle their second-hand denim jeans, and 17.8% their second-hand button shirt upon discarding it ("D%" in Figure 13). 4.1% of the second-hand denim jeans is planned to be discarded along with the MHW, which was 1.1% for second-hand button shirts ("C%" in Figure 13). Respondents plan on donating or reselling their second-hand denim jeans after discarding it in 58.1% of the cases, and 62.2% of the cases for second-hand button shirts ("E%" in Figure 13). Travel distances to the store to hand in the garments are 8.14 km for second-hand denim jeans, and 6.18 km for second-hand button shirts, which follows the distribution of transport methods displayed in Figure 14.

Table 32: Overview Reuse: disposition

Overview Reuse: disposition			
Description step	Assumption(s)	Data source	Dataset
Repurposing [A%]	- A total of 20.3% of a pair of second-hand denim jeans is repurposed (includes percentage from recycling) - A total 19.9% of a second-hand button shirt is repurposed (includes percentage from recycling) - All material repurposed avoids the production of textiles for rags	-	Textile, woven cotton {GLO}| market for | Cut-off, U
Stored indefinitely [B%]	- A total of 1.4% of a pair of second-hand denim jeans is stored indefinitely	-	-

	- A total of 5.6% a second-hand button shirt is stored indefinitely - No impacts nor credits from storing indefinitely		
Recycling [D%]	- All recycled clothing avoids the production of rags	Ecoinvent unit processes; Ahsmann et al. (2020)	-
Waste incineration [C%]	- A total of 6.1% of a pair of second-hand denim jeans is incinerated along with MHW - A total of 2.5% of a second-hand button shirt is incinerated along with MHW - Incineration occurs in the Netherlands	IenW (2023c) Ecoinvent unit processes	Disposal, textiles, soiled, 25% water, to municipal incineration/kg/CH
Reuse [E%]	- Garments are dropped of at the store that sells them, using transport methods as displayed at Figure 14 and a travel distance of 8.14 km for second-hand denim jeans, and 6.18 km for second-hand button shirts - A total of 72.2% of a pair of second-hand denim jeans is reused - A total of 72.0% of a second-hand button shirt is reused	IenW (2023c) Ecoinvent unit processes	Operation, passenger car, petrol, 15% vol. ETBE with ethanol from biomass, EURO4/CH U Operation, passenger car, petrol, 4% vol. ETBE with ethanol from biomass, EURO4/CH U Operation, passenger car, petrol, EURO5/CH U Operation, passenger car, electric, LiMn2O4, certified electricity/CH U Operation, passenger car, diesel, EURO5, city car/CH U

			Operation, passenger car, natural gas/CH U Operation, electric bicycle, certified electricity/CH U Operation, electric scooter, certified electricity/CH U Electricity, low voltage, production NL, at grid/NL U

4 Results

In this chapter are the results of all collected data discussed. Data collected from the store manager interviews is first discussed (4.1), followed by data collected from the consumer interviews (4.2). Daat collected from the survey is discussed in 4.3.

4.1 Results store manager interviews

Six out of the ten store manager interviews stated that denim jeans are the most sold second-hand garment with a steady demand throughout the entire year in the city of Utrecht. This was equally distributed between the specialised second-hand stores and kringloopwinkels. All specialised second-hand stores that stated that denim jeans were their top-selling garment also specifically mentioned that the Levi's 501 model was their most popular type of jeans sold. This model can however not be considered a true representative garment for this study, because none of the kringloopwinkels mentioned this specific model. The second top-selling second-hand garment were parkas (50%). Demand for parkas is in the Netherlands season-bound, and the fact that parkas were ranked second is likely a result of the interviews taking place during the winter. Parkas are therefore excluded from this research. The third most sold garment type were button shirts, as stated by 40% of the stores. This distribution is skewed towards specialised second-hand stores, which make up 75% of this 40%. Figure 15 and 16 display the results by garment type, and garment type split by store type.

The store managers were not able to accurately answer the questions regarding the material composition- and production location of each garment. One store manager stated that this is a result of the variety of garments that are acquired, and that the acquired garments differ in terms of time of production – which influences the materials used and the production location.

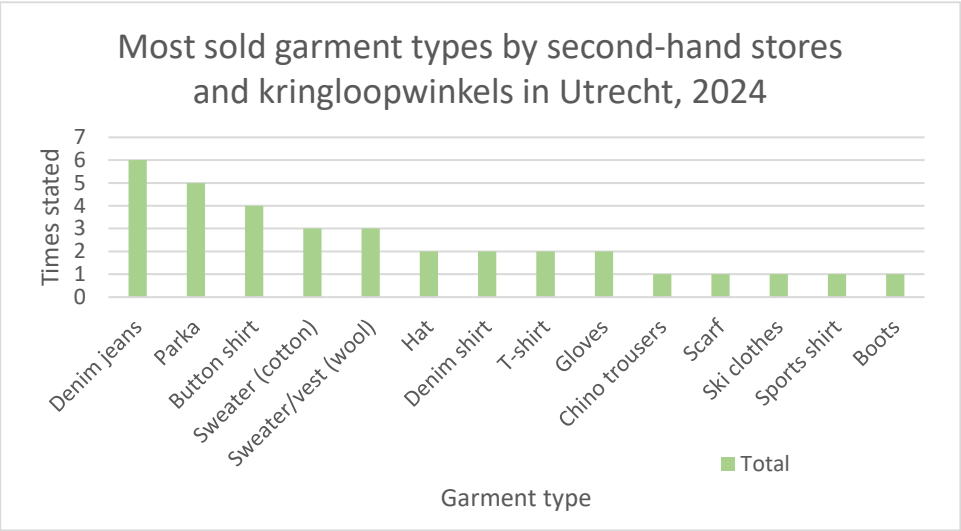


Figure 15: Most sold garment types by second-hand stores and kringloopwinkels in Utrecht, 2024

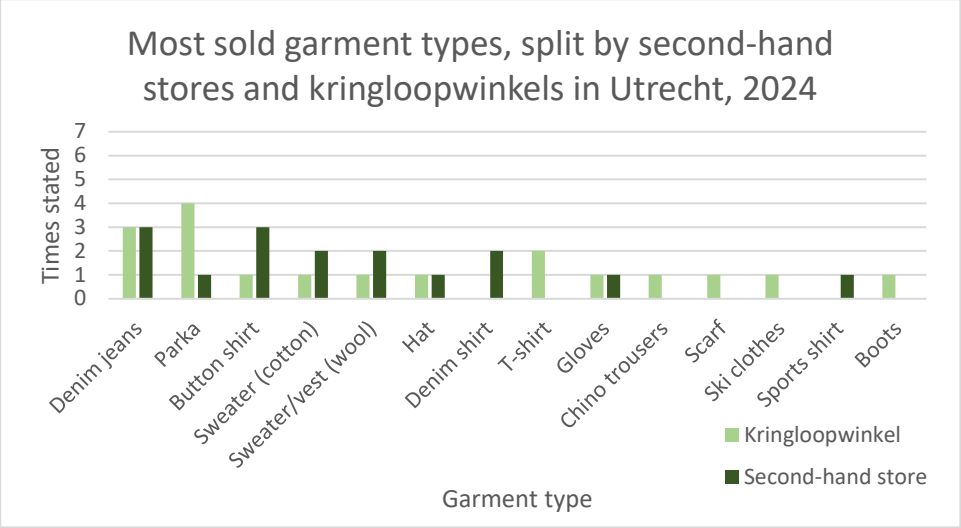


Figure 16: Most sold garment types, split by second-hand stores and kringloopwinkels in Utrecht, 2024

4.2 Results consumer interviews

The ten consumer interviews had a duration between five and ten minutes. The respondents were aged between 18 and 58 years old. Six of the ten respondents identified as male, and four as female. Subsequent paragraphs explain the results, categorised according to the topic list (section 3.5.2).

4.2.1 Obtainment motivation

Appendix 9 provides an overview of statements that the respondents made, grouped by topic. The only topic that was not yet covered by the theory in section 2 was 'uniqueness of the product'. Two respondents (1; 2) stated that second-hand garments can be more unique than newly sold garments. Unique garments are hard to find, thus finding one induces a purchase. This topic was thus also considered while operationalising the survey.

4.2.2 Displacement rates

Respondents answers regarding displacement rates are diverse. Figure 17 displays statements regarding displacement rates, ordered on the extent of displacement. A new insight is that convenience seems important for displacement.

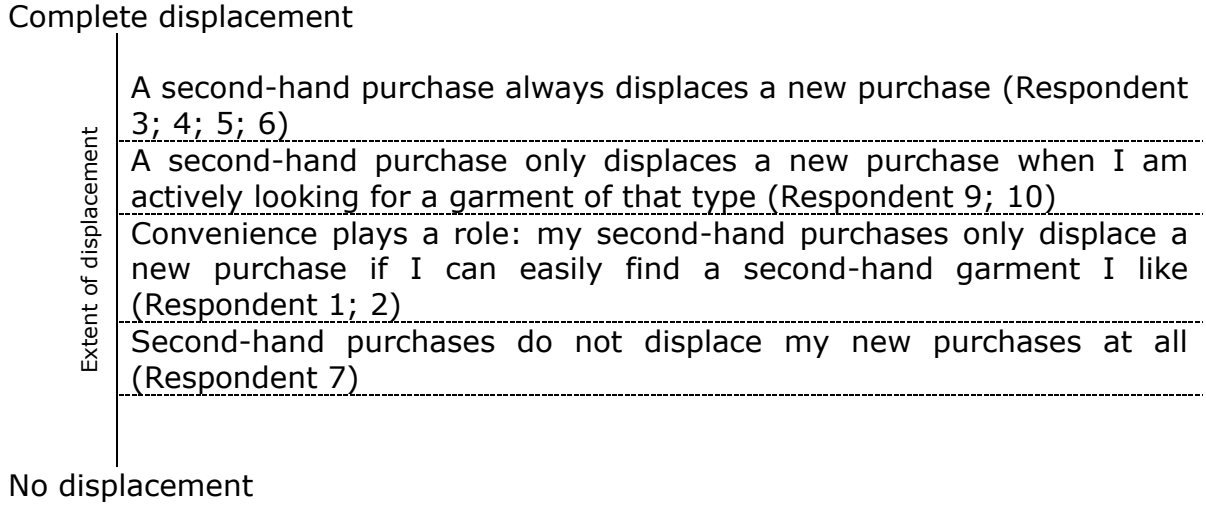


Figure 17: Extent of displacement

4.2.3 User valuation of product properties

Figure 18 displays the times that each product property (André & Björklund, 2023) was stated to be of importance when purchasing second-hand- or new garments. Enjoyment of purchase was not stated to be of importance when purchasing new garments. Two respondents remarked that purchasing second-hand does not bring joy by itself, but the shopping experience can. Another remark was made regarding appearance; one respondent stated that second-hand purchases must still look like new in order for them to purchase it. The interviews revealed that one product property – "supports vegan lifestyle" – was not covered by the theory (section 2).

4.2.4 Re-spending – buying

Five of the respondents stated to save money by purchasing second-hand clothing. All of these respondents stated to spend the money saved on maintaining their normal lifestyle. One respondent added that they may also spend it on recreational activities. No new insights were found.

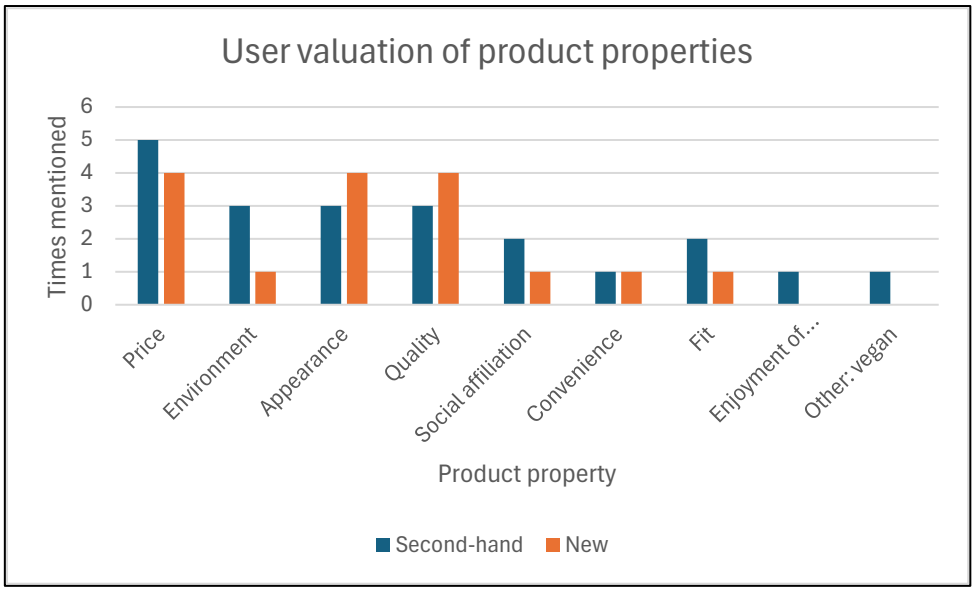


Figure 18: User valuation of product properties

4.2.5 Consumption accumulation and Price

Several respondents (1; 2; 3; 10) stated to have purchased second-hand clothing because they were bargains, which indicates the Price-mechanism. The occurrence of consumption accumulation cannot be easily concluded. Respondent 2 and 10 state that some garments are occasionally worn, while others are never worn. Respondent 3 states that some of the acquired garments serve as a back-up, while others turned out to be favourite garments among the wardrobe and are worn extensively. No new insights for survey input were found.

4.2.6 Motivational (direct) and -(indirect)

Respondent 3 argued against Motivational (direct), stating that they cannot afford to consider sustainability when making an obtainment motivation. No other new insights were found.

Only one of the respondents (2) stated to make trips specifically to second-hand stores. The respondent however stated that this trip usually consists of multiple second-hand stores and is treated like a day out. All other respondents stated to combine the trip made with other business en-route. Distances travelled ranged between 3km and 50km. Respondents made these trips by foot, bike, scooter, car, or by public transport. No new insights for survey input were found.

4.2.7 Use-phase

Most respondents (1; 2; 3; 6; 9; 10) stated to have the same wash- and dry habits for second-hand and new clothing. Respondents 9 and 10 did add the remark that second-hand garments will get a wash before first use, opposed to new clothing. Two respondents (7; 8) stated to treat second-hand garments more carefully, and not use a clothing dryer on them. This supports the theory: no new insights for survey input regarding use were found.

Table 33 displays the respondents' statements regarding repairing. All respondents state to repair clothing to some extent. Four respondents (3; 8; 9; 10) state to only repair clothing themselves and never go to a repair shop. Cost (1; 2; 3; 9; 10) and emotional attachment (1; 2; 7; 9) are the most important factors when considering to make a repair – either in favour of- or against a repair action. This is in line with Koch and Vringer (2023).

Table 33: Statements repairing

Statements repairing	
Respondent	Statements
1	I rarely repair clothing. I think a garment has already fulfilled it's purpose when it breaks, because I purchase second-hand. Garments to which I am emotionally attached will get repaired, or garments that were costly and are economically worth a repair
2	Trousers usually get a repair, but it mostly depends on the extent to which I am emotionally attached to the garment, and how much I paid for it
3	I repair shoes, because of economic reasons. I also attach buttons to garments myself. Garments are repaired about once per year. I never go to a repair shop
4	Clothing will be repaired, there are no differences between new- or second-hand repairs
5	Both second-hand and new garments will be repaired. I bring them to a repair shop
6	Garments are repaired if possible. Only garments which cannot be repaired are replaced. I was taught that you should not throw things out unless strictly necessary
7	Second-hand garments are more often repaired than my new purchased garments. This is because I am usually more emotionally attached to the second-hand garments due to their uniqueness
8	I will repair shoes myself, re-glue the sole for example. But not if there is a hole, I cannot fix that
9	I repair garments myself. Cost and emotional attachment are major factors to this. I don't bring garments to repair shops
10	Whether or not a garment is repaired depends if I can repair it myself. I never go to a repair shop, because purchasing a new garment is almost as expensive as the repair

4.2.8 Disposition

Appendix 9 includes an overview of the respondents' statements on disposition. Respondent 5 states that second-hand clothing is disposed of faster than new clothing because it wears out faster. None of the respondents state to have differences in discarding habits for second-hand- and new garments. No new insights for survey input were found.

4.3 Results survey

This section discusses the survey results.

4.3.1 Non-response and representativeness

451 invitational flyers were distributed, along with invites over social media. The survey concluded with 182 entries, of which 104 were complete and suitable for analysis. The excluded entries were either incomplete (76), which is likely due to survey length, or invalid (2). It is impossible to make a definitive statement regarding the non-response rate of the distribution, because it is unknown how many individuals have seen an invitation as the invites were also distributed digitally. Neither is it possible to make definite statements regarding a non-

response bias, as the exact user characteristics of consumers of second-hand clothing in the Netherlands are unknown. Paragraph 4.3.2.1 – 4.3.2.4 however provide insights into the user characteristics of the respondents.

The collected sample is of insufficient size to formulate generalising statements for the Dutch population, even if weighing factors were to be applied. Therefore is no test on representativeness conducted.

4.3.2 General results

Subsequent paragraphs summarise the survey answers which are not used for to calculate CER-mechanisms (4.3.2.1 – 4.3.2.4).

4.3.2.1 General user characteristics

Table 34 provides a summary of the respondents' general user characteristics. Respondent's ages ranged between 18 and 67 years, with a modal age of 27 (8 respondents), and an average age of 33.6 years. The modal age category is 25-34 years (43.3%), and the largest share of the sample (83.7%) is aged between 18 and 44 years old. This distribution is likely because the survey was distributed within the author's network and through specific stores, resulting in a response-bias.

Most respondents (78.8%) identified as female, opposed to male (18.3%) or a different gender (2.9%). This was expected because other research on second-hand clothing also reported an overrepresentation of women (Sohn et al., 2021; Ciechelska et al., 2023), and Dutch women in general purchase more garments per year than Dutch men (Ahsmann et al., 2020, p.23-24; Koch & Vringer, 2023, p.37).

Most respondents (80.8%) had either a Bachelor's, Master's, or Doctor's degree. This overrepresentation is likely because the survey was also distributed within the author's network, resulting in a response-bias. None (0.0%) of the respondents had primary education as their highest completed level of education.

Most respondents (66.3%) had either a minimum- (26.0%) or below modal income (40.4%). Norum and Norton (2017) state that lower incomes correlate with purchasing second-hand clothing in the United States, which could be a possible explanation for behaviour shown in the survey.

Table 34: Characteristics respondents in sample (n = 104)

Characteristics respondents in sample (n = 104)			
Category	Absolute	Relative (%)	Cumulative (%)
Age			
18-24	22	21.2	21.1
25-34	45	43.3	64.4
35-44	20	19.2	83.7
45-54	5	4.8	88.5
55-64	10	9.6	98.1
65-74	2	1.9	100.0
Gender			
Female	82	78.8	78.8
Male	19	18.3	97.1
Other	3	2.9	100.0
Level of education			
Primary education	0	0.0	0.0
Secondary education	4	3.8	3.8

Vocational education	15	14.4	18.3
Higher education	84	80.8	99.0
Don’t know/unknown/unavailable	1	1.0	100.0
Income			
Minimum income	27	26.0	26.0
Below modal	42	40.4	66.3
Modal	17	16.3	82.7
Between 1 and 2 times modal	10	9.6	92.3
Between 2 and 3 times modal	2	1.9	94.2
Over 3 times modal	1	1.0	95.2
I’d rather not say	5	4.8	100.0

4.3.2.2 Acquisition

Figure 19 shows that 74 (71.2%) of the respondents had purchased a pair of second-hand denim jeans, and 92 (88.5%) had purchased a new pair. 90 (86.5%) had purchased a second-hand button shirt, and 83 (79.8%) had purchased a new button shirt. 12 (11.6%) of the respondents stated to not have purchased a new garment of either type at all. Figure 20 and Figure 21 display where the respondents have purchased garments of either type in the past, sorted by condition.

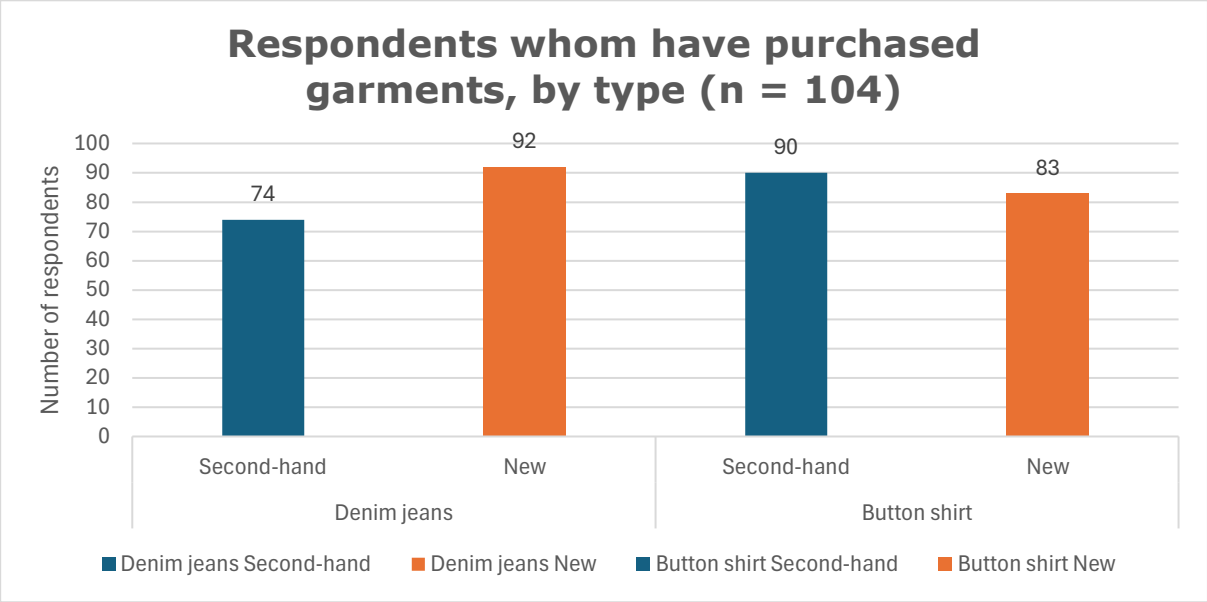


Figure 19: Respondents whom have purchased garments, by type (n = 104)

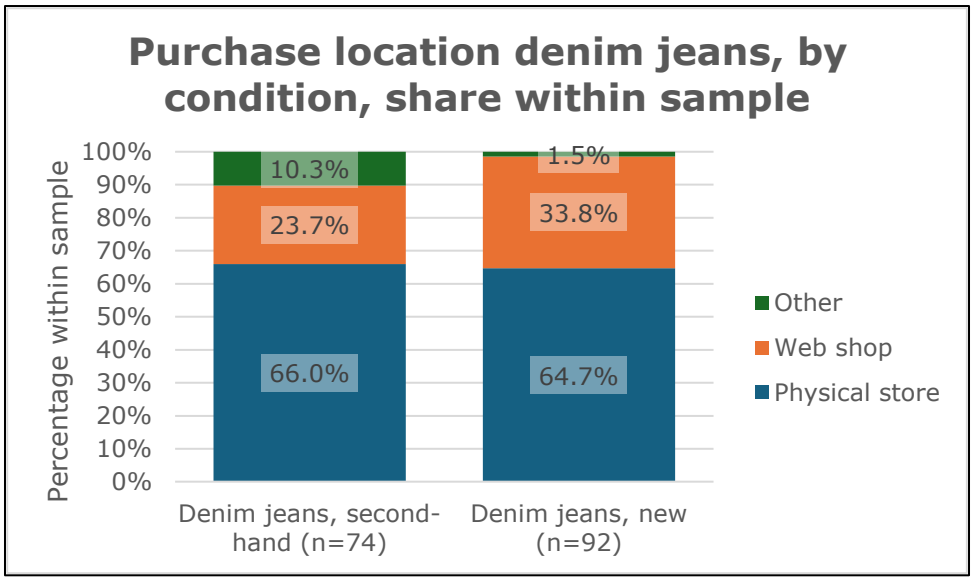


Figure 20: Purchase location of denim jeans, by condition, share within sample

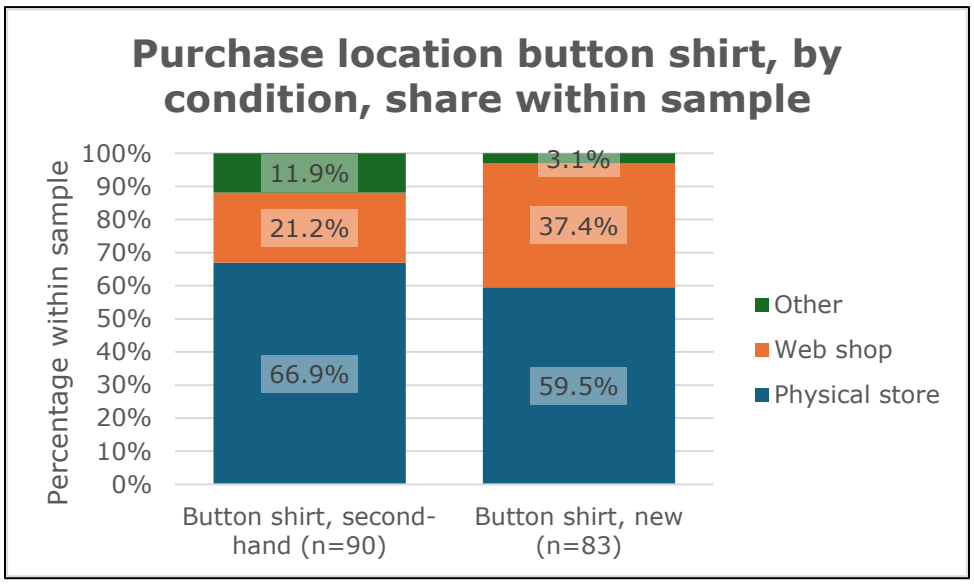


Figure 21: Purchase location of button shirt, by condition, share within sample

The average travel distances to the store were 6.70 km for a second-hand pair of denim jeans, 9.43 km for a new pair of denim jeans, 6.68 km for a second-hand button shirt, and 8.11 km for a new button shirt (Table 35). Travel distances ranged between 0.0 km and 94.0 km. A travel distance of 0.0 km is understood as an respondent that lives in the city centre and travels a few metres to the store.

Table 35: Travel distances, sorted by garment type and condition

Travel distances, sorted by garment type and condition			
	Average distance travelled [km]	Minimum distance travelled [km]	Maximum distance travelled [km]
Jeans, second-hand (n=74)	6.70	0.0	60.0
Jeans, new (n=91)	9.43	0.0	94.0
Button shirt, second-hand (n=90)	6.68	0.0	90.0
Button shirt, new (n=83)	8.11	0.0	70.0

Figure 22 and 23 display the shares of transportation methods used to purchase each respective garment. Most respondents (40.6%-47.4%) used a bicycle to go to the store. The share of respondents that used public transportation is higher for both second-hand purchases, compared to their new counterparts. None of the respondents used a scooter to purchase a garment.

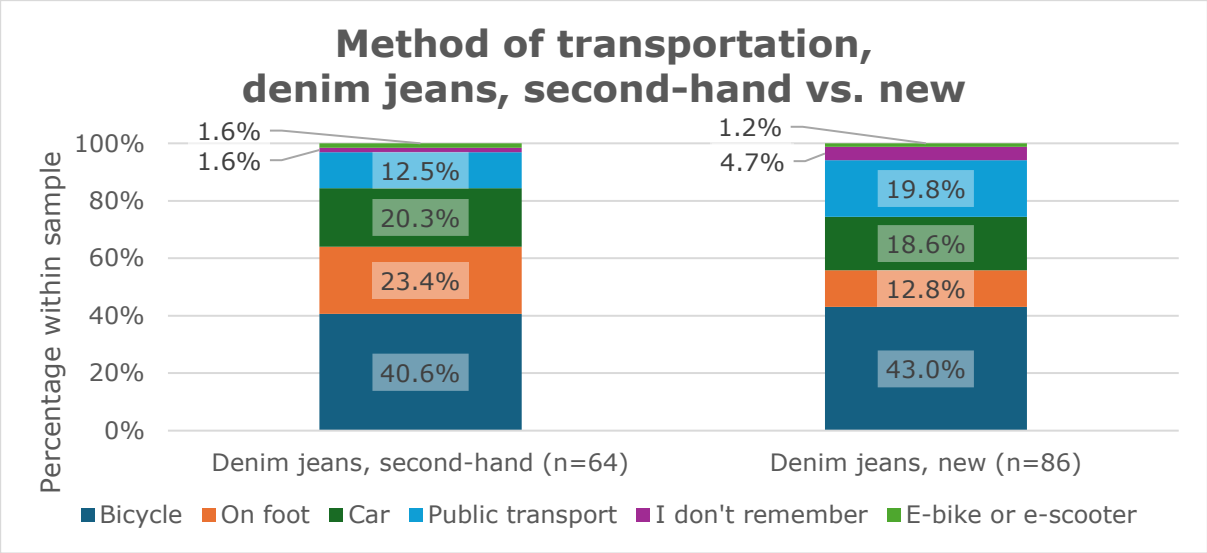


Figure 22: Method of transportation, denim jeans, second-hand vs. new

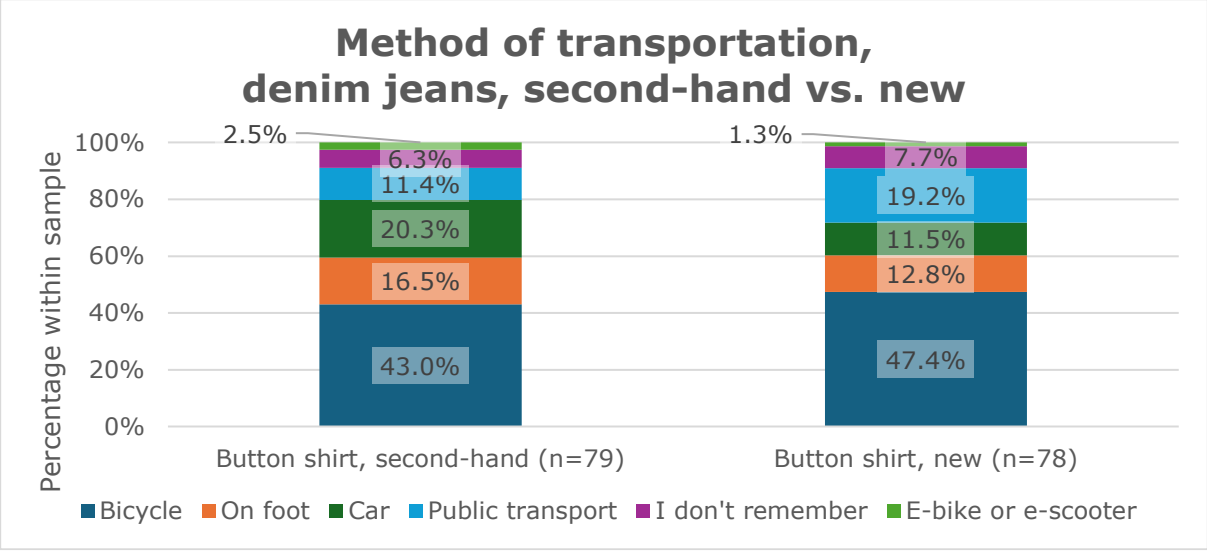


Figure 23: Method of transportation, denim jeans, second-hand vs. new

4.3.2.3 User valuation of product property

Figure 24 displays how the respondents (n=104) have rated the product properties for both garment types. All ratings can be rounded to 4, which corresponds with a rating of "good", which implies that second-hand garments are comparable to new garments for the respondents, and can thus be compared in the LCA. Noteworthy is that the average performance of second-hand denim jeans is rated higher (4.08) than its new counterpart (3.95). A possible explanation could be that second-hand garments purchased in stores are checked before reselling, in terms of performance. This may also explain the small difference between rating of performance of button shirts. Quality in button shirts is on average also rating slightly higher (3.98) compared to its new counterpart (3.96). New garments were

furthermore consistently rated higher than second-hand garments. Differences in rating are the highest for denim jeans in terms of quality (0.34 points), and button shirts (0.47 points) in terms of fit.

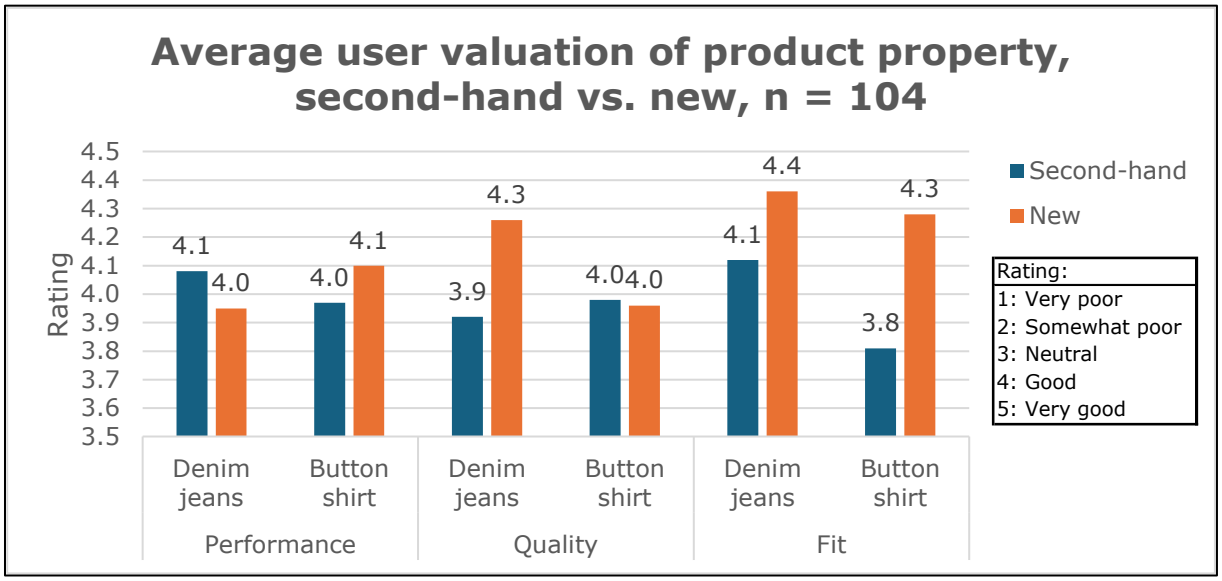


Figure 24: Average user valuation of product property, second-hand vs. new, n=104

4.3.2.4 Use

Paragraph 4.3.2.4.1 – 4.3.2.4.4 describe all practices relating to the use-stage.

4.3.2.4.1 Garment lifetimes

Initial answers regarding expected lifetimes for garments showed large variances. Boxplots were plotted for each of the garments, which showed that the answers were positively skewed by outliers. All initial outliers were excluded from the analysis in order to determine more accurate lifetimes. This resulted in the average lifetimes as displayed in Table 36. Appendix 11 contains the boxplots and results for the original sample.

The average lifetime of second-hand garments analysed in this study are 30.72 months (denim jeans) and 38.35 months (button shirt), while these are 37.80 months and 45.75 months for their second-hand counterparts. These lifetimes are shorter than reported in international research, which were 42.00 months (denim jeans) and 57.60 months (button shirt) (Laitala & Klepp, 2020). The combined average of all garment lifetimes within the sample is 38.16 months, which is close to the Dutch average of 36.12 months for jeans and shirts (Van Oorschot et al., 2020).

Table 36: Descriptives with initial outliers excluded, Q15.1.1: "For how long do you think you will use the garment?" [months]

Descriptives with initial outliers excluded, Q15.1.1: "For how long do you think you will use the garment?" [months]					
	n	Minimum	Maximum	Mean	Std. Deviation
Jeans, second-hand	71	4.00	90.00	30.72	18.98
Jeans, new	87	6.00	120.00	37.80	21.84
Button shirt, second-hand	86	4.00	120.00	38.35	24.17
Button shirt, new	77	6.00	120.00	45.75	29.11

4.3.2.4.2 Garment use rates

Boxplots regarding use rates were plotted for each of the garments, which showed that the answers were positively skewed by outliers. All initial outliers were excluded from the analysis in order to determine more accurate use rates. This resulted in the average use rates as displayed in Table 37. Appendix 12 contains the boxplots and results for the original sample.

Denim jeans are worn between 1 and 20 times per month, with an average of 7.24 wears/month for second-hand-, and 7.72 wears/month for new jeans. Button shirts are worn between 0 and 12 times per month, with an average of 3.25 wears/month for second-hand-, and 3.24 wears/month for new button shirts. These is higher than research by Cooper et al. (2014), whom state 6.2 wears/month for jeans, and 1.3 wears/month for shirts.

Formula 5 displays how the garment's total lifetime uses are calculated, of which Table 38 displays the distribution sorted by condition. Denim jeans have an average of 514 uses before discarding it, which is 273 for button shirts. The number of total uses before discarding the garments are higher than assumed in literature; Sandin et al. (2019) assumed 240 wears before discarding denim jeans, and Cooper et al. (2014) assumed 233 wears for denim jeans, and 58 wears for shirts.

Table 37: Descriptives with initial outliers excluded, Q15.1.2: "How often do you think you will use the garment?" [times/month]

Descriptives with initial outliers excluded, Q15.1.2: "How often do you think you will use the garment?" [times/month]					
	n	Minimum	Maximum	Mean	Std. Deviation
Jeans, second-hand	71	1.00	18.00	7.24	3.97
Jeans, new	86	1.00	20.00	7.72	3.90
Button shirt, second-hand	84	0.00	12.00	3.25	2.25
Button shirt, new	76	0.50	8.00	3.24	1.83

$$
\begin{aligned}
&Total\ lifetime\ uses \\
&\quad = expected\ time\ [months] before\ discarding_{second-hand} \\
&\quad * expected\ uses\ per\ month_{second-hand} \\
&\quad + expected\ time\ [months]\ before\ discarding_{new} \\
&\quad * expected\ uses\ per\ month_{new}
\end{aligned}
$$

Formula 5: Total lifetime uses (wears)

Table 38: Overview of uses by garment type and condition

Overview of uses by garment type and condition		
Garment	Expected uses by condition	Total lifetime uses
Jeans, second-hand	222	514
Jeans, new	292	
Button shirt, second-hand	125	273
Button shirt, new	148	

4.3.2.4.3 Garment washing practices

The number of lifetime washes is 111 for second-hand denim jeans, 145 for new denim jeans, 62 for second-hand button shirts, and 74 for new button shirts. This is based on the assumption that a garment is worn twice before washing it. These numbers differ from Wiprächtiger et al. (2022), whom assumed 222 lifetime

washes per garment. It is assumed that the number of washes derived from the survey are a more accurate reflection, because this relies on primary data.

Figure 25 displays the washing methods within the sample. Denim jeans are exclusively washing by machine. The majority (95.2-95.6%) of the button shirts is also washed by machine, opposed to 4.4% which is washed by hand and 1.2% with an "other" washing method[11].

Figure 26 displays the reported washing temperatures. The most commonly used temperatures for both garment types are 30°C and 40°C, although button shirts are more often washed at 30°C (±64.5%) than denim jeans (±54.0%). Denim jeans are more often washed at 40°C (±37.8%) than button shirts (±28.5%). Washing temperatures are distributed similarly for both conditions, indicating that garments are washed the same regardless of condition.

Table 39 displays that between 95.2% and 98.6% of the respondents use detergent. The dataset indicates that the respondent that does not use detergent when washing denim jeans neither uses detergent when washing button shirts. One respondent washes their second-hand button shirt without detergent, but does so when washing their new button shirt – while another respondent does the inverse. The largest share of the respondents (74.4%-80.4%) do not use fabric softener. No major differences between both garment types exist.

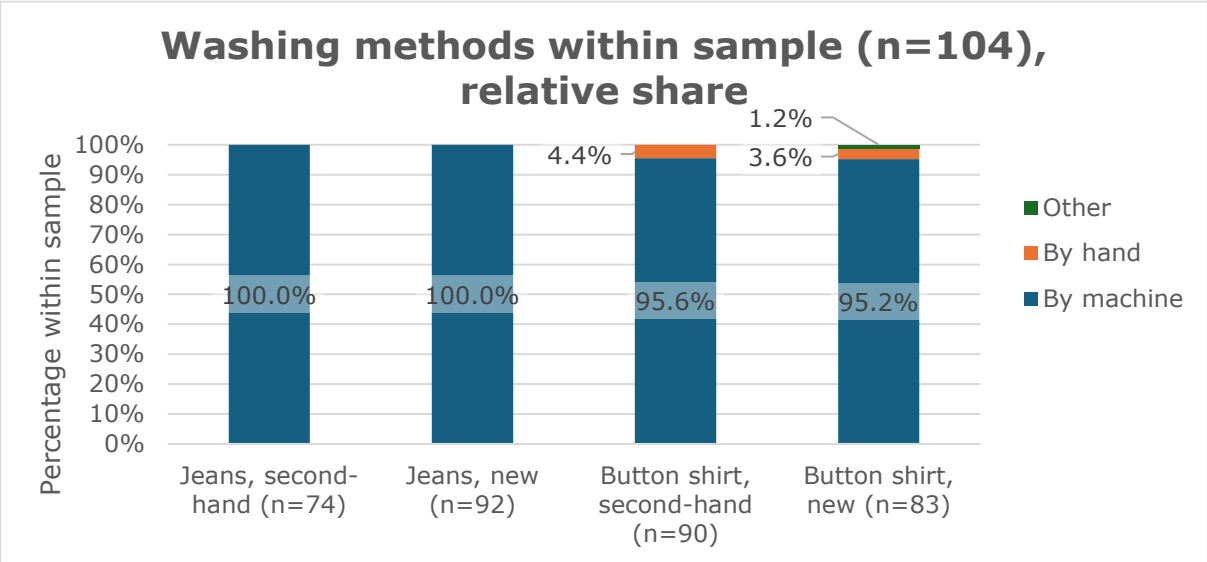


Figure 25: Washing methods within sample (n=104), relative share

[11] This 1.2% consists of one respondent, who stated that their button shirt is dry cleaned.

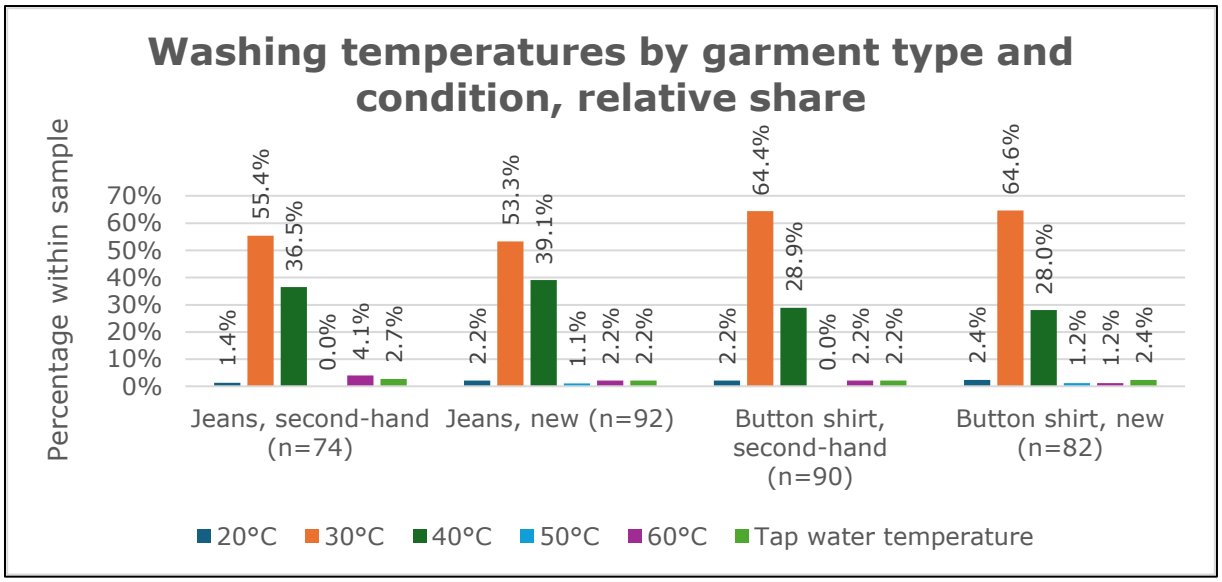


Figure 26: Washing temperatures by garment type and condition, relative share

Table 39: Use of detergent and fabric softener, by garment type and condition

Use of detergent and fabric softener, by garment type and condition								
	Detergent				Fabric softener			
	Yes		No		Yes		No	
	f	%	f	%	f	%	f	%
Jeans, second-hand (n=74)	73	98.6	1	1.4	17	23.0	57	77.0
Jeans, new (n=92)	91	98.6	1	1.1	18	19.6	74	80.4
Button shirt, second-hand (n=90)	87	96.7	3	3.3	23	25.6	67	74.4
Button shirt, new (n=82)	79	95.2	3	3.6	18	22.0	64	78.0

4.3.2.4.4 Garment drying practices

Figure 27 displays the drying practices within the sample. The largest portion of the sample (81.5%-88.9%) does not use a clothes dryer for the respective garment. This is in line with data for the Netherlands (2022), which states 87.2% (Kloosterman et al., 2021). This statement is however only an indication; respondents may use a clothes dryer for other garments.

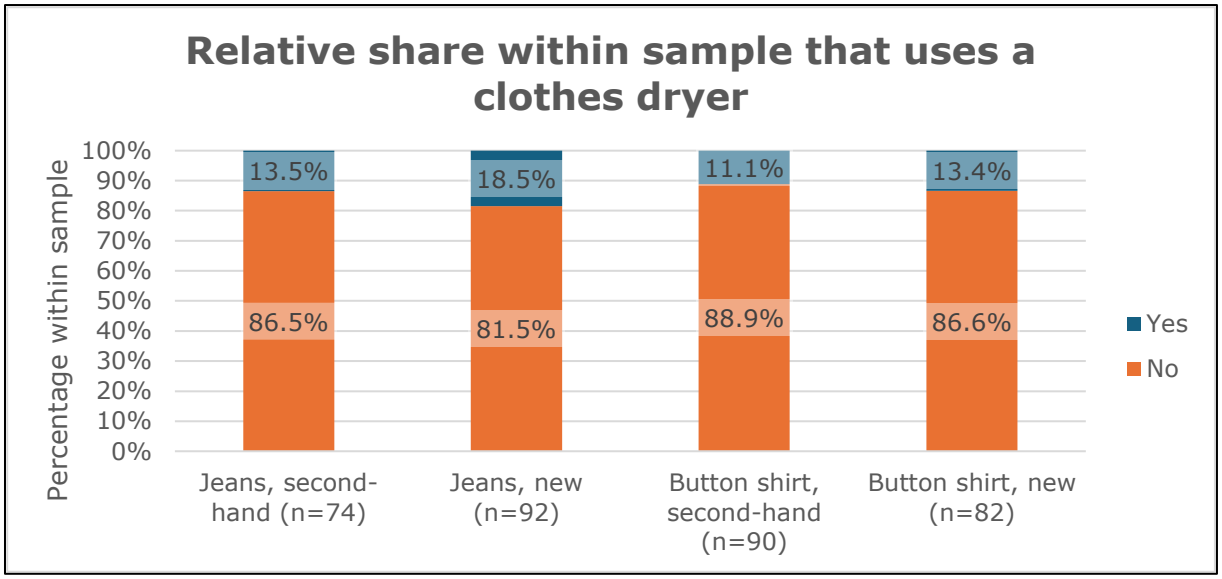


Figure 27: Relative share within sample that uses a clothes dryer

4.3.2.5 Disposition

Figure 28 displays the expected method of disposal for each garment type, sorted by condition. Donate/give away is the most popular (38.6%-51.1%) method of discarding it, followed by recycling the garment (17.8%-29.3%). Throwing away the garment is the least popular method, except for second-hand denim jeans.

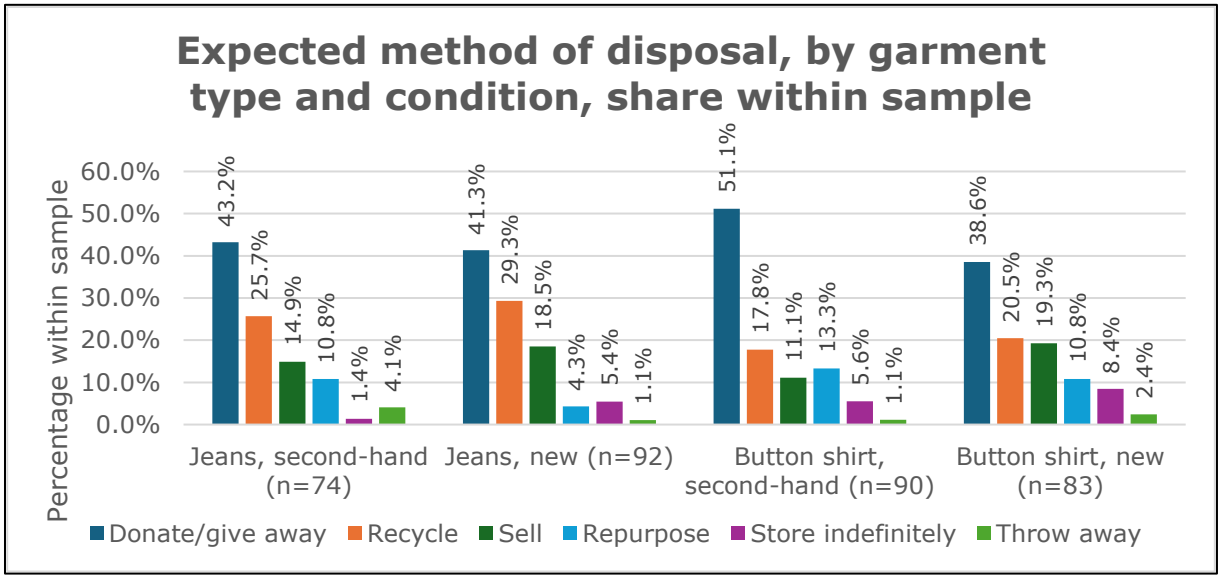


Figure 28: Expected method of disposal, by garment type and condition, share within sample

4.3.3 Occurrence of CER-mechanisms

This section aims to answer sub question 2, by first analysing if each CER-mechanism has occurred within the sample, and then discussing how this affects the environmental impacts of clothing consumption.

4.3.3.1 Price

A correlation analysis between the respondents' scores regarding the statement "I bought this garment because it was a bargain or cheap" (Q13.3) and the restock rate for the respective garment was conducted. The variables were checked on linearity and outliers prior to conducting the analysis (Appendix 14). Three outliers were removed from the analysis for second-hand denim jeans, and three from the analysis for second-hand button shirts. The analysis concluded that no correlation was found for second-hand denim jeans ($r(49) = 0.02$, $p = 876$), nor for second-hand button shirts ($r(65) = 0.04$, $p = 767$). This means that the CER-mechanism Price is not proven to have taken place within the sample, despite that most respondents (70.3%) purchased a second-hand pair of denim jeans or a second-hand button shirt (68.9%) because it was a bargain or cheap. This means that the cheap availability did play a role in the purchase, yet was not the main driver.

4.3.3.2 Motivational (indirect), and –(direct)

A reliability analysis was conducted to test the internal consistency of Q8's statements (Appendix 13). The analysis concluded that the three statements to measure subjective norms had a sufficient internal consistency ($\alpha = .717$, $M = 2.71$) and the three statements to measure the attitudes had a good internal consistency ($\alpha = .812$, $M = 4.71$).

4.3.3.2.1 Motivational (direct)

A correlation analysis between the respondents' scores on Q8's (Table 10) and scores regarding induced purchases was conducted. The variables were checked on linearity and outliers prior to conducting the analysis (Appendix 15). Two outliers were removed from the analysis for second-hand denim jeans, and four outliers from the analysis for second-hand button shirts. The analysis concluded that no correlation was found for second-hand denim jeans ($r(70) = 0.01$, $p = 0.465$), nor for second-hand button shirts ($r(85) = 0.01$, $p = 0.380$). This means that the CER-mechanism Motivational (direct) is not proven to have taken place within the sample.

The statistical non-significant correlation is likely a result of a biased sample (see section 4.3.1), which is implied by the scores displayed in Table 40. Most respondents in the sample (70.2%) ascribed priority to the sustainability performance of clothing, which is impractical for a correlation analysis. This result is thus not interpreted as a refutation of theory.

4.3.3.2.2 Motivational (indirect)

Most respondents (70.2%) ascribed priority to the sustainability performance of clothing, while the priority was low for 6 respondents (5.8%) and neutral for 25 (24.0%). The small sample size (n=104) resulted in groups of insufficient size to conduct a t-test, which requires at least 30 cases in both groups. This CER-mechanism is thus analysed with descriptive statistics.

Trips to purchase second-hand denim jeans were mostly combined with other business en-route (94.2%). Six trips (5.8%) were made exclusively to purchase the garment at the store. Respondents whom made these trips ascribed a low- (33.3%) to neutral priority (66.7%) to the sustainability performance of clothing, which argues against the occurrence or Motivational (indirect). All trips were made by car, with an average travel distance of 12.42 km.

Trips to purchase second-hand button shirts were mostly combined with other business en-route (95.2%). Five trips (4.8%) were made exclusively to purchase the garment at the store. Respondents whom made these trips had either a low- (40.0%), neutral- (40.0%), or moderate priority (20.0%) ascribed to the sustainability performance of clothing, which argues against the occurrence or Motivational (indirect). All trips were made by car, with an average travel distance of 10.10 km.

Four of the respondents whom made specific trips did so for both garment types. The respondents furthermore overlap in terms of gender, as all are female. Five out of the respondents have a vocational degree as highest achieved level of education. Ages range between 19 and 58 years old.

Table 40: Categorised priority ascribed to sustainability performance of clothing

Categorised priority ascribed to sustainability performance of clothing			
Category	Score range	Number of respondents	Relative share [%]
No priority	-1.00 – -0.60	0	0.0
Low priority	-0.59 – -0.20	6	5.8
Neutral	-0.19 – 0.20	25	24.0
Moderate priority	0.21 – 0.60	58	55.8
High priority	0.61 – 1.00	15	14.4

4.3.3.3 Re-spending – buying, and –(selling)

Table 41 summarises the answers on the price of second-hand denim jeans compared to a new one. Most respondents (72.2%) did not have any plans for spending the money saved, while 22.2% planned on saving the money and 5.6% had specific plans. These plans consisted of purchasing other clothing, going on a holiday, and renovating their home.

Table 41 summarises the answers on the price of second-hand button shirt compared to a new one. Most respondents (59.6%) did not have any plans for spending the money saved, while 12.5% planned to save the money and 3.8% had specific plans. Plans were to spending it at a coffee bar, on home renovations, on more clothing, or on a holiday.

Respondents that stated to resell their second-hand denim jeans upon disposal (14.9%) thought they could resell it for a price ranging between €5.00 and €40.00, with an average price of €15.68 and a modal price of €15.00. Most of these respondents (63.6%) did not have any plans to re-spend the money earned from selling, while 27.3% planned on saving the money, and 9.1% planned to spend it on a replacement garment.

Respondents that stated to resell their second-hand button shirt upon disposal (11.1%) thought they could resell it for a price ranging between €2.50 and €20.00, with an average price of €10.75 and two modal prices of €10.00 and €15.00. Most of these respondents (60.0%) did not have any plans to re-spend the money earned from selling, while 40.0% planned on saving the money.

Table 41: Answers Re-spending – buying

Answers Re-spending – buying						
Garment type	Lower than new		Higher than new		Average savings	Modal savings
	Absolute	Relative	Absolute	Relative		
Denim jeans	73	98.6%	1	1.3%	€50.76	€60.00
Button shirt	80	76.9%	9	8.7%	€24.53	€21.00

4.3.3.4 Conclusion CER-mechanisms

The first part of sub question 2 aims to analyse the extent to which rebound effects have occurred during consumption of second-hand clothing. The CER-mechanisms Price, Motivational (direct), and –(indirect) did not occur within the sample, thus can no extent be assigned to these CER-mechanisms.

Re-spending – buying, and Re-spending – selling did occur within the sample. 98.6% of the respondents that purchased denim jeans, and 76.9% that purchased a button shirt stated to have saved money by purchasing second-hand garments. Only a small portion of the respondents had concrete plans for spending the money. These plans included activities which traditionally result in large environmental impacts, such as holidays or consumption of drinks and more clothing. The extent of these impacts cannot be calculated from the data collected in this research.

In summary it can be stated that Re-spending rebound effects did occur during consumption of second-hand clothing, which indirectly increases the environmental impacts of consumption of second-hand clothing.

4.4 Results LCA

This section discusses the results of the LCA.

4.4.1 Results per stage

Subsequent paragraphs discuss the results of garment production (4.4.1.1), import of garments (4.4.1.2), retailing for primary use (4.4.1.3.), primary use-stage (4.4.1.4), disposal after primary use (4.4.1.5), retailing for reuse (4.4.1.6), reuse-stage (4.4.1.7), and disposal after reuse (4.4.1.8).

4.4.1.1 Garment production

Production of a pair of denim jeans in Bangladesh resulted in 14.20 kg CO_2-equivalent emissions, a *Cumulative Energy Demand* [CED] of 185.00 MJ, and consumption of 7.54 m^3 water. Cotton fibre production was the main contributor to each impact category, as it contributed a share of 57.9%, 57.4%, and 99.6% respectively, while the remainder was contributed by garment manufacturing. Within cotton fibre production, cotton cultivation was responsible for 57.4% of the emissions, 53.0% of the CED, and 99.8% of the water consumption. This was followed by carding, combing, and ring spinning, with 39.2%, 43.1%, and 0.1% respectively. Usage of non-renewable fossil fuels are the main drivers behind the GHG-emissions and CED. Water consumption is explained by irrigation for cotton cultivation.

Production of a button shirt in Bangladesh resulted in 7.46 kg CO_2-equivalent emissions, a CED of 113.00 MJ, and consumption of 2.02 m^3 water. Garment manufacturing was the main contributor to GHG-emissions (52.9%) and CED (50.7%), of which weaving was responsible for 90.6% of the GHG-emissions and 92.2% of the CED. Electricity consumption during weaving was the main driver for GHG-emissions and CED, which contributed 84.4% and 83.8% respectively. Cotton fibre production was the main contributor (98.6%) to water consumption, which is explained by irrigation for cotton cultivation.

All results are summarised in Figure 29. The reason that garment manufacturing plays a bigger role in button shirt production compared to denim jeans production, is that (1) the material inputs are smaller than that of denim jeans, and (2) that the analysed button shirts are made of a blend of cotton and polyester fibre. The share of impacts from fibre production are thus split, while impacts from garment manufacturing are distributed similarly to that of denim jeans manufacturing.

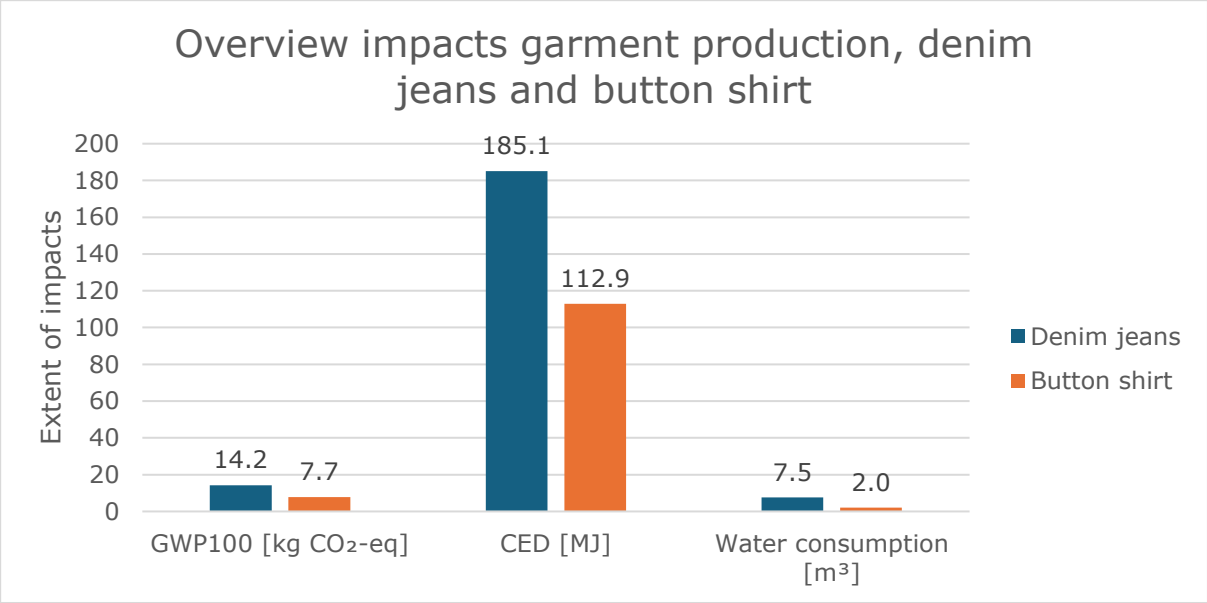


Figure 29: Overview impacts garment production, denim jeans and button shirt

4.4.1.2 Import of garments

Impacts from importing garments are very small, and are thus stated per 1000 garments (Figure 30). Import of 1000 pairs of denim jeans resulted in 0.016 kg CO_2-equivalent, a CED of 0.224 MJ, and a water consumption of 0.003 m³ water[12]. All impacts relate to transport by oceanic freight ship.

Import of 1000 pairs of button shirts resulted in 0.011 kg CO_2-equivalent, a CED of 0.157 MJ, and a water consumption of 0.002 m³ water[13]. All impacts relate to transport by oceanic freight ship.

The difference in impacts between both garment types is explained by the number of garments transported per trip by freight ship (3.6.2.5).

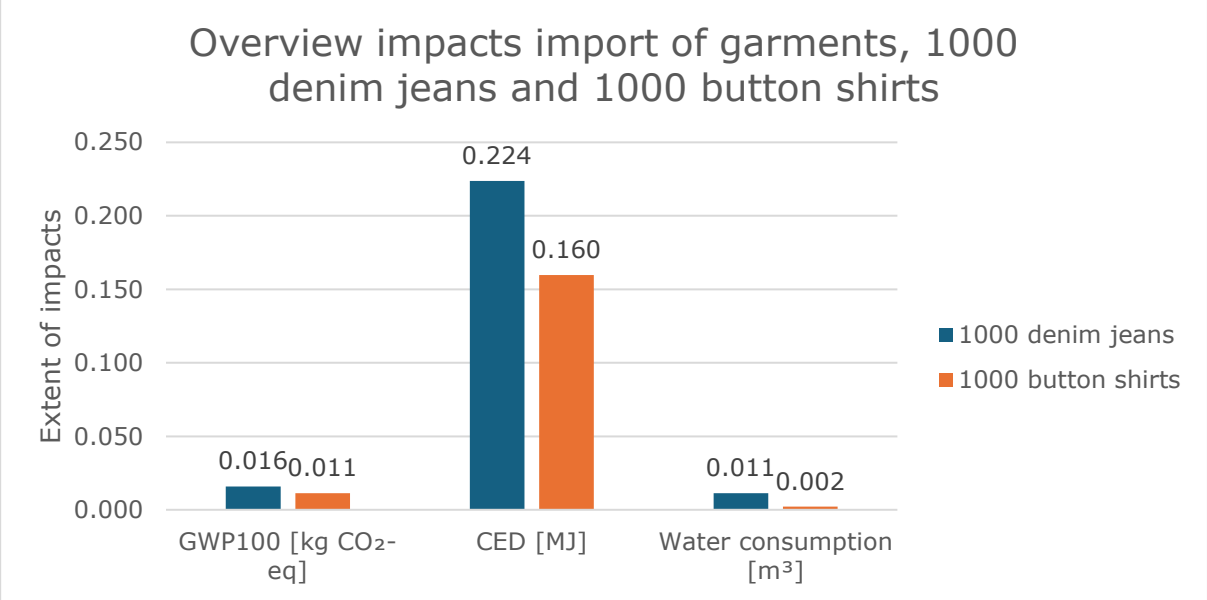


Figure 30: Overview impacts import of garments, 1000 denim jeans and 1000 button shirts

[12] This is 1.6E-5 kg CO_2-equivalent, CED of 2.238E-4 MJ, 3.12E-6 m³ for 1 pair of denim jeans, respectively.
[13] This is 1.14E-5 kg CO_2-equivalent, CED of 1.59E-4 MJ, 2.23E-6 m³ for 1 button shirt, respectively.

4.4.1.3 Retailing for primary use

Retailing of a pair of denim jeans for primary use resulted in 0.24 kg CO_2-equivalent emissions, a CED of 3.81 MJ, and a water consumption of 0.13 m³. Transport to the physical store was responsible for the largest part of GHG-emissions (58.0%) and CED (54.1%), which were caused by transport by car in 99.0% and 98.9% respectively. The largest part (44.3%) of water consumption was caused by online retailing, which was mainly (85.5%) caused by transport for parcel delivery.

Retailing of a new button shirt resulted in 0.14 kg CO_2-equivalent emissions, a CED of 2.18 MJ, and a water consumption of 0.08 m³. Transport to the physical store was responsible for the largest part of GHG-emissions (45.5%), of which 99.8% was caused by transport by car. Online retailing was responsible for the largest part of CED (41.5%) and water consumption (57.4%). The main contributors for CED were ICE-vehicles (46.2%), plastic packaging (33.9%), and EV delivery (16.8%). Water consumption was mostly caused from plastic packaging (85.5%) and EV-delivery (13.8%).

The different results between both garment types (Figure 31) is explained by the survey results, because the distribution of purchases and transportation methods used are derived from these results.

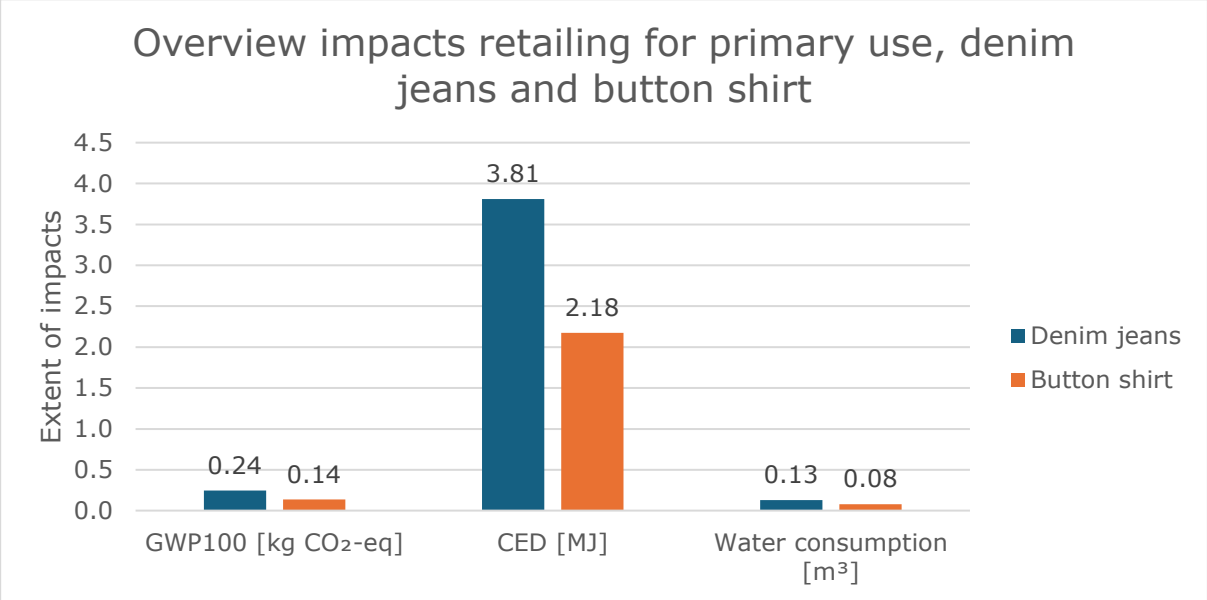


Figure 31: Overview impacts retailing for primary use, denim jeans and button shirt

4.4.1.4 Primary use

The primary use-stage of a pair of denim jeans resulted in 12.23 kg CO2-equivalent emissions, a CED of 201.90 MJ, and a water consumption of 9.42 m³ (Figure 32). Washing of the garment contributed the most to each of the impact categories, with a respective share of 46.3%, 50.5%, and 58.7%. Electricity consumption for washing was responsible for 94.9% of the GHG-emissions, 92.7% of the CED, and 55.2% of the water consumption.

The primary use-stage of button shirts resulted in 10.72 kg CO2-equivalent emissions, a CED of 168.32 MJ, and a water consumption of 7.22 m³ (Figure 32). Ironing of the garment contributed the most to each of the impact categories, with a respective share of 79.7%, 72.2%, and 71.7%. All contributions were entirely caused by electricity consumption during ironing.

Figure 33 displays the distributions within the use-stage. The difference in emphases during the use-stage is expected, because button shirts are often washed at lower temperatures compared to denim jeans, as demonstrated by the survey results (4.3.2.4.3). Button shirts are furthermore washed less often, and assumed to be ironed more often than denim jeans (Van der Plaat, 1998). Ironing is more electricity intensive than washing, as it consumes about half of the electricity of a full washing cycle for an 8kg load at 40°C or 60°C (ANWB, n.d.; EC, n.d.).

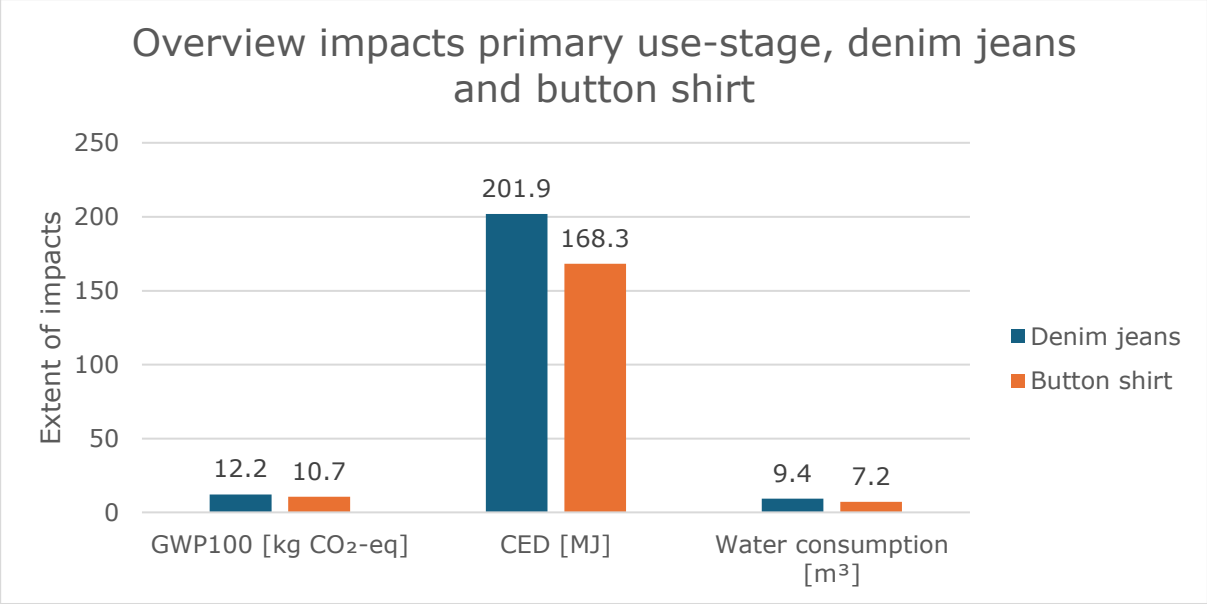


Figure 32: Overview impacts primary use-stage, denim jeans and button shirt

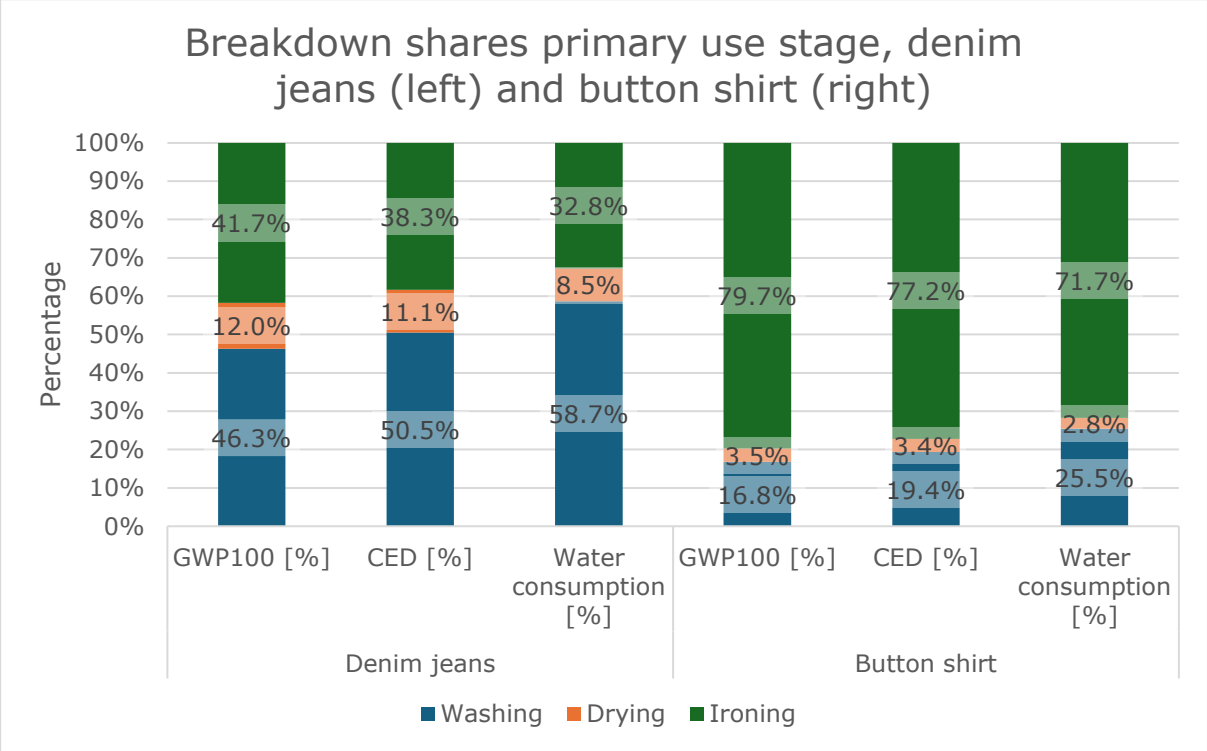


Figure 33: Breakdown shares primary use-stage, denim jeans (left) and button shirt (right)

4.4.1.5 Disposition after primary use

Disposition of a pair of denim jeans after primary use resulted in -1.29 kg CO2-equivalent emissions, a CED of -16.49 MJ, and a water consumption of -0.75 m³. All negative impacts are caused by the avoided production of rags, which caused -1.60 kg CO2-equivalent emissions, a CED of -20.9 MJ, and a water consumption of -0.86 m³ (Figure 34).

Disposition of a button shirt after primary use resulted in -1.09 kg CO2-equivalent emissions, a CED of -16.41 MJ, and a water consumption of -0.30 m³. All negative impacts are caused by the avoided production of rags, which had -1.24 kg CO2-equivalent emissions, a CED of -18.5 MJ, and a water consumption of -0.36 m³ (Figure 34).

Avoided impacts are larger for denim jeans, because denim jeans weigh more thus have a larger share of avoided production. Savings of disposed button shirts are still relatively high compared to denim jeans, considering the weight difference between both garment types. This is explained by the material composition; button shirts are assumed to be made of a cotton and polyester blend – while denim jeans are assumed to be made of cotton. Polyester production is more energy intensive, thus results in higher benefits when repurposing.

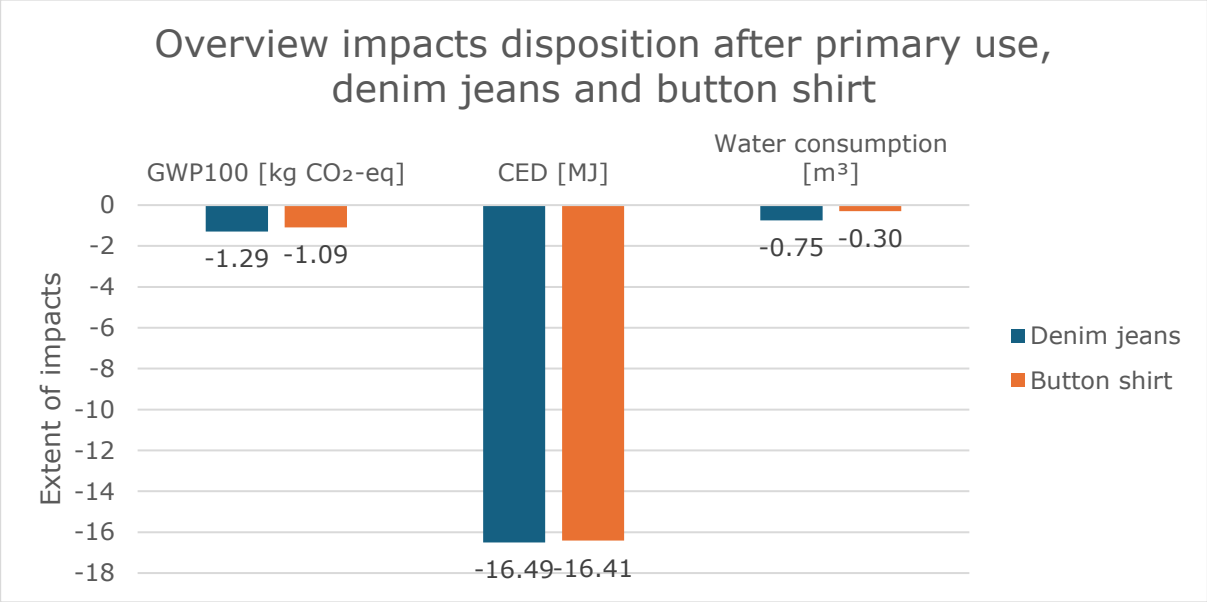


Figure 34: Overview impacts primary use-stage, denim jeans and button shirt

4.4.1.6 Retailing for reuse

Retailing of a pair of denim jeans for reuse resulted in 0.20 kg CO_2-equivalent emissions, a CED of 3.16 MJ, and a water consumption of 0.11 m³ (Figure 35). Transport to the physical store was responsible for the largest part of GHG-emissions (54.5%) and CED (50.7%), which were caused by transport by car in 98.8% and 98.6% respectively. The largest part (44.3%) of water consumption was caused by online retailing, which was mainly (85.5%) caused by transport for parcel delivery.

Retailing of a new button shirt resulted in 0.17 kg CO_2-equivalent emissions, a CED of 2.64 MJ, and a water consumption of 0.09 m³ (Figure 35). Transport to the store resulted in 64.2% of the GHG-emissions, 60.9% of the CED, and 50.3% of the water consumption. Transport by car contributed a share of 98.0%, 97.8%, and 71.8% to each respective category.

The different results are explained by the survey results, because the distribution of purchases and transportation methods used are derived from these results.

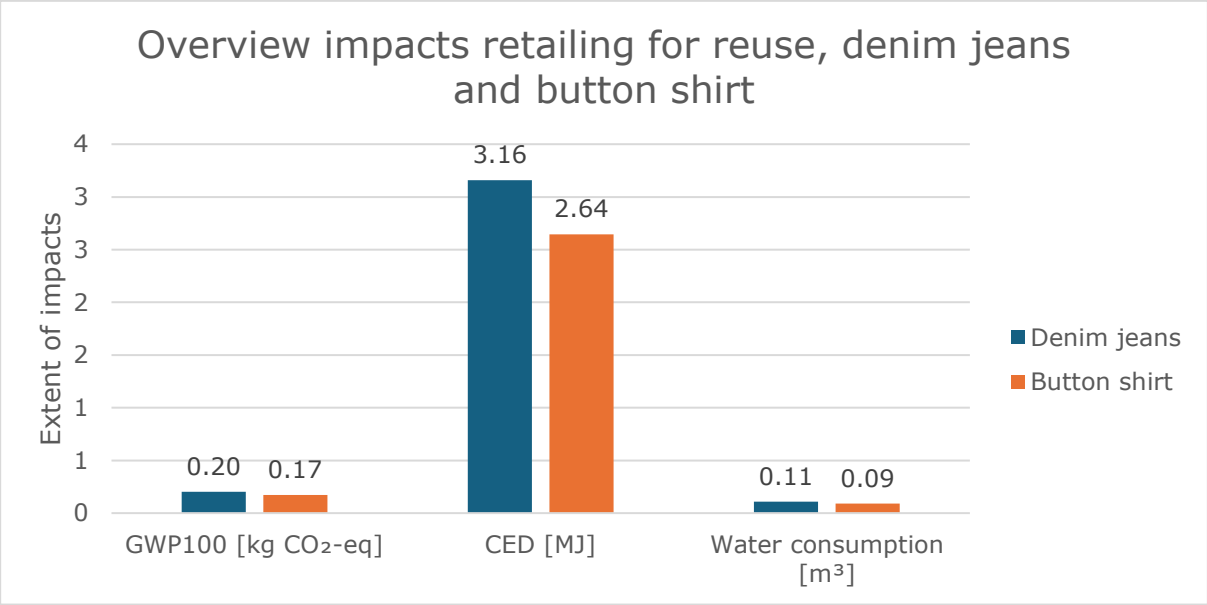


Figure 35: Overview impacts retailing for reuse, denim jeans and button shirt

4.4.1.7 Reuse

The reuse-stage of a pair of denim jeans resulted in 9.01 kg CO2-equivalent emissions, a CED of 148.90 MJ, and a water consumption of 6.88 m³ (Figure 36). Washing of the garment contributed the most to each of the impact categories, with a respective share of 47.8%, 52.0%, and 59.2%. Electricity consumption for washing was responsible for 94.9% of the GHG-emissions, 92.7% of the CED, and 55.2% of the water consumption.

The reuse-stage of button shirts resulted in 8.92 kg CO2-equivalent emissions, a CED of 140.69 MJ, and a water consumption of 6.06 m³ (Figure 36). Ironing contributed the most to each of the impact categories, with a respective share of 80.6%, 77.5%, and 72.1%. All these contributions were entirely caused by electricity consumption during ironing.

The result shows that the impacts for both garment types are similar; GHG-emissions of button shirts are 99.0% of those of denim jeans. This is 94.5% for CED, and 88.1% of water consumption. Washing however dominates the impacts from reuse of denim jeans, while ironing dominates this of button shirts (Figure 37). This is because of the higher number of washer-, higher washing temperatures-, and lower share of ironing for denim jeans. This was expected, as is described in the survey results (see 4.3.2.4.3).

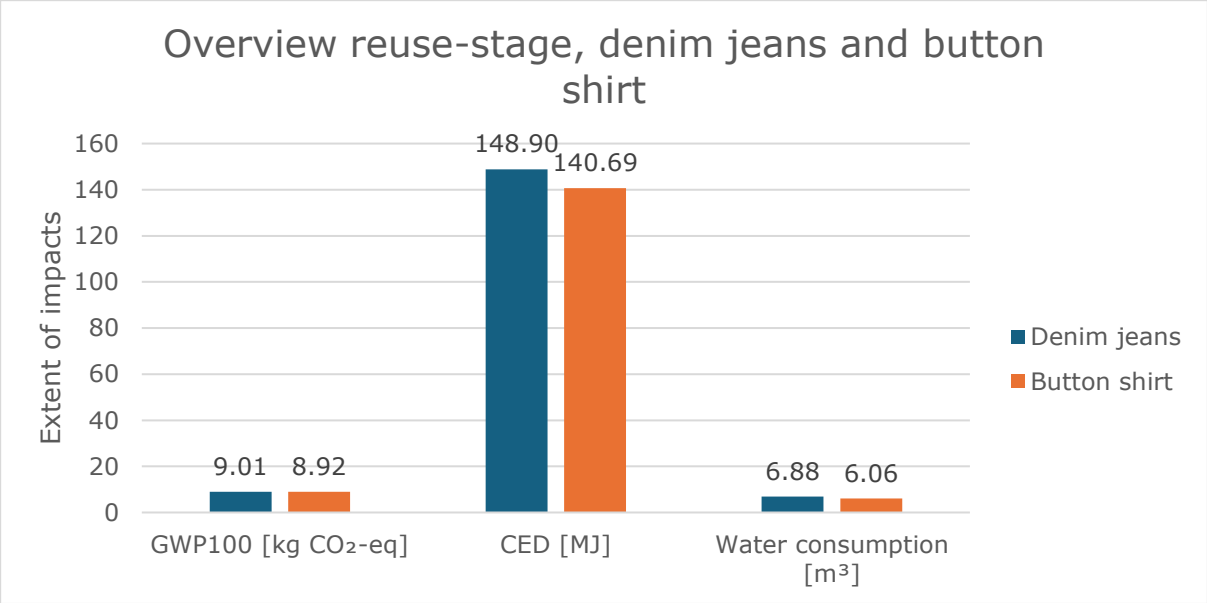


Figure 36: Overview impacts reuse-stage, denim jeans and button shirt

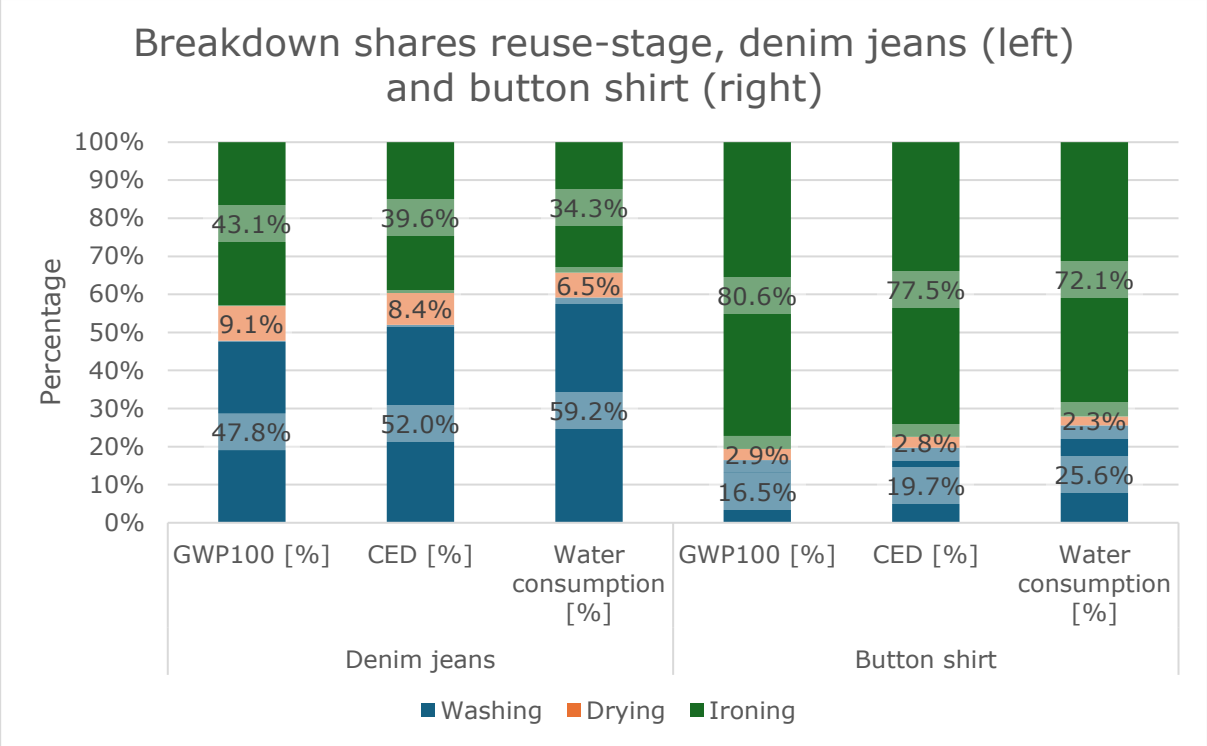


Figure 37: Breakdown shares reuse-stage, denim jeans (left) and button shirt (right)

4.4.1.8 Disposition after reuse

Disposition of a pair of denim jeans after reuse resulted in -1.87 kg CO2-equivalent emissions, a CED of -24.18 MJ, and a water consumption of -1.05 m³. All negative impacts are caused by the avoided production of rags, which caused -2.14 kg CO2-equivalent emissions, a CED of -28.0 MJ, and a water consumption of -1.15 m³ (Figure 38).

Disposition of a button shirt after primary use resulted in -1.16 kg CO2-equivalent emissions, a CED of -16.76 MJ, and a water consumption of -0.29 m³ (Figure 38). All negative impacts are caused by the avoided production of rags,

which had -1.38 kg CO2-equivalent emissions, a CED of -20.0 MJ, and a water consumption of -0.39 m³.

Avoided impacts are larger for denim jeans, because denim jeans weigh more thus have a larger share of avoided production. Savings of disposed button shirts are still relatively high compared to denim jeans, considering the weight difference between both garment types. This is explained by the material composition; button shirts are assumed to be made of a cotton and polyester blend – while denim jeans are assumed to be made of cotton. Polyester production is more energy intensive, thus results in higher benefits when repurposing.

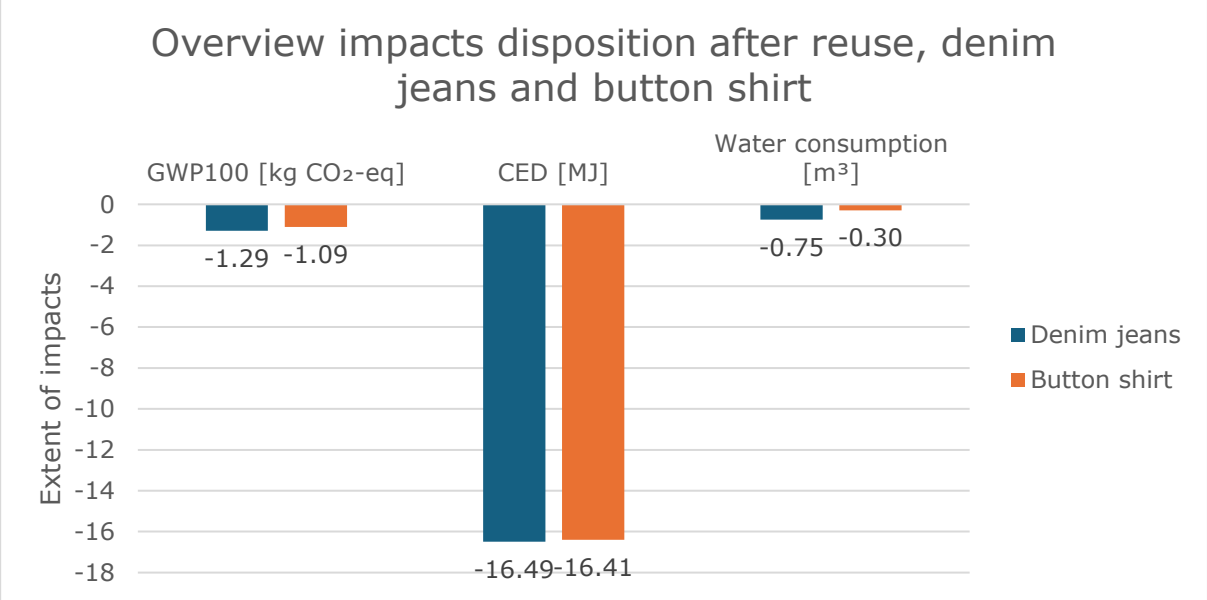


Figure 38: Overview impacts disposition after reuse, denim jeans and button shirt

4.4.2 Total lifecycle

Impacts for the total lifecycle were 32.71 kg CO2-equivalent emissions, a CED of 550.67 MJ, and a water consumption of 22.28 m³ for denim jeans. For button shirts these were 25.40 kg CO2-equivalent emissions, a CED of 393.72 MJ, and a water consumption of 14.88 m³. Impacts for the button shirt are generally lower because of the fewer material weight compared to a pair of denim jeans. Figure 39, 40 and 41 display the each stage's contribution to each impact category. Figure 42 and 43 display this on a relative scale.

Total lifecycle impacts show that the production stage, primary use-stage, and reuse-stage are responsible for most impacts for both garment types. Production had the largest (43.4%) contribution to GHG-emissions in denim jeans' lifecycle, while the primary use-stage was the main contributor to CED (40.2%) and water consumption. The lifecycle impacts of button shirts were mostly caused by impacts from the primary use-stage, with a share of 42.1% for GHG-emissions, 42.7% for CED, and 48.6% for water consumption. Results for the reuse-stage are lower than those of the primary use-stage because of fewer expected use cycles during reuse.

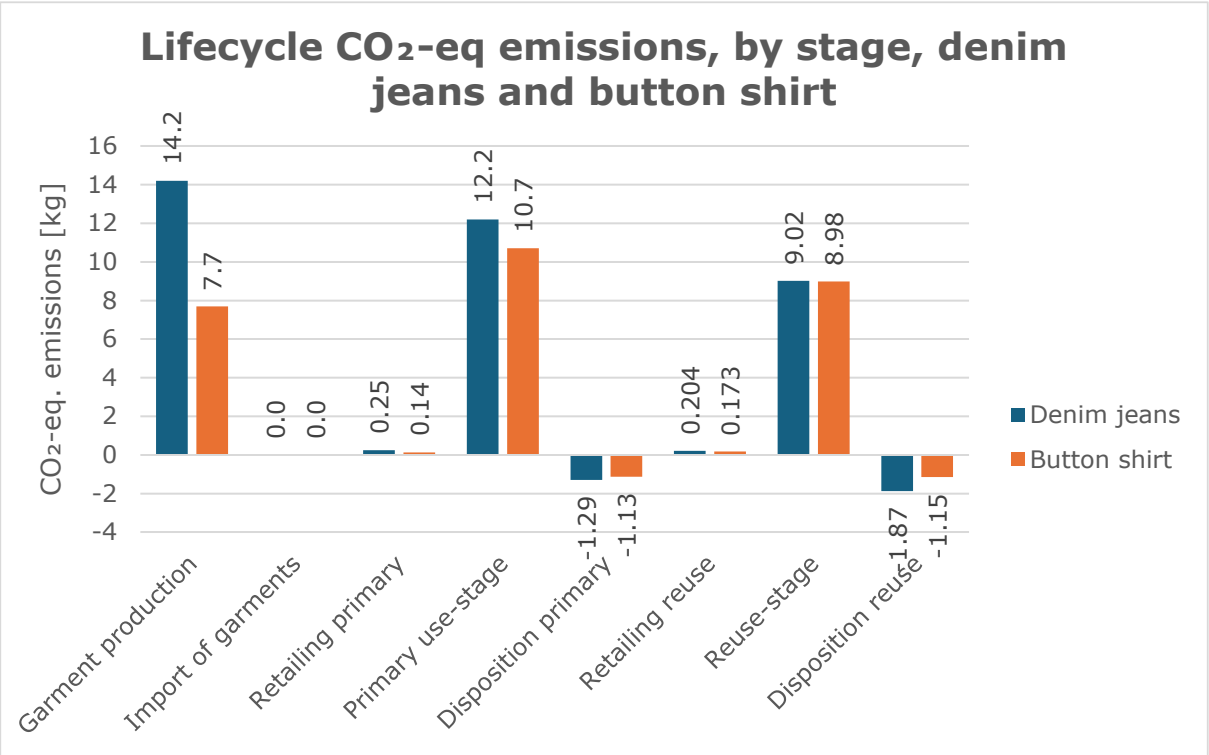


Figure 39: Lifecycle CO_2-eq emissions, by stage, denim jeans and button shirt

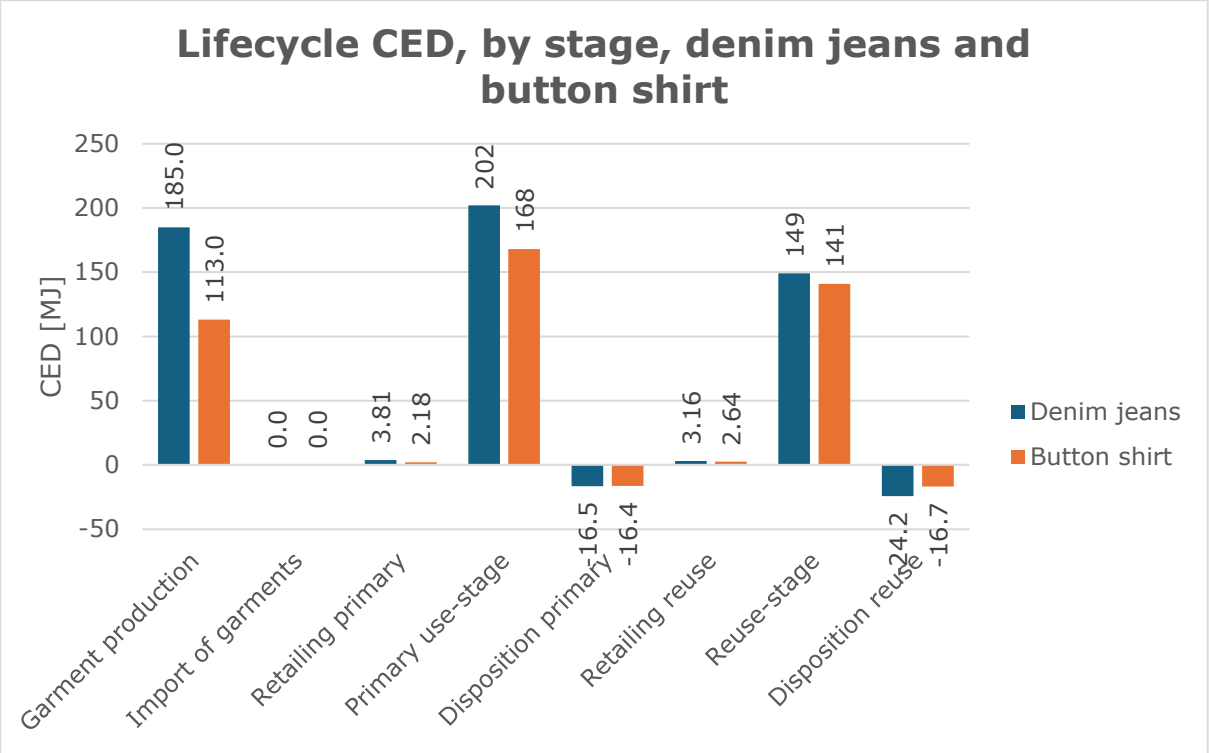


Figure 40: Lifecycle CED, by stage, denim jeans and button shirt

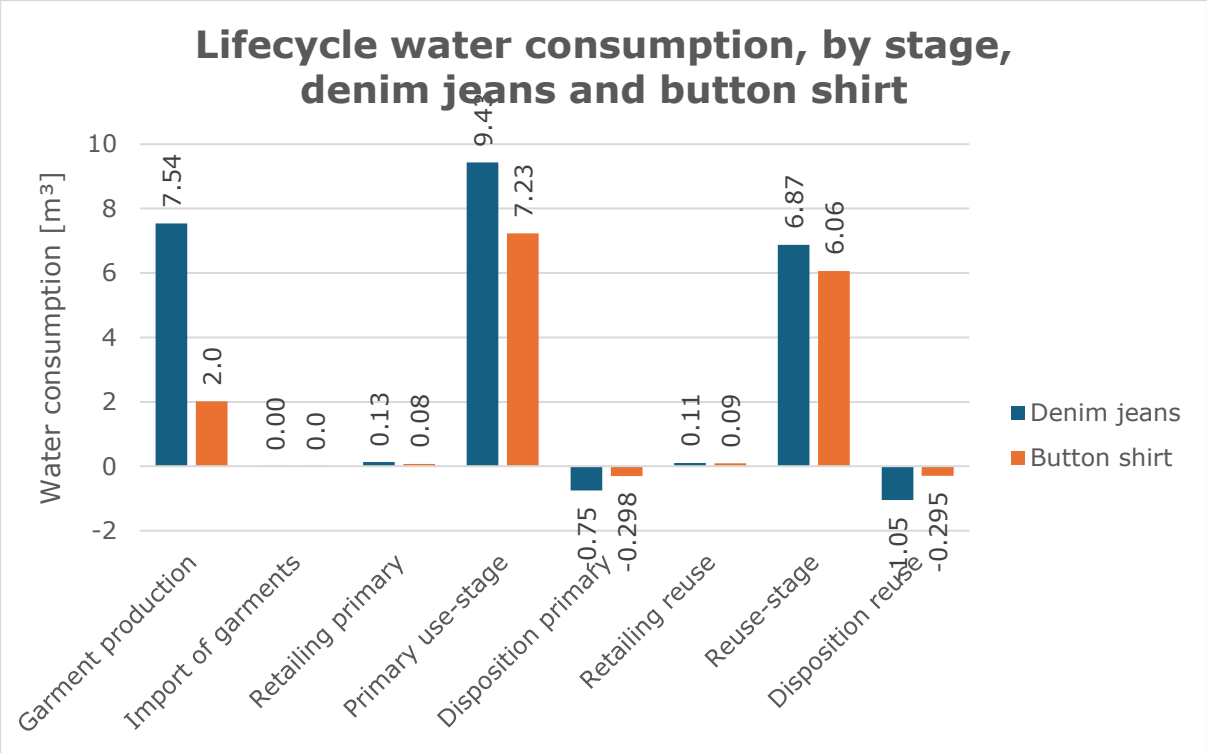


Figure 41: Lifecycle water consumption, by stage, denim jeans and button shirt

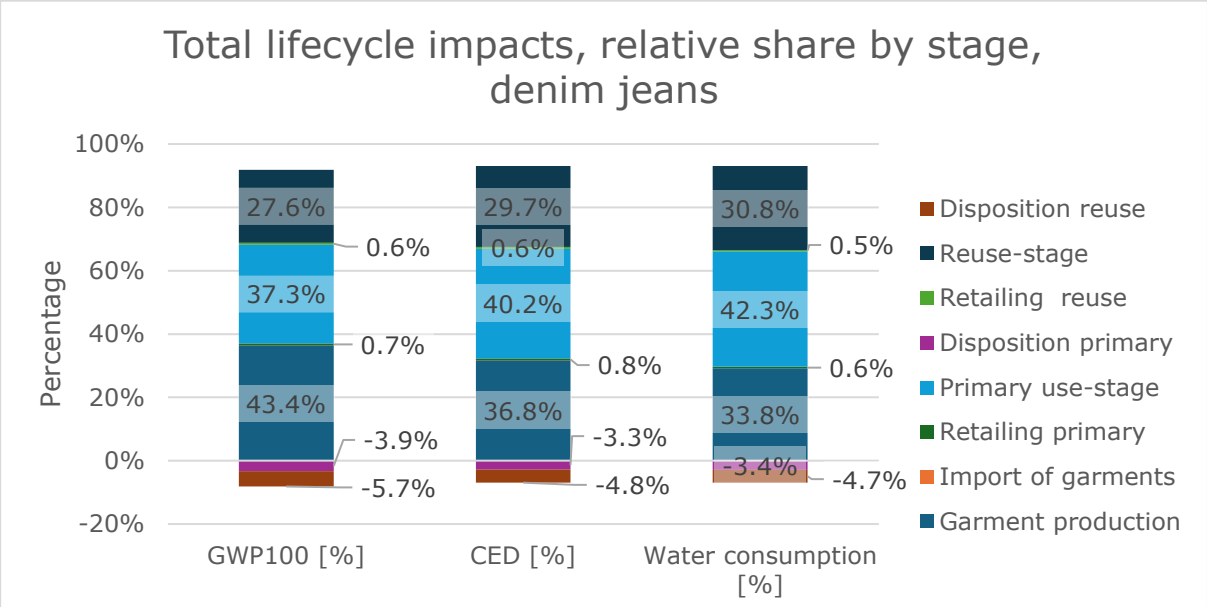


Figure 42: Total lifecycle impacts, relative share by stage, denim jeans (no data label for import of garments)

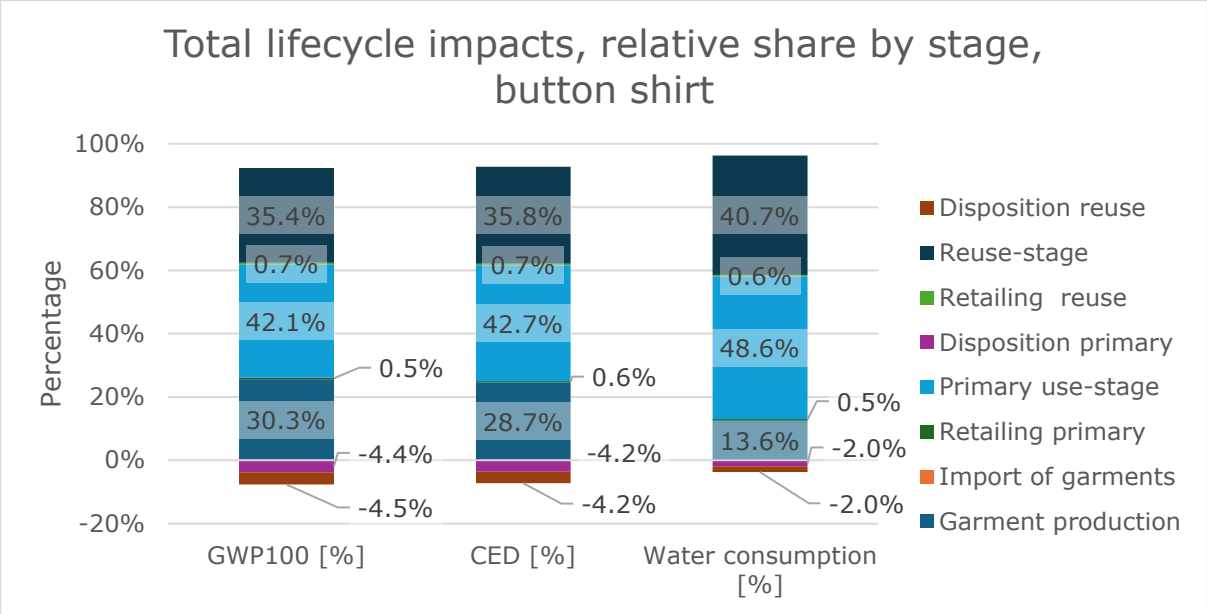


Figure 43: Total lifecycle impacts, relative share by stage, button shirt (no data label for import of garments)

4.4.3 Avoided environmental impacts

The FU described a total of 514 lifetime wears for denim jeans, and 272 for button shirts. 292 wears occurred in the primary use-stage of denim jeans, which was 148 wears for button shirts. The avoided burdens are calculated by comparing the environmental impacts of delivering the FU without the phases relating to reuse. The replacement rates (43.19% for denim jeans and 45.8% for button shirts, see 3.6.1.2.5) are used to calculate a multiplication factor to determine the same delivered function within just the primary use-phase (Formula 6). Concretely this means that the model is rerun with the input weight of the denim jeans multiplied by a factor 1.76, which results in a new garment weight of 1.084 kg for denim jeans. This factor is 1.84 for button shirts, and results in a garment weight of 0.784 kg. Rerunning the model resulted in the impacts as displayed in Figure 44, 45 and 46.

Reusing denim jeans avoided 12.14 kg of CO_2-equivalent, 156.35 MJ of CED, and consumption of 6.53 m^3 water. Reusing button shirts avoided 6.57 kg of CO_2-equivalent, 94.09 MJ of CED, and consumption of 1.63 m^3 water. These savings are almost completely because of the increased share of production, and because of imports because of a neglectable extent. The aggregated impacts of the primary use-stage and reuse-stage are the same as the single use-stage in the newly modelled single-use scenario.

$$\text{Multiplication factor} = 1 + \frac{Replacement\ rate}{100\% - Replacement\ rate}$$

Formula 6: Multiplication factor

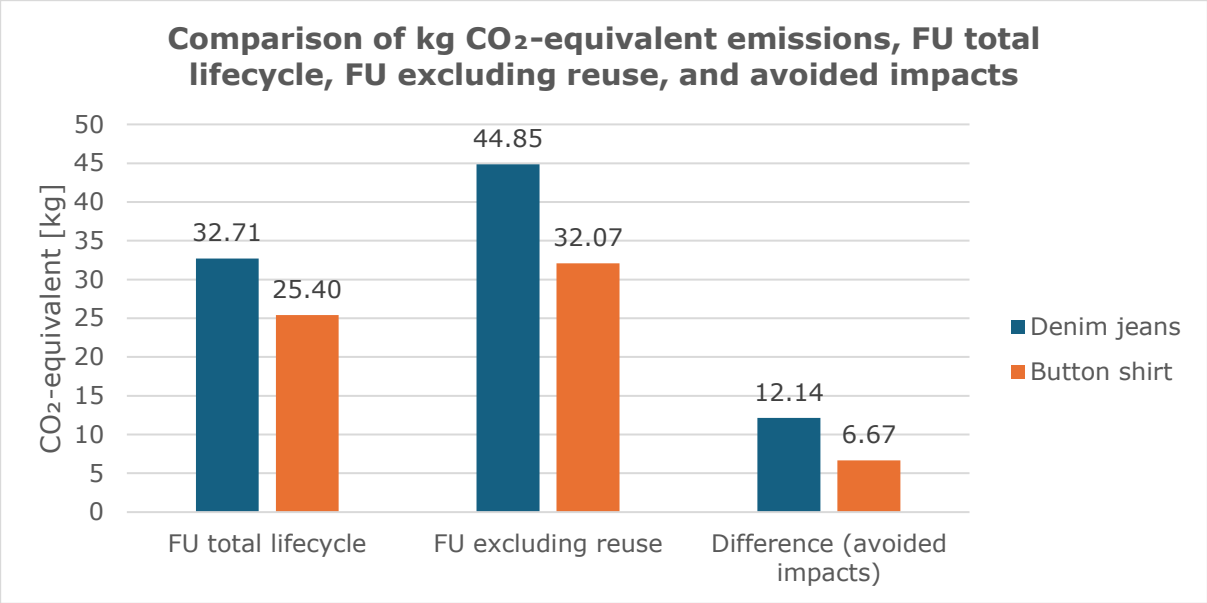


Figure 44: Comparison of kg CO_2-equivalent emissions, FU total lifecycle, FU excluding reuse, and avoided impacts

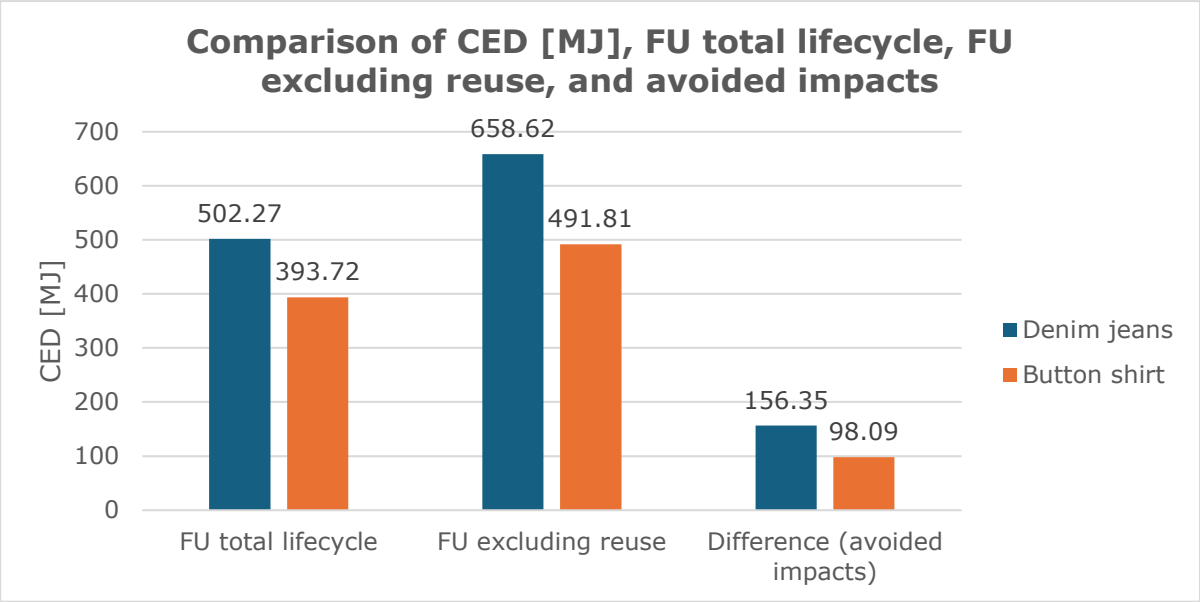


Figure 45: Comparison of CED [MJ], FU total lifecycle, FU excluding reuse, and avoided impacts

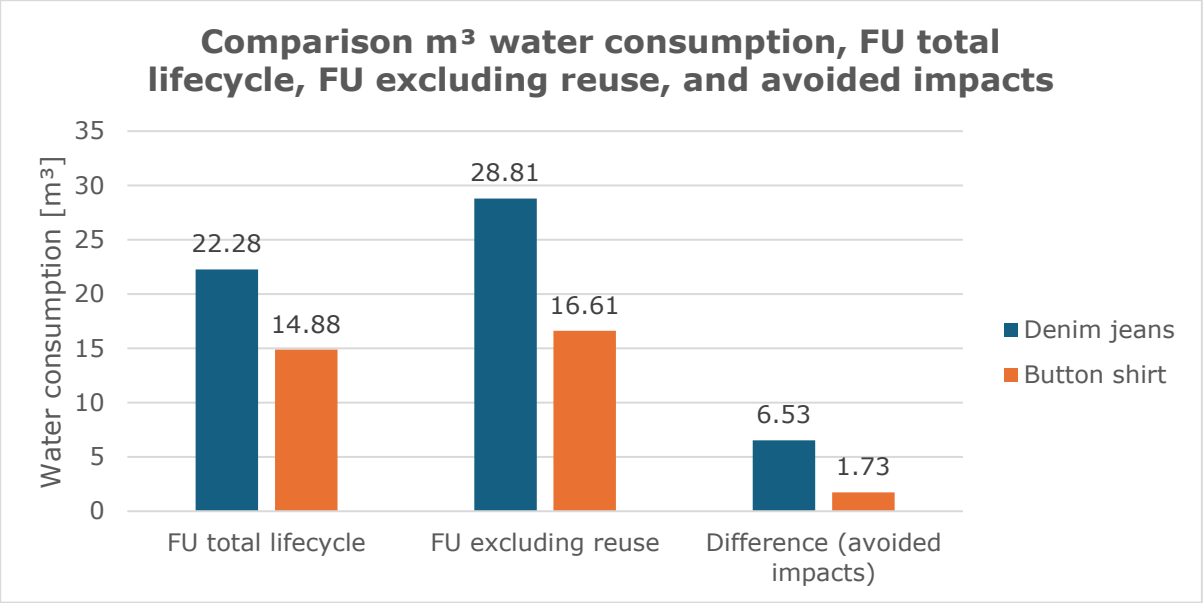


Figure 46: Comparison of m³ water consumption, FU total lifecycle, FU excluding reuse, and avoided impacts

4.4.4 Sensitivity analysis

A sensitivity analysis was conducted on the number of washing cycles within the garment's lifetime, because both use-stages greatly contribute to all impact categories, and to highlight the role of the consumer. The number of wears before washing of denim jeans is changed from two to ten, based on Cooper et al. (2014) and Sanding et al. (2019). Neither authors however analysed button shirts. The number of wears for button shirts is changed into five, to represent a full working week of wearing.

The sensitivity analysis concluded that total lifecycle GHG-emissions for denim jeans were reduced by 51.9%, while CED was reduced by 55.9%, and water consumption by 59.7%. The relative share of the production stage was increased for each impact category, because impacts from production remained the same while those of both use-stages decreased (Figure 47 and Table 42).

The sensitivity analysis concluded that total lifecycle GHG-emissions for the button shirt were reduced by 46.5%, while CED was reduced by 47.1%, and water consumption by 53.6%. The relative share of the production stage was increased for each impact category, because impacts from production remained the same while those of both use-stages decreased (Figure 48 and Table 43).

The production-, use-, and reuse-stages remained the most contributing stages to each impact category. Total impacts are however reduced, and the distribution has changed. The sensitivity analysis illustrates the impact that consumer behaviour can have regarding lifecycle impacts.

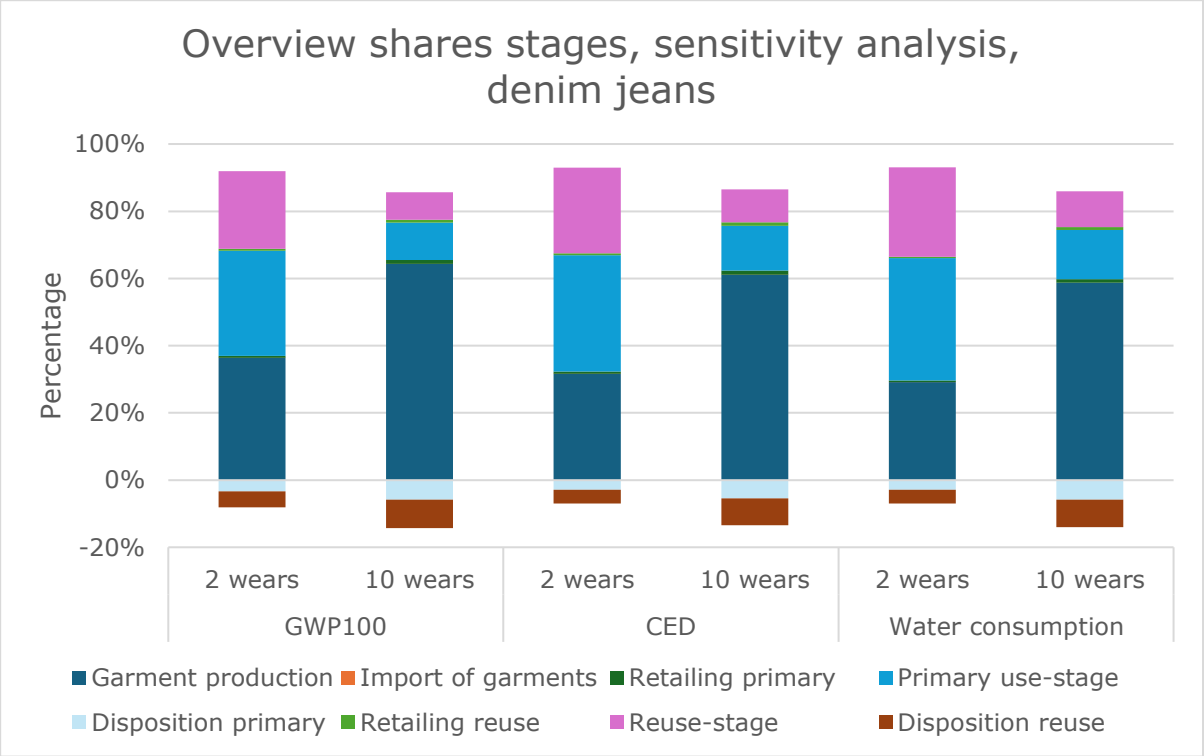


Figure 47: Overview shares stages, sensitivity analysis, button shirt

Table 42: Impacts by stage, sensitivity analysis wears, denim jeans

Impacts by stage, sensitivity analysis wears, denim jeans						
Stage	GWP_{100} [kg CO_2-eq]		CED [MJ]		Water consumption [m^3]	
	2 wears	10 wears	2 wears	10 wears	2 wears	10 wears
Production	14.2	14.2	185.0	185.0	7.5	7.5
Importing	0.0	0.0	0.0	0.0	0.0	0.0
Retailing primary	0.3	0.3	3.8	3.8	0.1	0.1
Primary use	12.2	2.5	202	40.3	9.4	1.9
Disposal primary	-1.3	-1.3	-16.5	-16.5	-0.7	-0.7
Retailing reuse	0.2	0.2	3.2	3.2	0.1	0.1
Reuse	9.0	1.8	149.0	29.8	6.9	1.4
Disposal reuse	-1.9	-1.9	-24.2	-24.2	-1.1	-1.1

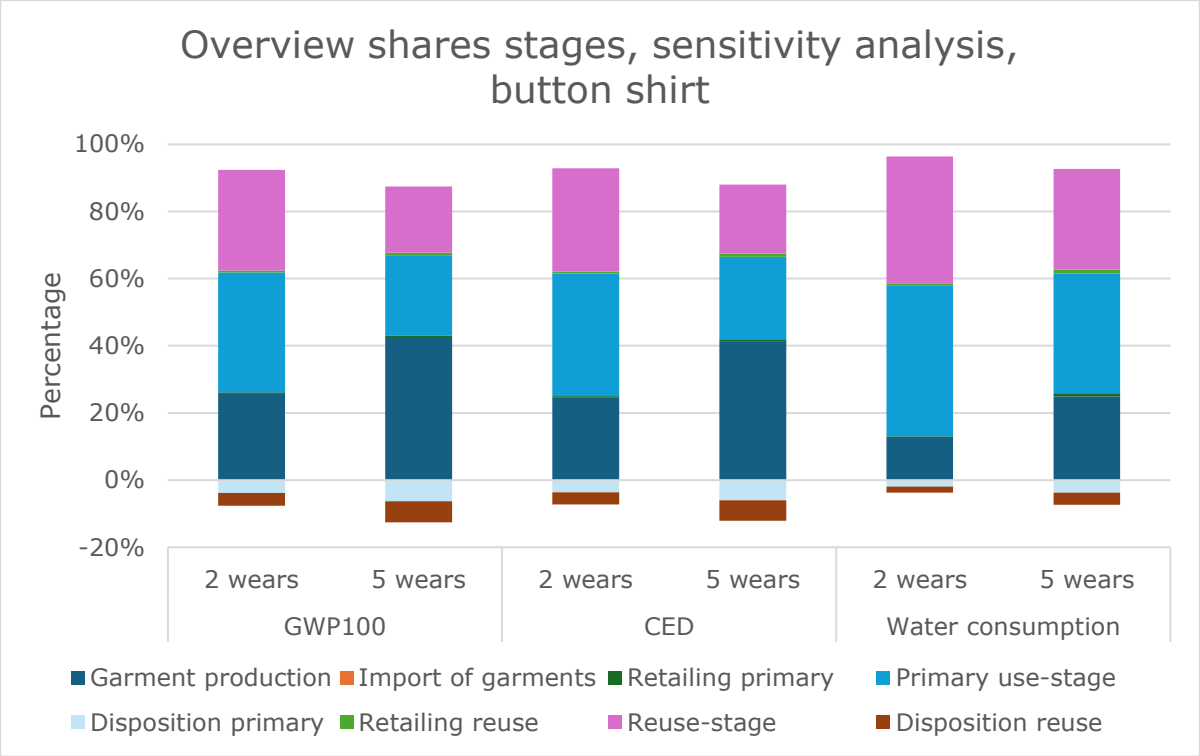


Figure 48: Overview shares stages, sensitivity analysis, button shirt

Table 43: Impacts by stage, sensitivity analysis wears, button shirt

Impacts by stage, sensitivity analysis wears, button shirt						
Stage	GWP_{100} [kg CO_2-eq]		CED [MJ]		Water consumption [m³]	
	2 wears	10 wears	2 wears	10 wears	2 wears	10 wears
Production	7.7	7.7	113.0	113.0	2.0	2.0
Importing	0.0	0.0	0.0	0.0	0.0	0.0
Retailing primary	.01	.01	2.2	2.2	0.1	0.1
Primary use	10.7	4.3	168.0	67.3	7.2	2.9
Disposal primary	-1.1	-1.1	-16.4	-16.4	-0.3	-0.3
Retailing reuse	0.2	0.2	2.6	2.6	0.1	0.1
Reuse	9.0	3.6	141.0	56.4	6.1	2.4
Disposal reuse	-1.2	-1.2	-16.7	-16.7	-0.3	-0.3

5 Discussion and limitations, and conclusion

The limitations of this research, and answer on the research question are discussed in this section.

5.1 Discussion and limitations

The first subparagraph discusses the goal of this study (5.1.1). This is followed by a discussion of the LCA results (5.1.2), and a discussion regarding this study's limitations (5.1.3).

5.1.1 Goal of the study

The goal of this study was to analyse the extent to which environmental benefits occur when consuming second-hand clothing compared to clothing purchased from a fast fashion store, while also considering rebound effects. The reason to analyse

this was to contribute to theory to (1) construct robust methods to incorporate behavioural aspects into LCA-research, and (2) to quantify the occurrence of CER. This research furthermore aimed to (3) contribute to society by providing insights into the role of the individual consumer in preventing REs and to support transitioning to a CE.

The first is goal met because this research did create a method to incorporate behavioural aspects into LCA-research. The framework proposed by André & Björklund (2022; 2023) was used and validated to hold up for the Netherlands, and it was revealed that the concept "uniqueness of product" was an additional product property influencing induced purchases. The survey is also a developed and can be used in future research. The robustness of all methods must however be further validated through future research.

The second goal of this research is partially met. This research contributed to the theory on REs by operationalising five relevant CER-mechanisms for clothing consumption. Two of these CER-mechanisms could be proven to have occurred in this research. However, no extent could be assigned to these occurrences, because the proven CER-mechanisms were indirect mechanisms.

This research did meet the prerequisites to fulfil the third goal. The LCA – and especially the sensitivity analysis – demonstrated the influence of the use-stage, which highlights the influence that consumers can on a product's lifetime impacts. Consumers are therefore recommended to use clothing as long as it is technically possible, and only purchase clothing when necessary. It is recommended that campaigns are held to raise awareness. These campaigns should communicate the impacts of clothing consumption and the benefits of clothing reuse in an easily understood form. Koch and Vringer (2023) called for a list of user characteristics of second-hand clothing. This research collected a sample of which the characteristics are described in 4.3.2.1. Females make up 78.8% of the sample, which appears to be an overrepresentation. It is however possible that this result is realistic for consumption of second-hand clothing, because exact user characteristics are currently unknown. This research provided an indication of this group, which is useful for future research.

5.1.2 LCA results

The LCA results demonstrated that the production-, primary use-, and reuse-stage dominate lifecycle impacts for both garment types, which is in line with other literature (Cotton Incorporated, 2017, p.104; Sandin et al., 2019). Denim jeans resulted in 32.71 kg CO_2-equivalent lifecycle emissions, when assuming two wears before washing. This was opposed to Sandin et al. (2019), whom concluded that consumption of denim jeans had around 12.0 kg CO_2-equivalent lifecycle emissions. Sandin et al. (2019) however assumed ten wears before washing. Cotton Incorporated (2017) concluded 21.16 kg CO_2-equivalent lifecycle emissions for woven pants. The sensitivity analysis in the research concluded 15.74 kg CO_2-equivalent lifecycle emissions when assuming ten wears before washing. The results of this research are therefore deemed realistic, because research by Sandin et al. (2019) referred to the Swedish situation and Sweden's electricity mix contains a larger share of renewable energy sources than the Netherlands (IEA, n.d.b; IEA, n.d.c) – the Swedish results are thus expected to be lower compared to those of the Netherlands. Research by Cotton Incorporated (2017) in turn referred to the global situation, and are thus expected to be higher than those of the Dutch situation. Neither studies analysed button shirts. The LCA on button shirts in this research is however structured similarly to that on denim jeans, and is thus expected to be accurate as well.

The CED of denim jeans was 502.27 MJ for total lifecycle, and 221.37 MJ when assuming ten wears before washing. Sandin et al. (2019, p.167) stated a CED around 242 MJ for denim jeans. These results are very similar, thus is the result of this research considered accurate. The same methodologies applied for button shirts. The result for button shirts is thus also considered accurate.

The result of the sensitivity analysis showed a similar result in terms of water consumption to Sandin et al. (2019), whom stated that 87.0% of the water is consumed during the production phase. The production-stage was responsible for 81.6% of the water consumption in this research.

5.1.3 Limitations

Several limitations are recognised in this study. Subsequent paragraphs discuss the limitations by theme.

5.1.3.1 Biased sample and sample size

86 respondents perceived purchasing second-hand clothing as something positive, which implies that the sample is biased. This is likely the result of distributing the survey over social media (see 4.3).

182 respondents started the survey, of which 104 finished it. It is likely that respondents stopped because of survey length. A shorter survey is likely to result in a higher number of respondents with valid datasets.

5.1.3.2 Self-reports for survey data

The survey relied on self-reports of garments purchased in the past, and expectations on future use. This data is not as robust as respondents whom keep regular reports, such as panel-research. This method was however chosen because of practical reasons.

5.1.3.3 Limitations when measuring CER-mechanisms

Motivational (indirect) is a broad concept. In this research it however reduced to only measure transport movements. The CER-mechanism Price is operationalised so that it enables correlation between the last purchase and being induced to make purchases because of economic reasons. This may however not always reflect a realistic situation, because the last purchase that the respondent has made may have not been induced. The operationalisation thus could be improved. Re-spending – selling is measured by asking how much money the respondent thinks to earn by selling the garment. It is however unknown how much money the respondent spent initially, which could put the result in perspective.

The small sample size furthermore resulted in an inability to measure many of the CER-mechanisms. A larger sample could statistically prove CER-mechanisms, which in turn would have allowed to construct user-profiles. Data of these user-profiles could be modelled in SimaPro to simulate the environmental impacts of users whom display CER-mechanisms. The impacts of these user-profiles could then be compared with the linear model as modelled in this study, to display the difference in impacts, which would be a way to quantify the impacts of CER-mechanisms.

5.1.3.4 Kringloopwinkels and second-hand stores grouped together

No distinction was made between purchases from kringloopwinkels and second-hand stores. It could be that consumers from both stores display different behaviours, which may have resulted in different results.

5.1.3.5 Measuring induced purchases

Measuring if the purchase is induced or not is done according to a few statements which are deemed equally important. It could be that not all dimensions influence a purchase decision equally. Dimensions could furthermore influence certain garment types differently. Respondents could additionally be biased to fill-in answers which they deem to be good, which influences the results. Further research should be conducted on this.

5.1.3.6 Assumptions in use-data

The washing load, wears before use, and percentage of ironing were not asked in the survey but assumed. This data was assumed from secondary sources and used as LCA-input, which could lead to differing results (section 4.4.4).

5.1.3.7 Unknown wears before reuse

The expected wears within the reuse-stage and primary uses are of similar size, which is 76.0% compared to total wears for denim jeans and 84.5% for button shirts. This could imply that garments bought from second-hand stores are relatively new.

5.2 Conclusion

The research question of this study was: "*To what extent do environmental benefits occur when consuming second-hand clothing compared to consuming new clothing bought from fast fashion stores, when also considering rebound effects?*". Answering this research question led to testing a framework (André & Björklund, 2023) in the case of the Netherlands, creating a survey which enables measuring CER-mechanisms, providing a list of user characteristics of consumer of second-hand garments, and calculating potential savings of reusing clothing. This research question can thus be answered with "reusing a pair of denim jeans is calculated to result in saving 12.14 kg CO_2-equivalent emissions, 156.35 MJ energy, and 6.53 m^3 water. Reusing a button shirt is calculated to result in saving 6.67 kg CO_2-equivalent emissions, 98.09 MJ energy, and 1.73 m^3 water. The actual savings are however somewhat lower due to the Re-spending rebound effect". This result highlighted the role that the consumer can have on a product's lifecycle impacts.

Future research directions based on this study are to validate the robustness of the survey, or to expand on methods to measure all CER-mechanisms.

5.3 Acknowledgements

I like to conclude this research with sharing my gratitude for the people that have made this thesis possible. Thank you to all the store managers that were willing to speak to me, allowed me to hang a flyer in-store, or let me promote my survey in-store. Thank you to all the respondents and participants for taking the time to let me interview you or filling in my survey. And a special thank you to Dr. Blanca Corona-Bellostas, Richard Padi PhD, and Michał Bączyk MSc for all the help and feedback you provided during this process. Your input has been of tremendous value and is truly appreciated.

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Appendix 1: Circular Economy

The CE is a proposed alternative to the linear economic model, which is the currently dominant model (EC, 2020). The Netherlands aims to have transitioned into a CE by 2050 (IenW, 2023a). There is currently no consensus on the exact definition of the CE, and several definitions have been proposed (see Table X for examples). A systematic literature review by Prieto-Sandoval et al. (2018) concluded that there are four main components that the CE entails (Table X). The same authors proposed a definition based on these findings, which serves as a good description of the CE when referred to in this research. The reason that this definition is deemed fitting for this research, is that this definition explicitly mentions the role of the individual consumer and the importance of how society as a whole consumes. This definition is as follows:

> "[A CE is an] …*economic system that represents a change of paradigm in the way that human society is interrelated with nature and aims to prevent the depletion of resources, close energy and materials loops, and facilitate sustainable development through its implementation at the micro (enterprises and consumers), meso (economic agents integrated in symbiosis) and macro (city, regions and governments) levels. Attaining this circular model requires cyclical and regenerative environmental innovations in the way society legislates, produces and consumes*." (Prieto-Sandoval et al., 2018, p.613)

In the CE, ten strategies, also called "R-imperatives", are used to create environmental benefits (Table X). These R-imperatives are subdivided into three categories; short-, medium-, and long loops. A hierarchy within this subdivision exists; shorter loops are the most desirable while longer loops are the least, due to the amount of environmental benefits associated with these types of imperatives. Both businesses and consumers (can) implement R-imperatives, although shorter loops are more closely related to the consumer (Reike et al., 2018).

Examples of definitions of the CE	
Source	Definition
Korhonen et al. 2018	Circular economy is an economy constructed from societal production-consumption systems that maximizes the service produced from the linear nature-society-nature material and energy throughput flow. This is done by using cyclical materials flows, renewable energy sources and cascading-type energy flows. Successful circular economy contributes to all the three dimensions of sustainable development. Circular economy limits the throughput flow to a level that nature tolerates and utilises ecosystem cycles in economic cycles by respecting their natural reproduction rates.
Prieto-Sandoval et al. 2018	We defined circular economy as an economic system that represents a change of paradigm in the way that human society is interrelated with nature and aims to prevent the depletion of resources, close energy and materials loops, and facilitate sustainable development

	through its implementation at the micro (enterprises and consumers), meso (economic agents integrated in symbiosis) and macro (city, regions and governments) levels. Attaining this circular model requires cyclical and regenerative environmental innovations in the way society legislates, produces and consumes.
Kirchherr et al. 2017	A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations.

Table X: Examples of definitions of the CE

Four main components that the CE entails	
Number	Description
1	The recirculation of resources and energy, the minimization of resources demand, and the recovery of value from waste[1]
2	A multi-level approach
3	Its importance as a path to achieve sustainable development
4	its close relationship with the way society innovates
[1]These are equivalent to the three core ideas of 'narrowing', 'slowing', and 'closing' resource loops, as discussed in Bocken et al. (2016)	

Table X: Four main components that the CE entails (from Prieto-Sandoval et al., 2018)

R-imperatives categorised		
Category	**Number**	**Name**
Short: user choices	0	Refuse
	1	Reduce
	2	Resell/reuse
Medium: upgrading	3	Repair
	4	Refurbish
	5	Remanufacture
	6	Repurpose/rethink
Long: downcycling	7	Recycle
	8	Recover
	9	Remine

Table X: R-imperatives categorised (from Reike et al., 2018)

Appendix 2: Flyer invite survey

Appendix 3: Privacy- and data handling notice

Privacy notice and data handling

The following topics are described in this document:

1. Research aim and information
2. Consent
3. Data handling

1. Research aim and information

This research is a thesis research conducted by Buster Geeraths, for the Master's programme Sustainable Development at Utrecht University. The starting date of this research was the 7th of August, 2023. The expected end date is the 3rd of June, 2024. This research is supervised by four supervisors (Table 1).

The aim of this research is to expand the scientific knowledge of consumption of second-hand- and new clothing. This is relevant because this can contribute to the lowering of environmental impacts in the clothing sector, and allows further research regarding impacts from consumption of clothing. This knowledge is expanded by analysing the way that Dutch individuals consume second-hand- and new clothing.

Overview of individuals involved		
Name	Role	Contact information
Buster Geeraths, BSc	Researcher	b.i.d.geeraths@students.uu.nl
Dr. Blanca Corona Bellostas	Main supervisor 1	b.c.coronabellostas@uu.nl
Richard Padi, PhD	Main supervisor 2	r.k.padi@uu.nl
Michał Bączyk, MSc	Supporting supervisor	m.baczyk@uu.nl
Dr. Vivian Tunn	Second reader	v.s.c.tunn@uu.nl

Table 1: Overview of individuals involved

2. Informed consent and withdrawal of consent

Respondents (also called participants) have the right to withdraw from an interview or survey at any time, or withdraw their consent after participating in an interview or survey. Respondents can also withdraw consent after participating in an interview or survey, by emailing the researcher a withdrawal request. Preconditions for the withdrawal request to be fulfilled is that the withdrawal request happens before the deadline of this research (the 3rd of June, 2024), and that the dataset associated with the respondent can be identified. Withdrawal results in excluding the respondent's answers from the collected data, and is possible by emailing the researcher (see paragraph 1 for contact information). Withdrawal requires the respondent to share additional data, because data is collected anonymously and thus may be hard to identify. For interview-datasets, this means that respondents are required to state the date and time on which the interview started, which can be found on the paper with the QR-code that the researcher handed over at the start

of the interview. If the respondent does not know the starting date and time of the interview, additional information may be requested (for example the types of garments that the respondent has purchased in the past, as stated in the interview). Additional data that may be requested for withdrawal of survey-datasets especially relates to answers regarding the respondent's user age, gender, completed level of education, and the respondent's level of income. However, even after providing additional data, it could be possible that an exact dataset cannot be identified. In the case that a dataset cannot be identified, consent cannot be withdrawn. Respondents have the right to deny the request for additional data, after requestion their consent to be withdrawn. In such a case, consent cannot be withdrawn.

3. Data handling

3.1 (Personal) data handling, de-identification, and data storage

This research handles both regular- and personal data. Personal data is defined as "any information relating to an identified or identifiable natural person" (Utrecht University [UU], 2024, p.43). Only strictly necessary personal data will be collected. All data involved in this research is however treated as personal data. Office 365 SharePoint is used to store all collected data.

Gathered interview data will be de-identified. This means that interview sheets will be labelled using interview numbers (pseudonyms), rather than collecting respondent's/store (manager's) names.

3.2 Data usage, expiration, and deletion

Collected data will only be used for scientific research purposes. All collected survey-data, with the exception of contact information gathered to participate in the raffle, will be archived for at least 10 years on an UU-dedicated server. Collected contact information, and all data collected through the store manager- and consumer interviews will be completely destroyed upon completion of this research – which is expected to be on the 3rd of June, 2024. Data will be destroyed using software which is in compliance with UU research data policy (for example: *Eraser* – Eraser, n.d.; UU, 2024).

3.3 Data sharing and publishing

Contact information, such as gathered email addresses and IP addresses, will never be shared. Remaining gathered survey data will not be shared for commercial purposes, but may be shared for research purposes. Data shared for research purposes will always be minimised, which means that only relevant data for a specific research will be shared. Primary data, which refers to raw, unprocessed data (UU, 2016), will not be published. Data in processed form may be shared or published.

Sources

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Appendix 4: Data Storage Locator

The UU data storage locator was used to determine the storage location. The following table displays the answers and recommended storage location.

Answers Data Storage Finder-tool			
Number	Question	Answer	Reason for answer
1	Do you want to share your data with colleagues during your research?	Yes, with persons outside the university	This allows colleagues and the thesis-supervisor(s) to check and use the data[1].
2	Is the total amount of your data exceeding 1TB?	No	It is unlikely that the amount of gathered data is larger than 1TB, because the data mostly consists of spreadsheets and text documents[1].
3	What is the classification of your data regarding INTEGRITY?	Basic	Only this research relies on conclusions drawn from the gathered data. For this reason is selecting "Basic" sufficient[1].
4	What is the classification of your data regarding CONFIDENTIALITY?	Sensitive	Personal data is collected, but a data breach will not result in exclusion of future grants or life-threatening research. "Sensitive" is thus sufficient[2]
5	How much does your research depend on continuous availability	Basic	"Basic" is chosen because losing the gathered data would invalidate this research, or require significant rework. The conditions for "Sensitive" relates to delays of multiple research projects, which does not apply to the context of this research[1].
6	Do you want to be able to access previous versions of the data yourself?	Yes	Allowing to access previous versions is necessary because the data will be handled using the programme SPSS. This means that several calculations, and thus modifications, will be done on the file. Creating several back-up versions prior to large changes are preferred[1].
7	Do you have special performance needs?	No, performance is not an issue	This research does not consist over 1,000 files or a large file size. Therefore is "No, performance is not an issue" chosen[1].
8	How do you want to access your data?	From a browser,	Using a web browser to access the data allows flexibility to the researcher. This means that the

		anywhere (https)	researcher can work remotely with the data, from any laptop or pc. This is desirable, because this takes away the risk involved with the researcher's computer breaking down[1].
Answer	Possible storage locations: - OneDrive for Business - Microsoft Teams - Office 365 SharePoint - Office 365 SharePoint extra secure - YODA	Office 365 SharePoint	Office 365 SharePoint is chosen because the researcher already has experience with this programme[1].

UU, 2024a; [1]Answer by author; [2]UU, 2024b

Appendix 5: Interview sheet store managers ENG

Date:
Time:
Store number:

- Introduce + emphasize that participation is voluntary
- Purpose and aim research: minimise the impacts of the fashion industry by a better understanding of the use of consumption of second-hand and new clothing

Question	Answer
What are the top five types of garments that are mostly sold in your store?	1. 2. 3. 4. 5.
Is supply and demand for each of these garments balanced throughout the year?	1. Yes / Somewhat / No 2. Yes / Somewhat / No 3. Yes / Somewhat / No 4. Yes / Somewhat / No 5. Yes / Somewhat / No
What is the material composition of each of the garments?	1. 2. 3. 4. 5.
In what country are the garments generally produced?	1. 2. 3. 4. 5.
Are you willing to help the research in the future, for example by distributing a survey through your social media channels?	How to contact:

Thank respondent for their time

Appendix 6: Interview sheet consumer interviews ENG

- Introduce
- Purpose and aim research: minimise the impacts of the fashion industry by a better understanding of the use of consumption of second-hand and new clothing
- Participation takes around 15 minutes and is voluntary
- Answers are completely anonymous; data will only be seen and used by the researcher and supervisors; data will only be used for research purposes; data will be stored securely. Consent can be withdrawn by contacting the researcher (hand over paper). Consent?

1. Have you ever bought second-hand clothing? **Yes/no**
2. What type of garment(s) did you buy?
3. Did you buy these at a physical shop or a web shop?
   1)
   ……physical/web/other
   2)
   ……physical/web/other
   3)
   ……physical/web/other
4. 1) What are your reasons to buy second-hand? Are there product-related factors you consider important when buying a second-hand garment?
   2) Are there different things you consider important when buying new clothing?
   3) Social affiliation: "How does buying second-hand or new to the image you are trying to portray?" Follow-up: "Is this positively or negatively?"

Product property	Stated to be of importance	
	Second-hand	New
Price		
Environment		
Appearance		
Quality		
Social affiliation		
Convenience		
Fit		
Enjoyment of purchase		

Other 1
……
Other 2
……
Other 3
……
Other 4
……

3) If it is insinuated that the purchase was induced (uniqueness/economic factors/promotion or store loyalty programme), then ask "How often do you wear the garments you did not plan to buy beforehand?"

…….

…….

…….

…….

…….

4) If the respondent has stated that price is an important factor:
"If I summarise your words, I understand that buying second-hand saves you money compared to buying a new garment of the same type. This means that this saves you money. Do you usually have concrete plans on how to spend that money?" **Yes/no**:

…….

…….

…….

…….

5) If the respondent has stated that enjoyment of purchase is an important factor:
"You state that buying (second-hand) clothing brings joy/feels good/feels like the right thing to do. Do you think this may result in you buying more garments?" **Yes/no**, because:

…….

…….

…….

…….

5. Does buying second-hand replace your need to buy new clothing? **Yes/no**, because:

…….

…….

…….

6. 1) Have you ever bought a second-hand garment because it was a bargain, even though you initially did plan to buy that garment? **Yes/no**
   2) Have you ever bought more of the same garments within a transaction than initially planned, just because it was a bargain? **Yes/no**?
   3) How often do you wear these garments? (times per week/month/year, or relative to other garments more/less etc.)

   ……

   ……

   ……

   ……

   ……
7. How far do you usually travel to the store?
   ……..….**km/minutes**
8. What is your main method of transportation for those trips?
   0 Walking
   0 Bicycle
   0 Scooter
   0 E-bike or e-scooter
   0 Public transport
   0 Car
   0 Other:……
9. When you go a second-hand store, do you usually combine this trip with other business en-route or not? **Yes/no**:

   ……

   ……

   ……
10. Do you wear second-hand clothing more often or less often than new clothing? **More/less, because:**
    ……

    ……

    ……
11. Are your washing- and drying habits for second-hand clothing different compared to the way you wash- and dry new clothing?
    Washing: same/different
    Drying: same/different

    Remark:……

12. Do you ever repair clothing? **Yes/no** If so, how often? Do you do this more often for second-hand- or new clothing? Why is that?

    …….

    …….

    …….
13. Do you dispose second-hand clothing faster than new clothing? **Yes/no**
14. What are usually your reasons to dispose of a garment?

    …….

    …….

    …….
15. When you dispose of a garment, what do you do with it?
    0 Sell
    0 Throw away
    0 Donate/give away
    0 Recycle/hand in for recycling
    0 Repurpose
    0 Keep in storage indefinitely
    0 Other
    …….
16. Are there differences between the way you dispose second-hand clothing compared to new clothing? **Yes/no**:

    …….

    …….

    …….

    …….
17. If you like, you can participate in a raffle. May I gather your email address in that case (gather on a DIFFERENT paper, so there is no link to answers).
18. I will have a survey in the near-future about the differences in use between second-hand and new clothing. May I contact you for that survey? (Gather contact information on a DIFFERENT paper, so there is no link to answers).
19. Thank you for participating.

Appendix 7: Operationalisation survey questions

Paragraph 3.5.3 and subparagraphs explain how each survey question is used. This appendix provides an in-depth description of why each survey question is asked the way it is. The operationalisation of the survey questions is structured to follow a logical flow from the respondent's perspective. This means that the survey starts with general questions and leads up to more specific questions. Paragraph A7.1 discusses the operationalisation of the respondent's user characteristics. Paragraph A7.2 operationalises restock rates. Paragraph A7.3 operationalises the acquisition-stage. In paragraph A7.4 is discussed how the user valuation of product properties for the purchased garments is operationalised. Paragraph A7.5 operationalises obtainment motivation. In paragraph A7.6 is discussed how the use-stage is operationalised. Paragraph A7.7 concludes with an operationalisation of the disposition-stage.

A7.1 User characteristics

Mapping the respondent's user characteristics allows to check the representativeness of the sample population in comparison of the Dutch population as a whole. Representativity is typically checked on age, gender, level of education, and level of income. These indicators are thus first asked in the survey. Table 7.1 displays how each indicator is operationalised.

The survey starts with asking the age of the respondent, because only respondents aged 18 years and over are allowed to participate in the survey as explained in paragraph 3.3.3. Age is expressed in number of years, and is thus an interval variable. Furthermore are only respondents whom live in the Netherlands allowed to participate in the survey. Thus is asked whether or not the participant lives in the Netherlands. Then is asked if the respondent has purchased second-hand clothing in the past. This allows to filter out respondents that are not within the target group of this research. Answering "no" on either of these questions ends the survey for the respondent.

Gender is operationalised as a categorical variable, based on Fraser (2018). The question concerns what the gender the respondent mostly identifies with, rather than the gender assigned at birth. Gender identity is asked because one's identity is closely related to behaviour. Individuals can furthermore identify with other gender identities than "male" of "female". It is estimated that less than 7% of the Dutch population identifies with a different gender than the gender assigned at birth (Huijnk & Damen, 2023). Up to 15 different gender identities are distinguished within this 7% (Fraser, 2018). This makes is likely that this relative small group highly fractured, which makes it unlikely to derive meaningful patterns from this portion of the sample. Therefore has been chosen to group all gender identities other than "male" and "female" as "other", which results in three answer categories. The option "I'd rather not say" is added for respondents whom are not comfortable with sharing their gender.

Level of education is operationalised following example of CBS (2024b). This categorisation groups all common levels of education of the Dutch educational system within five groups. Using this categorisation also allows a comparison of the sample population with the entire Dutch population. It is possible that respondents have not followed education within the Dutch educational system. Therefore are international equivalent levels of education (Nuffic, n.d.) displayed in the English version of the survey. Furthermore is a button added besides the question which allows to display the Dutch terms when clicked. The Dutch terms will be shown initially in the Dutch version of the survey. Clicking the button will

result in an overview with international equivalents in that case. All international terms are displayed first in Table 7.1. The Dutch terms are displayed in italics. Level of education is an ordinal variable, because an order of magnitude within the categories exists. This is also the reason that only the highest level of completed education asked and respondents are only allowed to provide one answer.

Income is an ordinal variable expressed in income categories, based on the modal- and minimum income as defined by *Centraal Planbureau* [CPB] (2023) and UWV (2023) respectively. The formulation of the question is based on Duurkoop et al. (2021), but excludes the reference to the modal income to avoid confusion among the respondents. Respondents may not want to share their actual income, because of privacy-related reasons. Hence is the option "I'd rather not say" added.

Operationalisation user characteristics		
Indicator	Question	Number
Age	How old are you? … years	Q1
Geographical location	Do you live in the Netherlands? o Yes o No	Q2
Purchased second-hand clothing	Have you ever purchased second-hand clothing? o Yes o No	Q3
Gender[1]	With what gender do you identify the most? Please also select "other" when you identify with both male and female equally. o Male o Female o Other o I'd rather not say	Q4
Level of education[2]	What is the highest level of education you have completed? o Primary education/*Basisschool* o Secondary education/*VMBO, HAVO onderbouw, VWO onderbouw, MBO1* o Vocational education/*HAVO, VWO, MBO2, MBO3, MBO4* o Higher education (bachelor)/*HBO-bachelor, WO-bachelor* o Higher education (master)/*HBO-master, WO-master, doctor* o Don't know/unknown/not available	Q5
Income[3]	Please select your average monthly gross income level. o Below €1,408 o Between €1,407 and €3,291 o Between €3,292 and €3,625 o Between €3,626 and €6,958 o Between €6,959 and €10,375 o Over €10,375 o I'd rather not say	Q6

Table 7.1: Operationalisation General user characteristics ([1]Fraser, 2018; [2]CBS, 2024a; Nuffic, n.d.; [3]Duurkoop et al., 2021; CPB, 2023; UWV, 2023)

A7.2 Restock rates

Sohn et al. (2021) used restock rates to measuring clothing consumption of respondents. Questions regarding these indicators are derived from Sohn et al. (2021) and are displayed in Table 7.2. A time period of one year was chosen for the number of purchases, because it is unlikely that respondents purchase a garment each month. The time before discarding the garment is expressed in months, because this time period is more accurate than years and it is unlikely that garments are disposed within a few weeks. All questions relate to the specific garment types analysed in this study: denim jeans and button shirts, for both the case of second-hand and new garments. The questions are answered by a free answer field in which the respondent fills in a numeric value, whereby 0 represents an absence of acquisitions or disposals. All variables are ratio-variables.

Operationalisation Restock rates		
Q7: Please fill in the table. If you do not own-, buy-, or discard any of the garments, please fill in 0 in the respective field.		
Garment type	Please estimate how many of each garment type you usually buy per year:	After how many months do you usually stop using each garment:
Denim jeans, **second-hand**	[numeric value] months	… months
Denim jeans, **new**	… months	… months
Button shirt, **second-hand**	… months	… months
Button shirt, **new**	… months	… months

Table 7.2: Operationalisation restock rates (Sohn et al., 2021)

A7.3 Acquisition-stage

Consumption starts with the acquisition stage (Comacho-Otero et al., 2020; Sohn et al., 2021), hence is why this concept is relevant to measure. Acquisition refers to "*the process by which consumers get hold of the objects to be consumed*" (Comacho-Otero et al., 2020, p.75). In the context of clothing consumption, this refers to purchasing- or receiving clothes. Since this research entails clothing consumption in relation to purchases from BMs, acquisition in this research only refers to purchases of clothes. Survey-questions regarding the acquisition-stage start about acquisition in general, and proceed into questions about specific purchases.

The CER-mechanism 'motivational (indirect)' may occur during acquisition at a physical store. This happens when second-hand garments are perceived to be sustainable, which in turn induces transport movements towards the physical store in order to buy the garments. The environmental impacts originating from the mechanism can be calculated after determining the method of transport and the distance travelled. Quantifying the impacts of this CER-mechanism thus consists of three components; mapping the (1) individual's ascribed priority to sustainability of clothing, (2) -reason of the store visit, and (3) -method of transport to the store.

Mapping the ascribed priority to sustainability of clothing is done by measuring the individual's values, norms, and attitudes Metic and Pigosso (2022). Leclercq-Machado et al. (2022) analysed this this theory and constructed a framework to explain the full process that occurs when individuals purchase sustainable clothing, based on the Theory of Reasoned Action. The modules about measuring the values, norms, and attitudes are relevant for this research. The authors concluded that an individual's values only indirectly influence purchase intentions. Measuring one's values is therefore excluded from this research. Individual's subjective norms- and attitudes on sustainable clothing however directly influence purchase intentions, and are therefore adapted into this research. Subjective norms refer to perceived social pressures that an individual experiences to perform certain behaviour (Ajzen, 1991). Attitudes refer to the extent to which an perceives certain types of behaviour as positive or negative (Ajzen, 1991). This operationalisation is adapted into this research, although rewritten in modified form (except for SN1 and SN2) so that they are more easily understood by a wide audience. The essence of each statement has remained the same. Table 7.3 displays this operationalisation. SN1 – SN3 allow mapping of the social pressures an individual experiences. ATT1 – ATT3 allow mapping of the individual's perception of sustainability performance of second-hand clothing. Respondents are asked to fill in the extent to which they agree with each of the statements, using 4-point Likert-scales. The variables consequentially consist of interval variables.

Operationalisation Ascribed priority to sustainability performance of clothing and Acquisition		
Q8: Please state the extent to which you agree with each of the statements		
Indicator	Statement	Number
Subjective norms on sustainable clothing	- SN1: My friends expect me to buy sustainable clothes - SN2: My family expects me to buy sustainable clothes - SN3: The community I live in expects me to buy sustainable clothes	Q8.1 – Q8.3
Attitude on sustainable clothing	- ATT1: It is good when clothing becomes more sustainable - ATT2: Buying second-hand clothes is good - ATT3: Buying second-hand clothing instead of new clothing is good for the environment	Q8.4 – Q8.6

Table 7.3: Operationalisation Ascribed priority to sustainability performance of clothing and Acquisition (Leclercq-Machado et al., 2022)

After filling in Q8, the respondent is asked if they have ever purchased a pair of denim jeans or a button shirt, if this concerned a second-hand and new garment, and if this purchase took place in a physical store, web shop, or somewhere else (Table 7.4). Multiple answers can be selected. Asking this is relevant because this question introduces the specific garments to which the remainder of the questions will relate. Mapping in which store type the garment was purchased is relevant because the process of online shopping differs from shopping at a physical store. This means that CER-mechanisms relating to induced consumption must distinctively be analysed based on this indicator.

Operationalisation acquisition				
Q9: Have you ever purchased any of the following garments in the past, second-hand and/or new, and did you purchase this from a physical- or a web shop? Please tick any box that applies, multiple answers are possible.				
Garment	Second-hand	Type of store second-hand	New	Type of store new
Denim jeans	○ Yes ○ No	□ Physical store □ Web shop □ Other	○ Yes ○ No	□ Physical store □ Web shop □ Other
Button shirt	○ Yes ○ No	□ Physical store □ Web shop □ Other	○ Yes ○ No	□ Physical store □ Web shop □ Other

Table 7.4: Operationalisation acquisition

After filling in Q9, the respondent is informed that from this point all remaining survey questions will relate to their last purchased pair of denim jeans or button shirt (either new or second-hand). This is followed by a question regarding the reason of the store visit. The reason is asked because this determines whether or not the transportation movement was induced by wanting to buy a second-hand garment or not. The respondent can tick up to three boxes of reasons that apply. The reason that multiple answers can be selected, is that several answers may apply. For example; a respondent may went out specifically to the second-hand store that day, but also purchased groceries on the trip back home, resulting in a multi-purpose trip nonetheless. Because it could be that the purchase took place a long time ago and that the respondent does not exactly remember what the purpose of the store visit was, is the option "I don't remember" also included among the answers. A maximum number of three answers is chosen because the answers become mutually exclusive after filling in three answers – on the precondition that "I don't remember" is not selected. Table 7.5 displays the operationalisation.

The method of transportation is derived from André and Björklund (2023). It is recognised that respondent could have used multiple methods of transport to make the purchase. The main method of transport is however asked, because the main method would have resulted in the largest impact. Asking the main method simplifies the survey for the respondent, which reduces length and increases the likelihood of the respondent completing the survey. Table 7.5 displays the operationalisation.

The distance travelled allows to determine the magnitude of the environmental impacts resulting from the chose method of transport. This indicator is displayed in Table 7.5, and is asked by a free answer field in which the number of kilometres is asked. This indicator is an interval variable.

Operationalisation Motivational (indirect)		
Indicator	Statement	Number
Method of transportation	Please select the main method of transportation you used, and the distance	Q10.1

	travelled to the store for the trip(s) you made to buy your second-hand garment(s). ○ Walking ○ Bicycle ○ Scooter ○ E-bike or e-scooter ○ Public transport ○ Car ○ Other ○ I don't remember	
Distance (km)	Can you state the distance (in km) travelled to the store? … km	Q10.2
Reason of store visit[1]	Please tick a maximum of three boxes that apply to the last trip you have made to buy a (pair of) second-hand denim jeans/button shirt at the physical store. □ 1: Buying a pair of denim jeans/button shirt was the primary reason for me to make this trip that day □ 2: Visiting the store I bought this pair of denim jeans/button shirt at was the primary reason for me to make this trip that day □ 3: Buying a pair of denim jeans/button shirt was a secondary reason for me to make this trip that day □ 4: Visiting the store I bought this pair of denim jeans/button shirt at was a secondary reason for me to make this trip that day □ 5: I combined this trip with other business I had on-route □ 6: I don't remember anything about the trip I made to buy this pair of denim jeans/button shirt	Q11.1 – Q11.6

Table 7.4: Operationalisation Motivational (indirect) ([1]André & Björklund, 2023)

A7.4 User valuation of product properties of purchased garments

Mapping how the respondent would rate their acquired garments allows to determine to what extent second-hand garments are equal to new garments. Determining this supports the FU. The product properties "performance", "quality", and "fit", as operationalised in Table 7.5, are relevant to measure. This is because these properties represent technical properties of the garments, opposed to perceived properties such as appearance and social affiliation. Price is also a technical property, yet is excluded from this operationalisation because price is assumed to not influence use but rather only the purchase. Table 7.5 displays the operationalisation. This question is repeated for each of the garments that the respondent has purchased.

Operationalisation of user valuation of product properties of purchased garments	
Q12: Please state how you would have rated your garments **at the moment you bought them**, in terms of each of the following product properties.	
Product property	Examples
Performance	For example, that the garment is waterproof, windproof, lightweight, ventilate body heat, etc.
Quality	For example that the garment does not easily break/wear down, has good warranty, is dependable, etc.
Fit	For example that the garment fits your body type well

Table 7.5: Operationalisation of user valuation of product properties of purchased garments

A7.5 Obtainment motivation

The respondent is asked what their obtainment motivation was for each of the garments they have purchased, in order to determine if the purchases were induced or not. Mapping whether or not the purchase is induced is relevant to analyse all CER-mechanisms included in this research.

A new insight from the consumer interviews was that respondents value the uniqueness of a product when making a purchase decision. This is supported by theory. Rajagopal (2011) states that induced purchases of clothing are the result of three factors; the (1) uniqueness of the product, (2) -value for money, and (3) -discounts, promotions, and loyalty programmes of the store. These three factors are therefore mapped to analyse the obtainment motivation. The uniqueness of the product refers to the individual's need to display a social image. Indicators for this factor are represented in the product properties "appearance" and "social affiliation". A statement was formulated based on each of these properties (Table 7.6). André and Björklund (2023) provided a statement that refers to the value acquired for money. This statement is adapted into this research in modified form that fits the context of this research. A statement regarding discounts, promotions, and store loyalty is added in order to include all factors into the operationalisation. Four other statements are adapted from André and Björklund (2023). The first statement refers to semi-induced purchases, which are cases in which the respondent will need the garment in the nearby future; for example as a backup. The other three statements refer to instances in which the purchase is not induced, but when the purchase was required because the respondent needed the garment. All statements are rated accordingly to a 4-point Likert scale, resulting in interval variables. A 4-point rating is chosen, because this mitigates the possibility of providing a neutral answer to this question, which is important to determine whether or not the purchase was induced. Table 7.6 displays the operationalisation.

Operationalisation Obtainment motivation					
Q13: Please fill in the extent to which you agree with each of the following statements					
Statement number and indicator		Denim jeans, **second hand**	Denim jeans, **new**	Button shirt, **second hand**	Button shirt, **new**

1: Induced purchase; appearance	I bought this garment because a garment that looks like this one is hard to come by	4-point rating	4-point rating	4-point rating	4-point rating
2: Induced purchase; social affiliation	I bought this garment because of other people that wear this style	4-point rating	4-point rating	4-point rating	4-point rating
3 Induced purchase; value for money	I bought this garment because it was a bargain or it was cheap[1]	4-point rating	4-point rating	4-point rating	4-point rating
4 Induced purchase; discounts, promotions, and store loyalty	I bought this garment because the store promoted this specific garment[1]	4-point rating	4-point rating	4-point rating	4-point rating
5 Semi-induced purchase; back-up	I bought this garment to have as a backup[1]	4-point rating	4-point rating	4-point rating	4-point rating
6 Non-induced purchase; needed purchase	I bought this garment because I needed it[1]	4-point rating	4-point rating	4-point rating	4-point rating
7.1 Non-induced purchase; displacement	If I had not found this garment I would have bought a new garment of	4-point rating	Not applicable	4-point rating	Not applicable

	this type instead[1]				
7.2 Non-induced purchase; displacement	If I had not found this garment I would have bought a second-hand garment of this type instead[1]	Not applicable	4-point rating	Not applicable	4-point rating

Table 7.6: Operationalisation obtainment motivation ([1]André & Björklund, 2023)

The CER-mechanism "re-spending" occurs when money is saved from a circular purchase, which is then spend on other types of consumption. This CER-mechanism is measured by asking respondents whom stated that the second-hand garment was not as costly/expensive as a new garment what they plan to do with the money saved. The answer categories are derived from André and Björklund, 2023. This RE only occurs when the respondent spends the money, hence why the option "spend on…" is included. Choosing that option results in a next question which allows the respondent to fill in on what they plan on spending the money. Table 7.7 displays this operationalisation. All variables are categorical.

Operationalisation Re-spending – buying		
Q14.1: How costly/expensive was the **second-hand garment you have bought** compared to a new garment of that same type?		
Indicator	Denim jeans, **second-hand**	Button shirt, **second-hand**
Price	The price was… ○ Lower than new ○ The same as new ○ Higher than new ○ I don't remember	The price was… ○ Lower than new ○ The same as new ○ Higher than new ○ I don't remember
Q14.2: You have stated to have saved money by buying a second-hand garment instead of a new garment. How much money do you think you approximately saved compared to a new garment of the same type, and what do you think you will do with the money you saved?		
Denim jeans, **second-hand**	I have saved… [insert numeric value] I will do the following with the money saved: ○ Nothing in particular ○ Save ○ Spend on…	
Button shirt, **second-hand**		
Q14.3: Could you explain on what you plan to spend the money you have saved?		
Denim jeans, **second-hand**	I plan on spending the money saved by buying a (pair of) second-hand denim jeans/buttons shirt instead of new denim jeans/button shirt on the following: [insert text]	
Button shirt, **second-hand**		

Table 7.7: Operationalisation re-spending

A7.6 Use stage

Use refers to the "*physical deterioration of products…* [and] *…the creation of meaning*" (Comacho-Otero et al., 2020, p.75). In the context of clothing consumption, physical deterioration refers to wearing, washing, storing, maintaining, and drying the clothes (Sohn et al., 2021). Ironing of clothing is also relevant for the case of button shirts, but does not require extra survey-data because it can be assumed that this happens after each washing action. The creation of meaning is already represented by the user valuation of product properties (Table 7.5). This degrades over time and eventually results in disposition (André & Björklund, 2023). Mapping the entire process is however irrelevant for the scope of this research. The disposition stage is operationalised in A7.6.

The purchase action for each garment could have taken place shortly prior to answering the survey. This consequentially means that not all respondents can answer questions about actual use. Many questions concerning the use stage are therefore operationalised as expected use, following the example of André and Björklund (2023).

A7.6.1 Wearing

Wearing is the action in which the respondent carries the garment on their body. Asking about the respondent's wearing practices is relevant to calculate lifetime impacts with the LCA. Not using the garment results in a relative higher impact resulting from the production phase of the LCA.

Table 7.8 displays how wearing is operationalised. Wearing is herein expressed as number of times per month. Timescales of a month have been chosen, because it is assumed that respondents may not wear the garment each week. A timescale of a month is therefore assumed to be able to properly reflect the number of use cycles for each garment. This operationalisation results in a ratio variable.

Operationalisation wearing		
Q15.1: Please state for how many months you think you will use each garment, and how often. This time period starts when you have bought it, and ends when you actively stop using the garment. If the purchase happened recently, please provide an indication of what you think applies. If you do not think you will use the garment at all, please fill in 0.		
Indicator	Question	Number
Wearing	How long do you think you will use the garment? … months	Q15.1.1
	How often do you think you will use the garment? … times per month	Q15.1.2

Table 7.8: Operationalisation wearing

A7.6.2 Washing

Washing refers to the process of cleaning the garment. Asking about washing practice for each specific garment is relevant because this causes impacts, which is relevant as LCA-input

It is possible that the respondent washes the garments by hand or machine. Therefore is first asked by what method the respondent washes the garments. Sohn et al. (2021) state that using detergent or fabric softener, and the washing

temperature are important factors that contribute to the impacts of clothing washing. The operationalisation of these indicators is derived from Sohn et al. (2021). The options “00°C” and “tap water temperature” are added as an option for the washing temperature, because individuals may not know what temperature their tap water is, or may use a method that does not involve a washing temperature. The operationalisation is shown in Table 7.9.

Operationalisation washing		
Q15.2: Please state your washing habits for each garment		
Indicator	Question	Number
Washing method[1]	How do you wash your garment? ○ By hand ○ Machine ○ Other…	Q15.2.1
	You selected "other" as a washing method, can you explain what other method you use? …	Q15.2.2
Washing practice[1]	Do you use detergent while washing the garment? ○ Yes ○ No	Q15.3.1
	Do you use fabric softener while washing the garment? ○ Yes ○ No	Q15.3.2
	At what temperature do you wash the garment? ○ 20°C ○ 30°C ○ 40°C ○ 50°C ○ 60°C ○ Tap water temperature	Q15.3.3

Table 7.9: Operationalisation washing (Sohn et al., 2021)

A7.6.3 Drying

Drying of garments can happen by air drying or by using a clothing dryer. Using a clothing dryer imposes additional environmental impacts, which is therefore relevant as LCA-input. Table 7.10 displays the operationalisation for drying, which is derived from Sohn et al. (2021). Answers given for drying are categorical variables.

Operationalisation drying		
Indicator	Question	Number
Drying method	Do you use a clothes dryer after washing the garment? ○ Yes ○ No	Q15.4

Table 7.10: Operationalisation drying (Sohn et al., 2021)

A7.6.4 Maintaining

Maintaining of garments is operationalised as repairing the garment. The consumer interviews (section 4.2.6) demonstrated that Dutch consumers sometimes conduct easy repairs on garments they can fix themselves. These small repairs are left outside of the scope of this research.

A7.6.5 Storing

Storing the garment is the opposite of actively using the garment. Implicitly, this means that storing is operationalised as the time in which the garment is not being worn, washed, dried, or maintained. Storing itself does not result in any relevant impacts which can be used as LCA-input. For this reason are no survey questions relating to storing operationalised.

A7.7 Disposition

Disposition refers to the "*disposal of a good, which could mean disposal in a waste bin but also storage in (for example) a room*" (Comacho-Otero et al., 2020, p.75). In the context of clothing consumption, this refers to disposing the garment.

Disposition is relevant because disposal concludes the consumption phase by the user, and consequentially also the respective lifecycle. Concluding a lifecycle allows determining the number of use cycles within that lifecycle, which is relevant LCA-input. The way that the garment is disposed furthermore provides insights into the EoL-scenario of the garment, which is also relevant LCA-input. This is exemplified by the case of clothing donation or trashing, which both impose different environmental impacts. Related to the EoL is the quality of the garment upon disposal. For example, a garment of low quality will be worn less in a new lifecycle than a garment of high quality. Table 7.11 displays the operationalisation for each of the indicators.

The respondents are asked how they plan on disposal each of the garments. Logic branching is used to ask for how much the respondent thinks they can sell it when the respondent states to plan on reselling the garment. This is followed by a question regarding plans on what to spend the money gained. This allows to further determine the occurrence of an indirect form of the CER-mechanism Re-spending – selling, since consumers can spend the money gained on other forms of consumption. The formulation of the questions is derived from André and Björklund (2023) and the answer categories are supplemented with answer categories derived from Sohn et al. (2021).

Operationalisation Disposition/Re-spending – selling		
Indicator	Question	Number
Method of disposal[1; 2]	What will you most likely do with the garment when you don't (want to) use it anymore? o Sell o Throw away o Donate/give away o Repurpose (for example as rags) o Recycle/hand in for recycling o Keep in storage indefinitely	Q16.1
Re-spending – selling[2]	For how much do you think you could sell the garment upon disposal, and what do	Q16.2

	you expect to do with the money earned from selling? €… [insert numeric value]	
	I will do the following with the money: ○ Nothing in particular ○ Save ○ Spend on [insert text]	Q16.3

Table 7.11: Operationalisation disposition ([1]André & Björklund, 2023; [2]Sohn et al., 2021)

Appendix 8: Survey

This supplement provides an empty survey.

Q0.1:

Dear respondent,

This is the survey for my Master's thesis. The aim of my thesis is to better understand consumption of clothing, which can contribute to minimising the environmental impacts that occur in the clothing sector. This is done by analysing the differences between reuse of second-hand clothing and the use of newly bought clothing. You can make an important contribution by participating in this survey.

Anyone that is aged 18 years or older, lives in the Netherlands, and has bought second-hand clothing in the past can participate in the survey. All your provided answers are completely anonymous; your identity cannot be traced. Your given answers (data) are confidential, and will not be shared for commercial purposes. Data may be (partially) used in other scientific research. You have the right to withdraw from the survey at any point.

Filling in the survey takes around 15 minutes. It is recommended to do this on a laptop or desktop, although it is also possible on a phone or tablet. You can participate in a raffle at the end of the survey, in which three prizes with a total worth of €150 are available. You can win a gift card worth €50 for either Holland & Barrett, Odin, or Ekoplaza. Participation in the raffle requires you to leave your contact information. This will not link your answers to your identity. Contact information will only be seen by the researcher and will never be shared. You can change the language to Dutch on the top right corner.

For further questions about privacy- and data handling you can visit www.edu.nl/tnrk3, or email the researcher at b.i.d.geeraths@students.uu.nl.

Thank you for your interest and participation,

Buster Geeraths

Q0.2: Do you agree with the aim of this research?
- Yes
- No

Q0.3: Do you agree with the way that the collected data will be handled?
- Yes
- No

Q1: How old are you?
…

Q2: Do you live in the Netherlands?
…

Q3: Have you ever purchased second-hand clothing?
- Yes
- No

Q4: With what gender do you identify the most? Please also select "other" when you identify with both male and female equally.
- Male
- Female
- Other
- I'd rather not say

Q5: What is the highest level of education you have completed?
- Primary education/*Basisschool*
- Secondary education/*VMBO, HAVO onderbouw, VWO onderbouw, MBO1*
- Vocational education/*HAVO, VWO, MBO2, MBO3, MBO4*
- Higher education (bachelor)/*HBO-bachelor, WO-bachelor*
- Higher education (master)/*HBO-master, WO-master, doctor*
- Don't know/unknown/not available

Q6: Please select your average monthly gross income level.
- Below €1,408
- Between €1,407 and €3,291
- Between €3,292 and €3,625
- Between €3,626 and €6,958
- Between €6,959 and €10,375
- Over €10,375
- I'd rather not say

Q7: Please fill in the table. If you do not own-, buy-, or discard any of the garments, please fill in 0 in the respective field.		
Garment type	Please estimate how many of each garment type you usually buy per year:	After how many months do you usually stop using each garment:
Denim jeans, **second-hand**	[numeric value] months	… months
Denim jeans, **new**	… months	… months
Button shirt, **second-hand**	… months	… months
Button shirt, **new**	… months	… months

Q8: Please state the extent to which you agree with each of the statements					
My friends expect me to buy sustainable clothes	O	O	O	O	O
My family expects me to buy sustainable clothes	O	O	O	O	O
The community I live in expects me to buy sustainable clothes	O	O	O	O	O
It is good when clothing becomes more sustainable	O	O	O	O	O
Buying second-hand clothes is good	O	O	O	O	O
Buying second-hand clothing instead of new clothing is good for the environment	O	O	O	O	O

(range from left to right: Completely disagree, somewhat disagree, neutral, somewhat agree, completely agree)

Q9: Have you ever purchased any of the following garments in the past, second-hand and/or new, and did you purchase this from a physical- or a web shop? Please tick any box that applies, multiple answers are possible.				
Garment	Second-hand	Type of store second-hand	New	Type of store new
Denim jeans	○ Yes ○ No	□ Physical store □ Web shop □ Other	○ Yes ○ No	□ Physical store □ Web shop □ Other
Button shirt	○ Yes ○ No	□ Physical store □ Web shop □ Other	○ Yes ○ No	□ Physical store □ Web shop □ Other

Q9.2: Please think of the last time you purchased denim jeans and/or a button shirt/blouse (as declared in the previous question). All remaining questions in the survey will relate to those purchases. If you have bought denim jeans and/or a button shirt/blouse at multiple store types, please answer the question for the case of the physical store.

- ○ Okay

Q10: Please select the main method of transportation you used, and the distance travelled to the store for the trip(s) you made to buy your (second-hand) garment(s).		
	Method of transport	Distance (km)
Denim jeans, **second-hand**	○ Walking ○ Bicycle ○ Scooter ○ E-bike or e-scooter ○ Public transport ○ Car ○ Other ○ I don’t remember	…
Button shirt, **second-hand**	○ Walking ○ Bicycle ○ Scooter ○ E-bike or e-scooter ○ Public transport ○ Car ○ Other ○ I don’t remember	…

Q11.1: Please tick a maximum of three boxes that apply to the last trip you have made to buy a pair of second-hand denim jeans at a physical store.

- □ Buying a pair of second-hand denim jeans was the primary reason for me to make this trip that day
- □ Visiting the store I bought this pair of denim jeans at was the primary reason for me to make this trip that day
- □ Buying a pair of second-hand denim jeans was a secondary reason for me to make this trip that day

- Visiting the store I bought this pair of denim jeans at was a secondary reason for me to make this trip that day
- I combined this trip with other business I had en-route
- I don't remember why I made the trip in which I bought this pair of denim jeans

Q11.2: Please tick a maximum of three boxes that apply to the last trip you have made to buy a second-hand button shirt/blouse at a physical store.

- Buying a second-hand button shirt/blouse was the primary reason for me to make this trip that day
- Visiting the store I bought this button shirt/blouse at was the primary reason for me to make this trip that day
- Buying a second-hand button shirt/blouse was a secondary reason for me to make this trip that day
- Visiting the store I bought this button shirt/blouse at was a secondary reason for me to make this trip that day
- I combined this trip with other business I had en-route
- I don't remember why I made the trip in which I bought this button shirt/blouse

Q12: Please state how you would have rated your garments **at the moment you bought them**, in terms of each of the following product properties					
Q12.1: Denim jeans, **second-hand**					
	Very poor	Somewhat poor	Neutral	Good	Very good
Performance	O	O	O	O	O
Quality	O	O	O	O	O
Fit	O	O	O	O	O
Q12.2: Denim jeans, **new**					
Performance	O	O	O	O	O
Quality	O	O	O	O	O
Fit	O	O	O	O	O
Q12.3: Buttons shirt, **second-hand**					
Performance	O	O	O	O	O
Quality	O	O	O	O	O
Fit	O	O	O	O	O
Q12.4: Button shirt, **new**					
Performance	O	O	O	O	O
Quality	O	O	O	O	O
Fit	O	O	O	O	O

Q13: Please state the extent to which you agree with each of the statements				
Q13.1 Denim jeans, **second-hand**				
I bought this garment because a garment that looks like this one is hard to come by	O	O	O	O
I bought this garment because of other people that wear this style	O	O	O	O
I bought this garment because it was a bargain	O	O	O	O
I bought this garment because the store promoted this specific garment	O	O	O	O
I bought this garment because I will need it in the nearby future (as a back-up)	O	O	O	O

I bought this garment because I need it now (for example to replace a recently broken garment)	O	O	O	O
If I had not found this second-hand garment I would have bought a new garment of this type instead	O	O	O	O
Q12.2: Denim jeans, **new**				
I bought this garment because a garment that looks like this one is hard to come by	O	O	O	O
I bought this garment because of other people that wear this style	O	O	O	O
I bought this garment because it was a bargain	O	O	O	O
I bought this garment because the store promoted this specific garment	O	O	O	O
I bought this garment because I will need it in the nearby future (as a back-up)	O	O	O	O
I bought this garment because I need it now (for example to replace a recently broken garment)	O	O	O	O
If I had not found this new garment I would have bought a second-hand garment of this type instead	O	O	O	O
Q12.3: Buttons shirt, **second-hand**				
I bought this garment because a garment that looks like this one is hard to come by	O	O	O	O
I bought this garment because of other people that wear this style	O	O	O	O
I bought this garment because it was a bargain	O	O	O	O
I bought this garment because the store promoted this specific garment	O	O	O	O
I bought this garment because I will need it in the nearby future (as a back-up)	O	O	O	O
I bought this garment because I need it now (for example to replace a recently broken garment)	O	O	O	O
If I had not found this second-hand garment I would have bought a new garment of this type instead	O	O	O	O
Q12.4: Button shirt, **new**				
I bought this garment because a garment that looks like this one is hard to come by	O	O	O	O
I bought this garment because of other people that wear this style	O	O	O	O
I bought this garment because it was a bargain	O	O	O	O
I bought this garment because the store promoted this specific garment	O	O	O	O
I bought this garment because I will need it in the nearby future (as a back-up)	O	O	O	O
I bought this garment because I need it now (for example to replace a recently broken garment)	O	O	O	O
If I had not found this new garment I would have bought a second-hand garment of this type instead	O	O	O	O

(range from left to right: Completely disagree, somewhat disagree, somewhat agree, completely agree)

<table>
<tr><td colspan="3">Q14.1: How costly/expensive was the second-hand garment you have bought compared to a new garment of that same type?</td></tr>
<tr><td>Indicator</td><td>Denim jeans, second-hand</td><td>Button shirt, second-hand</td></tr>
<tr><td>Price</td><td>The price was…
○ Lower than new
○ The same as new
○ Higher than new
○ I don’t remember</td><td>The price was…
○ Lower than new
○ The same as new
○ Higher than new
○ I don’t remember</td></tr>
<tr><td colspan="3">Q14.2: You have stated to have saved money by buying a second-hand garment instead of a new garment. How much money do you think you approximately saved compared to a new garment of the same type, and what do you think you will do with the money you saved?</td></tr>
<tr><td colspan="2">Denim jeans, second-hand</td><td rowspan="2">I have saved… [insert numeric value]

I will do the following with the money saved:
○ Nothing in particular
○ Save
○ Spend on…</td></tr>
<tr><td colspan="2">Button shirt, second-hand</td></tr>
<tr><td colspan="3">Q14.3: Could you explain on what you plan to spend the money you have saved?</td></tr>
<tr><td colspan="2">Denim jeans, second-hand</td><td rowspan="2">I plan on spending the money saved by buying a (pair of) second-hand denim jeans/buttons shirt instead of new denim jeans/button shirt on the following: [insert text]</td></tr>
<tr><td colspan="2">Button shirt, second-hand</td></tr>
</table>

Q15.2.1: How do you wash your garment?

Denim jeans, **second-hand**:
- By hand
- Machine
- Other

Denim jeans, **new**:
- By hand
- Machine
- Other

Button shirt, **second-hand**:
- By hand
- Machine
- Other

Button shirt, **new**:
- By hand
- Machine
- Other

Q15.2.2: You selected "other" as a washing method, can you explain what other method you use?

Denim jeans, **second-hand**:
…[insert text]

Denim jeans, **new**:
…[insert text]

Button shirt, **second-hand**:
…[insert text]

Button shirt, **new**:
…[insert text]

Q15.3: Please state your washing habits for each garment			
	Do you use detergent while washing the garment?	Do you use fabric softener while washing the garment?	At what temperature do you wash the garment?
Denim jeans, **second-hand**	○ Yes ○ No	○ Yes ○ No	○ 20°C ○ 30°C ○ 40°C ○ 50°C ○ 60°C ○ Tap water temperature
Denim jeans, **new**	○ Yes ○ No	○ Yes ○ No	○ 20°C ○ 30°C ○ 40°C ○ 50°C ○ 60°C ○ Tap water temperature
Button shirt, **second-hand**	○ Yes ○ No	○ Yes ○ No	○ 20°C ○ 30°C ○ 40°C ○ 50°C ○ 60°C ○ Tap water temperature
Button shirt, **new**	○ Yes ○ No	○ Yes ○ No	○ 20°C ○ 30°C ○ 40°C ○ 50°C ○ 60°C ○ Tap water temperature

Q15.4: Do you use a clothes dryer after washing	
Denim jeans, **second-hand**	○ Yes ○ No
Denim jeans, **new**	○ Yes

	○ No
Button shirt, **second-hand**	○ Yes ○ No
Button shirt, **new**	○ Yes ○ No

Q16.1: Do you use a clothes dryer after washing What will you most likely do with the garment when you don't (want to) use it anymore?	
Denim jeans, **second-hand**	○ Sell ○ Throw away ○ Donate/give away ○ Repurpose (for example as rags) ○ Recycle/hand in for recycling ○ Keep in storage indefinitely
Denim jeans, **new**	○ Sell ○ Throw away ○ Donate/give away ○ Repurpose (for example as rags) ○ Recycle/hand in for recycling ○ Keep in storage indefinitely
Button shirt, **second-hand**	○ Sell ○ Throw away ○ Donate/give away ○ Repurpose (for example as rags) ○ Recycle/hand in for recycling ○ Keep in storage indefinitely
Button shirt, **new**	○ Sell ○ Throw away ○ Donate/give away ○ Repurpose (for example as rags) ○ Recycle/hand in for recycling ○ Keep in storage indefinitely
Q16.2: For how much do you think you could sell the garment upon disposal?	
Denim jeans, **second-hand**	€… [insert numeric value]
Denim jeans, **new**	€… [insert numeric value]
Button shirt, **second-hand**	€… [insert numeric value]
Button shirt, **new**	€… [insert numeric value]
Q16.3: What do you expect to do with the money earned from selling?	
Denim jeans, **second-hand**	○ Nothing in particular ○ Save ○ Spend on [insert text]
Denim jeans, **new**	○ Nothing in particular ○ Save ○ Spend on [insert text]
Button shirt, **second-hand**	○ Nothing in particular ○ Save ○ Spend on [insert text]
Button shirt, **new**	○ Nothing in particular ○ Save ○ Spend on [insert text]

Appendix 9: Statements consumer interviews

Statements obtainment motivation	
Topic	Statements (respondent number)
Performance	- Sometimes I need a garment for one occasion so I purchase it second-hand (3)
Price	- Second-hand clothing is cheaper than new clothing (1) (2) - Fast fashion is affordable and allows me to save money, which I need because living is expensive (2) (10)
Environment	- Consumerism is bad (1) - Fast Fashion is bad (1) - Second-hand clothing is more sustainable (2) - I cannot afford to consider sustainability when purchasing clothing (3) - My impression is that second-hand clothing is more sustainable, but I honestly do not pay attention to it when purchasing new clothing (10)
Quality	- Second-hand purchases allow me to purchase more premium garments for an affordable price (2)
Convenience	- New clothing is more convenient to purchase: you always know that a garment of that type will be present in the store. Second-hand clothing has a lot more uncertainty around it. Garments in stock are limited and you might not like them (1)
Enjoyment of purchase	- Second-hand clothing brings more enjoyment to purchase, because you really have to search for a garment you like. It brings joy when you finally find that garment (1)
Uniqueness	- Second-hand garments can be more unique than new garments (1) (2)
Impulse purchases	- Buying new clothing results in less impulse purchases, because I specifically go to the store to purchase a certain garment type. There are a lot more impulsive purchases when I go shopping second-hand, because I run into garments that I like (1) - I have had impulse purchases of second-hand garments, but I did 'need' those garments eventually. I kept them as a back-up, and some of those garments actually turned out to be some of the favourite garments I own (3) - I have purchased second-hand garments on impulse. I ran into the garment by coincidence. It is a garment for formal settings, so I wear it occasionally (6) - The impulse purchases turned out to be among my favourite garments, so I wear them more often (7)

Table 8.1: Statements obtainment motivation

Statements disposition	
Respondent	Statements
1	Garments that are worn out or broken are recycled. Garments of which I am tired are donated
2	Garments are sold, thrown away, donated, of kept in storage indefinitely upon disposal
3	Garments that are worn out or broken down are recycled. Sometimes garments are donated
4	I discard garments when I do not like the style anymore, or if they do not fit me properly anymore. The clothes are then donated
5	Second-hand clothing is disposed of faster than new clothing, because it is worn out faster. Garments which are worn out or broken down are recycled. Garments that do not fit anymore are donated
6	Garments that cannot be repaired are thrown away. Garments that are still good are donated to an NGO which exports them to Gambia
7	I discard garments when they do not appeal to me anymore. I sell them or donate them
8	Garments that are worn out or broken are recycled
9	Garments are disposed of if they look old, are worn out, do not fit me properly anymore, or if I am not that attached to them. They are either recycled or donated
10	Worn out garments are handed in for recycling. Garments that are still usable are donated. I occasionally use an old garment as a rag, if I happen to need one.

Table 8.2: Statements disposition

Appendix 10: Ingredients liquid detergent and fabric softener

The following composition of ingredients is adapted from Sandin et al. (2019), Table B-58.

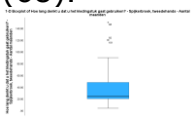
Liquid detergent	
Ingredient	Share
Alkyl sulphate	9.665%
Citric acid	2.123%
Enzymes	0.540%
Glycerine	2.654%
Non-ionic surfactant	5.503%
Polyethylene	4.339%
Soap	2.244%
Sodium hydroxide	2.151%
Water	65.384%
HDPE bottle	4.339%
PP cork	0.940%
Label	0.117%
Electricity	0.25 kWh

The following composition of ingredients is adapted from Sandin et al. (2019), Table B-3.

Average fabric softener	
Diethanolamine	3%
Stearic acid	20%
Ultrapure water	77%

Appendix 11: Garment lifetimes: data including outliers

Case 68, 82, and 101 are excluded when determining average lifetimes for second-hand denim jeans because these are outliers (82 and 101) or extreme outliers (68).



Case 68, 54, 79, 22, and 71 are excluded when determining average lifetimes for new denim jeans because these are outliers (79, 22, and 71) or extreme outliers (68 and 54).

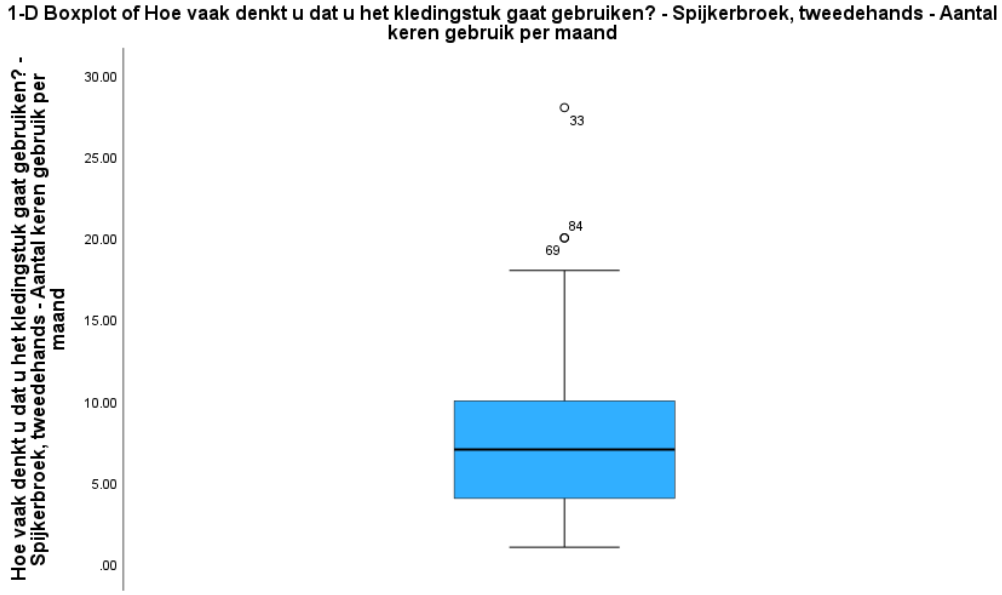
Case 68, 35, 22, and 82 are excluded when determining average lifetimes for second-hand button shirts because these are outliers.

Case 25, 68, 4, 35, 14, and 47 are excluded when determining average lifetimes for second-hand button shirts because these are outliers (4, 35, 14, and 47) or extreme outliers (25 and 68).

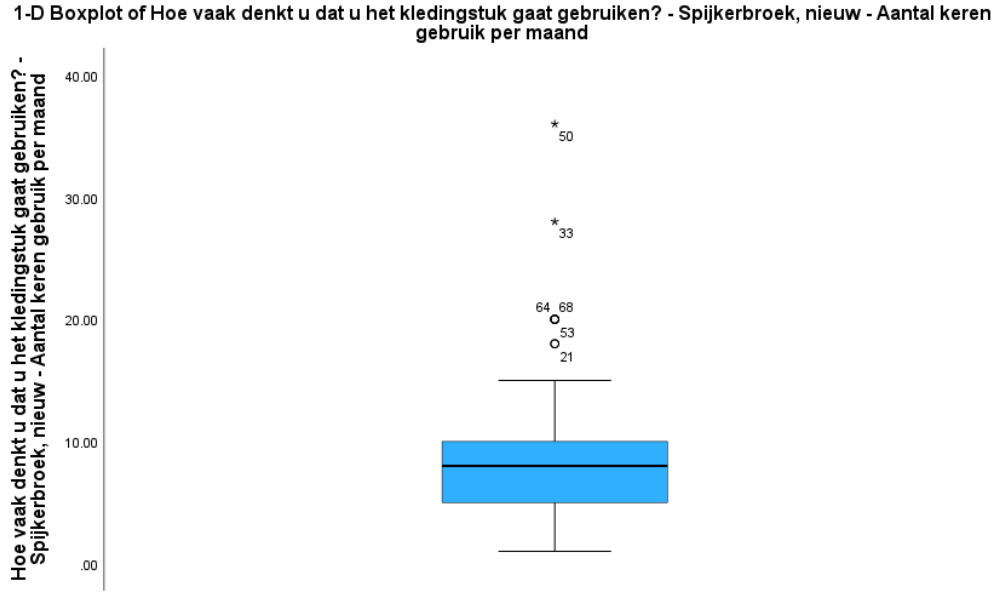
Descriptives with all outliers included, Q15.1.1: “For how long do you think you will use the garment?” [months]					
	n	Minimum	Maximum	Mean	Std. Deviation
Jeans, second-hand	74	4.00	150.00	34.74	27.24
Jeans, new	92	6.00	400.00	45.97	47.64
Button shirt, second-hand	90	4.00	150.00	42.31	30.11
Button shirt, new	83	6.00	480.00	59.12	68.95

Appendix 12: Garment use rates: data including outliers

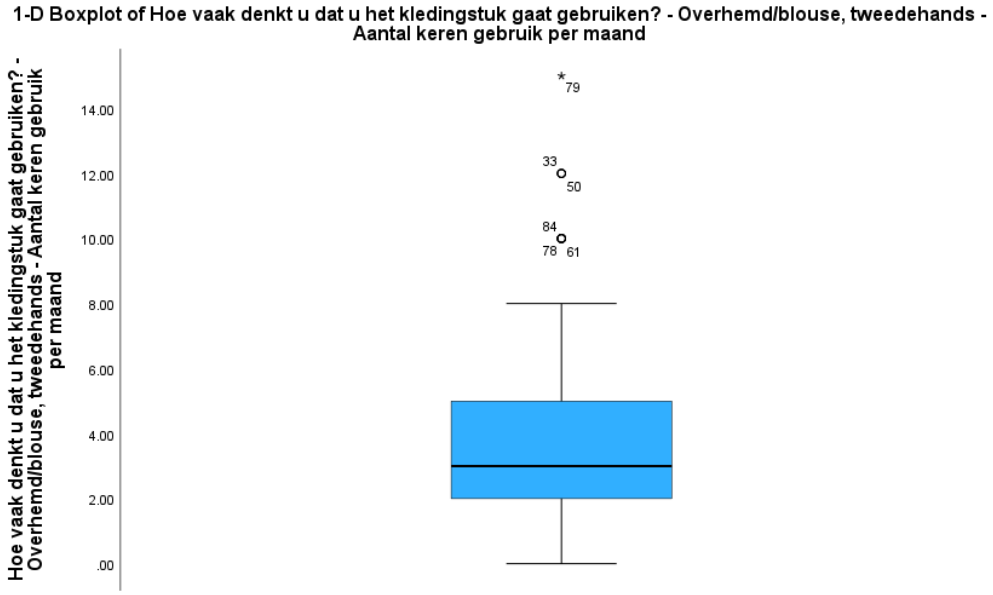
Case 33, 84, and 69 are excluded when determining average use rates for second-hand denim jeans because these are outliers.



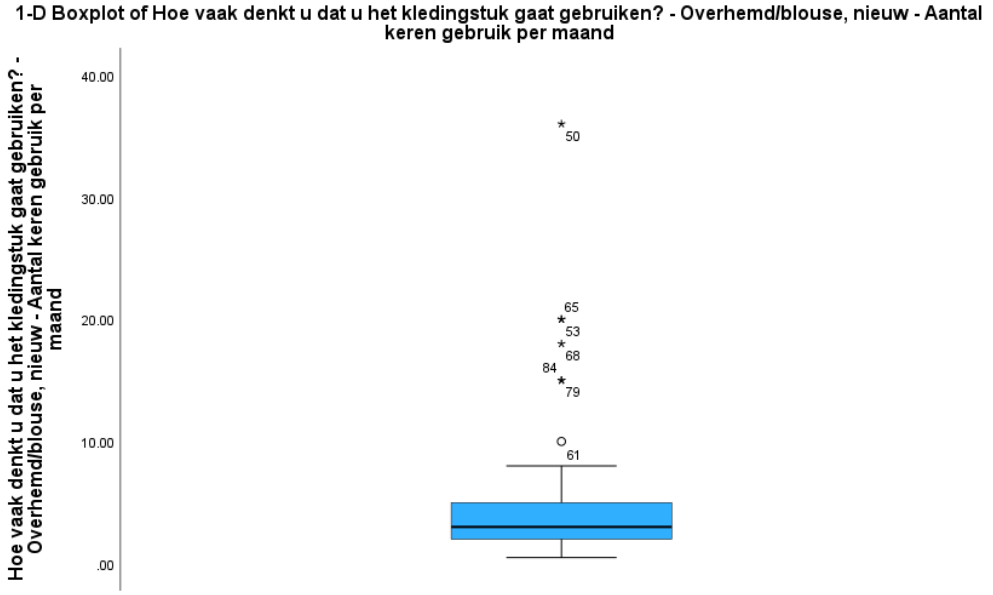
Case 50, 33, 64, 68, 53, and 21 are excluded when determining average lifetimes for new denim jeans because these are outliers (64, 68, 53, and 21) or extreme outliers (50 and 33).



Case 79, 33, 50, 84, 78, and 61 are excluded when determining average lifetimes for second-hand button shirts because these are outliers (33, 50, 84, 78, and 61) or extreme outliers (79).



Case 50, 65, 53, 68, 84, 79, and 61 are excluded when determining average lifetimes for second-hand button shirts because these are outliers (61) or extreme outliers (50, 65, 53, 68, 84, and 79).



Descriptives with all outliers included, Q15.1.1: "How often do you think you will use the garment?" [per month]					
	n	Minimum	Maximum	Mean	Std. Deviation
Jeans, second-hand	74	1.00	28.00	7.86	5.01
Jeans, new	92	1.00	36.00	8.76	5.71
Button shirt, second-hand	90	0.00	15.00	3.80	3.04
Button shirt, new	83	0.50	36.00	4.58	5.27

Appendix 13: Internal consistency Q8

Internal consistency Q8 (SN)

Case Processing Summary

		N	%
Cases	Valid	104	100.0
	Excluded[a]	0	.0
	Total	104	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.719	.717	3

Item Statistics

	Mean	Std. Deviation	N
Mijn vrienden verwachten van mij dat ik duurzame kleding koop	2.84	1.263	104
Mijn familie verwacht van mij dat ik duurzame kleding koop	2.55	1.214	104
De gemeenschap waarin ik leef verwacht van mij dat ik duurzame kleding koop	2.74	1.166	104

Inter-Item Correlation Matrix

	Mijn vrienden verwachten van mij dat ik duurzame kleding koop	Mijn familie verwacht van mij dat ik duurzame kleding koop	De gemeenschap waarin ik leef verwacht van mij dat ik duurzame kleding koop
Mijn vrienden verwachten van mij dat ik duurzame kleding koop	1.000	.509	.531
Mijn familie verwacht van mij dat ik duurzame kleding koop	.509	1.000	.335
De gemeenschap waarin ik leef verwacht van mij dat ik duurzame kleding koop	.531	.335	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.708	2.548	2.837	.288	1.113	.022	3
Item Variances	1.476	1.359	1.594	.235	1.173	.014	3
Inter-Item Correlations	.458	.335	.531	.197	1.588	.009	3

Internal consistency Q8 (ATT)

Case Processing Summary

		N	%
Cases	Valid	104	100.0
	Excluded[a]	0	.0
	Total	104	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.812	.812	3

Item Statistics

	Mean	Std. Deviation	N
Het is goed wanneer kleding duurzamer wordt	4.84	.559	104
Tweedehandskleding kopen is goed	4.63	.669	104
Het kopen van tweedehandskleding in plaats van nieuwe kleding is goed voor het milieu	4.65	.721	104

Inter-Item Correlation Matrix

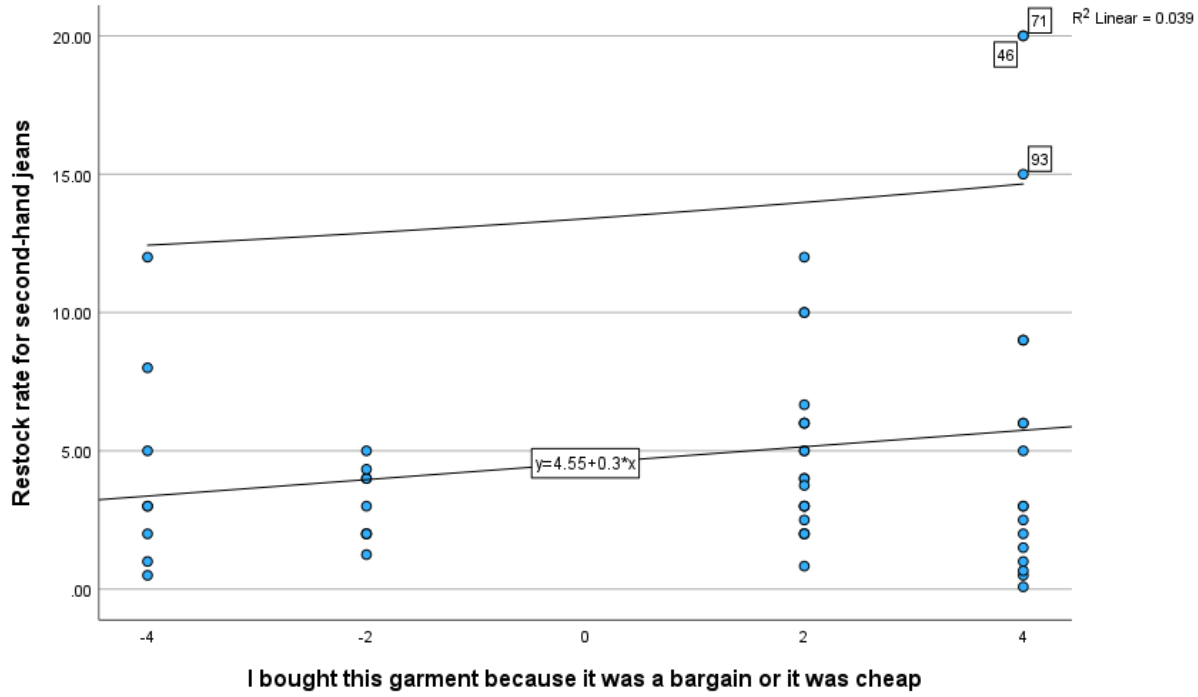
	Het is goed wanneer kleding duurzamer wordt	Tweedehands kleding kopen is goed	Het kopen van tweedehandskleding in plaats van nieuwe kleding is goed voor het milieu
Het is goed wanneer kleding duurzamer wordt	1.000	.539	.508
Tweedehandskleding kopen is goed	.539	1.000	.721
Het kopen van tweedehandskleding in plaats van nieuwe kleding is goed voor het milieu	.508	.721	1.000

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	4.708	4.635	4.837	.202	1.044	.012	3
Item Variances	.427	.313	.520	.207	1.662	.011	3
Inter-Item Correlations	.590	.508	.721	.213	1.419	.011	3

Appendix 14: Preconditions analysis Price

Three cases (46, 71 and 93) were outliers, and were thus excluded from the correlation analysis conducted for the hypothesis "*Respondents that have purchased second-hand denim jeans because it was a bargain or cheap purchase more second-hand denim jeans per year*".

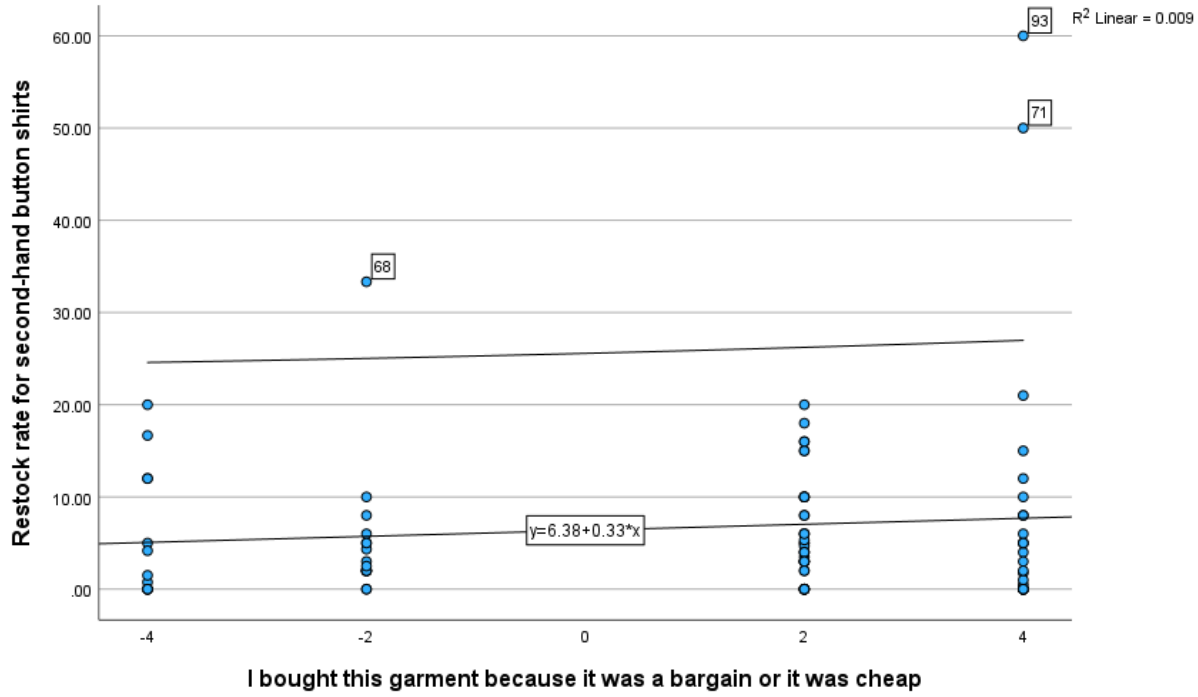


The correlation analysis concluded that there was no correlation between the variables, within the sample $r(49) = 0.02$, $p = 876$.

Correlations

		I bought this garment because it was a bargain or it was cheap	Restock rate for second-hand jeans
I bought this garment because it was a bargain or it was cheap	Pearson Correlation	1	.022
	Sig. (2-tailed)		.876
	N	51	51
Restock rate for second-hand jeans	Pearson Correlation	.022	1
	Sig. (2-tailed)	.876	
	N	51	54

Three cases (93, 71, and 68) were outliers, and were thus excluded from the correlation analysis conducted for the hypothesis "*Respondents that have purchased second-hand denim jeans because it was a bargain or cheap purchase more second-hand button shirts per year*".



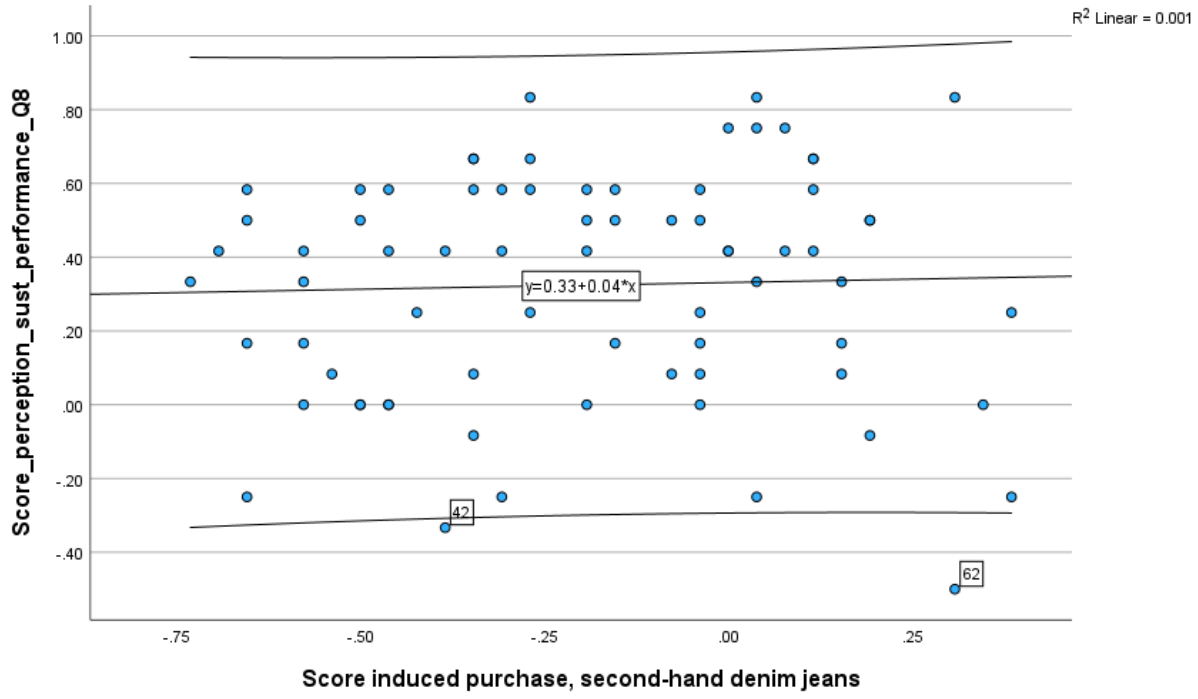
The correlation analysis concluded that there was no correlation between the variables, within the sample $r(65) = 0.04$, p = 767.

Correlations

		I bought this garment because it was a bargain or it was cheap	Restock rate for second-hand button shirts
I bought this garment because it was a bargain or it was cheap	Pearson Correlation	1	.037
	Sig. (2-tailed)		.767
	N	67	67
Restock rate for second-hand button shirts	Pearson Correlation	.037	1
	Sig. (2-tailed)	.767	
	N	67	68

Appendix 15: Preconditions analysis Motivational (direct)

Two cases (42 and 62) were outliers, and were thus excluded from the correlation analysis conducted for the hypothesis "*Ascribing higher levels of priority to the sustainability performance of clothing correlations with making induced purchases of second-hand denim jeans*".

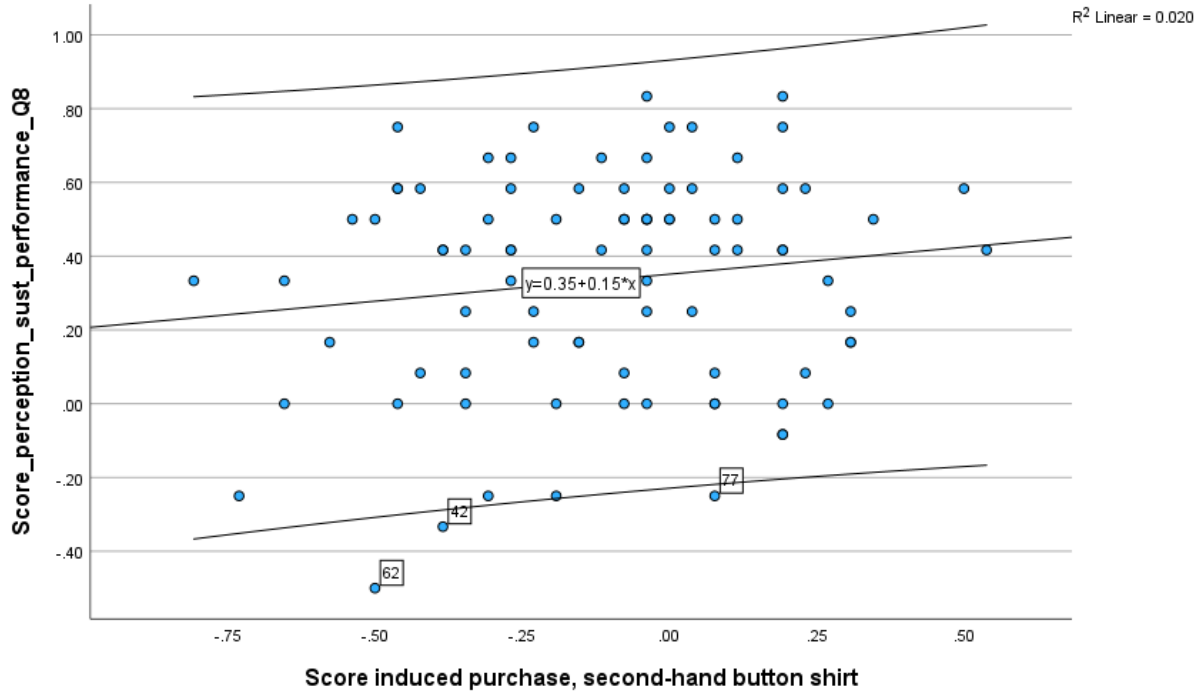


The correlation analysis concluded that there was no correlation between the variables, within the sample $r(70) = 0.01$, p = 465.

Correlations

		Score induced purchase, second-hand denim jeans	Score_perception_sust_performance_Q8
Score induced purchase, second-hand denim jeans	Pearson Correlation	1	.088
	Sig. (2-tailed)		.465
	N	72	72
Score_perception_sust_performance_Q8	Pearson Correlation	.088	1
	Sig. (2-tailed)	.465	
	N	72	102

Three cases (62, 42, and 77) were outliers, and were thus excluded from the correlation analysis conducted for the hypothesis "*Ascribing higher levels of priority to the sustainability performance of clothing correlations with making induced purchases of second-hand button shirts*".



The correlation analysis concluded that there was no correlation between the variables, within the sample $r(85) = 0.01$, $p = 380$.

Correlations

		Score_perception_sust_performance_Q8	Score induced purchase, second-hand button shirt
Score_perception_sust_performance_Q8	Pearson Correlation	1	.095
	Sig. (2-tailed)		.380
	N	101	87
Score induced purchase, second-hand button shirt	Pearson Correlation	.095	1
	Sig. (2-tailed)	.380	
	N	87	87