The environmental benefit of Marktplaats trading

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Delft, CE Delft, July 2019

Publication code: 19.2N83.108

Client: Marktplaats

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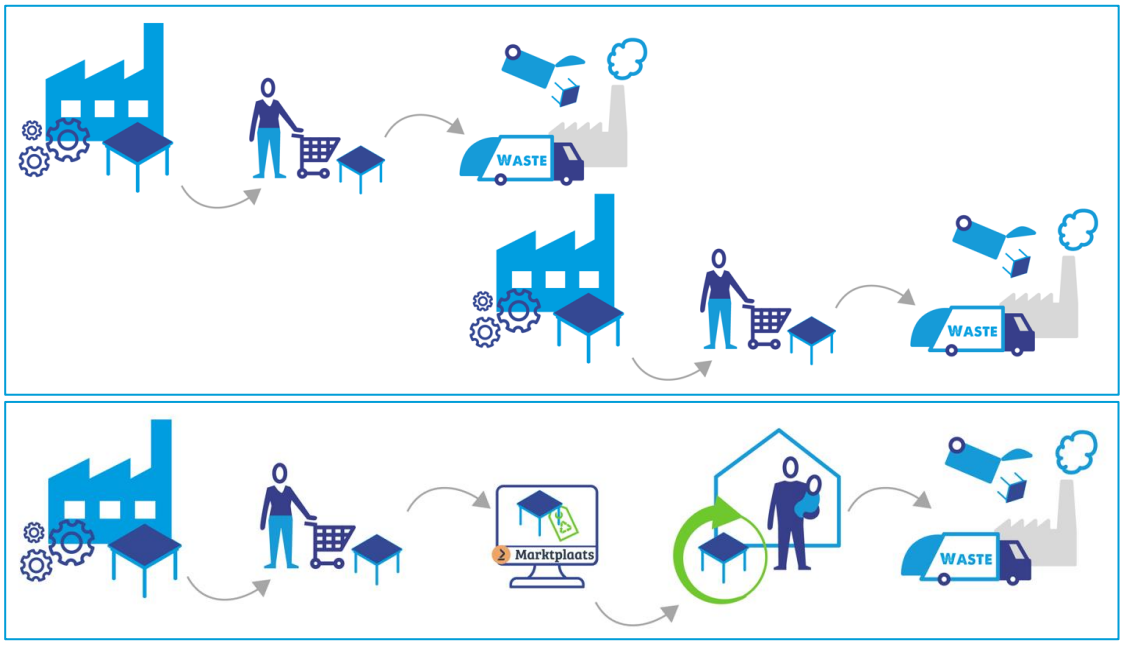
Summary

Introduction

Marktplaats ('marketplace') is the largest online second-hand trading platform in the Netherlands. It enables consumers to sell products directly to other consumers. The trading platform receives 8.2 million unique visitors a month. The second-hand trading that Marktplaats facilitates can reduce the amount of products that end up in incinerators and reduce the demand for new products, resulting into lower costs for consumers, but also lower demand for resources and lower CO_2 emissions. By extending the life span of consumer products (Figure 1), trading on Marktplaats can play a role in meeting the Netherlands' environmental policy targets on climate change and the circular economy.

Figure 1 – Comparison of the 'linear' and 'circular' or reuse models from production to end-of-life



The goal of this study is to derive a first-order estimate of the climate change impact reduction realised by consumer trading on Marktplaats in 2018. This is done by assessing the life span extension that Marktplaats enables, and by comparing the current situation (with Marktplaats) to a situation in which no life span extension takes place and more newly manufactured products would be purchased and more discarded products would be sent to waste treatment.

Approach

Given that Marktplaats sellers offer a highly diverse selection of products (as essentially any item can be traded on the platform), the analysis is based on a selection of 15 products. The selected categories and product subcategories are:

- Electronics: Loudspeakers, mobile telephones, laptops.
- Furniture[1]: Couches, tables, beds, box-springs.
- Clothing: Trousers, t-shirts, tops, jeans, shoes.
- Children and babies: Strollers, beds and cribs, car seats.

The climate change impact reduction is estimated by combining the results of a survey held among Marktplaats traders with information on the total number of trades (internal Marktplaats statistics) and the carbon footprint of producing and discarding the products.

Results

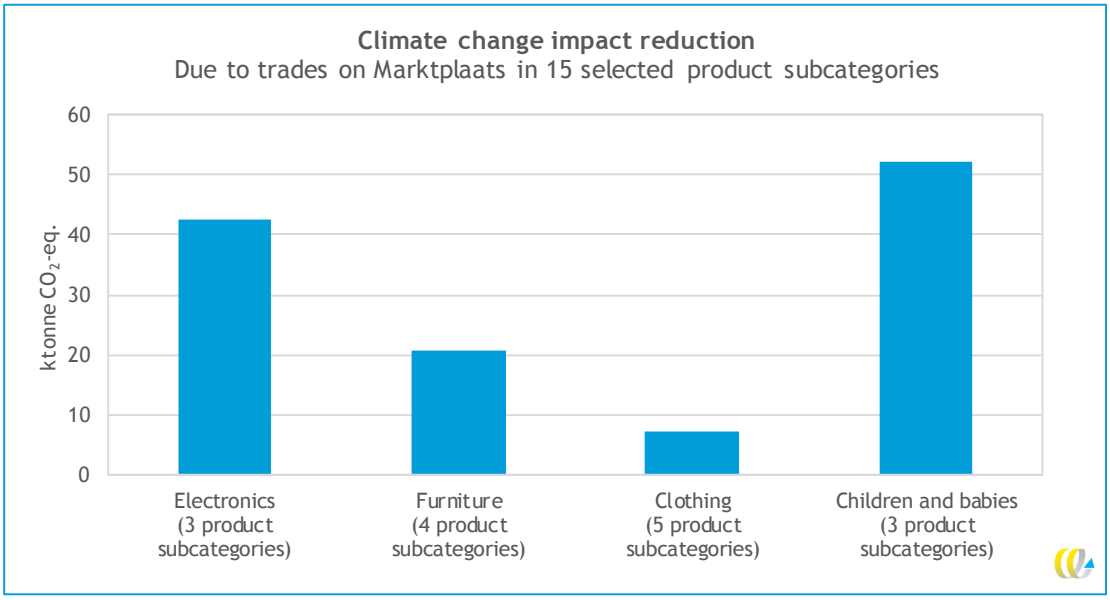
Based on the survey, it is estimated that the life span of products in the electronics, furniture, clothing and children and babies categories traded on Marktplaats is about 1.4 to 1.6 times longer than the standard life spans. Because these products have a longer life span, fewer products are required to fulfill consumers' needs. This results in a climate change impact reduction of the traded products by about one third compared to a situation in which Marktplaats trading would not exist.

Combining this finding with the volume of trades on Marktplaats and the carbon footprints of producing and discarding the products, the total climate change impact reduction for the 15 selected subcategories can be estimated. The result is shown in Figure 2. The estimated climate change impact reduction is about 43 kilotonne (ktonne[2]) CO_2-eq. for electronics, 21 ktonne CO_2-eq. for furniture, 7 ktonne CO_2-eq. for clothing and about 52 ktonne CO_2-eq. for children and babies in 2018. Given the uncertainties present in the analysis, we estimate that the total climate change impact reduction (for the 15 selected product subcategories) may lie in the range of 80 to 140 ktonne CO_2-eq. in 2018.

[1] This category is called 'Huis en inrichting' in Dutch.

[2] One kilotonne equals one million kilogram.

Figure 2 - Approximate climate change impact reduction due to trades on Marktplaats in 2018 for 15 selected product subcategories, 2018



It is also important to note that, especially for cotton clothing and electronics, besides climate impact also other environmental impacts are lowered. This environmental gains could be calculated later more in depth.

The results for the selected subcategories can be extrapolated to give a first idea of the overall climate change impact reduction of trading on Marktplaats. If we move beyond the 15 selected subcategories and consider the entire product categories, we estimate a total climate change impact reduction of 150–260 ktonne CO_2-eq. (assuming the reduction per product traded is comparable for similar products) for 2018. To put these results into perspective:

- the climate change impact of the category electronics (52 ktonne CO_2-eq.) is comparable to the production of circa 1 milion mobile phones;
- the climate change impact of the category furniture (52 ktonne CO_2-eq.) is comparable to the production of circa 1 milion tables;
- the climate change impact of the category clothing (19 ktonne CO_2-eq.) is comparable to the production of circa 0.4 milion jeans;
- the climate change impact of the category children and babies (88 ktonne CO_2-eq.) is comparable to the production of circa 0.2 milion strollers.

If we go one step further and assume that all trades made on Marktplaats result in a comparable reduction (of 25 kg CO_2-eq. per trade[3]), we can estimate the total climate change impact reduction of all trading on Marktplaats. Since the 15 subcategories cover about 12% of all trades on Marktplaats, a rough estimate for the entirety of Marktplaats would be a reduction in the range of 600 to 1,000 ktonne CO_2-eq. in 2018 (0.6 to 1 Mtonne). Due to the large diversity of products traded on the platform, ranging from stamps to cars, these figures can only be viewed as a first indication the order of magnitude of Marktplaats' yearly influence.

[3] Average reduction across the 15 studied subcategories, weighted by the number of connections.

Note that this environmental benefit could be substantially larger if more people were to use Marktplaats to sell old products and buy second-hand products. At present, only a part of the Dutch citizens use Marktplaats to fulfill all their product requirements, while many others use the platform incidentally or never at all. A substantial expansion of second hand trading is possible and could result in megatonnes of CO_2 emission reductions.

Conclusions

It should be noted that it is not straightforward to estimate the climate change impact reduction of Marktplaats trading. A number of uncertainties and limitations apply, including:

- not all products traded on Marktplaats may replace newly manufactured products;
- life span extensions may be over- or underestimated;
- proxy products were used to estimate carbon footprints.

Nevertheless, this analysis shows that Marktplaats already plays an important role in lowering the climate change impact of Dutch consumers and developing a more circular economy. The environmental benefits could be substantially larger if more people were to use Marktplaats to sell old products and buy second-hand products. If Marktplaats or other second-hand trading platforms can help to increase the life span of all consumer goods, the potential climate change benefits could be in the range of several megatonnes of CO_2-eq. This could make a considerable contribution to the climate change impact reduction targets set by the Dutch government.

1 Introduction

Marktplaats ('marketplace') is the largest online second-hand trading platform in the Netherlands. It enables consumers to sell products directly to other consumers[4]. The trading platform receives 8.2 million unique visitors a month. The second-hand trading that Marktplaats facilitates can reduce the amount of products that end up in incinerators and reduce the demand for new products, resulting into lower demand for resources, lower CO_2 emissions and lower costs for consumers.

This study derives a first-order estimate of the climate change impact reduction of trading on Marktplaats in 2018.

Background

In line with several other European nations, the Netherlands has set ambitious goals related to climate change and the environment:

- The coalition agreement of the present Dutch government has set a target of 49% CO_2 emission reduction by 2030.
- In 2016, the Dutch cabinet published its circular economy programme (I&M/EZ, 2016). This contains the aim to reach a 50% reduction in the use of primary resources by 2030, and to reach a fully circular economy by 2050.

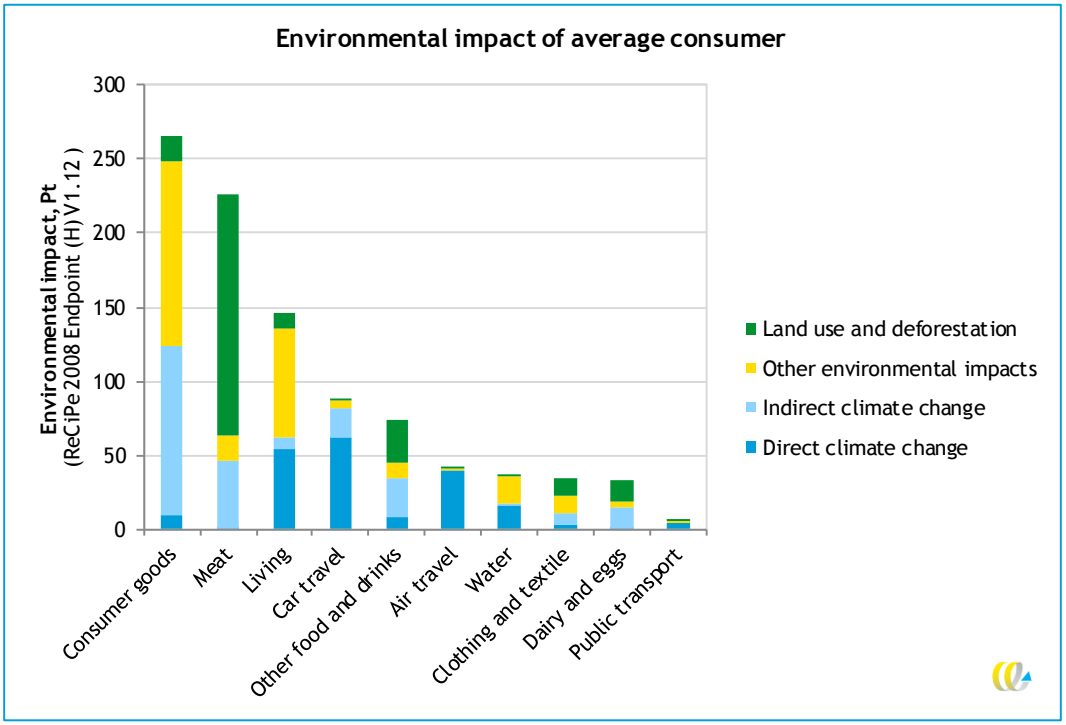
As part of realising these ambitions, the Dutch government is investigating how different technologies, policies and practices can contribute to reducing environmental impacts and promoting the circular use of materials. It has for instance developed so-called transition agenda's for the circular economy for five selected economic sectors: biomass and food, plastics, construction, the manufacturing industry, and consumer goods.

Consumer goods cover a wide range of products, such as chairs, tables, smartphones, labtops and clothes. Their contribution to the overall environmental impact of households can be substantial. In an analysis for Studio Babette Porcelijn, CE Delft previously concluded that purchasing new consumer products represents the average consumer's largest environmental impact (Figure 3). For climate change specifically, the impact of consumer goods was estimated at about 2.5 tonne of CO_2-eq. per consumer. For the Netherlands as a whole (with 17 million inhabitants), this amounts to approximately 43 megatonnes of CO_2-eq. per year.

As described in the transition agenda (IenW; EZK, 2018), this impact can be reduced by making more efficient use of products such as by extending their life span. Existing trading platforms such as Marktplaats can thus play a important role in reducing the environmental impact associated with consumer goods.

[4] In addition to consumer-to-consumer trading, Marktplaats also enables businesses to sell (new) products to consumers. However, this analysis focuses on consumer-to-consumer trading of (second-hand) goods.

Figure 3 - Estimated environmental impact of the average Dutch consumer



Bron: (CE Delft, 2018).

Goal

In this context, the goal of this study is to derive a first-order estimate of the climate change impact reduction realised by consumers trading on Marktplaats in 2018. This is done assessing the life span extension that Marktplaats enables, and by comparing the current situation (with Marktplaats) to a situation in which no life span extension takes place and more newly manufactured products would be purchased and more discarded products would be sent to waste treatment.

By focusing on the environmental impacts of trading, this study does not quantify Marktplaats' own, direct climate change impact (e.g. through the use of electricity, offices). Furthermore, we focus on the climate change impact (and exclude other environmental impacts) due to its high environmental relevance and priority in environmental policymaking.

Approach

Given that Marktplaats sellers offer a highly diverse selection of products (as essentially any item can be traded on the platform), the analysis is based on a selection of 15 products. The selected categories and product subcategories are:

- Electronics: Loudspeakers, mobile telephones, laptops.
- Furniture[5]: Couches, tables, beds, box-springs.
- Clothing: Trousers, t-shirts, tops, jeans, shoes.
- Children and babies: Strollers, beds and cribs, car seats.

[5] This category is called 'Huis en inrichting' in Dutch.

In early 2019, a survey was held among Marktplaats buyers and sellers of these products to estimate the life span extension achieved by second-hand trading. The climate change impact reduction is estimated by combining the survey results with information on the total number of trades (internal Marktplaats statistics) and public life cycle assessment (LCA)[6] studies on the carbon footprint of producing and discarding the products. The results for the selected subcategories are extrapolated to give a first idea of the overall climate change impact reduction of trading on Marktplaats.

Disclaimer

The analysis as presented here is to some extent based on important assumptions, approximations and uncertain data. The results should therefore be viewed as an estimate of the potential order of magnitude of the climate change impact reduction of trading on Marktplaats. The uncertainties and limitations (as discussed in Chapter 4) should be kept in mind when interpreting the results.

[6] Life cycle assessment is a method to assess the environmental impacts associated of a product or service, over all its life cycle stages (e.g. raw material extraction, processing, use, and disposal or recycling).

2 Methodology

2.1 Background: extending product lifetimes by second-hand trading

Trading platforms such as Marktplaats can increase the period of time during which products are actively used, preventing them from being discarded/treated as waste. By increasing the product life time in this way, fewer products need to be produced to fulfill the needs of consumers.

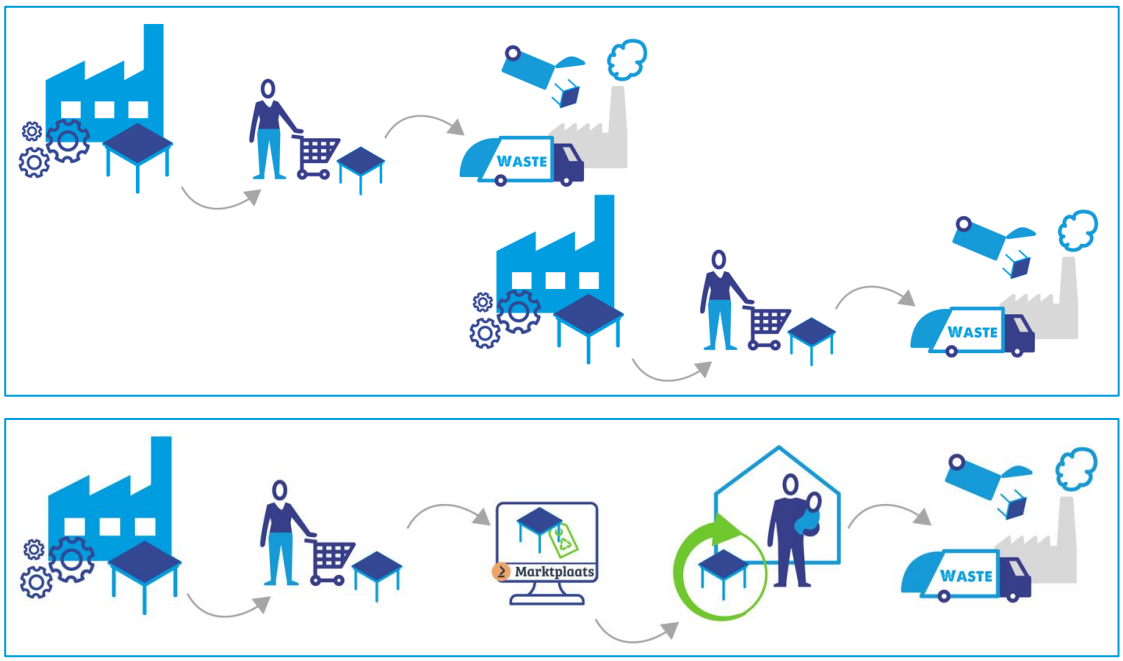
For example, when buying a new dinner table, a household may choose to discard its old table or sell it on a trading platform. If they decide to sell it to another household which requires a dinner table (e.g. a student moving out), the latter will not have to buy a newly produced table. By facilitating these sort of transactions, Marktplaats plays a role in avoiding the production of new goods, as well as the waste treatment of discarded goods (the end-of-life stage).

Since both the production and end-of-life of products[7] contribute to climate change and other environmental impacts, extending the life cycle of products (i.e. extending the time during which a product provides its useful function to consumers) helps to reduce climate change impacts. Figure 4 illustrates this principle; by extending a product's life time, fewer products need to be produced to offer the same functionality[8].

[7] In many cases the use phase also contributes to climate change (e.g. in the case of electric equipment or fuel-consuming products). However, in this analysis the use phase is not considered; regardless of whether consumers buy new or second-hand products, the use phase impacts is estimated to be comparable. See also Section 4.1.

[8] The implicit assumption made here is that second-hand trades directly replace sales of new products; in the absence of Marktplaats, consumers would buy newly manufactured products. This is in line with other studies, as evidenced by the literature review by (Fortuna & Diyamandoglu, 2017). However, this is a simplification (as consumers may not want to or may not be able to buy the new product), as discussed in Section 4.1.

Figure 4 - Comparison of the 'linear' and 'circular' or reuse models from production to end-of-life



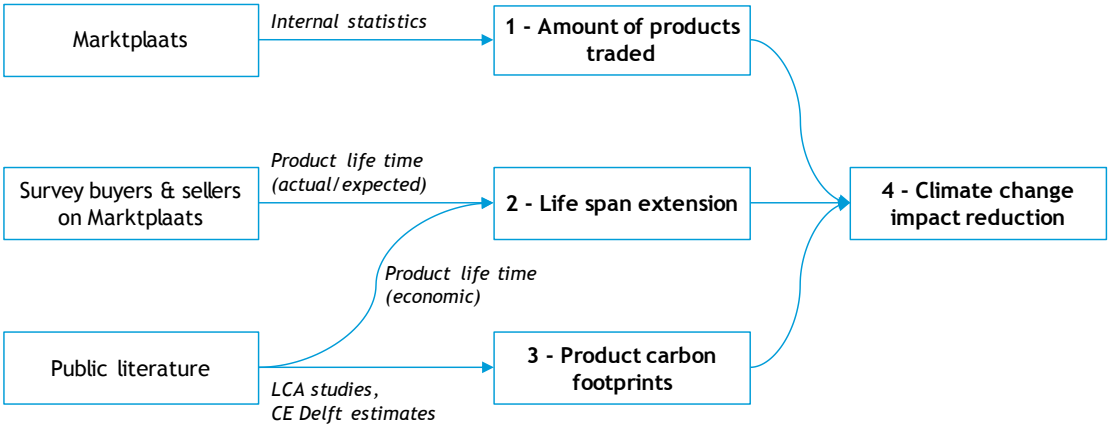
It should be noted that second-hand products may not offer the same life time as new products. For example, they may be slightly damaged or become dated more quickly. For this reason, second-hand products may reach their end-of-life more quickly than newly manufactured products. It is therefore important to not simply assume that one traded product replaces one newly manufactured product, but to carefully consider the **life time extension** achieved by trading. Furthermore, note that the life time extension may differ strongly between product groups (some goods may go out of fashion more quickly than others, for example).

2.2 Analysis overview

The analysis is carried out in four steps (also visualised in Figure 5), which are the subject of the subsequent sections:

1. Establishing the **amount of products traded** in selected subcategories (Section 2.3).
2. Determining the expected **life span extension** (Section 2.4).
3. Estimating the **carbon footprints** of selected product subcategories (Section 2.5).
4. Estimating the **total climate change impact reduction** (Section 2.6).

Figure 5 - Methodology overview



2.3 Amount of products traded

Marktplaats uses a system of 36 product categories and many more subcategories to facilitate trading. This analysis focuses on a selection of 15 subcategories from four overarching categories, as shown in Table 1. Electronics was selected as a category as it contains complex and valuable products which often have short use times by consumers. Furniture includes relatively large and heavy products with potentially very long life spans. Clothing is traded in very large volumes on Marktplaats, is (typically) used for relatively short periods, and has a high carbon footprint per kg of material. Finally, the category of children and baby products can potentially be traded in large volumes due to the short use time by consumers.

These categories also match with three of the four focus products in the transition agenda consumer goods of the Dutch government (which are furniture, textiles, electrical equipment, and packaging and single-use products (IenW; EZK, 2018)).

Table 1 - Overview of selected categories and subcategories

Category	Subcategory
Electronics	Loudspeakers
	Mobile telephones
	Laptops
Furniture	Couches
	Tables
	Beds
	Box-springs
Clothing	Trousers
	T-shirts
	Tops
	Jeans
	Shoes
Children and babies	Strollers
	Beds and cribs
	Car seats

For the relevant subcategories, Marktplaats provided internal data on the number of 'connections' established between buyers and sellers in 2018. The amount of connections provides an indication[9] of the number of products traded on Marktplaats within a (sub)category. This data is therefore used as a proxy for the amount of trades per subcategory in 2018.

Based on the overview of connections provided by Marktplaats, the selected subcategories cover approximately 12% of the total number of trades conducted in 2018.

2.4 Estimated life span extension

The life span extension achieved by trading on Marktplaats is calculated by comparing the estimated life span of traded products to standard product life spans. The latter is based on the economic life as used for instance by insurance companies. The former, the estimated life span of traded products, is derived from a survey held among Marktplaats buyers and sellers.

Determining the life span of products traded on Marktplaats

The survey, conducted by Markplaats in early 2019, was held among (potential) sellers and buyers[10] of the subcategories included in this study (Table 1). Respondents were asked a number of questions in connection to selling and purchasing an item. In total, 1,656 surveys were received (650 for buyers and 1,006 for sellers). The answers on questions related to the age of a product (at the time of trade) and the (expected) use time after the trade were used to determine the estimated life span extension of the products.

A first analysis of the survey results showed that both the age at trading and the expected use time were unusually high due to outliers. Outliers are observations that do not seem to fit in with the others. The presence of these outliers in de dataset for clothing may be because respondents take into account the time clothing spends in closets (unused). Because the time in the closet does not create an life span extension, we want to leave this out of the analysis. Secondly, for furniture, a few respondents indicated a singnificantly higher life span compared to others, which could be due to vintage furniture. To avoid overestimating the influence of second-hand trading, we have decided to remove these higher values (outliers). This will result in a lower estimate of the life span extention. The outliers were identified using the interquartile range method and removed.

The results, after removing outliers, are shown in Table 2. We assume that the seller can best estimate the age of the product and the buyer can best estimate the life span after buying the product. Hence, we use the Equation 1 to estimate the total life span.

[9] Marktplaats facilitates trade between consumers by connecting sellers and buyers, but is only occasionally involved in the actual (financial/physical) exchanges (only with the Gelijk Oversteken Service/Equal Crossing Service). It is therefore not able to monitor when specific items are sold (or at what price). Based on client surveys and the number of messages sent between sellers and (potential) buyers on Marktplaats, the number of connections provides an indication of the amount of products traded.

[10] Business-to-consumers traders were excluded; only consumer-to-consumer sales were included. Nevertheless, the total amount of surveys still includes the nine business-to-consumer trader surveys.

Equation 1

$$Expected\ life\ span = Age\ at\ time\ of\ sale\ (indicated\ by\ seller) + Life\ span\ after\ buying\ (expected\ by\ buyer)$$

Results show that the total life span after Marktplaats trade is 14.2 years for eletronics, 17 years for furniture, 8.6 years for clothing and 7.3 years for children and babies (Table 2).

Table 2 - Estimated life span (extension) by buyer and seller in year. Number of outliers removed from analysis shown in brackets

		Electronics	Furniture	Clothing	Children and babies
Seller	Age of product	7.9 (23 outliers)	8.3 (29 outliers)	4.0 (22 outliers)	4.8 (16 outliers)
	Expected life span after selling	9.8 (15 outliers)	9.5 (29 outliers)	5.8 (23 outliers)	5.3 (23 outliers)
	Total life span	18.0 (24 outliers)	17.4 (32 outliers)	10.2 (21 outliers)	11.3 (14 outliers)
Buyer	Estimated product age	3.7 (23 outliers)	3.3 (26 outliers)	1.5 (33 outliers)	2.0 (19 outliers)
	Expected life span after buying	6.3 (21 outliers)	8.7 (18 outliers)	4.6 (21 outliers)	2.5 (28 outliers)
	Total life span	13.1 (16 outliers)	12.9 (25 outliers)	6.1 (31 outliers)	5.3 (17 outliers)
Expected life span (Equation 1)		**14.2**	**17**	**8.6**	**7.3**

Comparison with economic life span

The economic life span of a product is based on life span of products determined by Dutch insurance companies. These insurance companies publish a depreciation list, on which the economic life span is indicated. The economic life span is the time during which a product is expected to be (economically) usable for the purpose it was acquired. We use data of AEGON and ABN Amro regarding the economic life span for the different product subcategories (Table 3). The average economic life span for the category electronics, furniture, clothing and category children and babies is 5.4, 12.1, 3 and 4.5 years respectively.

Table 3 - Selected life span values for the studied product subcategories

Category	Subcategory	Economic life span[11] year	Expected life span (corrected using literature) year	Estimated life span extension year	Life span extension factor
Electronics	Loudspeakers	8.7	14.2	5.5	1.6
	Mobile telephones	3.0	4.0	1.0	1.3
	Laptops	4.5	6.5	2.0	1.4
	Average[a]	**5.4**	**6.7**	**1.3**	**1.4**
Furniture	Couches	11.7	17.0	5.3	1.5
	Tables	13.4	19.4	6.1	1.5
	Beds	9.7	14.1	4.4	1.5
	Box-springs	12.0	17.4	5.4	1.5
	Average[a]	**12.1**	**17.0**	**4.6**	**1.5**

[11] Based on an average resulting from the depreciation list of (ABN AMRO, 2019) and (AEGON Schadeverzekering N.V., 2019).

Category	Subcategory	Economic life span[11] year	Expected life span (corrected using literature) year	Estimated life span extension year	Life span extension factor
Clothing	Trousers	3.3	4.7	1.4	1.4
	T-shirts	2.5	3.5	1.0	1.4
	Tops	3.3	4.3	1.3	1.4
	Jeans	3.3	4.7	1.4	1.4
	Shoes	3.0	4.3	1.3	1.4
	Average[a]	**3.0**	**4.3**	**1.5**	**1.4**
Children and babies	Strollers	5.0	8.2	3.2	1.6
	Beds and cribs	4.3	7.1	2.8	1.6
	Car seats	4.0	6.6	2.6	1.6
	Average[a]	**4.5**	**7.4**	**2.9**	**1.6**

a) Values are averages for the selected products within a category, weighted by the number of connections in 2018.

Based on the survey, on average a electronic device last times 2.6 longer than the economic life span, a piece of furniture 1.5 times, a piece of clothing 2.4 times and a product in the categorie children and babies last 1.6 times longer when traded through Marktplaats.
Note that the survey was carried out for each *category*, e.g. clothing, in general, without distinguishing the specific products. Therefore, it yielded a single value for the expected life span. Since in reality not all products are expected to last the same amount of time (see e.g. the economic life span), we applied a correction to distinguish different clothing types.

In addition, another correction was applied to electronical devices and clothing.
As mentioned before, a piece of clothing lasts 2.4 times longer than the economic life span. Comparing these values to (scientific) literature, these results appear to be too high. Clothing is known to be used for an average of approximately 3.1 years (Laitala & Klepp, 2015) and discarded after lying in a wardrobe for about 2.8 years (WRAP, 2016). Therefore we decided to express the life span of clothing by its active use time (time that the garment is actively worn and washed). The discarded time after lying in a wardrobe (3.1 years) is substracted from the indicated age of the clothing by sellers (4.2 years, see Table 2), resulting in an active use time by sellers of 1.4 years. For the buyers the active use time of 3.1 years was taken instead of the expected life span after buying by the buyers (4.6 years, see Table 2). With this correction clothing traded through Marktplaats lasts 1.5 years longer than the economic life span.

Another corection was applied to the electronical category. According to the survey results, devices should last 2.6 longer than the economic life span if traded through Marktplaats. For mobile telephones and laptops that have an economic life span of 3 and 4.5 years respectively, the expected life span would be 7.9 and 11.8 years. These values seem too optimistic. In some cases this long life may happen but for an average this is not credible. Smart phones are known to be used for an average of approximately 2.5 years. Laptops for 5 years (Consumentenbond, 2016). For these two categories the results from the questionnaire could not be used in this research. Therefore we decided to estimate conservatively the life span extension with help of the other products results.
A conservative factor 1.4 for laptops and a more conservative factor of 1.3 for smartphones which are a real fashion article. This results in a life span extension of 1 year for mobile telephones and 2 years for laptops. This results in a total expected life span of 4 years for mobile telephones and 6.5 for laptops. For loudspeakers no correction was applied.

The results of the estimated life span extension in years are shown in Table 3. In addition, a life span extension *factor* is included, which is derived based on Equation 2. The life span extension factor indicates the time that the products are used longer if traded through Marktplaats. The average life span extension factor for electronics is different for the three devices: 1.3 for mobile telephones, 1.4 for laptops and 1.6 for loudspeakers. On average this results in a life span extension factor of 1.4. The average life span extension factor for furniture is 1.5, for clothing 1.4 while for the category children and babies it is 1.6.

Equation 2

$$Life\ span\ extension\ factor = \frac{Expected\ life\ span}{Economic\ life\ span}$$

2.5 Product carbon footprints

In this step we derive estimates for the carbon footprint of the products included in the selected subcategories. When Marktplaats extends the life span of products (see Section 2.4), fewer products are needed in total, which means this carbon footprint can be avoided.

For each product subcategory, we derive an estimate of its *carbon footprint*. Carbon footprints, derived in LCAs, express a product's contribution to climate change. Carbon footprints generally include the impact of all material and energy inputs, emissions and wastes generated during the life cycle.

In this analysis, we use carbon footprint data covering the production stage (e.g. the extraction of raw materials, transporation, conversion into a final product, etc.) and its end-of-life (e.g. incineration, recycling, etc.). This means the impact of the use phase (e.g. electricity consumption) is not included, as we assume it is not influenced by the existence of second-hand trading. Similarly, transport to/from the point of sale is not included.

The carbon footprints used in this study are shown in Table 4. They are derived from various public literature sources, and supplemented by analyses by CE Delft where required. The values are indicative; since they are derived from different sources there can be differences in the specific LCA method applied (e.g. different methodological choices or background data used). Furthermore, they are generally based on product *proxies*, meaning a specific product is selected as it is considered representative for all products in the subcategory. For example, a single table for which good environmental impact data is available is considered representative for all tables traded on Marktplaats. Given the overall goal of the study (Chapter 1) and other uncertainties in this study (see also Section 4.1), this approach is considered to strike an appropriate balance between accuracy and research effort.

Table 4 - Selected carbon footprint values for the studied product subcategories

Category	Subcategory	Carbon footprint[a] kg CO_2-eq./item	Source/remarks
Electronics	Loudspeakers	35	CE Delft estimate. Assumptions: weight of 4 kg, composed of MDF (55%), steel (15%), copper (15%) and permanent magnets (15%). Modelled using Ecoinvent data (Ecoinvent, 2016).
	Mobile telephones	39	Rounded average of different phone LCAs (CE Delft, 2018).
	Laptops	300	Rounded average of different laptop LCAs (CE Delft, 2018).
Furniture	Couches	66	Production (cradle-to-gate) based on (FIRA, 2011). Simplified estimate for end-of-life carbon footprint added by CE Delft, based on the carbon footprint breakdown in (FIRA, 2011). Assumptions: treated in Dutch waste incinerator with energy recovery; Materials: Timber & board modelled as medium density fibreboard, Foams & fillings as polyvinylchloride, Textiles as polyethylene terephthalate, Metal as steel, Plastic as high density polyethylene.
	Tables	23	
	Box-springs	26	
	Beds	72	Production (cradle-to-gate) based on dining tables (FIRA, 2011). Simplified estimate for end-of-life carbon footprint added by CE Delft, based on the carbon footprint breakdown in (FIRA, 2011). Assumptions: weight of the bed frame is 44.4 kg (based on IKEA bed frames), end-of-life added to ratio of the weight of the bed.
Clothing	Trousers	18	CE Delft estimate. Assumption: 300 g, pure cotton. Impact of fibre based on Ecoinvent database (Ecoinvent, 2016), using the *Cotton fibre {GLO}| market for* dataset. Other production steps (e.g. fabric production, cutting, packaging) assumed equal to jeans (Levi Strauss & Co., 2015).
	T-shirts	1.5	Assumption based on literature. Reported values range from about 1.1 to 1.8 kg CO_2-eq./shirt, excluding consumer use (Roos, et al., 2015) (Cartwright, et al., 2011) (Continental, 2009).
	Tops	1.5	Carbon footprint assumed equal to t-shirts.
	Jeans	20	Literature value reported by jeans producer (Levi Strauss & Co., 2015). Includes climate change impact of fibers, fabric production, cut, sew & finish, sundries and packaging, transport, logistics & retail and end-of-life. The use phase (consumer care) is reported but not taken into account here.
	Shoes	10	Assumption based on literature. Reported values for different shoe types range from about 3 to 40 kg CO_2-eq./pair (Cheah, et al., 2012) (Gottfridsson & Zhang, 2015) (Muñoz, 2013).
Children and babies	Strollers	321	Carbon footprint based on (Ang & Yifan, 2012).
	Beds and cribs	40	CE Delft estimate. Assumed to weigh 25 kg (based on IKEA child beds) and have a similar material composition as tables (FIRA, 2011).

Category	Subcategory	Carbon footprint[a] kg CO_2-eq./item	Source/remarks
	Car seats	31	CE Delft estimate. Assumptions: weight of 7.5 kg, composed of PET textile (20%), PUR foam (40%), steel (20%) and ABS (20%). Modelled using Ecoinvent data (Ecoinvent, 2016).

a) The carbon footprints reported here cover the production and end-of-life phases of the products. The consumer use phase has been excluded.

2.6 Climate change impact reduction

Main results for selected subcategories

We estimate the total climate change impact by combining the number of trades, life span extension and carbon footprint for each of the studied subcategories. This is done based on Equation 3, as shown below.

Equation 3

$$Climate\ change\ impact = \sum_{x} (Trades_x * (Life\ span\ extension\ factor_x - 1)\ * CF_x)$$

Where:

Climate change impact	=	The total climate change impact reduction achieved by trades in the selected subcategories, expressed in CO_2 equivalent (eq.).
$Trades_x$	=	Number of trades of products from subcategory x on Marktplaats in 2018.
Life span extension $factor_x$	=	Factor expressing the life span of a product from subcategory x traded on Marktplaats compared to its economic life span (dimensionless), see Equation 2.
CF_x	=	Carbon footprint, the climate change impact of the production and end-of-life of a product from subcategory x.

Extrapolating results for entire categories and for Marktplaats as a whole

Finally, in order to be able to provide an indication of the climate change impact reduction for the entire product category (not just the selected subcategories) and for Marktplaats as a whole, two extrapolation steps are taken.

First, to estimate the reduction for entire product categories, we mark all subcategories that are not included in the main analysis but are somewhat similar to the studied subcategories, e.g. in terms of the materials used and production process. For example, we note that dresses (not included) are similar to t-shirts (included) and that sidetables (not included) are similar to tables (included). Where required, a (conservative) correction factor is applied. For example, since sidetables are smaller, a correction factor of 0.5 is used.

Based on the number of connections per subcategory and taking into account the correction factor, we estimate the climate change impact reduction for all products similar to the selected products. However, this method could not be used for all products in these

categories. For example, none of the products with a known carbon footprint (see Table 4) in the category furniture are comparable to lamps.

Secondly, to give a (very) rough estimate of Marktplaats as a whole, we calculate the average climate change impact reduction per connection based on the included products. By assuming this reduction is comparable for all Marktplaats trades, we derive an estimate for Marktplaats as a whole.

Note that since both these steps introduce significant additional uncertainties, their results are only intended to give a rough idea of the overall environmental benefit of second-hand trading facilitated by Marktplaats in the Netherlands today.

3 Results

In this section, we first show the results for the selected (15) products, then discuss what the overall impact of Marktplaats could be and finally interpret the results and put them into context.

Main results (15 product subcategories)

For the selected subcategories, Table 5 summarises the main data underlying the analysis, as well as the overal climate change impact reduction.

Table 5 - Climate change impact reduction of Marktplaats in 2018 for 15 selected product subcategories

Category	Number of trades via Marktplaats Amount, 2018	Life span extension factor	Carbon footprint[a] kg CO_2-eq./item	Climate change impact reduction ktonne CO_2-eq.
Electronics	1,259,367	1.4	81	43
Furniture	939,331	1.4	47	18
Clothing	1,621,150	1.5	10	8
Children and babies	521,668	1.6	156	52
Total (15 subcategories)				**80-140[b]**

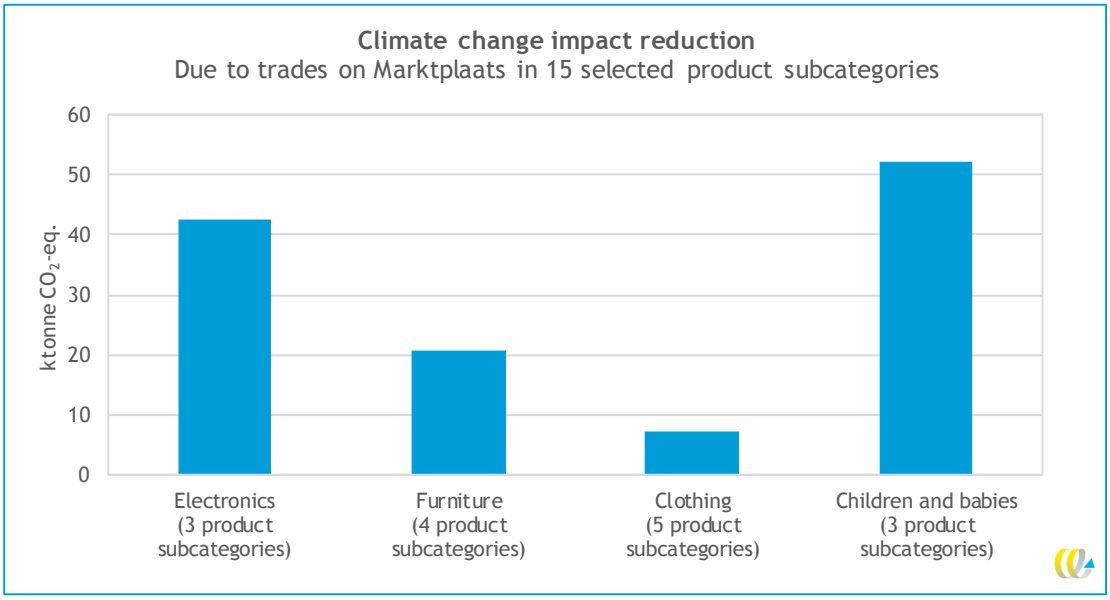
a) Values are averages for the selected products within a category, weighted by the number of connections in 2018.

b) Note: this is not the sum of the values listed per category due to the uncertainties in the study (Section 4.1)

The result per subcategory is shown visually in Figure 6. The estimated climate change impact reduction is about 43 kilotonne (ktonne[12]) CO_2-eq. for electronics, 21 ktonne CO_2-eq. for furniture, 7 ktonne CO_2-eq. for clothing and about 52 ktonne CO_2-eq. for children and babies. As this is a first approximation, the limitations and uncertainties of the analysis (discussed in greater detail in Chapter 4) should be kept in mind when interpreting these results. Given these uncertainties we estimate that the total climate change impact reduction (for the 15 selected product subcategories) may lie in the range of 80 to 140 ktonne CO_2-eq.

[12] One kilotonne equals one million kilogram.

Figure 6 - Approximate climate change impact reduction due to trades on Marktplaats in 2018 for 15 selected product subcategories, 2018



Estimates for entire product categories and Marktplaats as a whole

We now expand our scope beyond the 15 product subcategories and consider the entire categories (electronics, furniture, clothing and babies and children), by taking into account all similar products (see 'Extrapolating' in Section 2.6). Based on the number of connections for the similar products (and the included correction factors), the results for electronics are multiplied by 1.2, those for furniture by 2.5, those for clothing by 2.6, and those for children and babies by 1.7.

As shown in

Table 6, the climate change impact reduction for the entire product categories are about 52, 52, 19, and 88 ktonne CO_2-eq., respectively for electronics, furniture, clothing and children and babies, *assuming the reduction per product traded is comparable for similar products*. The total is estimated at 150–260 ktonne CO_2-eq. in 2018.

Table 6 - Climate change impact reduction of Marktplaats in 2018 for entire product categories, assuming the reduction is comparable for all products traded in a category

Category	Number of trades (selected subcategories) Amount, 2018	Number of trades (incl. similar products, corrected) Amount, 2018	Extrapolation factor (compared to Table 5)	Climate change impact reduction (incl. similar products) ktonne CO_2-eq.
Electronics	1,259,367	1,533,389	1.2	52
Furniture	939,331	2,385,730	2.5	52
Clothing	1,621,150	4,254,042	2.6	19
Children and babies	521,668	879,331	1.7	88
Total				**150-260**

If we go one step further and assume that all trades made on Marktplaats result in a comparable reduction (of 25 kg CO_2-eq. per trade[13]), we can estimate the total climate change impact reduction of trading on Marktplaats. Since the 15 subcategories cover about 12% of all trades on Marktplaats, the total volume of trades is about 8.4 times larger. Based on the result of 80–140 ktonne CO_2-eq. of climate change impact reduction for the selected products (Table 5), a rough estimate for the entirety of Marktplaats would be a reduction in the range of 600 to 1,000 ktonne CO_2-eq. in 2018. Due to the large diversity of products traded on the platform, ranging from stamps to cars, these figures can only be viewed as a first indication the order of magnitude of Marktplaats' influence.

Note that this environmental benefit could be substantially larger if more people were to use Marktplaats to sell old products and buy second-hand products. At present, only a part of the Dutch citizens use Marktplaats to fulfill all their product requirements, while many others use the platform incidentally or not at all.

Interpretation

To put the results derived here into context, we focus on the main finding of 80–140 ktonne CO_2-eq. for the 15 selected products. The magnitude of this reduction is equal to the climate change impact of the annual electricity use of about 65,000 to 110,000 Dutch households[14]. The findings can also be compared to the climate change impact of an average Dutch consumer's purchases of consumer goods, which was previously estimated at about 2,700 kg CO_2-eq./year (CE Delft, 2018). The climate change impact reduction due to trading in the 15 subcategories (80–140 ktonne CO_2-eq.) thus amounts to the annual impact of the consumer goods purchases of about 30,000 to 50,000 consumers. These numbers increase proportionally when the estimates for the entire categories (150-260 ktonne CO_2-eq.) or the entirety of Marktplaats are considered (600-1,000 ktonne CO_2-eq.).

For the studied categories this study estimated that the lifespan of products can be extended by 40 to 50%. If this is true for consumer goods in general, the environmental impact per year of using consumer goods can be lowered by about a third through second-hand trading. As mentioned in the Introduction, the climate change impact of producing consumer goods was previously estimated at 43 megatonnes of CO_2-eq. A reduction of a third would thus amount to about 14 megatonnes of CO_2-eq. This shows that the the current climate change impact reduction of Marktplaats is only a fraction of the theoretical potential, and that the environmental benefits of second-hand trading can still be expanded.

As shown in Table 6, the climate change impact reduction the entire product categories electronics, furniture, clothing and children and babies are respectively 52, 52, 19, and 88 ktonne CO_2-eq.To put these results into perspective:

- the climate change impact of the category electronics (52 ktonne CO_2-eq.) is comparable to the production of circa 1 milion mobile phones;
- the climate change impact of the category furniture (52 ktonne CO_2-eq.) is comparable to the production of circa 1 milionmilion tables;
- the climate change impact of the category clothing (19 ktonne CO_2-eq.) is comparable to the production of circa 0.4 milion jeans;

[13] Average reduction across the 15 studied subcategories, weighted by the number of connections.

[14] Based on an annual electricity use of 3,000 kWh and a carbon footprint of 0.41 kg CO_2-eq./kWh (www.co2emissiefactoren.nl).

- the climate change impact of the category children and babies (88 ktonne CO_2-eq.) is comparable to the production of circa 0.2 milion strollers.

4 Discussion and conclusion

4.1 Uncertainties and limitations

The analysis presented here is a first estimate of the environmental impact of trading on Marktplaats. Due to the complexity of the topic, it is not straightforward to estimate Marktplaats' influence and a number of assumptions were required. In this section, the most important uncertainties and limitations are discussed.

Each product traded on Marktplaats was assumed to replace a newly manufactured product (corrected for estimated life span extension). This does not always need to be the case, however, since buyers may not be willing or able to buy a new product if they cannot find it on second-hand markets. In the survey, buyers were asked what they would have done if they had not bought the product on Marktplaats. About half of them indicated that they would have bought a newly manufactured product, while half of them indicated they would not have bought the product at all. Similarly, not all sellers would have discarded the product if they had not been able to sell it on Marktplaats. Although the responses on such questions differed strongly per product category[15], this indicates that the main result may overestimate the climate change impact reduction achieved through trading on Marktplaats. However, it can be noted that the survey reached people who are already active on Marktplaats. In other consumer groups, the amount of people who would buy new products/discard products without considering second-hand trade, are likely higher.

The life time extension may be over- or underestimated. The life time extension is not straightforward to assess due to a number of reasons:

1. The economic life span of a product does not indicate the time that products are normally used before being discarded. Nevertheless it is the best available indication of the real lifetime of products.
2. Only traders active in the selected subcategories were selected for the survey. This could create a bias when scaling the results to the entire category or the entirety of Marktplaats, if the life span of these products is lower/higher than average.
3. Products can be possessed without being actively used, which will extend their life span while not offering any useful function. This may create a bias in the survey results on life time extension. This effect may be especially strong for clothing, which can be stored without taking up much space. Because the shelf life does not degrade the product, we decided to substract this from the life span using literature.
4. The survey data may not reflect the real or expected life span (extension). According to the so-called endownment effect, people tend to value things more highly when they already own them. This could have an effect on the estimated age at time of sale (indicated by seller) and the life span after buying (expected by buyer).
5. The survey data on life span was influenced by outliers: life span estimates that were much higher than the others. These outliers were removed from the results in order to avoid overestimating the effect of Marktplaats trading (e.g. due to vintage furniture which may not be representative for second-hand trading in general).

[15] For buyers of electronics, about 70% of respondents indicate they would have bought a newly manufactured product, while this percentage was 55% for the babies and children category, 41% for furniture, and 36% for clothing.

6. Most of these uncertainties could have a positive as well as a negative influence on the estimated life span of products. Therefore it is not possible to determine whether the results are too high or low. Where it was possible (i.e. for numbers 3 and 5 above) we decided to use conservative data. In this way we tried to prevent overestimating the (extended) life span of products.

The analysis relies on proxy products and estimates. As noted in Section 2.5, the carbon footprints for the subcategories are often derived from a specific proxy product, meaning we assume this product (and its carbon footprint) is representative for all products in the subcategory. In reality the carbon footprint will vary from product to product, although the extent of variability will differ per subcategory. For example, the impact of wooden dinner tables will differ from tables made from steel and glass. Furthermore, rough estimates were used in assessing the environmental impact of the end-of-life of furniture.

However, in this analysis it was not feasible to use more precise carbon footprint data, since the survey (used to estimate life span extension) and the number of Marktplaats connections (used to estimate trade volume in 2018) also do not distinguish between more specific subgroups of products (e.g. steel and wooden tables). Nevertheless, the use of proxies introduces uncertainty, meaning the main results of the analysis may be over- or underestimating the impact reduction of Marktplaats trading. To minimise this risk, where possible market average carbon footprints (or averages from multiple products) were used (as described in Section 2.5).

Some parts of the life cycle of products have not been studied in depth. Most notably, the use phase by consumers and transportation to/from a purchasing location were not included. For the use phase, second-hand trading may affect the environmental impact in the case of energy-consuming products such as electronics, especially if the energy efficiency of the products changes over time. In this case, extending the life span means that older, less efficient products remain in use instead of newer models. This factor will be especially relevant for products whose use phase dominates the total carbon footprint, and will be minor when the production/end-of-life are more important.

Also for transportation to and from sellers, differences may exist between the 'second-hand' and 'new' models. It is possible that buyers travel further or via different means to a seller when trading on Marktplaats when compared to buying new products in shops. Shops may be more centrally located, facilitating the use of public transport. However, the buyers' survey shows that in about 70-80% of cases, the product was sent to the buyer by mail. Since it is not known to what extent these factors differ between the 'second-hand' and 'new' models, it is not possible to assess whether the current results are overly optimistic or conservative.

The exact number of trades is not known. As mentioned in Section 2.3, the analysis is based on the number of connections between traders, but the actual amount of trades made on Marktplaats could be higher or lower.

Environmental impacts other than climate change have not been considered in this analysis. The LCA method aims to include a wide range of environmental impacts, in order to avoid shifting burdens from one type of impact to another. In this case, only climate change impact was considered due to its high environmental relevance and highest data availability. However, also for other types of environmental impacts, preventing the production and discarding of products is generally beneficial.

Indirect economic and/or psychological effects have not been taken into account. For example, as products traded on Marktplaats tend to be cheaper than new alternatives, consumers may save money by buying second-hand products. This enables them to spend the money on other goods or services, which may offset the climate change impact reduction created by buying second-hand. Similarly, it can be argued that the existence of second-hand markets may increase the amount of goods people buy, as they may find it easy to sell the product (e.g. if it does not meet their expectations). This could result in 'unnecessary' consumption. These effects are considered too indirect to take into account here.

4.2 Conclusions

This study provided first estimates of the climate change impact reduction of consumer trading on Marktplaats. The main results are:

- It is estimated that the life span of products in the electronics, furniture, clothing and children and babies categories traded on Marktplaats is about 1.4 to 1.6 times longer than the standard life spans. When product life spans are extended by 50%, the amount of products required in total to meet consumer needs is reduced by about a third.
- For the 15 selected product subcategories, the climate change impact reduction in 2018 is estimated to lie in the range of 80 to 140 ktonne CO_2-eq., based on the estimated life span extension and the volume of trades on Marktplaats.
- If all products traded on Marktplaats result in comparable climate change impact reductions, the total reduction realised would be in the range of 600 to 1,000 ktonne of CO_2-eq. in 2018. However, given the diversity of products traded on the platform, this estimate is more uncertain.

The report shows that Marktplaats, and second-hand trading in general, already plays an important role in lowering the climate change impact of Dutch consumers and developing a more circular economy. The environmental benefits could be substantially larger if more people were to use Marktplaats to sell old products and buy second-hand products.
If Marktplaats or other second-hand trading platforms can help to increase the life span of all consumer goods, the potential climate change benefits could be in the range of several megatonnes[16] of CO_2-eq. This could make a considerable contribution to the climate change impact reduction targets set by the Dutch government.

4.3 Suggestions

This analysis shows that the current climate change impact reduction of trading on Marktplaats is considerable, but also that its theorerical potential is larger. It would be interesting to use market studies to investigate the maximum potential for second-hand trading. It can be noted here that the survey results for electronics were deemed unrepresentative/too optimistic (as discussed in Section 2.4). This would therefore be a relevant example product category to study further.

In the current Dutch circular economy transition agenda for consumer goods, second-hand trading receives little attention. This first estimate shows that the environmental and circular potential of second-hand trading is large and that there is still considerable room to

[16] The climate change impact of consumer goods were previously estimated at about 2.5 tonne of CO_2-eq. per Dutch citizen (CE Delft, 2018). If the life span of all these products is extended by 50%, about a third fewer products are required in total. For 17 million Dutch citizens, the savings would amount to about 14 megatonnes of CO_2-eq.

expand the environmental benefits. It would be interesting to introduce more policies which stimulate second-hand trading. This would require research into which policy option(s) would be most effective at stimulating second-hand trade.

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