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How cost competitive is a speed pedelec really?

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Executive Summary

The speed pedelec can in many cases be a cheaper and more energy efficient alternative to electric cars for commuters. The balance between purchase and operational costs is definitely different for a speed pedelec than for an electric car. A large part of the total cost of ownership (TCO) is determined by the maintenance and repair costs, which makes the real cost competitiveness of the speed pedelec still unclear. To refine the TCO-calculations, this study presents the preliminary results of a longitudinal study of one year into the maintenance and repair costs of speed pedelec users in Flanders, Belgium.

Keywords: cost, bicycle, light vehicles, BEV, EV

1 Introduction

The modal shift from petrol based vehicles to electric driving is unfolding in Europe. Most think of cars when they think of electric vehicles, but the world of micro-mobility and light electric vehicles offers a whole bunch of vehicles offering similar mobility in a more energy-efficient and cost competitive way [1]. The speed pedelec (SP) is such an alternative. A SP is a fast electric bicycle with a maximum continuous rated power of 4 kW and a maximum pedal assisted speed of 45 km/h [2]. Technically they are classified as cycles designed to pedal in the L1e-B category of the EU Regulation No 168/2013 [3]. With a reduced weight (max. 35 kg) and similar drive train technology, the lower primary energy use per kilometre of this vehicle compared to regular EVs, is unquestionable [4]. With a range up to 80 km in some cases [5], it can provide the necessary assistance power for an average commuter in Flanders, Belgium to reach cruising speeds above 35 km/h in all weather conditions. But on the matter of cost competitiveness, the situation is yet to be clarified.

In the USA, a different classification is used towards electric bicycles. No federal framework exists, but most states do use a similar structure of three classes of electric bicycles. The first class is comparable with the European pedelec (i.e. electric pedal assisted bicycles with a 250 W max. continuous rated motor power and a 25 km/h max. pedal assisted speed [3]), as it only provides motor assistance when pedalling up to 20 mph (32 km/h), which is higher than the maximum 25 km/h allowed in the EU. The second class electric bicycle is equipped with a motor which can propel the bicycle up to 20 mph, without the requirement of pedalling. This class is similar to the L1e-A class defined in the European legislation. These are known in Belgium as motorised cycles (i.e. electric cycles designed to pedal with a 1 kW max. continuous rated motor power and a 25 km/h max. pedal assisted speed) [3]. Finally, the third class of electric bicycles comes closes to the Belgian and European definition of the SP. This type of electric bicycle can provide motor assistance up to 28 mph (45 km/h), provided the cyclist pedals. In addition to the difference in classification, there is also a variation in legislation on licensing, operation and helmet requirement from state to state [6].

Previous work by the authors on the total cost of ownership (TCO) of SP suggested that money could be earned while riding a SP because of bicycle allowance [7], but much hinges on the cost of maintenance and the repair of broken parts [8]. As data regarding repair costs caused by accidents or wear are not centrally collected, the cost of repairs and maintenance is still uncertain. Some manufacturers collect data themselves (personal communication with manufacturers), as this provides important strategic information and is therefore not easily shared.

From time to time, media reports on accidents with SPs, mostly when a third party is involved [9], but no structural registration is done. Single bicycle accidents, where no third party is involved [10], are seldomly reported, as in most cases, there is only no to slight damage to the vehicle and/or rider. Examples are slipping with the vehicle, crashing into objects, falling due to certain manoeuvres. To the best of the authors' knowledge, no data record is kept on both third party and single bicycle crashes. Data on casualties with SPs in Belgium however, is collected by Statbel [11]–[16]. Similar to the registration numbers [17], the casualty numbers of SPs are on the rise in Flanders as shown in Table 1.

Table 1: Road casualties numbers of SPs in the last 5 years in Flanders

Statbel data	2017	2018	2019	2020	2021
# SP road casualties[1]	15 [14]	90 [12]	207 [13]	197 [15]	323 [11]
Total registered SPs in Flanders [17]	5,560	15,492	18,805	32,751	48,404

Collecting data on both these third party crashes and single bicycle crashes will provide more information on the frequency of these accidents and the cost they carry over the total cost of the vehicles. This would provide information for users and policymakers on the risks associated with using a SP.

In terms of the cost regarding maintenance and repair due to wear and tear, previous studies surveyed the bicycle repair shops to no avail [8], [18]. Only general numbers were available and provided, based on experience in the business and generalisations. This study will therefore attempt to clarify the role of maintenance- and accident-related costs within the TCO-calculation by surveying SP users on a longitudinal basis over a period of one year. By doing so, we will determine more clearly how cost competitive the SP really is. This paper reports on the preliminary results a longitudinal study, surveying participants from October 2022 up to February 2023.

2 Methodology

This study adopts a longitudinal approach to help clarify the costs associated with the ownership of a SP. A total cost of ownership consists of three groups of costs: purchase costs, operational costs and non-operational costs. The determination of these costs were performed in previous work [8], [18]. For clarity the main structure will be repeated in this paper here. Then, the approach towards the longitudinal study is explained.

2.1 TCO calculation

The TCO calculation is determined by three types of costs, as aforementioned. Following sections will describe these costs shortly.

The **purchase costs** are the costs that are associated with the acquirement of the vehicle, being either by a purchase, by leasing, a company SP or a loan. For the former, the initial purchase price with the charging adaptor is taken into account. The necessary accessories are included in the initial purchase, as well as the obligatory helmet and license plate. The current purchase cost of such license plate is €30 [19]. The purchase price of €5650 was previously determined, based on the market study of 131 models of 17 different brands in 2021. The monthly leasing prices, which includes all costs except the accessories, such as cycle bags, is based on market research of different leasing companies. The purchase costs for Internal Combustion Engine Vehicles (ICEVs) and EVs are taken from literature, as discussed in previous work [8].

The **operational costs** are the costs related to the use of the vehicle. For the electric vehicles (i.e. SP and electric car), these costs are the charging costs. The calculation of these operational costs over the total ownership of the vehicle requires information on the price of electricity, which can vary monthly (e.g. €0.7/kWh in October 2022, €0.59/kWh in November 2022, €0.57/kWh in December 2022, €0.5/kWh in January 2023 and €0.4/kWh in February 2023[20]), on the driving efficiency of the vehicle and on the distance travelled during the total period. The values for these parameters were previously determined (i.e.

[1] Only in Flemish region, so not including Walloon or Brussels region.

the efficiency, cost of electricity) and the commuting information of the specific persona (total kilometres travelled during ownership) [8].

The **non-operational costs** are the remaining costs, which are split up into four categories, being: benefits, insurance costs, leasing costs and maintenance costs. The benefits in the case of SPs are primarily the bicycle allowance, which is a tax-free allowance paid by the employer to the employee per kilometre travelled. The maximum tax-free amount is currently 0.27 €/km [7]. Civil liability insurance is not obligatory, but advisable for a SP. Both the insurance costs and the leasing costs were based on previous work and literature. The reader is directed to the earlier work of the authors for a more detailed description [8], [18].

The maintenance costs were earlier determined by surveying 36 Flemish bicycle dealers. Three aspects were identified as the main contributors to maintenance: standard check-ups, replacement of parts and the replacement of the battery. General numbers on when these maintenances occur were established. However, these numbers were mostly based on data provided by the manufacturers on when a component should be replaced to ensure optimal performance. This resulted in a very high maintenance cost over the total ownership. This is because the assumption was made that a user would replace parts or have the vehicle serviced without those parts being worn out or broken. The frequency in time or kilometres at which these servicing or replacements took place was determined by the general values given by the cycle repair shops or manufacturers. Common knowledge however learns that users do not have knowledge of those expiry periods or maximum amount of kilometres, and use their vehicles until some parts are worn out or break. Further research into the maintenance occurrence and cost was thus warranted and the set-up using the longitudinal approach and approaching users on a personal level to determine their actual maintenance costs is explained in the following section.

2.2 Longitudinal approach to determining non-operational costs

To reach current SP users, a recruitment survey was launched with Qualtrics via an open call on social media platforms (i.e. Facebook, Instagram, LinkedIn). The researchers used personal contacts and contacted specifically the members of the 'SP Vlaanderen' group, an online group for SP users. This recruitment approach is therefore biased towards active and engaged speed pedelec users. In this survey, the participants were asked about their ownership of a SP, the way of acquirement, the purchase price, battery size, model, maintenance habits, cost of accessories, commuting behaviour, bicycle allowance and insurance. At the end of the recruitment survey, the respondents of the survey were asked if they would participate in the monthly follow-up in which the maintenance costs were tracked over a period of one year. Participation was voluntary and without any compensation. The mail address of each respondent willing to participate in the monthly follow-up was asked and used as identification during each month. The monthly survey asked the respondents about their current SP, if this had changed since last month and if applicable why, their daily commuting distance that month, the amount of days commuting with a SP in the last month, the total bicycle allowance acquired that month.

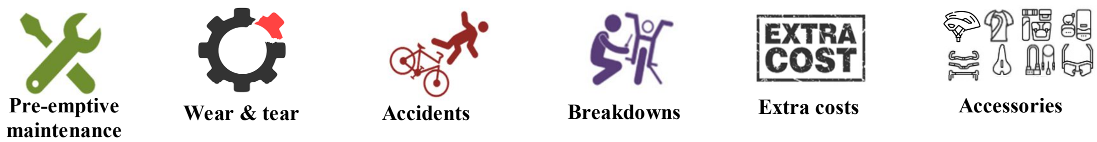

Figure 1: Categories of costs surveyed within longitudinal survey

The participants were, within the context of the longitudinal survey, not only surveyed on their maintenance costs, but also on other costs closely related to the maintenance costs. The survey makes six distinctions as can be seen in Figure 1, being pre-emptive maintenance, costs as a result of wear and tear, costs due to accidents, cost associated to breakdowns, extra costs and costs of extra accessories. More in detail: the respondents were surveyed about the amount of and what **pre-emptive maintenance** that was performed during the past month, who performed that certain maintenance at what cost. The respondents were also asked which components were replaced due to **wear and tear**, by who this was done at what cost. They were asked each month if they had either a **third party accident** or a **single bicycle accident**, what this was, what the consequences were to the vehicle and themselves. They were asked if they had any **breakdowns**, and if there were costs related to that event and if they had **extra costs** which were not included in the preceding categories. Finally, the participants were asked to specify which **extra accessories** they bought and at what cost. The respondents were asked each month to indicate if they agreed on continuing the study and if not, were no longer contacted from that point on.

During analysis, the data was anonymised and analysed in Excel, due to the qualitative nature of the data in the form of remarks given by the respondents, and the high need for overview. To compare the preliminary results of the five month study, a persona was created to compare with the persona of the average Belgian from the previous work [8]. The visualisation was partly done in Excel and partly in R.

3 Results

In this section, the general results of the respondents from the recruitment survey that wished to continue with the longitudinal study are first discussed. Secondly, the preliminary results of the first five months of the longitudinal study are described. This description starts with the general descriptives of the 25 monthly respondents and continues with the general cost results and a graphical overview of the individual costs per month per participant.

3.1 Recruitment survey

The recruitment survey reached 355 entries, of which 272 entries were valid. This paper will focus on the descriptives of the participants who wanted to join the longitudinal survey. The analysis of the 272 valid entries will be performed in a different publication, where differences within groups of SP users will be analysed. Of those 272 entries, 111 respondents indicated their willingness to continue with the longitudinal survey. The majority of these 111 respondents were male (76.6 %). The majority are between 35 and 54 years old (62.1 %) and quite sporty (58.5 % sports at least twice a week). 77.5 % of the respondents that wanted to continue with the longitudinal survey, purchased their SP, 10.8 % leased, 7.2 % had the SP as a company bike and the others used either a bicycle loan or received a sum of their employer to help with the purchase. The purchase prices of the SP vary mostly between the categories of €5000 - €5999, €6000 - €6999 and €7000 - €7999, with respectively 16.2 %, 22.5 % and 21.6 % of the respondents within those categories. Noticeably is that also 16.2 % has a SP with a purchase price of less than €4000. Most respondents have a SP with a large battery: 44.1 % has a battery of 1 kWh or more and 33.3 % has a battery with a capacity between 800 - 999 Wh. This is rather logical as the median one way commuting distance is 26 km. An average driving efficiency for a SP is 19 Wh/km at maximum assistance level, which gives a 52 km range with a 1000 Wh battery. Thus, a 1000 Wh battery allows a median round trip with a single charging session per day.

Most respondents ride a SP from the following brands: Stromer (36.7 %), Klever (18.3 %) and Riese & Müller (15.6 %). The remainder of the respondents ride SPs of the following brands (in descending order of frequency): Ellio, Trek, Giant, Qwic, Gazelle, Haibike, Sparta, Kalkhoff, MTB cycletech, Flyer, Bulls, Oxford, Stevens and Specialized. 82 % are insured and pay €120 per year (median value). 81.9 % receive a bicycle allowance, which is on average €162.6 per month. With regard to maintenance, the respondents mostly clean their SP and chain or belt and check their tyre pressure on a regular basis, more than six times a year. A maintenance by a professional happens for the majority not more than 3 times a year. Finally, the median budget spent on accessories of the 111 respondents who wanted to participate in the longitudinal survey is €350. This median value largely exceeds the value published in the previous work on the TCO of SPs [8]. In that paper, the assumption was made that a person would buy a helmet and cycle bag for €150. This data shows that the respondents buy more accessories for a large price. The accessories bought by the respondents also vary strongly. Most indicate purchasing a helmet, bicycle bags and cycle clothing (i.e. clothing fit for cycling, not specific for rain protection). However, more investments are done and a distinction can be made between personal accessories and vehicle specific accessories. Personal accessories involve fluorescent clothing, rain protection clothing, cycling shoes, gloves, headlights, cycling glasses, a bonnet and scarf. Vehicle specific accessories are bicycle locks, a bell, extra lights, saddle and/or front suspension, different saddles, adjustments to the handle bar, bicycle carriers, new pedals, mudguard extenders, an extra battery and/or charger, blinkers, GPS trackers and smartphone holders or mounts and even an USB chargeable bicycle pump. The maximum budget spent on the vehicle specific accessories by one person is €1300 and the median of those who reported on the price of such accessories is €120.

3.2 Preliminary results of five months

The 111 respondents that wanted to continue with the longitudinal survey were contacted by mail during the first week of October 2022. These respondents were then contacted each month, unless they wished to stop their participation. On that first call in October, 81 participants responded, the second call yielded 68, the third 45, fourth 42 and the fifth as of now has 32 respondents. The participation rate dwindled over time, which is understandable, as there is no extrinsic motivation to participate. Of the remaining 32 respondents, 25 filled out the survey each month. The responses of these 25 respondents are discussed in following section.

Descriptives

The descriptives of the 25 respondents are the following: 76% are men, 40% are in the age category of 45-54 years old, both categories 25-34 and 34-44 years have an equal percentage (28%), 4 % is older than 54 years. Similar to the respondents of the recruitment survey, from the 25 respondents, 56% sports at least twice per week. The median commuting distance is 30 km single trip. A third has already had one SP, but for the majority it is their first SP. Most have a Stromer (12 out of 25), 6 have a Klever and the others have either a Ellio (2), Riese & Müller (2) or single users of a Specialized, Gazelle and a Giant. Price-wise the distribution is equal to the recruitment survey respondents (52.4 % are above €7000 and 23.8 % are less than €4000). 10 of the respondents have a battery of 1000 Wh of larger, 11 have a battery between 800-999 Wh and four have a battery in the category 500-799 Wh. 20 of them privately bought their SP, three of them are leasing and the other two have a company SP or cycle loan. The chain (14) and belt (11) distribution are rather equal.

Of the 25 respondents, most clean their SP, check their tyre pressure and grease/clean their chain/belt often. 84% get a bicycle allowance, and earn on median €173. 76 % have a SP insurance and pay a median of €150 per year. Table 2 gives an overview of the 25 participants and shows the gender, age category, SP brand, purchase cost, single commuting distance and total days commuted over the period of five months. This gives some context to the costs and earnings of each participant, which are shown in Figure 2, Figure 3, Figure 4.

Table 2: Overview of descriptives of 25 respondents

ID	Gender, Age	SP brand Purchase cost	Single commute (# $\text{days}_{\text{commuted}}$)	ID	Gender, Age	SP brand Purchase cost	Single commute (# $\text{days}_{\text{commuted}}$)	ID	Gender, Age	SP brand Purchase cost	Single commute (# $\text{days}_{\text{commuted}}$)
P01	F 45 - 54 years	Ellio €7000 - €7999	27 km (5)	**P10**	M 35 - 44 years	Stromer €6000 - €6999	22 km (66)	**P19**	M 25 - 34 years	Stromer €7000 - €7999	35 km (72)
P02	M 45 - 54 years	Stromer €7000 - €7999	22.5 km (57)	**P11**	F 45 - 54 years	Giant < €4000	21 km (38)	**P20**	M 35 - 44 years	Klever €8000 - €8999	86 km (36)
P03	F 55 - 64 years	Stromer €6000 - €6999	25 km (15)	**P12**	M 35 - 44 years	Stromer < €4000	28 km (59)	**P21**	M 45 - 54 years	Klever €8000 - €8999	68 km (76)
P04	M 25 - 34 years	Stromer €6000 - €6999	10 km (74)	**P13**	F 45 - 54 years	Stromer €4000 - €4999	23 km (49)	**P22**	M 45 - 54 years	Klever €7000 - €7999	60 km (44)
P05	M 35 - 44 years	Specialized €4000 - €4999	/ [2]	**P14**	M 45 - 54 years	Riese &Müller €5000 - €5999	41 km (63)	**P23**	M 45 - 54 years	Klever €8000 - €8999	30 km (89)
P06	M	Stromer < €4000	21 km (72)	**P15**	M	Gazelle < €4000	30 km (95)	**P24**	M	Riese & Müller	34 km (83)

[2] P05 did not specify their commuting distance, as he was abroad during up till the end of February and his SP was under repair.

	45 - 54 years				35 - 44 years				25 - 34 years	€6000 - €6999	
P07	F	Klever	20 km	**P16**	M	Stromer	25 km	**P25**	M	Stromer	42.5 km
	25 - 34 years	€5000 - €5999	(63)		35 - 44 years	€7000 - €7999	(69)		25 – 34 years	< €4000	(3)
P08	F	Klever	31 km	**P17**	M	Ellio	38 km				
	25 - 34 years	€5000 - €5999	(36)		25 - 34 years	€6000 - €6999	(46)				
P09	M	Stromer	30.5 km	**P18**	M	Stromer	30 km				
	45 - 54 years	€7000 - €7999	(19)		35 - 44 years	€8000 - €8999	(35)				

Costs results

Overall cost overview

In total over the five months with the 25 respondents 74,121 km was commuted by SP. On average this meant 60 km round trip per day with a median of 12 days a month. A median of €0.24/km was earned through bicycle allowance. In total €17,997.5 was earned during the period from October 2022 up until February 2023. During this period, a total of 90 pre-emptive maintenances were performed. The majority was done by the respondents themselves (55), but also 31 small maintenances and 4 large maintenances were carried out by a professional. The median cost of a 'self' maintenance is €6, of a small maintenance is €36 and of a large maintenance is €323.5.

Table 3: Maintenance numbers over a period of five months

Pre-emptive maintenances over five months	N	Occurrences pp (Median)	Costs pp (median)	Specific actions (top three reoccurring)
Self	55	1	€6	Cleaning SP, greasing chain, greasing components
Small by professional	31	1	€36	Control of chain/belt tension, greasing components, exchange of brake pads
Large by professional	4	0	€323.5	Cleaning SP, greasing chain, greasing components

The top three of specific actions with the large maintenance are similar to the things that are performed during a 'self' maintenance. That is because these actions are the most reoccurring and are thus done by the professional besides a variety of other actions such as a system update or the replacement of the cassette, chain, the brake system or electric components.

In total, 22 repairs due to wear and tear were performed, with a total cost of €1588.38. Eight of those repairs were performed by the respondents themselves (mostly brake pads replacement), 14 were performed by a professional. These last fourteen involve mostly inner tubing and tyres replacement and the replacement of cassette and chains.

Over the period of five months, the respondents indicated that for only eight times road assistance was necessary due to breakdowns. All these breakdowns were related to flat or punctured tyres. Costs for this road assistance was covered for all by their insurance.

With regards to accidents during the survey period, six single bicycle crashes and one third person crash were reported by the 25 respondents that filled in the survey. The costs related to these accidents are in the case of the single crashes close to non-existent: one respondent had a cost of €50 for a new set of trousers and another €20 for a non-specified cost. The person P20 had a third party accident during the period of the longitudinal research and had a cost of €793.70 to repair the SP (front wheel, side mirror, kickstand and man hours). P25 also had a third party accident, but this occurred before the start of the survey.

Finally, the respondents also bought extra accessories during the period of five months, which can be again categorized into two groups: the personal accessories (e.g. Clothing) and the vehicle specific accessories (e.g.

suspension). The personal accessories bought by all 25 respondents over the period of five months were: seven sets of warm gloves for cycling (not rain-specific), six rain coats, three cycling pants (not rain-specific), two sets of rain gloves, two rain pants, two sets of overshoes against rain and dirt, two pairs of sun glasses, two extra helmets, two pair of thermic socks, thermic underwear, a winter coat, a buff, a balaclava, a fluorescent jacket and a fluorescent waterproof cover for a backpack. The vehicle specific accessories bought over the period of five months: four sets of extra bicycle lights, three bicycle bells, two cycle bags, an extra side mirror, a set of breakdown assistance material, an extra lock, tube sealant, two Tannus armour inner tube enforcements [21], adjusted handle bar grips, inner bar ends, a bicycle camera and a belt tension gauge.

Cost overview per participant

The figures shown in this section give an overview of the costs and earnings made by each respondent in the order of magnitude over the period of five months. The stacked bars are the costs with each months, the dots are the earnings made by each respondent through bicycle allowance.

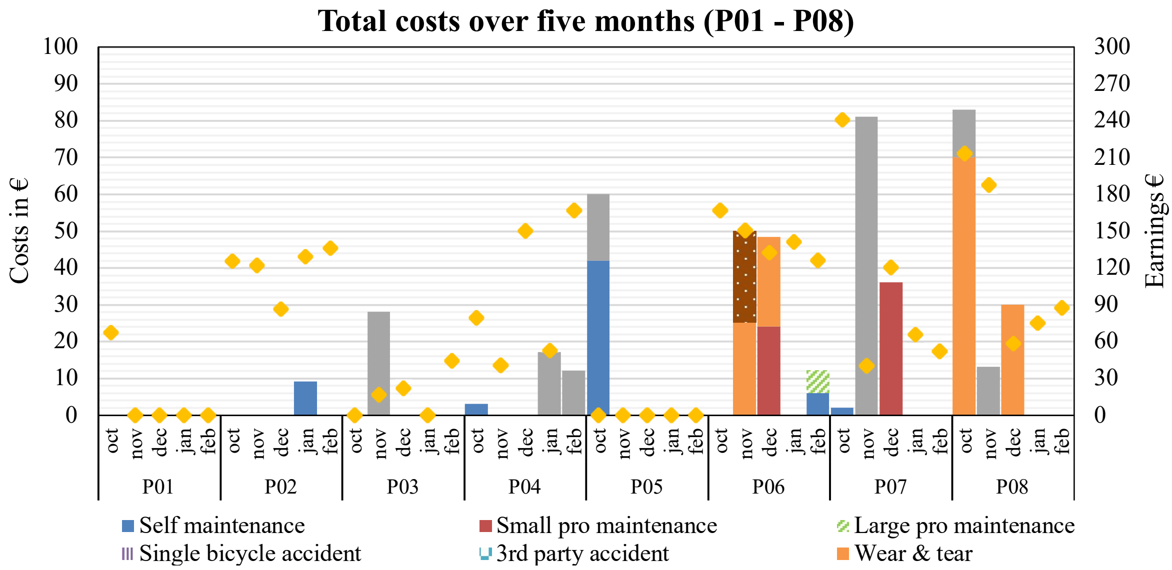

Figure 2: Stacked overview of total cost over five months per respondent (part 1)

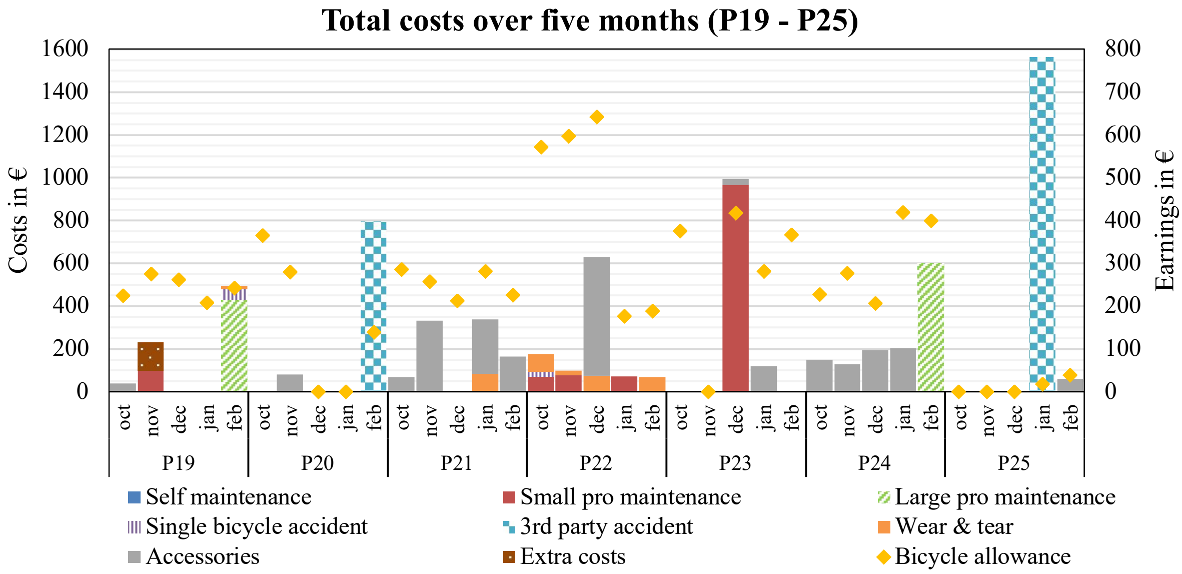

Figure 3: Stacked overview of total cost over five months per respondent (part 2)

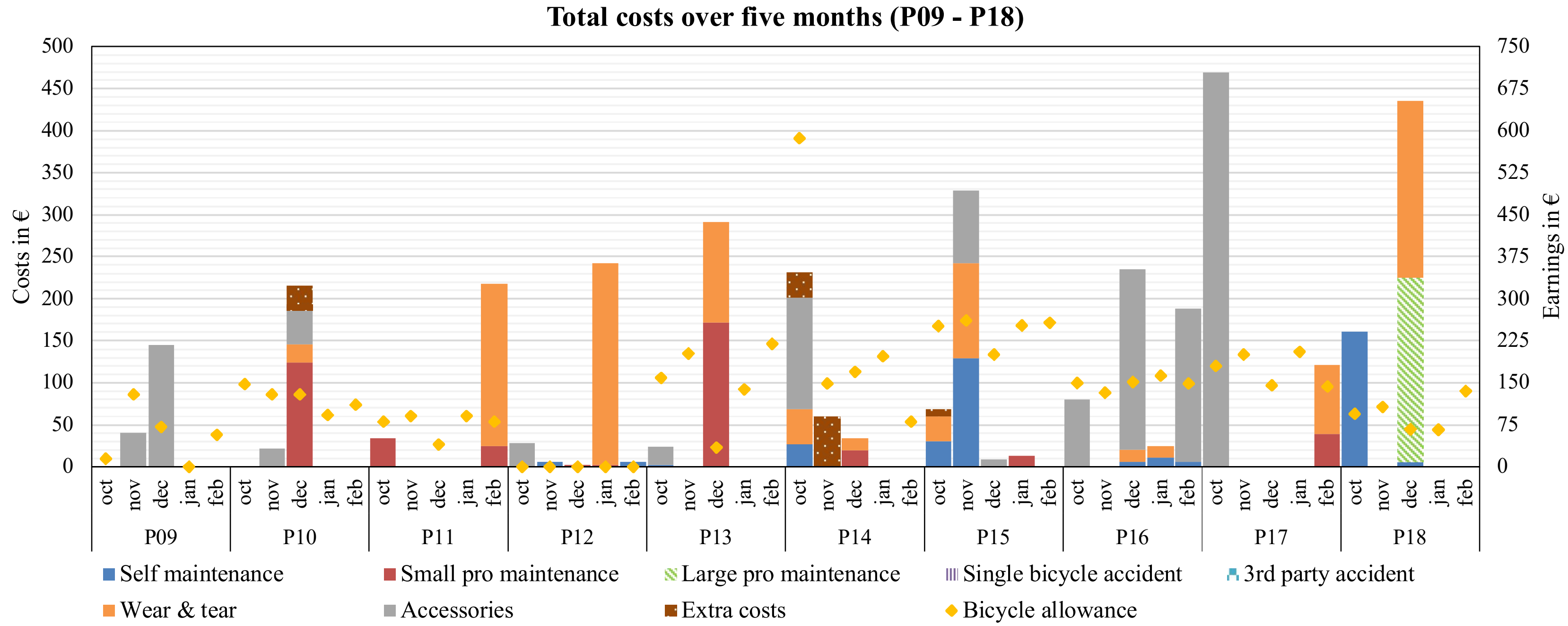

Figure 4: Stacked overview of total cost over five months per respondent (part 3)

It is noticeable that some participants did not made or had any costs or had any earnings in certain months, for example P01, P03, P05 and P12. These respondents either did not use their SP, or did not have their SP available for commuting due to repair as a result of an accident or did not receive bicycle allowance from their employer. For example in Figure 3, P12 receives no bicycle allowance from his employer, P05 did not use his SP during the five months due to repairs. P01 only used her SP in October 2022. It is also noticeable that most pre-emptive maintenance by a professional are performed in the winter months (December-February). This might indicate that participants might be less willing to travel with a SP and/or took the opportunity to schedule such maintenance during the winter months. However, more data is necessary to confirm these hypotheses and it will be interesting to see how this evolves over time.

3.3 Cost comparison longitudinal vs. projected costs

The calculator that is discussed in the authors' previous work [8], [18] uses the data gathered from bicycle repair shops to determine the maintenance costs over the period of ownership. According to this data, the moment a maintenance should be performed is based on the number of kilometres already travelled with the SP. This is shown in Table 4. Distinctions in maintenances were made by the repair shops between the cost of material and work hours of a standard check-up, a chain/belt replacement or a gear, tyre or bearing replacement. The replacement of the battery was also included in [8], [18], but is not included in Table 4, as irrelevant when comparing the costs captured in the five month period and the costs projected in the calculator. This is because a SP battery should be replaced after 500 cycles and Table 2 shows that none of the respondents is near that threshold.

Table 4: Difference in frequency and costs of maintenance from calculator between chain and belt drivetrains

Chain			Belt		
Type of maintenance	Frequency (km)	Price (€)	Type of maintenance	Frequency (km)	Price (€)
Standard check-up	3000	120	Standard check-up	5000	120
Replacement of chain	4000	60	Replacement of belt	18000	285
Replacement of tires	9000	160	Replacement of tires	9000	160
Replacement bearings	15000	90	Replacement bearings	15000	90
Replacement of gears	6000	130		0	0

The frequency of replacements are used to calculated the maintenance costs that are projected by the multi-criteria calculator. Figure 5 shows those maintenance costs compared with the preliminary maintenance costs from the longitudinal study. The former includes the costs of the 'self', minor and large maintenance, the costs associated to wear and tear and the costs as a result of accidents, both single bicycle as well as third party crashes. Figure 5 shows higher values for costs coming from the longitudinal study compared to the projected costs for seven participants, specifically for P18, P20, P22, P23, P24, P25. The ratio of the maintenance cost for the longitudinal study are shown by the stacked bar charts in Figure 2, Figure 3 and Figure 4. The origin of these costs is mostly due to large repairs. The high cost amount of P20 and P25 in particular is the result of major repairs of their SPs. For P20, this was a major accident with the SP in November 2022. The user was only able to receive his SP back in the end of January 2023. For P25, this was a major accident in August 2022, and the participant got his SP back at the end of December 2022. Hence, no costs were also calculated with the calculator over this period, as almost no kilometres were travelled in January and February 2023. Four respondents did not make any costs and did not have any projected costs due to their kilometrage: P01 did not use their SP to commute during four months for unknown reasons, P03, P04 and P09 did not do enough kilometres for the calculator to project costs and did not make any costs during the five month period.

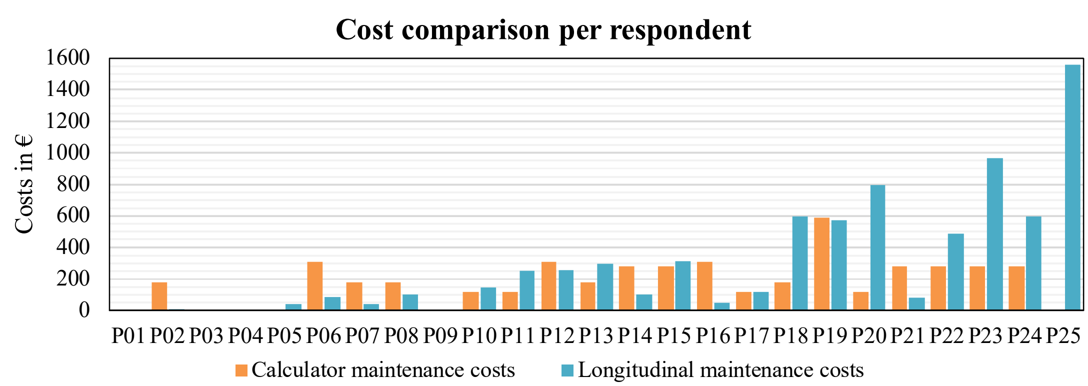

Figure 5: Cost comparison of maintenance costs projected by calculator and costs from longitudinal study over a period of five months

Overall in Figure 5, it is very noticeable that the costs from the five months study exceed the projected costs of the calculator for 12 respondents. The calculation of the projected costs is considering the respondents' commuting distance, their indicated total days commuting with a SP during the five month period and the type of the drivetrain (chain or belt). The difference in drive train is important as belts are more durable and lasts for more kilometres compared to chains, but the maintenance on belts is more expensive when performed as can be seen from Table 4. This is compared to the summation of the reported maintenance costs over a period of five months. So almost half of the respondents pay more to maintenance than the projected costs by estimation of the bicycle repair shop owners and half pay less. This would mean that these preliminary results show that the estimation of the bicycle repair shops is relatively accurate and even quite conservative in half of the cases. The impact of major accidents and resulting major repairs is considerable when looking at the total maintenance costs. Nonetheless, these results remain preliminary and might evolve over time.

3.4 Implementation of longitudinal costs into TCO-calculation

The TCO based on the preliminary longitudinal study results can now be compared with the TCO of an average Belgian as determined in previous work [8]. To do so, a persona needs to be created and some assumptions need to be made with regards to certain costs. The median values of the 25 participants determine the characteristics of the persona: a male SP owner with a 30 km single commute, bicycle allowance of 0.24 €/km and a 57% commute frequency. The SP of the persona costs €6500, has a 1000 Wh battery and is equipped with accessories worth €330. The current median costs of the pre-emptive 'self', small and large maintenances are respectively €6, €36 and €323.5. It is assumed that the frequency of pre-emptive 'self' maintenances will continue throughout the years at the same rate as during the past five months. The median value will thus be multiplied with 2.4 to get the value of one year. The frequency of the small maintenances is assumed to be half the frequency of the 'self' maintenance and thus be multiplied with a factor 1.2. The frequency of the large maintenances will be assumed only once a year. For the single bicycle accidents, a median cost value is assumed of €35 and will be multiplied by a factor of 2.4, following a similar reasoning as with the 'self' maintenance. The median third party accident costs is €1176.87 and is assumed to occur only twice during the ownership of the SP. The median values for wear & tear and extra costs are respectively €54.5 and €15 and is assumed to occur with the same ratio as the 'self' maintenance and the single bicycle accidents. Including these values into the calculation of the TCO leads to the results shown in Figure 6. The TCOs for the ICEV (P) (i.e. petrol) and battery electric vehicle (BEV) are added for context and originate from [8].

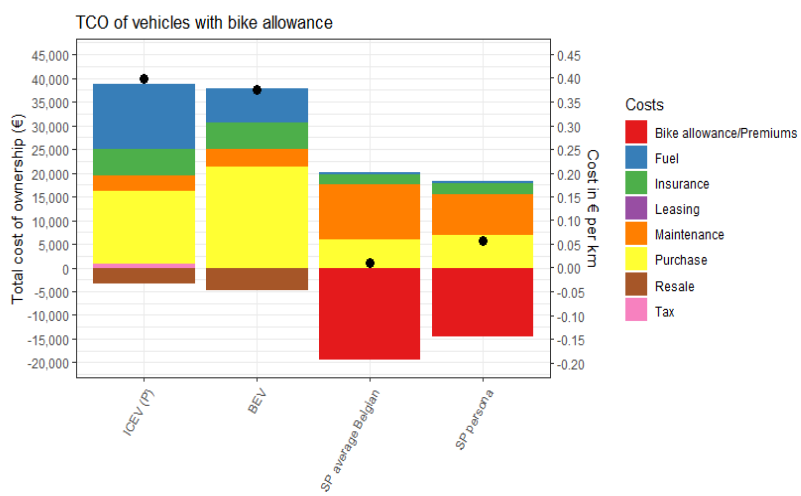

Figure 6: TCO and €/km for ICEV(P), BEV, SP for an average Belgian and SP for the created persona

Figure 6 shows a TCO for the persona of €18,361.29 (not including the €14,446.08 bicycle allowance) and a 0.057 €/km. The persona thus has paid over the total ownership period a smaller amount towards maintenance, but also earned less bicycle allowance compared to the average Belgian with a SP, due to its specific commuting profile. The total amount of maintenance costs based on the earlier assumptions (€ 8768.6) is also slightly lower than the projected maintenance cost by the calculator (€8886) for the same persona. The continuation of the study will give more information on the correctness of the assumptions and the possible refinement of the calculator.

4 Conclusions

This paper reports on the preliminary results of a longitudinal study on the maintenance cost regarding the use of a SP for commuting. This study is performed with the aim to further refine the results of a TCO calculator, which is described in [8] by the same authors. The results from the recruitment survey and the eventual longitudinal survey are discussed for 25 monthly participants for a period of five months. Besides socio-demographic information, the participants were also questioned on their commuting behaviour and their monthly costs. These costs are divided in six categories: pre-emptive maintenance, wear & tear, accidents, breakdowns, extra costs and extra accessories. The results show that there is a large variability in the costs made by each respondent. A difference can already be noticed in the maintenance costs made by the participants and the costs projected by the calculator based on earlier research with bicycle repair shops. About half of the respondents have already made more costs than the projected values. More data is however needed to conclude that the values provided by the bicycle repair shops are valid. Another important finding is the high budget spent on all sorts of different extra accessories, both personal and vehicle specific. This implies that the initial purchase cost of accessories in the calculator needs to be increase from €150 to €330. Finally, the TCO of an average Belgian is compared to the TCO of a persona based on the values gathered from the 25 respondents. This comparison indicates that the maintenance costs based on longitudinal data are lower than the projected maintenance costs of the calculator. The further continuation of this study will provide more information which will enable the refinement of the calculator.

5 Limitations

The limitations of this research is the small data sample. The remaining respondents are probably the highly motivated and avid SP users, which could influence the results. Nevertheless these are the first data points gathered in this field and have value as indications.

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