FIELD TESTS AND PILOT PROJECTS AS SUPPORTIVE INSTRUMENT TO FOSTER THE MARKET DEPLOYMENT OF MOBILITY INNOVATIONS – THE CARGO BIKE CASE

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1. INTRODUCTION

Bikes are not only a potential mode for mobility but can also play a major role in the transformation of urban transport. Within former studies[1] and research projects on the potentials of cargo bicycles for commercial urban transport cargo bikes were identified as "*promising vehicle for innovative urban logistics concepts in terms of sustainable urban transport an improvement of efficiency and reliability of last mile deliveries"* (Heinrich, Schulz, & Geis, 2016a). The cargo bike as an alternative mode of urban transport still lacks in user acceptance due to the comfort restrictions in combination with the perception of disproportionate financial investments. In addition, the potentials and benefits of cargo bike usage for private and commercial transports by now are not feasible and visible for individuals, as the advantages can only be experienced by active usage of the vehicle[2]. Therefore, trial offers and field tests that possess the chance to test the vehicle without any financial and personal commitment may offer the chance to convince potential users to use the vehicle frequently or even to purchase one. The aim of the presented paper is to demonstrate, how trial projects and field tests can support the implementation of usage concepts and thereby support the market deployment of disruptive mobility innovations. The focus hereby is set for products and related services, that require a high level of user acceptance and interdisciplinary cooperation by demonstrating the conception, conduction and findings of the cargo bike project in Herne to identifying the potentials of the vehicle as alternative mode of urban commercial transport and related contributions to governmental energy transition objectives accordingly.

2. BACKGROUND

The cargo bike project HELFI (www.helfi-herne.de) is one out of 12 subprojects of the framework program "Energie-Wende-Ruhr" under the lead of the *Wuppertal Institute for Climate, Environment,, and Energy.* The program aims to answer the question, how the objectives related to the energy transition in Germany can be implemented locally in the communes of the Ruhr metropolitan area with the help of an interdisciplinary consortium represented by 12 sub-projects (Wuppertal Institut für Klima, Umwelt, Energy gGmbH, 2017). It is funded by the Stiftung Mercator GmbH, a private, independent foundation (www.stiftung-mercator.de) with focus on fostering the stability of Europe, integration, energy transition and cultural education – with 950,000 Euros (190,000 per sub-project). The HELFI project is an implementation project on a communal level in the Ruhr area at the test site Herne, a city with about 156,000 inhabitants, with the aim of result transfers to the overall Ruhr area/ Germany. The project has a funding volume of about 162,000 Euro for 24 months (04/2014-04/2016). With regard to the funding budget, whereby the material costs for the cargo bikes, including equipment, are accounted at only 15,000 Euro. The project and field test design are subject to certain restrictions. Nevertheless, the cargo bike project HELFI achieved huge success in terms of an enormous output of findings in contrast to the small investments and additional public image effects[3] and therefore contributed to the all-over success of the framework program. The details on the methodological and implementation approaches including the specific limitations are presented in the following section 3.

3. METHODOLOGY AND FIELD TEST CONCEPTION

The substitution potentials for goods transport respectively commercial transport relocation on (electric) cargo bikes already has been investigated within former research projects on European and national level (e.g. Huschebeck, 2016; Jorna, Mallens, & Mobycon BV, 2013; Reiter & Wrighton, 2014; VCD, 2015). Nevertheless, with the project start of the HELFI project in Herne, the idea of replacing commercial transport by cargo bikes in urban agglomeration areas with insufficient factor endowment and structural defiance has not been explicitly taken into consideration before. Furthermore, the contribution potentials linked to overall macroeconomic effects have not been investigated by using real data from a designated user group. Based on the presented study`s findings, the contribution potentials of cargo bike usage for implementing governmental sustainability objectives for urban transport, the following aspects have been considered: 1) application areas and business model potentials, 2) substitution potentials, 3) ecological benefits and resilience and 4) economic benefits on private business and macroeconomic level. In a first step, the findings of related projects and best practices (existing cargo-bike business models as well as strategical organizations of the City of Copenhagen and Amsterdam as so-called bicycle capitals) have been used for concrete use-case and concept definition that are applicable in the Herne case by aligning the identified framework conditions. In a second step, suitable test pilots in terms of business structure and personal attitude have been selected for a 6 month trial period. Due to the limited budget, only seven cargo-bikes could be provided.

The major objective of the selection phase therefore was to choose seven businesses (business owners as core test-pilots and employees) that in a sum build a heterogeneous group that represents the majority of the locally established business sectors (for the test site as well as the whole Ruhr area), to ensure the validity of data extrapolation. To exploit the full potential of the field test with limited equipment, test users that have high potentials for establishing sharing systems or have a broad employee base were prioritized, as those ensure generating more user feedbacks and a broader data set with no additional investments accordingly. In addition, only test pilots with some degree of skepticism regarding cargo bike usage were chosen for closer selection. Herewith it was ensured, that the findings are not biased due to the personal attitude. In addition, the authors were able to assess to what extend the personal expectations and attitudes differ between the start and the completion of the field test period to evaluate the importance of field tests as a tool for preliminary product and concept feasibility testing.Table 1 presents the test pilot businesses, which have been chosen.

Table 1: Test pilot selection

Test pilots/ businesses	Business segment	Application area
1 REWE Kenkmann	Supermarket	Food, non-food deliveries
2 Tischlerei Molzahn	Carpenter	Customer and construction site visits for façades, roofing,, and interiors
3 Neumarkt Apotheke	Pharmacy	Medicine delivery
4 City Center Herne	Shopping Mall	Centre management, errands, sharing system with living units and center-shops
5 Elektro Sprick	Electrical installation	Construction site and customer visits
6 Meister Lieder	Electronic retail	Deliveries and customer visits
7 Blumen Maylahn	Florist	Deliveries and gardening
8 Konrmühle (replaced user 1)	Organic supermarket	Food, non-food deliveries

4. FIELD TEST COURSE OF EVENTS

For evaluating the cargo bike usage potentials, the selected user group of seven test pilots received one cargo bike each, including a company specific project branding (see Figure1). The cargo bike usage was free of charge, whereby the test users committed themselves – based on a specific user contract – to not conduct any adoption measures without the agreement of the Zeppelin University as project leader and the Zweirad Einkaufsgenossenschaft and related repair services as bicycle specialists. Also they had to ensure to immediately report any issues or difficulties linked to the vehicle or usage barriers and to give qualitative, personal feedbacks as well as submitting the driving lock books on a monthly base. As mentioned initially, within the field test cargo bike prototypes have been used. The selection of these specific cargo bike models has been regarded as critical from the experts and experienced users point of view, as a custom-fit modification based on the single user's needs was not given, and the investigation scope in terms of applicability was limited per se. The uniformity of the prototypes did not allow investigating user specific implementation potential that could have been derived with a customized model that fits the specific needs and the practicability for the application areas accordingly. On the other hand, the usage of the prototypes can be justified by the fact that the vehicle was constructed for commercial transport and equipped with the following specifications: 1) Double-battery system that ensures longer driving distances and the carriage of higher loading volumes as well as 2) the option to separate the conveying area to optimize vehicle storage (use of space, protection against theft) and logistic processes (preparation of several boxes for fast replacement, in-door deliveries). The cargo bike prototype is demonstrated in the following Figure 1.

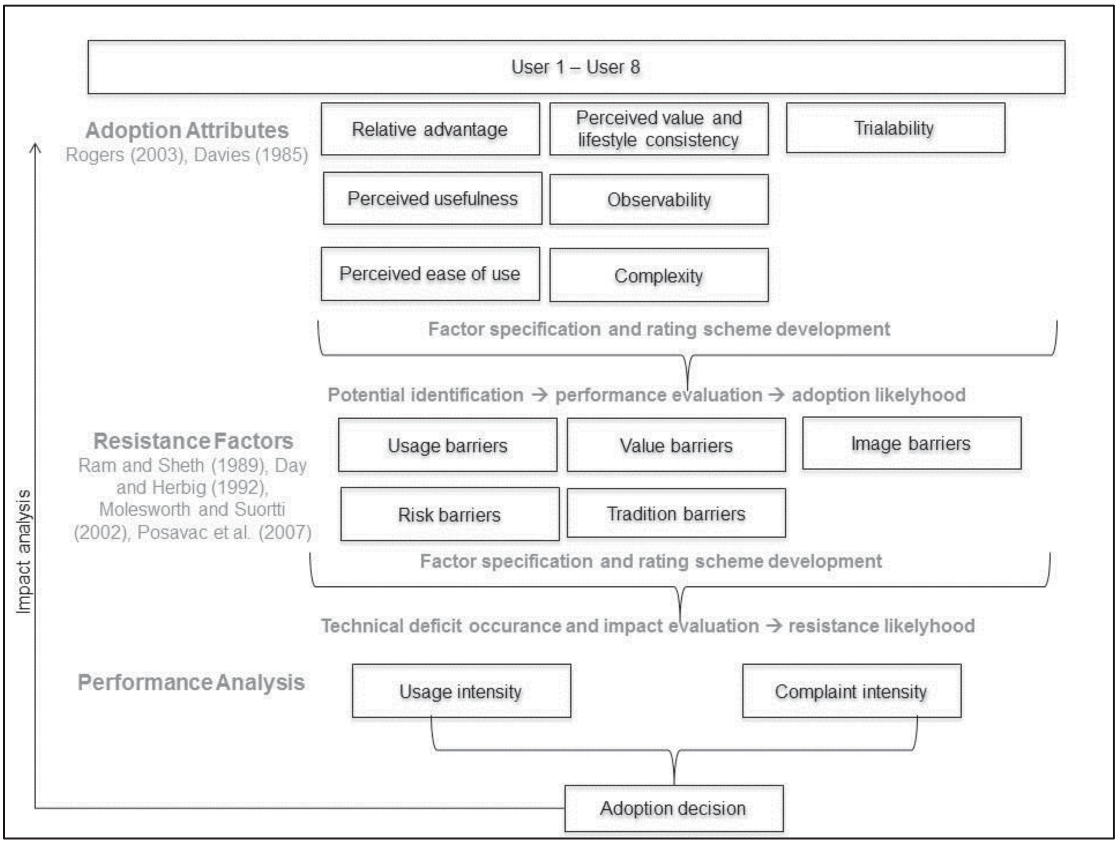
Figure 1: The Cargo Bike Prototype (own illustration, technical drawing: ZEG)

The prototype models „Hercules Cargo“ used for the field test are a so-called “zero-series,” which have been provided as test-fleet for trying out the drivability in general as well as with the intended payload, loading capacity, and stability to initiate adoption measures before the actual market introduction in the given case. Nevertheless, the vehicles have been tested and certified for usage with respect to stability, endurance and the provisions of the road traffic licensing authority (StVO, 2012) to ensure usage without concerns. Besides the potential evaluation of cargo bike usage for commercial transport, the field test conduction was additionally used for evaluating the model fit for this particular application area. The wholesale partner ZEG, as institutional interface between the user and the manufacturing industry, granted a special purchasing discount for the 7 vehicles accounted at 10,000 Euro instead of about 35,000 Euro catalog price in total. The reduced purchasing price in this context ensured to set up a large test group out of different businesses to test various application areas with a comparably small project budget. Nevertheless, the limited budget and the decision to use prototypes for the cargo bike field test yielded certain limitations that could only partially be balanced. Prototype testing excludes the option of vehicle customization to meet user specific needs. Due to inadequate model fit and related legal issues (establishment of a rental service for shop customers), the REWE supermarket was forced to quit the field test already in the second month of the test period. The REWE supermarket could rapidly be replaced by an organic supermarket Also the other user's had to face certain problems due to the inadequate model fit and technical issues. One of the core barriers in this context was the usability aspect related to the employees' willingness to use the vehicle. The detailed results of the usage intention and results are presented in section 5. In this context, it haskept in mind that the findings can only be applied on the tested prototype, whereby the potentials of cargo bike usage in general may remain unexploited.

5. USER DATA EVALUATION AND ADOPTION POTENTIALS

The aim of conducting a field test was to verify the potentials ascribed to cargo bike usage for urban transport that has been pointed out to various related research projects and studies (e.g., Pro E-Bike, Cargologistics, Lasten auf die Räder). To evaluate the experiences of the selected heterogeneous user group that consisted of 7 business owners and service providers out of different business areas, the feedbacks that have been collected throughout the field test period have been categorized based on various researchers' approaches in the field of innovation diffusion and consumer adoption (Bass, 1969; Davies, 1985; Day & Herbig, 1992; Greve & Seidel, 2014; Molesworth & Suortti, 2002; Posavac, Brakus, & Herzenstein, 2007; Ram & Sheth, 1989; Rogers, 1962, 2003). The evaluation scheme is presented in the following Figure 2.

Figure 2: Adoption Likelihood Assessment Scheme, own illustration (Heinrich, Schulz, & Geis, 2016)



The evaluation[4] of the user experiences regarding the adoption willingness allows the derivation of the following principal findings:

- *Emphasizising the decisive impact factors and the user acceptance once the barriers were overcome.*
- *Poor product quality and technical deficits related to purchase price and future investments lead to total rejection of the specific cargo bike model.*

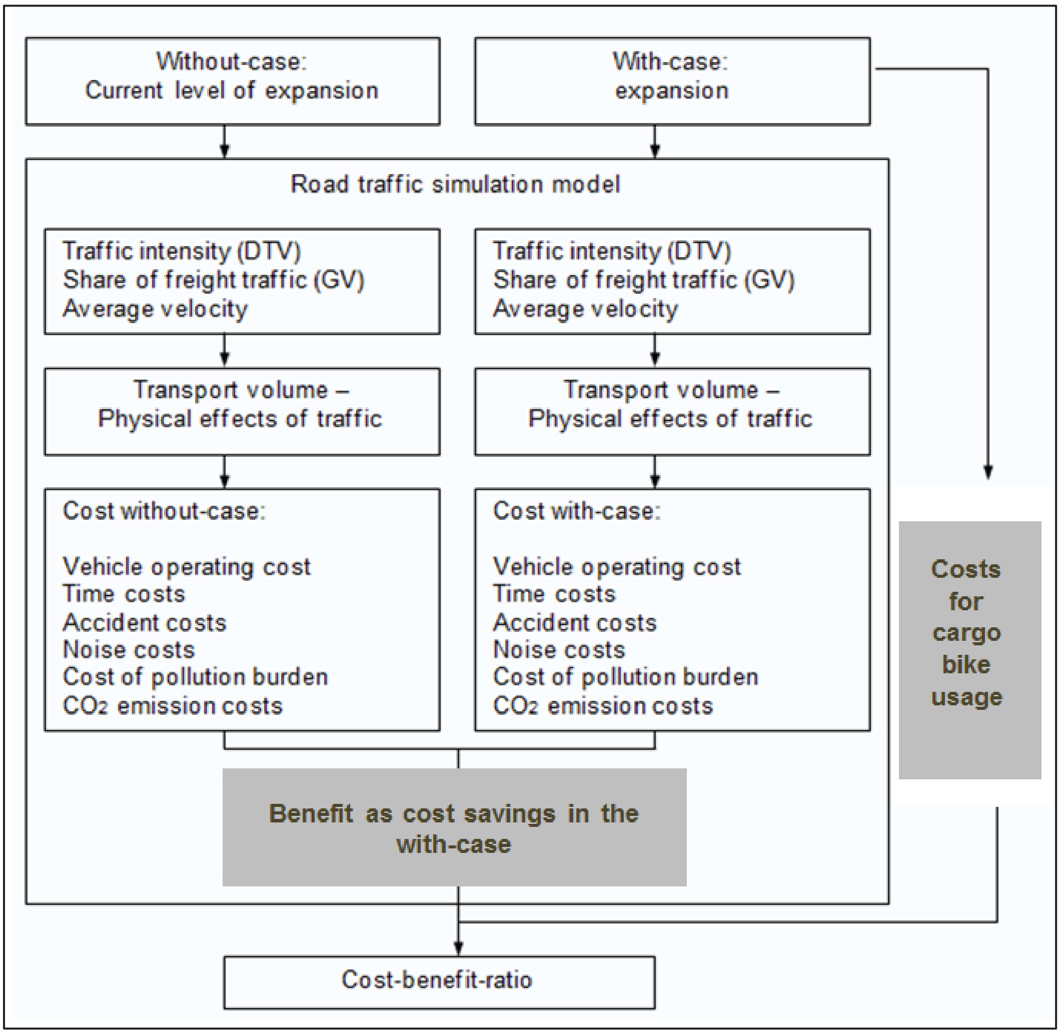
- *Adopters are critical users that are ambitious to support product refinement: high prototype potential, low adoption resistance likelihood, high claim intensity, high usage intensity.*
- *Rejecters are likely to be indifferent: low prototype potential, high/medium resistance likelihood, low claim intensity, low usage intensity.*
- *Prototype adoption decision mainly based on low purchase price (90% discount on list price).*
- *"'Heavy User' adopters want to act as role models that share their experience"* (Heinrich, Schulz, & Geis, 2016b).

All users stated that the impacts of technical deficits should be considered by the industry and that enforcing cross-stakeholder networks would be highly appreciated. Despite the technical issues of the prototypes, a high level of user acceptance and willingness to use and promote the vehicles could be reached within the test group. As pointed out in the guideline on local energy transition design of the framework program „Energie-Wende-Ruhr" as a final product (Wuppertal Institut für Klima, Umwelt, Energie gGmbH, 2017), the test pilots in this context are nominated as change-agents. They represent the group of early adopters that act as neighborhood role models or „the individuals to check with" (Rogers, 2003, p. 283). Those are in the center of attention for implementing energy transition measures on local base and beyond, depending on the operation base of the individuals. In the case of the framework program they are related to the efforts that are taken to spread the results and to make them visible to the general public. The cargo bike case demonstrates that with ensuring visibility and observability of the innovation's benefits, the market deployment potential of alternative transport modes is fostered. With the help of *Early Adopters* the implementation of related measures can be successful, thus supporting a change of mindset of the public to acting climate friendly. Besides the qualitative evaluation of cargo bike usage and field test conductions, the contribution and benefit potentials can be quantified by evaluating and extrapolating the test pilots driving date. The evaluations based on the drivers` logbooks are presented in the following section.

6. COST BENEFIT ANALYSIS

With the conduction oft cost-benefit-analysis, based on the test pilot`s log-books data on driven kilometres during the test period, the overall effects on macroeconomic resources savings that could be realized within the project period have been examined. A cost-benefit-ratio exceeding 1 indicates that from the macroeconomic perspective the usage of cargo bikes is beneficial in terms of increasing an economy`s welfare. A cost-benefit-ratio below 1, on the other hand, indicates that cargo bike usage is not worth to be fostered. With the extrapolation of the trial period results, the contribution potentials of cargo bike usage in terms of the realization of a reduction in harmful environmental impacts for larger scale implementation were projected. The herewith derived cost-benefit-ratio, therefore, allows to state assumptions on the overall im-pacts from a macroeconomic perspective. The results, therefore, deliver valu-able information that builds the base for recommended actions in the field of governmental decision makings that aim to foster further investments and measures to promote the use of alternative, environmentally friendly transport modes. The functional relations, which are specified in the EWS-97 (e.g., be-tween traffic intensity and velocity) are the base for the road traffic simulation model (Schulz, 1994). Additional to this, advances of the BVWP (federal transport plan) with regards to the modernization and a focus on monetary valuation regarding the environmental impact (air-borne emissions, CO_2) in particular, will also be used. The monetary evaluation of the physical effects is based on the average cost-unit rates of the BVWP 2003 and the EWS-97 (Bundesministerium für Verkehr, Bau und Wohnungswesen (BMVI), 2003; Empfehlungen für Wirtschaftlichkeitsuntersuchungen von Straßen, 1997) .

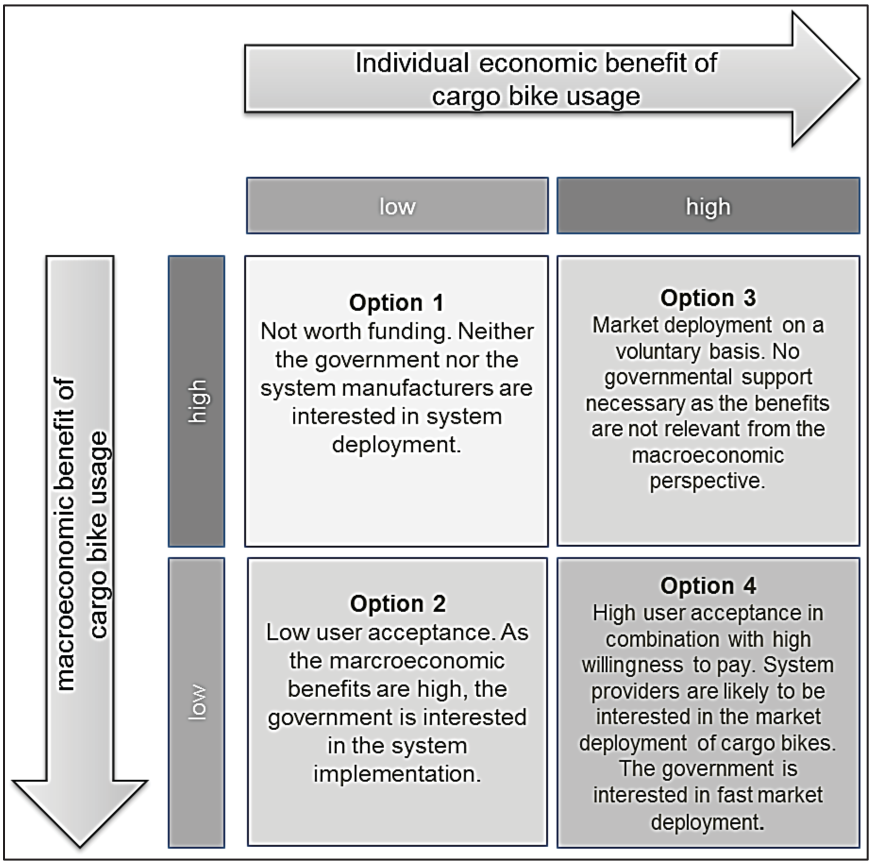
Figure 3: Traffic Simulation Model, own illustration (Schulz, 2013)



With the aid of the monetary assignment records, it is possible to evaluate the changes in the different traffic expenses from an economic point of view. The individual economic effects, which are realized due to substitution effects, are the subject matter of the macroeconomic cost-benefit-analysis.

Nevertheless, the individual economic cost changes are of high relevance regarding user acceptance or more specifically the willingness to actively use cargo bikes. The aim of the macroeconomic analysis therefore is to determine the economic benefits that can be realized with the substitution of (a certain number) of conventional combustion engine vehicles actively used for commercial transport by cargo bikes. By opposing macroeconomic and individual economic benefits it is possible to derive recommendations for action on a governmental level. These are demonstrated in the following Figure 4.

Figure 4: Recommendation of action under the consideration of individual and macroeconomic benefit impacts, own illustration



Based on the test pilots' records, the following data input has been defined: The intended usage period for the cargo bike was 132 days[5]. Together the users covered a distance of 18 kilometers per day with the cargo bike. Based on different traffic surveys for the test site Herne, an urban street with priority drive and barriers (due to junction impacts and/or stationary traffic) has been identified as relevant and representative street type with an average daily traffic density (ADT) value of 15,000 vehicles and a freight traffic portion of 7.1% (Ingenieurgesellschaft für Verkehrswesen mbH, 2012, 2015; Weiser, 2015). The statistical population in this context is represented by the number of businesses in Herne that equal the test pilots in terms of business activities. Based on this assumption, the authors calculate with a population of 460 businesses, whereby the test pilots represent a share of 1,5%. The evaluations of the test pilot's data and extrapolations are demonstrated in Table 2.

Table 2: Cost-Benefit-Analysis for the cargo bike field test and extrapolations for Herne and the Ruhr Area, Bundesministerium für Verkehr, Bau- und Wohnungswesen, Grundzüge, a.a.O., S. 37ff.; EWS-97, a.a.O., S. 13ff.; own calculations.

	Herne	**Extrapolation Herne**		**Extrapolation Ruhr**	
	Test Pilots	Additional Participants	Additional Participants	Additional Participants	Additional Participants
	7	230	460	9,436	18,872
Operation Cost Savings	2,862	94,025	188,049	434,518	869,037
Time Cost Savings	1,502	49,339	98,679	228,013	456,027
Accident Cost Reduction	1,809	59,443	118,886	274,706	549,413
Noise Cost Savings	100	3,291	6,581	15,207	30,414
Pollutant Savings	8,763	287,928	575,857	1,330,610	2,661,221
CO_2 Reduction	860	28,257	56,515	130,587	261,173
Economic Benefit in Million EURO	**0,016**	**0,522**	**1,045**	**2,414**	**4,827**

The calculation underlies certain limitations with regard to the data input. The number of test users with a sum of 7 businesses (core users and employees) is comparably small. With regard to the basic population (businesses in Herne and the Ruhr area), the test group only represents a small sample. With the detailed daily logbook records and the indemnification of representativeness due to the selection process, the data input can be valued to being statistically significant though. Overall, with a comprehensive implementation of cargo bike usage for commercial transport, the achievable benefits in Herne can be quantified with a benefit valued between 0.5 and 1.1 Euro per year. With the user data gathered in Herne, the benefit intensity can be extrapolated for the Ruhr metropolitan area. The benefit can be valued between 2.4 and 4.8 Million Euros accordingly. For the extrapolation, no business-specific evaluation could be conducted. Therefore it was assumed, that 5% or respectively 10% of the businesses (portion of local businesses with homogenous business structures of the test pilots) in this area are able to use cargo bikes as an alternative transport mode. The annual investment and operating costs can be quantified with 1,332 Euro per test pilot. By considering a year-round cost ratio, the cost-benefit-ratio is 1.7. With this conduction scheme, the cost-benefit-ratio has been underestimated, as the benefits only have been measured for the test period of 132 days, whereby the actual targeted investing and operating costs have been taken as a basis on an annual base. With regard to the field test, with an equal proportional allocation of benefits and costs within the test period, a cost-benefit-ratio of 4.7 can be calculated. Every Euro of the project expenses that is spent for cargo bike usage implementation has a macroeconomic benefit for the test site Herne rated with 4.7 Euro accordingly. The implementations based on the findings evaluation are demonstrated in the following chapter.

7. CONCLUSION AND OUTLOOK

The evaluation of the cargo bike field test in HERNE has verified the assumption that the usage of cargo bikes for commercial urban transport is beneficial from the macroeconomic as well as the individual business perspective. This has been demonstrated with the results of the macroeconomic cost-benefit-analysis, as the evaluations represent a valid base for political decision making in terms of dedicated funding measures. As the evaluations are based on the representative group of test pilots, only the usage potential and related benefits could be identified within the CBA regardless the user acceptance (Option 2, cf. Figure 4). Additionally considering the qualitative evaluation based on the user's feedback and adoption willingness potentials, Option 4 also can be taken into consideration, provided that the *Early Adopter's* and industry, trade (including services), as well as communes as enablers and driving force, are actively involved in product deployment measures. The demonstration of the methodological framework supported by the adoption measures issuing the use-case based inconsistency of framework conditions in this context deliver valuable information and recommended actions supporting future research as well as for potential users as initiators and core actors with similar implementation objectives (e.g., communes, city planners and related interest groups, institutions and associations). Regardless of the limitations, the HELFI field test opens up entirely new dimensions in the field of cargo bike potentials assessment that has not been investigated before. With the combination of specific business use-case potential assessment in and prototype testing, valuable information on technology performance and related user acceptance, that deliver concrete fields of action for the manufacturing industry, could be provided on top to the assessment of the eligibility from the governmental perspective. The contribution of the HELFI Project, therefore, exceeds the framework program's objectives regarding the regionally limited implementation and transferability potentials with exceeding pure data evaluation and figure based success indication regarding environmental impact reduction and transformation potentials in the mobility segment. Furthermore, the usage-related technology barriers gave valuable information for the cargo-bike manufacturing industry and retail regarding necessary product adoption and development as well as the need for improved consultancy activities. The evaluations of the cargo bike trial project as a representative case, therefore, can be regarded as a guideline for future projects that aim to foster the deployment of innovative technologies and business concepts in the field of mobility and beyond.

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NOTES

[1] e.g. Pro-E-Bike (http://www.pro-e-bike.org/), Lasten auf die Räder. (http://lastenrad.vcd.org/vorteile), Cylcelogistics (www.cyclelogistics.eu), BESTFACT (http://www.bestfact.net/).

[2] Experiences gained by the author's within the presented cargo bike trial project based on user feedbacks, expert interviews and network activities and conferences (e.g. Beckmannn, Brügger, Schmidt, & Zosso, 2016; Brügger, 2015; Nocerino, 2016; Rzewnicki, 2015; von Rauch, 2014).

[3] The project was nominated by the German Minister for Building, Accommodation and Traffic North Rhine Westphalia as qualified project of the framework program klimaexpo.NRW (www.klimaexpo.nrw) to being step 139 out of 1,000 steps towards the German energy transition.

[4] For lack of space, the detailed evaluations have been omitted. The poster with the detailed information that has been presented at the mobile.TUM 2016 conference can be retrieved from https://www.mobil-tum.vt.bgu.tum.de/fileadmin/w00bqi/www/mobilTUM2016/Conference_Proceedings/Poster/Lea_Heinrich.pdf. The related Abstract is available at http://www.sciencedirect.com/science/article/pii/S2352146516308729?via%3Dihub.

[5] Reasoned with an adoption phase in the first month and the period, where the cargo bikes could not be used due to technical issues and repair work, the period under consideration was adjusted from 7 to 6 month with 22 working days in average.