

The economic value for cycling – a methodological assessment for Starter Cities

El valor económico del ciclismo - una evaluación metodológica para las “Starter Cities”

João Pedro Ferreira,¹ Catarina Isidoro,² Frederico Moura Sá³ y José Carlos Baptista Da Mota⁴

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Abstract

The concerns about climate change, the effects of congestion and pollution in urban areas have led to the debate about the need for alternative mobility patterns to reduce the negative impacts of transport. At the same time, research on sustainable urban mobility highlights the value of cycling as a mean of transport and its economic, social and environmental benefits. Despite the proven benefits, investments in cycling are not always considered a priority, especially in contexts where cycling is residual, such as Portuguese cities, with an average modal share of 0.5%. In this context, the Boost project is developing a Starter Cities Roadmap to promote cycling. This article aims to discuss the methodological steps beyond a comprehensive Economic Value for Cycling (EVC) tool. This tool is aimed to analyze the impacts of a higher use of the bicycle as a transportation mode and its multi-dimensional impacts in the economy. Departing from the example of starter cities in Portugal and the available statistical information, a full description of the methodology applied (and challenges) is offered. This method covers from the calculation of the bicycle industry value chain; economic impacts of reduced fuel consumption caused by modal shift; and the value of environmental, energy and health benefits at a local level.

Key words

Value of Cycling; Cycling Impacts; Cycling Benefits; Economic Impacts

Resumen

Las preocupaciones sobre el cambio climático, los efectos de la congestión y la contaminación en las áreas urbanas han puesto en evidencia la necesidad de patrones de movilidad alternativos que reduzcan los impactos negativos del transporte. Al mismo tiempo, la investigación sobre movilidad urbana sostenible destaca la bicicleta como un medio de transporte eficaz y sus beneficios económicos, sociales y medioambientales. A pesar de esto, la inversión en la bicicleta no siempre se considera una prioridad, especialmente en contextos donde el uso de la bicicleta es residual. Esto ocurre en las ciudades portuguesas con una participación modal promedio de 0,5%. En este contexto, el proyecto Boost desarrolló un guion de “Starter Cities” para promover el uso de la bicicleta. Este artículo tiene como objetivo discutir los pasos metodológicos para desarrollar una herramienta multidimensional a partir Valor Económico para la Bicicleta (VEB), para analizar los impactos directos e indirectos de un mayor uso de la bicicleta sobre la economía. Partiendo del ejemplo de las “Starter Cities” en Portugal y de la información estadística disponible, se ofrece una descripción completa de los desafíos y metodología aplicada. Este método abarca el cálculo de la cadena de valor de la industria de la bicicleta; los impactos económicos del consumo reducido de combustible causado por el cambio modal; y el valor de los beneficios ambientales, energéticos y para la salud a nivel local.

Palabras clave

Valor del ciclismo; Impactos de la bicicleta; Beneficios del ciclismo; Impactos económicos

1 University of Florida, USA. E-mail: joao.ferreira@ufl.edu.

2 Department of Social, Political and Territorial Sciences, University of Aveiro, Portugal E-mail: catarina.isidoro@ua.pt.

3 *Ibíd.* E-mail: fredericomsa@ua.pt.

4 *Ibíd.* E-mail: jcmota@ua.pt.

Introduction

The promotion of soft (or active) mobility and the use of bicycles as a means of transport for daily urban mobility has gained recognition in recent years (Banister, 2008; Zayed, 2017). The growing concern about climate change, congestion and pollution in urban areas have led to the need to rethink transport policy and urban planning policy (Ferreira, Ramos, Cruz & Barata, 2017; Moura & Sá, 2017). In terms of mobility, this has translated into promoting the use of bicycles as a daily means of transport (Dill & Carr, 2003; Lindsay, Macmillan & Woodward, 2011). From mobility and transport policies point of view, this has translated into new guidelines and the allocation of funds for sustainable mobility. In 2009 the concept of Sustainable Urban Mobility Plans (SUMP) is introduced, whose implementation should consider the growth of active modes as a determining factor for long-term change of urban mobility (Rupprecht Consult, 2019). In the European Commission's White Paper on Transport (2011)⁵ which will guide transport policy for the period 2010-2050, it is mentioned the importance of promoting cycling as an alternative to car use, and cycling as an opportunity to provide urban clean and sustainable urban mobility, and also to improve safety by reducing the number of road transport victims. The European Strategy for Low-Emission Mobility (2016)⁶ reinforces the importance of SUMP to enable and encourage cycling.⁷ Although there is no official European Union (EU) bicycle strategy, in 2017 the European Cycling Federation (ECF) has developed its own strategy and a set of recommendations - EU Cycling Strategy. Recommendations for Delivering Green Growth and Effective Mobility in 2030 – that has 4 general objectives are: place cycling as an equal partner in the mobility system; increase bicycle use in the EU by 50%; reduce deaths and serious injuries among cyclists for miles traveled; and increase EU investment on cycling to € 3 billion over the period 2021-27 and € 6 billion over 2028-34 (European Cyclists' Federation, 2017). Regarding the funding policy, there are € 70 billion of the Cohesion Fund and the European Regional Development Fund for the for 2014-2020 period to support and co-finance investments to help create smarter, efficient and safer transport systems, including investments for pedestrian and bicycle mobility.⁸ In Portugal, the program "Portugal Ciclável 2030" was launched in September 2018 by the Assistant Secretary of State of the Environment, with a 300 million euros budget to build 960 kilometers of cycle paths over 12 years (Ministério do Ambiente, 2018) and in the following the National Strategy for Cyclic Active Mobility 2020-2030⁹ was approved. Other major investments are planned in countries such as the United Kingdom or Italy, among others (ECF & COLIBI-COLIPED, 2014; Vergnani, 2019).

At the same time, as infrastructure investment is taking place, there is an increase in research on soft mobility, namely to understand what may motivate bicycle use instead of motor vehicles (Cox, 2019; Delso *et al.*, 2018; Dill, 2009; Held *et al.*, 2015; Marqués *et al.*, 2014; Tiwari *et al.*, 2008). Even within the ECF, the emergence of the Scientists for Cycling¹⁰ network reflects the need to produce knowledge and bring it to decision makers.

In this context, this work aims to discuss the concept of the economic value for cycling and the appropriated calculation methodologies. The paper begins by listing the main advantages of cycling. It then describes the reality of modal split in Portugal. Finally, it summarizes part

5 https://ec.europa.eu/transport/themes/strategies/2011_white_paper_en

6 https://eur-lex.europa.eu/resource.html?uri=cellar:e44d3c21-531e-11e6-89bd-01aa75ed71a1.0002.02/DOC_1&format=PDF

7 https://ec.europa.eu/transport/themes/urban/cycling/guidance-cycling-projects-eu/cycling-policy-a-nd-background_en

8 Cf. 6 COM (2017)283 final.

9 <https://dre.pt/application/conteudo/123666113>

10 <https://ecf.com/community/scientists-cycling>

of the ambition and objective of the Boost project,¹¹ a research project promoted by the University of Porto and University of Aveiro and funded by the FCT, and the methodology chosen to calculate the economic value for cycling, considering the Portuguese reality, but also the available statistical information. In this work, we will look to a specific type of cities. BYPAD (2008) and Silva *et al.*, (2019) there are the “champion cities” (modal split above 20%), “climber cities” (between 20 and 10 %) and the “starter cities” (modal split below 10%). These “starter cities” are in an unfavorable situation, with no tradition of cycling, and without information and tools that specifically consider their problems and respective solutions.

Focused on Portugal, the economic impacts of bicycle use will be studied at national and local levels. At the national scale, the bicycle value chain and impact of changing the commuting patterns will be analyzed. At the local level and in a context where the majority of the municipalities fit a profile of “starter cities”, it will be assessed the environmental, energy impacts and health benefits related to the use of bicycles for the 308 Portuguese municipalities. It is expected that the developed tool, which includes an evaluation model of the Economic Value for Cycling (EVC), will be useful and noteworthy to policy makers in order to encourage policies that promote soft/active mobility. In the end of the project, it should be readily apparent to various audiences and agents, the costs and advantages of promoting cycling in the Portuguese economy.

The Economic Value for Cycling – a multidimensional approach

Many studies have underline the benefits associated with the modal shift to bicycle, ranging from the promotion of a flexible mobility (Fishman, Washington & Haworth, 2014); reduction of fossil fuel consumption and pollutant emissions (Blondel, Mispelon & Ferguson, 2011); congestion reduction (Litman, 2016) public health and quality of life benefits (Oja *et al.*, 2011). In other words, we can say that cycling brings economic benefits to both users and society (European Cyclists’ Federation, 2017; Fishman *et al.*, 2014). According to the estimate presented by the ECF in 2016, the economic benefits associated with cycling in Europe were € 513 billion per year (Neun & Haubold, 2016). As recently underline by Brey *et al.* (2017), in Seville, investment in the remarkable economic benefits of the bicycle promotion policy in Seville, with significant savings in travel times, vehicle use and infrastructure maintenance, health, traffic accidents, and air pollution for both cyclists and society as a whole. However, investment in cycling is not considered a priority (Krizec, 2007) and is not evenly distributed throughout the territory. In this context, we highlight the “bike friendly cities” that are characterized by the adoption of transport policies, the creation of infrastructures and the awareness of society to prioritize bicycle use (Zayed, 2017).

Beyond an object or a good, a bicycle is a means of transport that induces action by its user. Its usefulness lies in either serving to move faster or more efficiently than by other means or the fact that its use generates joy and pleasure. In any case, it has impacts that can influence the way society organizes itself: in the daily consumption, in the time we spend, in jobs and production of our economy and country, in the

¹¹ <https://boost.up.pt/>

means of transportation that we choose, the speed at which we move, or even the diseases we may or may not have. This has been recently recognized in by Bullock, Brereton & Bailey (2017). In their work, these authors conclude that wider economic benefits are a significant and often overlooked benefit of bike-share. Generally, all these benefits (which include economic, cultural, social, environmental dimensions among others), as underlined by Gössling *et al.* (2019), can be translated into a monetary framework as a way to allow comparison. In this way, it turns out to be more useful for decision makers when dealing with a multiplicity of phenomena and distinct needs. However, from a methodological point of view this assessment according to a general framework is not that simple. In terms of the available statistical information, Raje & Saffrey (2008) and Weston *et al.* (2012) highlight the problems associated with the lack of data. The ECF considers that the bicycle counts are ad hoc and linked to specific infrastructure projects, making it impossible to evaluate and analyze its evolution (European Cyclists' Federation, 2017). The lack of statistics is an even more critical phenomenon when, as stated by Krizec (2007), there is an advantage in identifying benefits at the municipal or regional level. Additionally, Steenberghen *et al.* (2017) underline the absence of a standard methodology as well as methods that incorporate the full extent of the benefits associated with cycling (also underlined by Raje & Saffrey, 2008).

Thus, it is common to simplify when assessing the direct benefits of cycling, based on indicators such as turnover, bicycle sales and rental activity, or jobs generated. Alternatively, ECF limits these indicators to a microeconomic benefits category associated with the bicycle manufacturing industry and bicycle components and accessories (including bicycle rental and tourism services).¹² Such a narrow view diminishes the calculation of the possible benefits of bicycles compared to other modes of transport (Zeebroeck & Charles, 2014). According to Krizec (2007) and Gössling *et al.* (2019), a particular case of undervaluation of the economic value of cycling occurs in Cost Benefit Analysis (CBA).

This methodology usually includes criteria such as: travel time, vehicle operation costs, accidents/collisions, noise, air pollution and environmental impacts. This excludes from the generality of CBAs the externalities of transport.¹³ One exception is the Copenhagen study (Gössling *et al.*, 2019; Gössling & Choi, 2015) where important concepts such as contingent assessment, hedonic price index, travel cost assessment, avoided social costs, health costs, and shadow prices are included. This work, as well as others that followed (Blondiau & Zeebroeck, 2014; Macmillan *et al.*, 2013; Sustrans, 2019) had the merit of assessing the impact of cycling not just as an alternative to the car that generates a certain financial impact, but by also incorporating different societal dimensions. More recently, Pelechris, Zacharias, Kokkodis & Lappas (2017) in a study about the introduction of a bike sharing system in Pittsburgh, have recently concluded that being close to a station contributed for the increase of housing prices and rents. In their study, they also argue that the positive impact on the housing values is consequently translated to increased income for the local government due to increased property taxes.

In this line, the ECF, in addition to the already listed microeconomic benefits, also highlights other key factors, in particular those related to environment, energy, natural resources and health issues¹⁴ (Macmillan *et al.*, 2014; Neun & Haubold, 2016). The following table summarizes the benefits and indicators presented in this paper.

12 A report by the League of American Bicyclists and the Alliance for Biking & Walking (Flusche, 2012) attributed more than € 5 billion to the US bicycle manufacturing industry. In the European case, Blondiau *et al.* (2014; 2016) conclude that over 650,000 jobs are linked to cycling and over 400,000 new jobs can be created with duplication of bicycle users in the EU-27, particularly in the most vulnerable population groups.

13 Some examples are: There is no public participation in the definition of the criteria to be included and in some cases only those aspects that translate into monetary values are considered, leaving out relevant social aspects. Raje & Saffrey (2008) goes beyond this explanation and also considers that the benefits of cycling are only measured when a modal shift occurs.

14 Other benefits of a more qualitative nature linked to the bicycle culture are also identified in this paper.

BENEFITS	INDICATORS
Environment and Climate	CO2 Emission Savings
	Air pollution reduction
	Noise reduction
	Environmental assets
Energy and Resources	Fuel savings
	Resource savings in vehicle production + infrastructure construction
	Active Mobility and E- Mobility
Health Benefits	Mortality Reduction
	Healthier Lifestyles - Reduction of Morbidity
	Mental Health Benefits
	Children Health Benefits
	Road Safety Benefits - Accidents Avoided
	Decrease of employee absenteeism
Economic Benefits	Bicycle industry
	Sales and Repairs
	Cycling tourism
	Material damage prevented (car accidents)
	Shopping by bike - Local retailers/business
Social Benefits	Social equality
	Gender equality
	Children's Welfare
	Security
	Accessibility
	Connectivity between people
Mobility	Traffic congestion
	Construction and maintenance of road infrastructure
	Public transport
	Connectivity - inter and multi mobility

Table 1. -Summary of the benefits associated with the cycling and the indicators for assessing the associated economic value. Source: Own elaboration based on Neun & Haubold, 2016.

The “starter cities” in Portugal and the Boost Project

After decades of over-reliance on cars, many cities around the world are adopting non-motorized modes of transportation to meet environmental challenges and improve urban quality of life (Zayed, 2017). In Europe, the promotion of a modal split in urban travels, such as the shift from motorized individual transport to cycling, is part of the EU policy, expressed on the Urban Mobility Package (COM(2013) 913 final) and Sustainable Urban Mobility Plans (European Commission, 2013). But, the introduction of such measures is happening at different rates, and in 2008 the BYPAD had considered “champion cities”

those with modal share above 20% (e.g. Copenhagen 35% and Amsterdam 32%), “climber cities” when the modal split varies between 10 and 20% (e.g. Helsinki with 11% and Berlin with 13%) and “starter cities” which have a cycling modal split below 10%.¹⁵ The central challenge of European public policy is to maintain the cycling rates where they are high, and in other places to boost its growth (BYPAD, 2008; Deffner, Hefter, Rudolph & Ziel, 2012).

Nowadays, Portuguese cities overwhelmingly correspond to “starter cities”. According to the Mobility Survey in the Porto and Lisbon Metropolitan Areas, commuting by bicycle represents 0.4% in AMP and 0.5% in AML (INE, 2018). In AMP, Póvoa do Varzim is the municipality with the highest percentage (1.96%), while in AML the highest value observed is in Cascais (1.41%) (INE, 2018). The 2011 Census also show residual values of bicycle use in Portugal, with a national average of 0.5% per municipality. It is in the Baixo Vouga sub-region that most people regularly ride bicycles (3.9%). In this region, Murtosa stands out with 17% of trips made by bicycle (INE, 2011; Mota, 2015). These numbers reflect the motorization of Portuguese society (in 2011, 60% of trips were made by private car), a consequence of the territorial transformations that have been taking place based on individualized mobility, which are characterized by an extensive and fragmented occupation of the territory that requires the use of individual motorized transport (Ferreira, 2016; Moura e Sá, 2017). So, among urban planners and national and regional entities there is the consensus that it is necessary to start by qualifying urban spaces and implement basic cycling infrastructures (bicycle lanes, bicycle parking, traffic calming zones). Only then, it is more adequate to implement information and promotion campaigns, communicating the measures and the advantages of cycling (BYPAD, 2008; Deffner *et al.*, 2012). At the same time, more authors support that cycling is an opportunity for a orderly transformation of the territory, enabling to achieve a better quality of life with minimum energy, environmental and financial costs (Moura e Sá, 2017).

Within this context, project Boost – Boosting starter cycling cities aims to promote change and bridge the knowledge gap in starter cities by developing a planning support system for cycling: The Starter City Roadmap. The Roadmap that provides specific technical know-how and support to local authorities and urban planners, comprises three main tools: an assessment framework of the Gross Potential for Cycling—aims to identify the areas with the higher and lower potential for cycling in relation to the target-population, given their willingness to cycle, and the target-areas, due to their built environment, land use and geographic conditions; an assessment framework of the Economic Value for Cycling (EVC) —aims to reveal the economic value of the cycling both at the local and at the national levels, by providing a set of economic indicators considering the bicycle industry and environmental, energy impacts, and health benefits, among others; and (3) a Cycling Measures Selector (CMS)— aims to support the identification of the most appropriate mobility management measures to encourage cycling in starter cities, depending on specific contexts and objectives. Next, we will detail how the EVC tool is going to be developed.

¹⁵ <https://ecf.com/resources/cycling-facts-and-figures/capital-cities>

A comprehensive methodology for economic assessment

Bearing in mind the difficulties and limitations previously reported, we propose a new methodology for the assessment of economic value for cycling in Portugal. As any other study, the methodology applied is restricted to the data available and to the specific circumstances concerning the bicycle implementation in Portugal. Unfortunately, data collection and availability are even more critical when the goal is to develop a tool that can be used on a municipal scale and which results should be simple to interpret based on clear assumptions. Thus, the methodology developed seeks to anticipate four distinct indicators to highlight the benefits of increased bicycle use. Firstly, an economic indicator linked to the generate value added chain that will seek to improve the analysis of production and sales. A second linked to the change in the consumption patterns of the Portuguese induced by a greater use of the bicycle. A third dimension associated with the effect of reducing fuel consumption and its effects on greenhouse gas emissions and other local pollutants. And finally, a fourth dimension that corresponds to the health benefits.

The value-added of bicycle production

Any product or good that is produced results from the use of other goods as intermediate products. To produce a bicycle a set of other materials and inputs are necessary to make the product final assembly possible. There are no bicycles without roller chains or without plastic or similar materials. In turn, there are no roller chains without the production and exploitation of metals. And ultimately, nothing could happen without electricity production. Thus, among the central aspects of the economic valorization of cycling, one that has been neglected is the bicycle production chain and the value added and employment during its final assembly but also in all its components and components inputs. This assessment aims to better understand how promoting cycling can generate gains in the national economy or the different regions.

Other studies have focused on other economies and different production processes. Tzeng, Tang, Hung & Chang (2006) have classified the bicycle production as a conventional industry and concluded that the material costs represent 70% of the production cost. The second most important cost was the labor costs, followed by export-related costs and importation taxes from places of demand that could make international trade of this product more expensive. In its turn, Randall & Ulrich (2001) stressed the need for producers to obey and compete for the best product differentiation strategies. Somehow, since bicycle production (and concurrence) is made to serve the international public, then also manufacturing, distribution and sales practices tend to follow international rules (Tzeng *et al.*, 2006). However, Towill & Christopher (2010) states that there is still room to obey to the customer proximity logic, and product customization is a way to respond to the customers' demands from different markets. Recently Gylling, Heikkilä, Jussila & Saarinen (2015) reported the advantages of small and medium-sized enterprises to maintain local production close to customers and market where they operate because they are less expose to currency fluctuations, but essentially because they know better the market in which they operate.

In any case, all this analysis has still to be done regarding the Portuguese market, and the perception of the value of cycling is limited to its direct indicators. This approach is even more relevant considering how this industry has evolved in recent years (more than 75% in the last 8 years, according to the national statistical office).

Considering this direct method, the Portugal Bike Value project¹⁶ had already estimated that the bicycle sector in Portugal was in 3rd place among the European counterparts in 2014, with 1.6 million units produced, ten leading companies, twenty component companies and 7500 associated jobs. A significant part of this production was for the external market. This is the opposite situation of the car sector, since in Portugal 98% of purchased cars are imported (Ferreira, Ramos, Cruz, Barata & Lahr, 2018; INE, 2012). From the Portuguese economy perspective, this factor immediately reveals a comparative advantage of bicycles “consumption” over cars. To ascertain the contribution of bicycles production to the Portuguese economy, it is necessary to use models capable of integrating the dependency relations between this industry and the components required for assembling and selling the bicycles. In turn, these components also use other components. Thus, the final contribution of bicycles, as other products, corresponds to an intricate relationship between various products that can be produced either domestically or abroad and in different industries.

In summary, analyzing the value added chain is to estimate the contribution of all activities that create value for a specific product or service (Gylling *et al.*, 2015), since the raw materials development to the final product that is delivered to the consumer (Humphrey, 2003).

In our case, we will use the methodology of Ferreira, Ramos & Lahr (2020), based on the adaptation of the multi-regional input-output model (MRIO) that accounts for all the contributions required in the national and international context for a bicycle to reach the market. Other dimensions of the production chain are also considered, namely, employment, taxes and subsidies (Ferreira *et al.*, 2020). At the same time, this contribution is allocated to the regions with the most value added generated.

Commuting and changes of the consumption patterns

The decision to use or not to use a bicycle as a means of transport is a decision made by a member or several members of a family and that results from the weighting of several factors. Saelens, Frank & Med (2003) begins by pointing out two factors for choosing non-motorized transport: proximity (distance) and connectivity (direct direction). In turn, Parkin, Wardman & Page (2008) listed different aspects that may determine the preference for cycling, grouped into different categories: (1) socioeconomic (age, gender, car ownership, income, qualifications, ethnicity, household and marital status, type of employment, experience in cycling, and practice in other physical activities); (2) geographical (travel distance, house location); (3) weather (rain and wind); and (4) associated with the transportation system (cycling infrastructures, motorized traffic volume and public transportation systems) (Parkin *et al.*, 2008). This factors heterogeneity shows that the decision to change the commuting mode choice may be subject to a multitude of variables, some of which are difficult to control, while others may be the subject of political intervention at national, regional or local level.

16 <http://portugalbikevalue.pt/0/pt/>

Another important advantage of cycling is its potential impact on the local economy over other modes of transport. Blondiau & Zeebroeck (2014) and Haubold (2016) conclude that cyclists go more to local shops, restaurants and cafes (Blondiau, Van Zeebroeck & Haubold, 2016) and customers arriving by bike spend more than those arriving by car, shop closer to home and are loyal customers (Haubold, 2016). More recently, Blondiau *et al.* (2016) estimated that 111 billion euros a year are spent by people bike in the EU-28.

Other study estimates that 60 million recreational cyclists per year in the US spend over 40 billion euros on meals, transportation, accommodation, souvenirs and entertainment (Flusche, 2012). Also in Europe with the expected growth of tourism and the increasing pressure on resources, particularly on fossil fuels, low-carbon tourism agendas are becoming more important (Weston & Mota, 2012). In this context, to calculate the economic value of bicycle tourism in Europe, the Cycle Route Demand Forecast Model was created, designed to generate estimates per year of the number of vacation trips, daily trips and direct expenses of those trips on a cycle route, by region and in total. The total economic impact of the estimated 2,295 billion trips —2,274 billion one-day trips and 20,4 million overnight stays in Europe in 2012 was 44 billion euros per year— € 35 billion in daily trips and € 9 billion in overnight stays (Piket, Eijgelaar & Peeters, 2013; Weston *et al.*, 2012).

What is clear is that from an economic point of view, replace cars with bicycles has direct implications for the family's consumption structure and this phenomenon is happening worldwide. The proliferation of Bike Sharing systems around the world precisely reveals this phenomenon. In 2010 there were around 100 Bike Sharing programs worldwide and by 2015 this number has increased to 800 cities (Ferreira, Barata, Ramos & Cruz, 2014; Ricci, 2015). This significant increase had consequences for the modal split. In Barcelona, the modal share of bicycles went from 0.75% in 2005 to 1.76% in 2007, while in Paris there was a 1.5% increase in the modal share between 2001 and 2007 (Demaio, 2009). This data shows thousands of people using less income and car-related products (in Europe, households spend on average 13.2% of their income on transports (Eurostat, 2018)) and thereby changing their consumption patterns.

In short, when the car is replaced by the bicycle, there is a reduction in fuel consumption and other costs associated with commuting (parking, tolls) so families have two possibilities: or save more money or spend on other products. Either way, this money will return to the economy, in the form of other expenses that the families will have because they will have more money available.

Ferreira *et al.* (2014) measure the economic and environmental impacts of these changes and estimate the important economic gains associated with the fuel consumption reduction which in turn generates less fossil fuel imports. More recently, the same authors applied this type of study to commuting patterns and mode-switching behavior commuting patterns scenarios in the Lisbon Metropolitan Area. This type of benefits, which results from changes on the consumption patterns, is usually included in the literature, among others, as one of the “shadow benefits” that result from investments in transport infrastructure or from behavioral changes Ferreira *et al.* (2018).

Environmental impacts

According to the Intergovernmental Panel on Climate Change, the transport sector is responsible for one-seventh of global CO₂ emissions, and in addition to travel, car production and infrastructure construction need significant energy and resources, further exacerbating environmental impacts (Médard de Chardon, 2016). In Portugal, the transport sector represents an important part of final energy consumption (37.2% of final primary energy consumption in 2017).¹⁷ In addition to this, as pointed out by Andrade (2012), the car also changed the travel habits and the distances traveled, and promoted territorial dispersion (Carvalho, 2013; Moura e Sá, 2016). Tolley (1996) pointed out the disadvantage of the car even in relation to the bus, since per passenger-km the car emits four times more CO₂, eleven times more NO and twelve times more hydrocarbons. Garrad *et al.*, (2012) conclude that cycling reduces noise and pollution and does not directly consume natural resources. Blondel *et al.* (2011), on the other hand, calculated the CO₂ savings inherent to bicycle use compared to the car, bus and pedelec. The methodology used was based on the life cycle analysis of each mode of transport and the conclusion shows that in the use phase, bicycles are the most environmentally efficient mode compared to vehicles with an internal combustion engine.¹⁸ The pollutants of production processes and of the use of each of these means transport also have different characteristics; some have more local impact (NO and particles) and others essentially global scale impacts (CO₂). In this line, several studies have highlighted the benefit of cycling as an alternative mode of transport for urban territory. For example, Montreal's shared bicycle system is estimated to have saved over € 3 million in greenhouse gases since 2009, and in Lyon the system launched in 2005 has already saved the equivalent of around € 21 million euros in CO₂ emissions (Demaio, 2009). The Shanghai system, on the other hand, saves 8358 tons of gasoline, and reduces CO₂ and NOX emissions by 25,240 and 64 tons, respectively (Zhang & Mi, 2018).

Finally, other studies that sought to predict the future contribution of cycling have highlighted the benefit that an increase of bicycle use would have in improving the environment. Sustrans (2019), in a study of seven English cities, concludes that increased bicycle use has the potential to generate annual savings of 345,000 tons of gas emissions, 729 tons of NOx and 81 tons of particles by 2040. And Mason, Fulton & McDonald (2015) predict that by 2050 cycling will represent 14% of the kilometers traveled in cities, which means over 21 billion euros in CO₂ emissions savings. In another context, Hamilton & Wichman (2018) estimated that a 4% congestion reduction in the city of Washington would imply an annual benefit of approximately 1.28 million dollars relative to the CO₂ emissions reduction.

Taking into account the specificities of starter cities and in order to articulate this tool with the Gross Potential for Bicycle (GPC), which together will allow to develop a roadmap with technical guidelines to promote cycling, this tool will evaluate the economic value for cycling on a local scale, based on:

- Kms travelled by municipality (average time at average speed);
- Current modal split - (2011 Census data with spatial disaggregation by municipality of residence and resident population by main means of transport and by the length of the commute);

17 <https://rea.apambiente.pt/content/pegada-energ%C3%A9tica-e-carb%C3%B3nica-dos-transportes>.

18 Blondel *et al.* (2011) and Cherry, Weinert & Xinmiao (2010) have used life cycle methodologies to assess the impacts associated with the production, use and maintenance phases

- Potential modal split that will be provided by the Gross Potential for the Bicycle GPC tool.

With the current modal split (2011 census) and the potential modal split (GPC tool), we will estimate the number of future trips by transport mode and the average fuel consumption, to see the potential for decarbonization and energy savings of each Portuguese municipality associated with increased bicycle use.

Health dimension

Physical inactivity is considered a major risk factor for global mortality, contributing to the increased risk of cardiovascular disease, diabetes and cancer (WHO, 2009). Geus & Hendriksen (2015) consider that the predominance of the private car as a means of urban transport is one of the causes of inactivity. In addition to this more direct and specific effect, the proliferation of the private car, as previously mentioned, has promoted the urban sprawl. As a result, because of the distance generated between residences and urban functions and activities, it became more difficult to walk or cycle and thus practice physical activity in the everyday life, which also contributed to affect and aggravate public health (Saelens *et al.*, 2003).

At the beginning of this century, the World Health Organization (WHO) (2002) recognized the need to promote cycling as part of daily activities and as a way to reduce the risk of heart disease, diabetes, hypertension, obesity and some forms of cancer. Other authors have assessed the relationship between regular physical activity and risk reduction of various chronic health conditions and related diseases (Saelens *et al.*, 2003; Rojas-Rueda, de Nazelle, Tainio & Nieuwenhuijsen, 2011; Rutter *et al.*, 2013; Deenihan & Caulfield, 2014). Additionally, Hendriksen *et al.*, (2010) concluded that workers who cycle to work have fewer absences, even considering that, as stated by Teschke *et al.*, (2012) cycling have a higher risk of fatality and injury by travel and distance traveled than by car.

To develop guidelines and instruments to assess the economic effects of cycling on health, WHO has developed the Health Economic Assessment Tool (HEAT) (WHO, 2011). This tool is used to estimate the economic value of the health benefits that occur as a result of reduced mortality due to physical activity; health effects caused by road accidents and air pollution.¹⁹ The tool applies users' inputs to calculate the total economic savings from mortality reductions. Even so, the tool does not consider other phenomena such as variations of accidents risk considering utilization levels and other socio-geo-demographic aspects. Similarly, estimates of air quality only consider the effect on adults and not the potential effect on children's health. On the other hand, the methods of assigning monetary value to human life and morbidity are complex, and the "statistical life value" approach does not consider the potential years of life lost (Lindsay *et al.*, 2011).

Recently, Sustrans (2019) also used the Heat tool and estimated that between 2017 and 2040, cycling can avoid 34,000 long-term health conditions, saving the National Health Service more than 370 million euros in the UK.

Following the methodology outlined above for calculating the impacts associated with increased bicycle use at the local level, to calculate the economic health impacts that occur as a result of the reduction in

¹⁹ <https://www.heatwalkingcycling.org/#homepage>

mortality due to increased physical activity associated with cycling, we will use the Heat tool to compare scenarios: current modal split (2011 census) versus potential modal split (GPC tool).

Other costs and benefits

In addition to these costs and benefits that will be assessed by the Boost project, there are yet another set of economic impacts that can be enumerated but do not necessarily translate into increased bicycle use and therefore on its economic value. A first example is infrastructure investment. In fact, the increase of cycling facilities does not necessarily translate into increased bicycle use. According to several studies, factors such as population and function density (employment, trade, services) and multimodality are considered critical for cycling (Parkin *et al.*, 2008; Goetzke & Rave, 2011; Faghih-imani, Eluru, El-geneidy, Rabbat & Haq, 2014; Zayed, 2017). Nonetheless, infrastructure investment is part of the current policy to encourage cycling, and the amounts involved will naturally have an impact on the regions where they take place. Investments such as those planned for London, with an investment of € 1 billion by 2023 (ECF & COLIBI-COLIPED, 2014) or as in Italy with an investment of € 500 million (Vergnani, 2019), both for the construction of urban and long-distance cycle paths and the promotion of bike share systems have an associated economic impact. In Portugal, is worth mentioning the planned investment of 300 million euros over 12 years, which will occur in many cases in rural areas (Ministério do Ambiente, 2018).

However, for reasons of simplification, and because it is not possible to estimate how these investments will translate into increased bicycle use, they are considered in our analysis only to the extent that they make it easier to assume growth scenarios of bicycle use.

Final Remarks

Research on the economic value of cycling has been following the growing importance of sustainable mobility, contributing to the emergence of new tools and evolution of the calculation methodologies commonly used in transport. However, the attribution of economic value to cycling continues to face methodological challenges, in particular: lack of consistent data; difficulty in extrapolating information collected at different scales due to local conditions and different methodologies used; the complexity associated with monetizing some benefits and the incommensurability of some of the effects associated with cycling. In countries or cities where the bicycle use is residual, it is even more complex to develop holistic models to calculate the economic value cycling, due to the almost complete lack of data and lack of technical expertise as well as resources for consistent data collection and gathering necessary information.

As mentioned, the Boost project, currently in development, will incorporate the current state of knowledge and existing models, to develop an evaluation system of the Economic Value for Cycling in Portugal at national and local level, which together with the Gross Potential for Cycling (GPC) and Cycling Measures Selector (CMS) tools, will contribute to the promotion of cycling mobility.

Understand the economic value of cycling is also to better understand the impact that these projects can have on the Portuguese con-

text but also in other contexts where bicycle implementation is still residual. The learnings and conclusions of this exercise will allow better informing policymakers and explaining some of the current good practices on bicycle promotion and sustainability in a way that more people and an important part of the political discourse can be better assimilated. If more people understand that, besides the social and environmental dimensions, also the economic dimension largely benefits of the increase in bicycle use, then easily more tenacious measures will be introduced, and a sustainable reality with better practices and cities can emerge.

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