13. The Gross Potential for Cycling: planning for human scale urban mobility

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13.1 INTRODUCTION

The (re)turn to human scale cities is inseparable from the shift of mobility paradigms towards sustainable modes of transport. As car dominance steadily transformed what was once public space into road space (Sheller and Urry, 2003), growing congestion and pollution have decreased the quality of life and equity among citizens. Non-motorized transport, and especially cycling, is associated with higher levels of happiness and emotional wellbeing (Zhu and Fan, 2018). It has been framed as a means to democratize the city (Cox, 2019) and as a convivial tool that increases opportunities for social relationships (Illich, 1973, 1974), in addition to other widely recognized environmental and economic benefits. Cycling, therefore, establishes and ensures mobility on a human scale (Quee and Bijlsma, 2018). Nevertheless, despite the growing policy and academic interest in cycling, when compared with other modes of transport little attention has been paid to it (Heinen et al., 2010), and analysis and planning methods have not kept pace with demand (Kuzmyak et al., 2014).

Promoting a modal shift towards cycling is a complex process, particularly in cities dominated by the car-centric paradigm, which cannot reproduce the path of champion cycling cities such as Amsterdam and Copenhagen. Starter cycling cities combine poor cycling conditions with low cycling rates (Dufour, 2010), where the lack of cycling culture and technical know-how limits strategies to sporadic interventions (such as hastily planned infrastructure or symbolic bike sharing systems). Long-term commitment is also weakened as cycling provision lacks the high profile of other infrastructure investments (such as, for example, the metro) and is associated with being ‘cheap’ (Aldred, 2013).

Nevertheless, cycling has entered the global urban mobility agenda, pushed by a widespread commitment towards the transition to post-carbon societies. Portuguese cities, which have extremely low bicycle rideshares – only 0.5 per cent of commuting trips, according to 2011 census data – now face the target raised by the National Strategy for Active Mobility, launched in 2019, to increase urban bicycle modal share to 10 per cent by 2030.

Within this context, project ‘BooST – Boosting starter cycling cities’ aims to integrate current knowledge with the needs of such cities by developing a planning support system for cycling. The shared know-how would substantiate future cycling strategies and facilitate the transition to implementation in planning practice. This chapter draws on research conducted for this project and presents the assessment framework of one of the developed tools, the Gross Potential for Cycling (GPC). It starts with a short review of planning support tools for cycling (section 13.2), followed by the presentation of the GPC tool (section 13.3). Section 13.4 details an application to the municipality of Matosinhos, located in Porto’s Metropolitan Area. The chapter finishes with some remarks on the potential of GPC to assist the development of cycling promotion strategies.

13.2 PLANNING SUPPORT SYSTEMS AND TOOLS FOR CYCLING

Research on cycling travel behaviour in the last decades has strengthened the empirical evidence on some of the most relevant factors influencing commuting mode choice. A complex array of explanatory factors, including psychological and socio-demographic characteristics, the built and natural environment and land use patterns (Heinen et al., 2010; Kuzmyak et al., 2014) has supported the development of tools focused on cycling policies and planning.

Planning support systems (PSS) have been developed to support evidence-based policy and decision-making processes in land use and transport planning (Klosterman, 1999; Te Brömmelstroet and Bertolini, 2008). Cycling-specific PSS include: (1) a set of broad measures evaluating the overall cycling environment in the city, such as the Index of City Readiness for Cycling (Zayed, 2017); (2) tools analysing the potential demand, through spatial and socio-economic analyses, for bicycle commuting, such as the Propensity to Cycle Tool from the British context (Lovelace et al., 2017) and the Analysis of Cycling Potential in the city of London (TfL, 2010, 2017); (3) micro-scale indicators assessing the usability of specific streets for cycling, such as the Bicycle Safety Index Rating (BSIR) and the Bicycle Compatibility Index (BCI) (Schwartz et al., 1999), the assessment of Levels of Traffic Stress for cycling (Mekuria et al., 2012) and bikeability indexes (Hoedl et al., 2010; Winters et al., 2016); and (4) frameworks to prioritize investment in infra-

structure based on the evaluation of predefined parameters weighted by expert judgement (Glavić et al., 2019).

Starter cities raise specific challenges to existing approaches. Those based on street-by-street analysis require vast amounts of micro-scale data, making it impossible to assess large areas, while disregarding relevant socio-economic factors. Others only provide city-wide averages, impeding the identification of the areas with the highest cycling potential, which is key to decide on where to prioritize investment. Certain tools focus on existing cycling infrastructure or rely on data on travel patterns or stated preference surveys (Cox, 2019), which is less relevant when there are no previous cycling habits.

The literature has also identified an implementation gap between the development of PSS and tools and their operational use in planning practice (Kuzmyak et al., 2014; Saujot et al., 2016; Vonk et al., 2005). In order to bridge this gap, assessment tools and models have to be understood by planners, making a claim for more bottom-up participatory approaches that consider planners' objectives and general needs (Te Brömmelstroet and Bertolini, 2008).

The GPC provides a user-friendly PSS whose main novelty is the assessment of the gross potential for cycling, rather than just previous travel patterns, the level of existing cycling infrastructure or user satisfaction, as is commonly used for 'champion cities'. It also entails a participatory process through a call for the participation of Portuguese municipalities.

13.3 THE GROSS POTENTIAL FOR CYCLING

The GPC builds on a literature review exploring the multiple factors influencing the choice of commuting by bicycle (socio-economic, built and natural environment, attitudinal and social factors) and on existing tools. A previous version of the tool (the Potential for Cycling Assessment Method by Silva et al., 2018), has shown the ability to test different scenarios, prioritizing on the location of new infrastructure and complementary bicycle promotion measures. Based on geographic information systems, the GPC employs a two-dimensional approach, combining the assessment of the target population according to their predisposition to cycle, based on socio-economic factors, with the target areas more suitable for cycling categorized by their geographical and built environment characteristics. The model is calibrated according to traffic conditions – comprising topography, road hierarchy, car parking pressure, average congestion, number of car accidents and current cycling infrastructure – which are incorporated into cycling and driving speeds.

13.3.1 Target Population

The first dimension, target population, relates to the spatial distribution of different population segments and is built by assessing four socio-demographic indicators: age, potential demand density, employment density and motorization rate. Age (P1) identifies the population groups more prone to cycle. Most of the literature shows that bicycle commuting tends to be more frequent among younger ages (Dill and McNeil, 2013; Goldsmith, 1992; Litman et al., 2018; Plaut, 2005). While some studies did not find age to be significant (Geus et al., 2008; Parkin et al., 2008), these are target-specific contexts, particularly ones where bicycle usage is already a mainstream behaviour, or focus specifically on work-based trips, excluding students from the analysis. It is our understanding that students and younger adults should be seen as the major target group for promoting the shift of travel behaviours and long-term changes when there is no established cycling culture.

Potential demand density (P2) aims to measure the concentration of prospective users, using travelled distance as a proxy, seen as having a direct negative impact on cycling (Goldsmith, 1992; Stinson and Bhat, 2004; Parkin et al., 2008; Heinen et al., 2010; Fraser and Lock, 2010; Handy et al., 2010; Handy et al., 2014; de Souza et al., 2014; Heesch et al., 2015; Litman et al., 2018). An 8 km threshold was used to filter out those who perform trips, on any transport mode, that can switch to cycling. Employment density (P3) focuses the density analysis on an accessibility perspective, identifying the hotspots of job opportunities. Motorization rate (P4) is a variable provided by census data (car drivers per 1000 inhabitants), based on the question on the main mode of transport used for commuting trips, with the results being used in comparison with the national average. This variable, a proxy of car ownership, follows a consistent pattern in the literature, having a negative effect on cycling levels (Buehler and Pucher, 2011; Heinen et al., 2010; Hoedl et al., 2010; Litman et al., 2018; Parkin et al., 2008; Plaut, 2005; Stinson and Bhat, 2004). As all car trips are addressed in this indicator, the risk of collinearity with indicator P2 is minimized, which filters those based on distance and combines it with other transport modes.

13.3.2 Target Areas

The second dimension identifies the most suitable areas for cycling in terms of accessibility to main centralities, education, and public transport, as well as connectivity and land use mix, while also comparing the relative performance of the bicycle with the car. Accessibility targets three types of destinations considered primordial for the promotion of cycling. Accessibility to education facilities (A1) combines two factors associated with higher propensity to cycle.

Empirical evidence indicates that starter cities should prioritize cycling promotion and infrastructure-based measures in areas with higher proportions of young people, such as schools and universities (Marqués et al., 2015; Whalen et al., 2013), which at the same time are important trip generation nodes.

Accessibility to centralities (A2) measures the city's compactness, as denser urban areas (in population and employment) allow shorter distances between multiple locations (Baltes, 1996; Stinson and Bhat, 2004; Parkin et al., 2008; Fraser and Lock, 2010; Heinen et al., 2010; Heesch et al., 2015; Litman et al., 2018), reducing the attractiveness of car use due to increased driving and parking difficulty (Parkin et al., 2008) and encouraging higher cycling levels.

Accessibility to transport interfaces (A3) takes advantage of the integration of cycling and public transport, significantly extending the catchment area of both, and making intermodal mobility more competitive than car travel (Doolittle and Porter, 1994; Kager et al., 2016; Pucher and Buehler, 2009). In these three indicators, accessibility was measured through predefined cycling travel isochrones towards the considered facilities.

Relative accessibility (A4) identifies the areas where the bicycle is more competitive than the car, comparing the distance reachable by both modes in five minutes' travel time from each census tract centroid. Here, the time spent for parking, based on existing parking pressure on each street, was incorporated as a penalty for the car's catchment area. Bicycle parking provision was not addressed, as the impact of parking on the overall travel time is residual.

Connectivity (A5) relates to how efficiently a road network connects destinations and to the importance of minimizing commuting trip lengths, especially relevant in the case of active mobility (Cantell, 2012; Dill, 2004; Handy et al., 2003; Tresidder, 2005). The GPC measure is the average block size, considering that smaller blocks increase physical connectivity, hence cycling potential. The reference values are inspired by the guidelines and good practices of urban design (Barton et al., 2003).

Occupation Diversity (A6) relates to the spatial distribution of services and facilities and the variety of functions within an area. While the car mobility environment is associated with high functional separation (low diversity) and low density, the cycling (and walking) environment is characterized by higher densities and diversity of uses (low functional separation) (Bertolini, 2017; Heinen et al., 2010; Litman et al., 2018; Ma and Dill, 2015). The index considers the diversity of nine types of activities at 500 metre radius buffers, selected by their high frequency of use in the Portuguese context: primary education institutions; secondary education institutions; restaurants; supermarkets and food shops; other shopping; pharmacies; health centres; services of public interest (banks, post office, public and administrative services); and leisure/culture (theatres, showrooms, museums, libraries).

Table 13.1 *Weight structure of the GPC*

Indicator		Weight
P1	Age	3
P2	Potential demand density	3
P3	Employment density	3
P4	Motorization rate	2
A1	Accessibility to education	3
A2	Accessibility to centralities	2
A3	Accessibility to transport interfaces	2
A4	Relative accessibility to car	3
A5	Connectivity	1
A6	Occupation diversity	1

13.3.3 **Data, Weights and Aggregation**

Data is provided by the municipalities, online databases and national planning organizations. Each indicator is represented on a scale from 1 (lowest potential) to 5 (highest potential), represented spatially at the census tract level. The individual scores are combined into an aggregated score, using weighting factors (see Table 13.1). These weights were determined based on their relevance and representativeness in the existing literature. Finally, a single municipality-wide value is computed for both indicators and the aggregated score, weighted by population.

13.4 **GROSS POTENTIAL FOR CYCLING OF
MATOSINHOS**

In this chapter we use the city of Matosinhos, in northern Portugal, as an illustrative application for the GPC. Matosinhos is a municipality of Porto Metropolitan Area, the second largest urban area in the country, and has a population of around 175 000, with a density of 2 811 inhabitants per km², according to 2011 census data. The city has a high motorization rate (61.9 per cent), against a residual bicycle share (0.4 per cent), therefore it is a starter cycling city. The modal share distribution is inseparable from the city’s land use patterns, characterized by a heterogeneous occupation and by a strong dependency on neighbouring municipalities (absorbing 40 per cent of daily commuting), especially Porto, with which Matosinhos shares its entire southern border. In recent years, the discourse on sustainability has entered Matosinhos’s agenda. While the city’s recent mobility plan has introduced a package of measures targeting the bicycle, describing the first steps towards

the implementation of a network of cycling infrastructure and traffic calming measures, those results have not been captured yet by the available data. Globally, Matosinhos has a medium potential for cycling, due to its GPC score of 3.5, with above average values in what concerns accessibility to education, urban centralities and the age potential of its population. This justifies the focus on younger age groups as ‘cycling ambassadors’. On the other hand, the reduced connectivity of most of its urban structure and a high motorization rate are the biggest impediments to a stronger performance. Each indicator has a unique physical configuration, which is a testament to the particularities of starter cities (Figure 13.1).

A significant portion of the territory is highly ranked when considering the accessibility to education facilities (A1). Still, most of the remaining area-based indicators reflect the territorial asymmetries between the north of the municipality, with lower densities and reduced provision of facilities and employment, and the south, which concentrates most of the population, services, activities and relevant infrastructure in a denser urban setting. This is particularly noticeable when addressing access to centralities (A2) and, although less noticeable, at occupation diversity (A6). The reduced congestion and parking pressure due to the sparser urban occupation of the less dense territories lead to a natural increase of the car’s average speed, which is reflected in a weaker competitiveness of the bicycle (A4). Public transport accessibility (A3) accompanies the metro network’s ‘J-shaped’ axis, while connectivity (A5) identifies the location of more ‘human scale’ urban configurations, roughly coinciding with the core of urban centralities, albeit far from the optimal levels.

The geographic distribution of younger residents (P1), while generally favourable, is marked by abrupt shifts reflecting ‘elderly-dominated’ neighbourhoods. As potential demand density (P2) accompanies the location of residential density hotspots, this signals that most of this city’s residents do indeed perform daily trips that could shift to the bicycle. The analysis of employment density (P3) identifies three key potential areas, deviating from the north–south dichotomy, while motorization rate (P4) reflects the presence of five major areas clearly marked as ‘car-centric’.

The spatial configuration of the GPC score (at the top left of Figure 13.1) attributes higher scores to most of the southern portion of the municipality, especially its western edge, coinciding with the central city area. While maintaining the north–south unevenness, the Matosinhos’ GPC pattern deviates from the sole consideration of population, employment or services hotspots. The areas with the maximum cycling potential are therefore the prime candidates for initial cycling infrastructure investment and where the benefits of policies will be felt more swiftly. While this might accentuate the territorial

Figure 13.1 Overall Gross Potential for Cycling

asymmetries, such is a necessary step to build the initial momentum in starter cycling cities.

13.5 FINAL REMARKS

The GPC is an evidence-based tool, which aims to be both scientifically robust and usable for planning practice. By assessing the areas with higher potential for cycling, supported by visual maps and numeric outputs, it provides easy-to-interpret information for urban planners, decision-makers and the general public. It breaks the initial resistance often associated with bicycle promotion strategies, and especially investment, increasing the initial chances of success, while also allowing targeted and customized policies for areas with differing potential within the same city. This is crucial to foster the development of a progressive strategy that addresses the constraints of specific areas, towards an integrated and inclusive city-wide cycling network. By addressing the spatial and functional specificities of starter cities, the GPC provides a basis for transformative thinking and planning. Future research will also focus on the application of the GPC to cities in more advanced stages of cycling usage, and comparing such results with other existing tools.

As highlighted by the GPC rationale, cities planned for cycling are compact, dense, connected, accessible and with mixed land uses, all features that are inseparable from the human scale city. Nevertheless, further research is needed on the links and tensions between the cycling city and the human scale city, engaging in the debates on mobility justice, affordability and the contradictions inherent to capitalist societies. Planning for cycling entails reclaiming public space and putting people back into the centre of transport planning, contributing to making cities more sustainable, equitable and convivial, while enhancing the quality of life and wellbeing of its inhabitants.

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BooST provides support instruments for cycling starter cities: the Starter City Roadmap. It provides technical know-how and support to local authorities and urban planners, comprising three main tools: (1) an assessment framework of the Gross Potential for Cycling (GPC), identifying the areas that present greater potential for cycling; (2) an assessment framework of the Economic Value for Cycling (EVC), providing estimates based on the bicycle industry value chain (a niche in Portugal), the economic impacts of reduced fuel consumption, health gains and environmental and energy savings; and (3)

a Cycling Measures Selector (CMS), supporting the identification and packaging of packaging mobility management measures suited to stakeholders' needs.

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