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# Revisiting modal split as an urban sustainability indicator using citizen science

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ABSTRACT

This paper discusses three uses of modal split indicators, and illustrates how it evolved from a technical, intermediate step in transport analysis, over a measure of transport system efficiency to a symbolic urban sustainable mobility indicator. A framework which includes 11 factors is presented and applied to the different uses of the modal split indicator. Besides the comparison of the three main uses of modal split in research and practice, this contribution focuses on a citizen science project (Straatvinken) in the region of Flanders, Belgium. In this project thousands of citizens carry out traffic counts. While the project was initially set up to monitor modal split targets in the urban area of Antwerp, the emphasis shifted towards street liveability. This is visible in the fact that the citizen science project added a narrative-based liveability survey to capture experiences with and evaluations of the liveability at street level. The case illustrates that citizen science is, besides a tool to address data gaps, also an approach to increase the validity of indicators. The reason is that citizen science, which seems to be underexplored in transport studies, differs in what gets measured, how it is measured and why. This approach has proven to provide a fine-grained, integrated assessment of street-level changes in the composition and intensity of the traffic and their effects on the perceived liveability. We argue that it strengthens and complements traditional modal split measurements at the regional or urban level, which typically rely on the modelling of individual mobility behaviour based on household travel surveys. Traditional approaches allow observing broad trends in mobility choices at the regional level, but they do not provide insights in how those individual choices translate into effects at street level. Although often initiated out of certain sustainability concerns, existing modal split models do not reveal how an observed modal shift at the regional level affects the perceived liveability or sustainability at street level.

## 1. Introduction

The measurement of mobility indicators has received increasing attention over the last few decades. There exists a plethora of transport indicators, 'transport scoreboards' (EC., 2016), sustainability 'dashboards' (Dobranskyte-Niskota, Perujo, Jesinghaus, & Jensen, 2009), traffic 'scorecards' (INRIX, 2023), and similar tools to summarise and measure the state of transport. To illustrate, one study found more than a thousand sustainable mobility indicators (Buldeo-Rai, Van Lier, & Macharis, 2015), and there is clearly no shortage of studies on transport indicators (Castillo & Pitfield, 2010; Chakhtoura & Pojani, 2016; Geurs & van Wee, 2004).

Besides methodological discussions, and the analysis of the misuse and non-use of indicators in practice (Lyytimäki, Tapio, Varho, & Söderman, 2013), the literature contains many critical assessments of the popularity of indicator projects (Rydin, 2007), including the comparison of countries and cities using a myriad of rankings (Mössner & Gomes de Matos, 2019). Such initiatives are seen as part of the New Public Management agenda and its abundant use of indicators and performance measures which generally pay more attention to competitiveness than to social concerns (Dardot & Laval, 2013). Furthermore, it has been argued that data initiatives play a key role in impression management by actors that claim authority by referring to the dashboards and other platforms they set up, instead of to democratic institutions (Currie, 2020). While the rhetorical use of quantitative data to give a scientific aura to arguments (McCloskey, 1998), and the 'fetishism for numbering' (Hacking, 2015) is not new, reflection on the role of indicators is called for since 'Democracy is being redefined as

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crowdsourcing, measuring, monitoring, and benchmarking. This is why the old publicly accountable data systems of governmentality of methodological positivism—government censuses— are being destroyed, while massive corporate data citadels grow' (Wyly, 2014, p.682). Even researchers who are heavily involved in 'creating/managing national, regional and city indicator projects, working on national spatial data infrastructure projects' (p.7) warn that while they 'believe in the utility and value of indicator and dashboard initiatives […] indicator and dashboard initiatives need to acknowledge and embrace their contingencies, shortcomings and inherent politics, and to not over-sell their utility and value.' (Kitchin, Lauriault, & McArdle, 2015, p.24). However, this era characterised by an avalanche of indicators and dashboards, and by smart city advocates that see data as the ultimate resource, has also witnessed the rise of many critical data collection initiatives in which other data is collected in different, more participatory ways (Moreno Pires, Magee, & Holden, 2017).

The contribution of this study is threefold. First, it offers a framework that uses a wide range of dimensions to compare different applications of an indicator, and which enables to explore relationships between the type and technical characteristics of indicators, their scope, the subjectivities that are constructed, and their role in policy. A particular characteristic of this framework is that it covers both rather technical, as well as factors from the more critical literature. Second, using the aforementioned framework the paper compares the three main applications of modal split as an indicator (a technical parameter in transport models, the optimal share of transport modes, and a sustainable mobility indicator). Given the popularity of modal split as an indicator, this comparison can also be considered a contribution in itself. Third, we introduce a case in which a citizen science project ('Straatvinken') reinterpreted modal split, which shows that the framework is helpful in understanding contestation and interpretive struggles.

## 2. Characteristics and roles of Indicators

Initiatives which define, measure and communicate indicators have been approached as, among other things, policy tools (Lehtonen, 2022), governmental technology (Rydin, 2007) or as part of an indicator industry or the 'indicator industrial complex' (Beaumont & Towns, 2021; King, Gunton, Freebairn, Coutts, & Webb, 2000). This highlights that indicators cannot be reduced to variables with only technical characteristics. Besides such rather technical indicator factors (1), there are also factors related to (2) the users and producers, and to (3) policy and the wider context (Gudmundsson & Sørensen, 2013). Using these three main categories, different aspects and roles of indicators will be discussed which will subsequently be applied to a specific indicator. This paper will particularly focus on modal split figures in general, as well as on their relation to (experiences of) street liveability in a particular case. Note that here the term 'indicator' is used to refer to all kinds of indices, benchmarks and other measures.

### 2.1. Indicator factors

First are the indicator factors, which relate to concepts such as reliability and validity as discussed in statistics and methodological work, as well as to characteristics of variables (Gudmundsson & Sørensen, 2013). Following types of indicators are often distinguished in the literature: (a) descriptive indicators with limited policy interpretation, (b) performance indicators that compare the measured value to a standard, reference or target, and (c) composite indicators that aggregate variables into a summarising figure to grasp a broad concept such as the economy or human development (Lehtonen, 2022). The unit of analysis and its scale form another feature and can encompass e.g. countries, urban areas, neighbourhoods, or streets. Defining the unit of analysis, as a technical step, is also related to the more general process in which the object of government is defined. It is by making this object knowable and legible that it becomes governable (Rydin, 2007; Walters & Haahr, 2005). A specific technical feature that is discussed for the case of sustainability is whether absolute or relative (percentages) numbers are used. Specifically, it has been argued that measuring only relative improvements is insufficient, and that estimates of absolute carbon emissions are needed to check whether planetary boundaries and thresholds are respected (Dillman, Heinonen, & Davíðsdóttir, 2023). Finally, some indicators are well-defined with clear measurement protocols while for others there are only vague descriptions available. The latter category may offer more room for interpretive flexibility and manipulation (Li & Lin, 2022).

### 2.2. Producers and users

Second, if we consider indicators as products, there is a corresponding group of producers and users. While many indicators are collected and distributed by government agencies in the form of official statistics, also other organisations collect, compile and produce indicators. This includes universities and research institutes, think tanks, consultancy firms, umbrella organisations and NGOs (Beaumont & Towns, 2021). Increasingly, IT and communication companies offer a range of transport and mobility data services, often on a payment basis. Producing indicators is also a practice which organisations use to ensure 'both the competence of the organisation for a specific policy field and their mandate to offer solutions' (Freistein & Koch, 2014, p.19). This is also the case for critical initiatives in which actors collect data to raise awareness, and to contest the dominant framing of issues.

While many indicator initiatives have been criticised as marketing devices, top-down surveillance tools or examples of a neoliberal audit culture and entrepreneurial urban policies (Currie, 2020; Li & Lin, 2022), a plethora of community initiatives have been set up that produce indicators as well (Rydin, 2007). The label community indicators movement has been used to group many initiatives in the 1990s and 2000s. Their aim is to empower citizens through involving them in the process of defining, measuring and communicating indicators, and it has been argued that the figures generated represent better their experiences, the things that matter most to them, and are more context-specific (Moreno Pires et al., 2017).

A particular way of indicator production is citizen science. This encompasses a wide variety of projects in which citizens count for example birds or traffic, the latter being the focus of this contribution. Citizen science revolves around public participation in knowledge production and ranges from standardized data collection tasks by citizens to participation of 'laypeople' in problem definition, data analysis and communication (Irwin, 2015). Even in citizen science projects that are less collaborative in the sense that citizens are simply asked to collect data in a prescribed manner, their engagement and commitment can be intense (Phillips, Ballard, Lewenstein, & Bonney, 2019).

Regarding the type of actors, their roles are not predefined. For example, academics and other researchers are involved in both critical community initiatives as well as in commercial and city branding projects. Likewise, governments participate in both 'genuine' community initiatives, as well as in monitoring and surveillance projects where citizens are recruited to report in prescribed ways nuisances which authorities then act upon (Currie, 2020). Actors not only can be data producers, but also audiences. Although it is hard to control what happens when data is made public, indicator producers have explicit or implicit ideas about the intended use and users of indicators (Lehtonen, 2022). Stated differently, it are actors that link indicators to policy, which is the topic of the next subsection.

### 2.3. Policy and wider context

The third group of factors relate to policy and the wider context. Following roles in policy processes are regularly distinguished (Gasparini & Mariotti, 2023): (a) instrumental: the indicator is directly used in policy, (b) conceptual: the idea and message embodied by the indicator influence policy through agenda setting or awareness raising, and (c) symbolic: the indicator is used to legitimise a policy strategy not directly linked to the indicator. Studies that discuss the use of indicators in policy invariably state that the intended use of indicators in decision-making processes as envisaged by experts is the exception (Gudmundsson & Sørensen, 2013; Lehtonen, 2022; Rydin, 2007). The use of indicators is thus not restricted to measuring in the strict sense or to providing input in a linear decision making process, which calls for a broader look at their role in policy processes.

Seeing indicators as an iterative process is related to the view that problems and solutions are developed simultaneously (Hajer, 1995). A problem definition suggests to some extent which policy instruments are considered effective to solve a problem. For example, defining a problem in terms of external costs, suggests that pricing is the appropriate solution. Analytically, the framework used here (Table 1) makes a distinction between problem and solution. However, this does not contradict the view that both problem and solution are connected since the overarching idea is that all factors included in the framework are related.

Policy instruments are linked to policy paradigms which are less specific and more stable, and encompass a set of ideas about what the main problems, type of solutions and actors are. In transport studies, reference is often made to 'predict and provide', 'demand management', 'sustainable mobility' and 'smart mobility' as key policy paradigms (Lyons, 2018; Owens, 1995).

Finally, indicators and the related policies construct actors in a process in which particular characteristics of human beings are used to describe their role (Rydin, 2007). In sustainability discourses, people are for example described as irresponsible polluters, but also as custodians of the Earth. The framework refers to such constructs as 'imagined subjects'.

## 3. Three uses of modal split

The different elements discussed in the previous section are now applied to the modal split indicator. Table 1 summarises the results using eleven factors that fall in the three main categories of 'indicator', 'user producer & user', and 'policy & wider context' factors. Modal split is an interesting indicator given that it is already present in transport research and policy for decades, and is used in significantly different ways. The table presents a comparison of three uses of modal split, which are approached as ideal types, acknowledging that applications in practice are seldom pure or entirely coherent, and that overlap and hybrid uses may exist. From a historical perspective, the first use was developed in the 1950s and 1960s, the second in the 1970s, and the rise of sustainable mobility can be seen in the 1990s and 2000s. However, this does not imply that there are distinct periods since all three interpretations have continued to exist.

### 3.1. Modal split as a technical parameter in transport models

The concept of modal split and modal split models have been part of the transport research toolbox for decades. The emphasis was initially on traffic flow forecasts for which one needs to know which share of trips is done by car and public transport respectively. As indicated in Table 1, modal split is here a descriptive indicator or technical parameter, predominantly used in the context of urban highways (Bates, 2007). While relative modal split numbers were provided, the focus was on absolute figures (traffic intensities) in order to estimate whether there was sufficient capacity (Deen, Mertz, & Irwin, 1963; Hutchinson, 1981; Salter, 1974). Defining the modal split is thus an intermediate step in transport analysis, and the indicator has a technical character with relatively limited interpretive flexibility. It is produced by experts (mainly transport engineers), and the intended audience consists of the decision makers in infrastructure departments responsible for transport infrastructure projects. The role of the indicator in policy is thus instrumental, providing objective information on where infrastructure needs to be delivered (solution) in response to increasing levels of congestion (problem). This is the dominant problem-solution pair in the predict and provide policy paradigm 'in which demands are projected, equated with need and met by infrastructure provision at least in as far as the public purse will allow' (Owens, 1995, p.44). Finally, the imagined subjects here are moving objects, namely road users who occupy road space, or transit users.

### 3.2. Modal split as the optimal share of transport modes

The second use of modal split figures is as indicators for rational mode choice (Goodwin, 1977). 'For instance, if the objective on a particular corridor is to achieve the combination of modes of travel for the journey to work which minimises the costs (to the community) of providing and using the transport system then modal split itself could be a suitable indicator.' (Tyson, 1977, p.40). The underlying idea is that for one group of trips, public transport is the most efficient option, particularly in high density zones, while for the other part of the trips, the private car is the option with the lowest social cost. Such an optimal modal split can then be estimated for each region based on the particular circumstances. In this case, the high-level objective of social cost-benefit or economic efficiency is translated in a low-level objective defined as the optimal modal split. Hence, modal split is here a performance indicator (Table 1), evaluating the extent to which the transport system under study deviates from the optimal state. In principle, this can be measured for the transport network of an urban or other region, but transport corridors that handle large traffic flows are seen as logical units for analysis and policy (Tyson, 1977). The optimal modal split, which is a percentage (relative number), is the key variable, which is

**Table 1**
Comparison of the three main uses of the modal split indicator.

| | Technical parameter in transport models | Optimal share of transport modes | Sustainable mobility indicator |
|---|---|---|---|
| indicator factors | | | |
| *Type* | Descriptive; technical parameter | Performance indicator | Performance indicator used as composite one |
| *Units* | Urban highways | Transport corridor | City |
| *Relative/absolute* | Relative (but used to estimate absolute traffic intensities) | Relative | Relative |
| *Flexibility in interpretation* | Low | Low | High |
| producer and user factors | | | |
| *Producer* | Experts (engineers) | Experts (economists) | Policymakers |
| *Users* | Infrastructure departments | Technocratic policymakers | Politicians, population |
| Policy and context factors | | | |
| *Role in policy* | Instrumental | (Conceptual->) instrumental | Conceptual -> symbolic |
| *Problem to solve* | Congestion | Suboptimal use of scarce resources | Environmental impact |
| *Policy instrument* | Infrastructure provision | CBA, pricing | Influencing behaviour (mode choice) |
| *Policy paradigm* | Predict & provide | Demand management | Sustainable mobility |
| *Imagined subjects* | Road users (moving objects) | Consumers | Trip-makers, polluters |

expected to be estimated using rigorous transport economic analysis, assuming low interpretive flexibility. Transport economists are thus the main producers who provide concise information to policy makers who have to evaluate policies. The role in the policy process is thus instrumental, although the message that an optimal modal split exists and that decisions should be based on rational economic analysis might play a conceptual role as well. Cost-Benefit Analysis (CBA) is the policy instrument that embodies this rational analysis, and is complemented with pricing to ensure that infrastructures are optimally used. The corresponding policy paradigm has been labeled demand management and is the translation of the principles of transport economics to policy. Within this paradigm, subjects are mainly seen as consumers of transport services.

### *3.3. Modal split as a sustainable mobility indicator*

In the context of energy conservation policies in the 1970s, but especially with the rise of the sustainable mobility paradigm since the 1990s, modal split is increasingly discussed with the objective to induce a modal shift away from the private car (Banister, 2008; Lee, Lee, Hiemstra-van Mastrigt, & Kim, 2022). Reducing the share of the car can be seen as a way to achieve a more efficient modal split, which can be estimated by including external environmental costs in the use of modal split discussed in the previous paragraph. Seen that way, it would be a performance indicator. However, the car has become the prototypical environmentally harmful travel mode in sustainable transport discourses, although attempts are made to promote specific car models or engine types as green or ecological. As the case in the next section will illustrate, modal split is regularly used as if it is a composite indicator that summarises how sustainable the mobility in an area is. Even when sustainability would be narrowly interpreted as environmental impact, modal split is in fact not a composite indicator. The total amount of emissions not only depends on the modal split, the share of a particular mode, but also on the absolute number of trips, distance, vehicle technology, driving style as well as some other factors (Heinen & Mattioli, 2019a, 2019b). This points to the issue that the emphasis is on percentages, instead of on absolute figures.

Regarding the unit of analysis, particularly popular are comparisons of modal split figures of cities, with the corresponding message that the lower the share of the car, the better. One issue is the comparability of figures. Often data based on different survey methods and study area delineations, and from different years is compared. One study which compared seven different modal split figures for Belgian cities showed that for the city of Antwerp (the main case study location) the share of the car ranged between 41 % and 68 % (Vanoutrive, 2015). While a more rigorous application of a common methodology may avoid biased comparisons, the interpretive flexibility of modal split figures in practice remains high.

Experts and researchers are often involved in the production process of modal split indicators, but governments, policymakers as well as think tank-like organisations play a significant role in compiling and disseminating the figures. Their audiences also include the wider public, and the role in policy is often symbolic directed towards awareness raising, and showing that an actor is on top of the problem. The higher-level objectives for the measurement of the modal split tend to be implicit and/or build on hidden assumptions of what should be changed to address the problem. Modal split figures are seen as an example of the use of indicators in policies characterised by 'easy-to-buy and uncritically propositional conclusions, supporting clear and implementable recommendations for governments and private agencies.' (p.252), based on "a naïve understanding of indicators (that is, a modal split in transportation [...]) that ignores the political complexity of negotiating between the environment, the economy and the social sphere. [...] reduces the political nature of indicators and rankings to an oversimplified juxtaposition of 'problem' and corresponding 'solution'." (Mössner & Gomes de Matos, 2019, p.245). Modal split figures, aggregates of individual modal choice, are a key indicator of a type of policy that emphasises individual, independent choice and sees individual behaviour change as main solution, downplaying the role of other, more structural factors (Bergman, Schwanen, & Sovacool, 2017). This is further reinforced by existing modal split measurement methods that typically focus on capturing the mobility behaviour of individuals rather than their combined effect on a given location. Summarising, the problem to be addressed is often a vague description of unsustainable mobility or car dominance, while the main solution is a modal shift away from the car. The role of policy instruments is to influence the modal choice behaviour of individual travellers.

As a response to the perceived anti-car rhetoric in sustainable mobility discourses, a good number of policymakers adopted a 'multimodal pragmatism' strategy (Walton & Shaw, 2003). This encompasses that the car is seen as a reasonable, but not necessarily dominant, alternative among a variety of transport modes. This approach is more politically acceptable than more critical variants of the sustainable mobility paradigm since it is less hostile towards car users. This illustrates that modal split and related indicators are embedded in policy debates and can take a symbolic and political meaning, but also that the political acceptability of policy messages and instruments shapes the process. Promoting a modal shift, which includes modal split monitoring, is one of the key elements of the sustainable mobility policy paradigm (Banister, 2008), together with trip reduction, the development of compact cities, and cleaner technologies. As a final element in Table 1, subjects are mainly seen as trip-makers who have to change behaviour towards a less polluting lifestyle, and less as citizens with political agency.

The next section uses modal split as a sustainable mobility indicator as reference and discusses how it was reconceptualised in a citizen science project. Some issues outlined above help to understand this reconceptualization. In essence modal split is a performance indicator but is often presented as if it is a composite one that offers a holistic view. As a result, the indicator plays a symbolic role which increases its interpretive flexibility. Furthermore, providing a rather abstract number at the level of an urban area is relatively disconnected from the daily experiences of people. Relatedly, as a determinant of experienced liveability or sustainability, the absolute number of cars might outperform relative numbers (percentages) such as modal split. Finally, the policy focus on individual behaviour change does not emphasise the role of people as citizens who participate in decision making.

## 4. The case of Straatvinken

This section discusses a citizen science project (Straatvinken) in which modal split plays a prominent role. Modal split as a sustainable mobility indicator acts here as a reference, and the interpretive flexibility of this indicator provided room to change the framing. The analysis of the alternative approach for modal split measurement brought forward in the citizen science project builds on the findings from five rounds of traffic counting and four rounds of narrative-based liveability surveys (see further under 'Liveability'). These are further complemented with participatory observation as the authors are active members of the core team of this project. The activities included approximately monthly project meetings, drawing up press releases, presenting the project to a variety of audiences ranging from school children, geography teachers, citizen groups to professionals and academics, staffing a booth at a festival organised by the citizen movement Ringland and at the main book fair in the region, cleaning and analysing data, and reading comments and suggestions of participants. As Straatvinken originally emerged from a citizen movement in the region of Antwerp, most members of the team are citizen scientists with limited expertise about transport issues at the start of the project. We start with a description of the broader context, after which the project is introduced, and summarised using the framework presented above.

### 4.1. Context

After the devolution of competences (especially in the 1980s), most competences related to transport, mobility and spatial planning in Belgium have been devolved to the three regions, including the region of Flanders. In the early 1990s, Flemish policy texts and related studies contained some modal split figures, but the emphasis was more on absolute figures of traffic flows (De Brabander & Verhetsel, 1989; Sauwens, 1991). In contrast, the regional draft mobility plan of 2001 contained modal split targets for car, public transport and cycling, and specific targets were set for flows between different types of subregions such as rural areas and different types of urban areas (MOW, 2001, p.70). The text stated that the aim is to obtain a more efficient modal split, and the figures show that this means a decrease in the share of the car for all categories of flows. For the region of Flanders as a whole the target for passenger transport (evening peak) was a modal shift from 70 % car trips in 1998 to 62 % in 2010. A similar target can be found in the 2005 'Commuting Plan' of the Flemish government. The ambition was to reduce the share of the car in commuting from 70 % to 60 % in 2010 (Emis, 2005). Based on data from the regional household travel survey (OVG) Flanders Environment Agency reports a share of the car in commuting of 69.9 % in 2010 and 67.5 % in 2019 (but 74.6 % in 2017 and 68.5 % in 2018). However, vehicle kilometres for passenger cars have risen from 43.6 billion in 2013 to 45.8 billion in 2019 (VMM, 2021a), and also the climate impact of road passenger transport has risen from 8119 kton $CO_2$-eq in 2010 to 8259 kton $CO_2$-eq in 2018 (VMM, 2021b). This illustrates that relative numbers needs to be complemented by absolute figures.

Regarding modal split targets relevant for the citizen science project discussed here, the most important document is the 'pact for the future' signed by three citizen movements and some governments (MOW, 2017). This pact is seen as a historical agreement after years of conflict mainly about a new motorway link near the city centre of Antwerp (Van Wymeersch, Vanoutrive, & Oosterlynck, 2020). The signing parties agreed on a modal shift to 50/50 in 2030. Although the pact itself does not provide any detail on the meaning of the 50/50 target, it is usually defined as 50 % car travel and 50 % alternative or sustainable modes. A participatory process called Routeplan 2030 (roadmap 2030) has been set up to ensure that the necessary measures are taken to reach the target. In the meantime, the ambition to increase the share of sustainable modes to at least 50 % in the Antwerp transport region as well as in two other transport regions, and to at least 40 % in the 12 remaining transport regions is included in the policy note of the Flemish Minister of Mobility and Public Works (Peeters, 2019), and in the Flemish Air Quality policy plan (dpt. Omgeving, 2019).

The next subsection describes how a citizen science project was organised. The choice to set up a citizen science project is not surprising. There is a general increase in attention for citizen science (Storme et al., 2022), and the citizen movement Ringland and the universities of Antwerp and Leuven already initiated another project in 2016, CurieuzeNeuzen, during which more than 2000 citizens measured air quality ($NO_2$) in their street. This project expanded to the whole of Flanders in 2018 (20,000 measurement points). The prize-winning project was brought forward as best practice in citizen science by the European Commission (EC, 2020), the European Environmental Agency (European Environment Agency, 2019) and the Flemish parliament (Vlaams Parlement, 2019), and was mentioned in two Nature articles (Fritz et al., 2019; Irwin, 2018).

### 4.2. The citizen science project

As a response to the modal split targets in the 2017 pact of the future, one of the citizen movements that signed the pact for the future which contains the modal split targets, Ringland, started the citizen science initiative Straatvinken in cooperation with researchers from two universities. In the conception phase, various modal split measurement instruments were considered, including asking the citizen scientists to use a dedicated app that would record their mobility behaviour. However, the project team finally had a preference for street-level traffic measurements because it would provide a more detailed and factual picture of what is happening on the location where the citizen scientists live. The models currently used by the government were judged to be too abstract and not fully transparent. As a consequence, since 2018, citizens are asked to count traffic in their street on a Thursday in May from 17 h to 18 h. The objective is to monitor whether the envisaged modal shift will materialise in practice. The number of counted street segments (after data cleaning) rose from 1506 in 2018 to 3800 in 2021 (and 2880 in 2022), and the plan was to continue the project until 2030.

The first edition of Straatvinken was organised in the Antwerp transport region and in the city of Leuven, where another citizen group recruited participants. The initiative gained national media attention on television, social media and print media. After the 2018 pilot edition, the 2019 edition of Straatvinken was expanded and the study included four transport regions, and from the 2020 edition onwards, the project covers the entire region of Flanders. With the geographical expansion, the project evolved from a rather urban initiative linked to a specific context (the contestation of an infrastructure project in Antwerp) to a region-wide project. This illustrates that traffic counts by citizens are seen as relevant in a wide variety of geographical settings. Each edition a growing number of local authorities promotes the traffic count, and in 2021 almost half of the 300 local authorities in the region of Flanders supports Straatvinken, mainly by asking citizens to participate.

### 4.3. Modal split

During the preparatory meetings for the first edition of Straatvinken in 2018, it emerged that it could not be derived from documents where the baseline modal split figures in the 'Pact for the future' came from. It was simply stated that the actual modal split was 70/30 (10 % public transport and 20 % soft modes), which needed to become 50/50 (20 % public transport and 30 % soft modes) in 2030. Eventually, a policy officer referred to an Environmental Impact Assessment (EIA) for a road project in the wider Antwerp region (Engels & Corthout, 2016). In that document, results from the official transport model of the regional government are used in line with the first 'use' in Table 1. The year 2009 was chosen as the actual situation (69.3 % car; 10.5 % public transport; 20.1 % soft modes), and the year 2020 as reference (70.2 % car; 10.4 % public transport; 19.4 % soft modes). These figures correspond well with the round numbers used in the communication of Straatvinken (Straatvinken, 2023). However, the study area of the EIA significantly differs from the transport region, so again, there are some inconsistencies in the numbers and the region they cover.

Regarding the ambitions set for the fifteen transport regions in Flanders, the administration drew up a methodological note in 2020. This note makes a distinction between modal split indicators to monitor the ambitions set for the transport regions on the one hand, and indicators to report on environmental targets on the other. For both groups of indicators, the number of trips of both adults and children with their origin and/or destination in the region under study are taken into account. The main data source will be the regional household travel survey (OVG), but the text mentions that this requires an increase of the sample size (and design) to obtain results for each of the 15 transport regions in Flanders. The definition of sustainable trips differs between the two groups of indicators. In both cases, trips made by bike, public transport, or foot are considered sustainable, just like trips of children by car (as passenger). The difference is carpooling by adults. Car passenger are part of the sustainable category in the monitoring at the level of transport regions. However, the monitoring done for environmental policy (air quality, and energy and climate) considers trips by car passengers as unsustainable. The text refers, for example, to an earlier regional household travel survey (OVG 5.4; 1/2018–1/2019) and reports that 17.28 % of the number of trips fall in the category car passenger (and

45.63 % car driver). This indicates that the definition used can significantly impact modal split figures. Finally, it is worth noting that the text explicitly states that vehicle kilometres need to be reported in all cases.

The project team realised from the start that achieving the modal split targets would be instrumental to decrease the footprint of cars in the city of Antwerp and the surrounding region, as they have an impact on various aspects of street liveability. The CurieuzeNeuzen project had, for example, provided evidence of how the city is confronted with serious air quality problems due to the motorway around the city, but also due to the presence of a large number of so called street canyons, saturated by car traffic. The choice to use standardized traffic counts at the street segments level, rather than household surveys was a deliberate choice. Traffic counting is traditionally used to examine traffic flows in a street and not in the context of modal split monitoring at the city or regional level. However, due to the observed limitations and gaps of the official modal split monitoring models by the authorities, as described in earlier sections, a street-level modal split indicator was found to be more relevant. It was clear that this indicator could serve as a kind of proxy that provides indications of different aspects of street liveability, including air quality, climate impact, traffic safety and social interactions. Also the slogan of the project, ‘How healthy is traffic in your street?’, indicates the link with air quality and other health impacts. Likewise, team members have been aware that the 50/50 modal split target is a symbolic value that works well in communication.

In addition, due to the large number of measurement points that can be realised with this citizen science project, Straatvinken could overcome the typical problem with traffic counting of only reaching a limited number of streets. Finally, as all the citizen scientists count at the same time and cover many streets across the region of Flanders, the aggregated numbers also provide an indication of the modal split in a large sample of streets. While the aggregated street-level modal split methodologically differs in several ways of the calculated modal split based on household surveys, the project assumes that changes in the latter should, at some stage, also be visible in the Straatvinken modal split indicator.

In general, a lesson learned by the Straatvinken team is that while the contestation of a motorway project and city-wide concerns were key in the birth of the project, the street level is important as this is closer to the social and living environment of citizens. Also in research and policy, especially by the regional government, the traditional emphasis is on motorways and other large infrastructures. In that sense, starting at the street and neighbourhood level is a welcome perspective. It is illustrative that while civil servants of the Flemish government are sympathetic to street data collection (also by other projects such as Telraam-WeCount; Telraam, 2023), the region does not invest in traffic monitoring schemes for streets that fall under the competence of municipalities (although this resulted in insufficient data for environmental monitoring by the environmental department of the Flemish government).

### *4.4. Liveability*

As a result of discussions after the first traffic counting in 2018 in the team and interactions with participants, other citizens, policymakers and a variety of other actors, the concept of liveability gained further prominence in the Straatvinken project. One of the responses was the launch of a new initiative that had the ambition to complement the monitoring of modal shift with an annual study of street liveability in the same streets. This became the start of the Straat-O-Sfeer liveability mapping in 2019, documenting perceptions on the liveability of streets through a narrative-based approach (Loyola, Nelson, Clifton, & Levinson, 2023). The main tool is based on the SenseMaker methodology which is a narrative-based approach involving the capture and analysis of a large number of short stories to understand and respond to complex issues (Lynam & Fletcher, 2015). Experiences are understood through the eyes and voice of the people themselves. This kind of analysis bridges the gap between qualitative case studies and large-sample surveys. In the Straat-O-Sfeer liveability mapping respondents are asked to write down what they would say when their best friend asks for advice on whether to move to their street. After they write a short ‘story’, questions are asked on street design, social, environmental and traffic-related factors and socio-demographics. Aside from the database of stories, the main output is a composite index of perceived street liveability based on the scoring of 20 street-level parameters (somewhat similar to the Healthy Streets approach) (Fig. 1). The strength of the liveability survey lays in the possibility of combining the traffic counting data, with quantitative indicators of perceived liveability. The qualitative dataset in the form of short stories can be used in the analysis to get a better understanding of why streets receive certain scores on the indicators. The liveability survey was together with the traffic counts also presented as part of a strategy to enhance participation and evaluation in street redesign processes (among other during a webinar on 8 December 2022, see Straatvinken, 2023).

The research team has invested substantial efforts in making the count data and the liveability surveys as accessible as possible for the Straatvinken participants by the development of digital platforms, participating in events, and communicating summaries in the media and in newsletters. However, it falls outside the scope of the current study to show how the different forms of data can be combined to gain insights in the relationships between the modal split and perceived liveability.

To summarise the discussion of the citizen science indicator project, the framework used in the previous section (Table 1) to compare the use of indicators will now we be applied to the case.

*Type*- the ‘liveability rose’ (Fig. 1) is a kind of composite indicator, although the communication puts more emphasis on the 20 indicators than on their sum. Traffic intensities can be seen as a performance indicator, although the effect on liveability is mediated by variables such as street width.

*Unit*- the main unit of analysis is the street segment, while some dimensions in the liveability rose refer to the neighbourhood, for example, accessibility of amenities.

*Relative/absolute*- for traffic figures, most attention is paid to car traffic intensities (absolute numbers), while the liveability indicators are scored 0–10.

*Interpretive flexibility*- the interpretation of traffic intensities and experienced liveability is rather straightforward. Nevertheless, participants might differ regarding the meaning they attribute to different liveability indicators.

*Producers*- the data result from a citizen science project, in which non-experts were involved in design, data collection and communication. Nevertheless, as is common in citizen science projects, some groups are overrepresented. For example, of the participants in the 2022 liveability survey, 52 % fell in the age category 40–64, 35 % had a Bachelor’s degree and 34 % a Master’s degree. Notwithstanding the typical biases, the liveability survey was inspired by the experiences of a member of the core team in the Global South where similar tools were used and local actors were recruited to interview participants, including those who were illiterate.

*Users*- the intended audience are citizens and (local) governments responsible for street design.

*Role*- the first role has been agenda setting, i.e. putting the role of traffic on street liveability on the agenda. But the aim of the dashboards and the methodology is also instrumental, providing tools and data to actors involved in street design processes.

*Problem*- the problem to be addressed is the impact of high traffic intensities on street liveability.

*Solutions*- the policy instruments that are most often mentioned are street (re)design and traffic circulation plans.

*Policy paradigm*- during the project, the researchers involved have become aware that many ideas fit into the liveable streets paradigm. Liveable street studies typically use absolute figures to examine the effects of high traffic volumes on factors such as liveability, community and sociability. Since the seminal work in the 1970s (Appleyard, 1980;

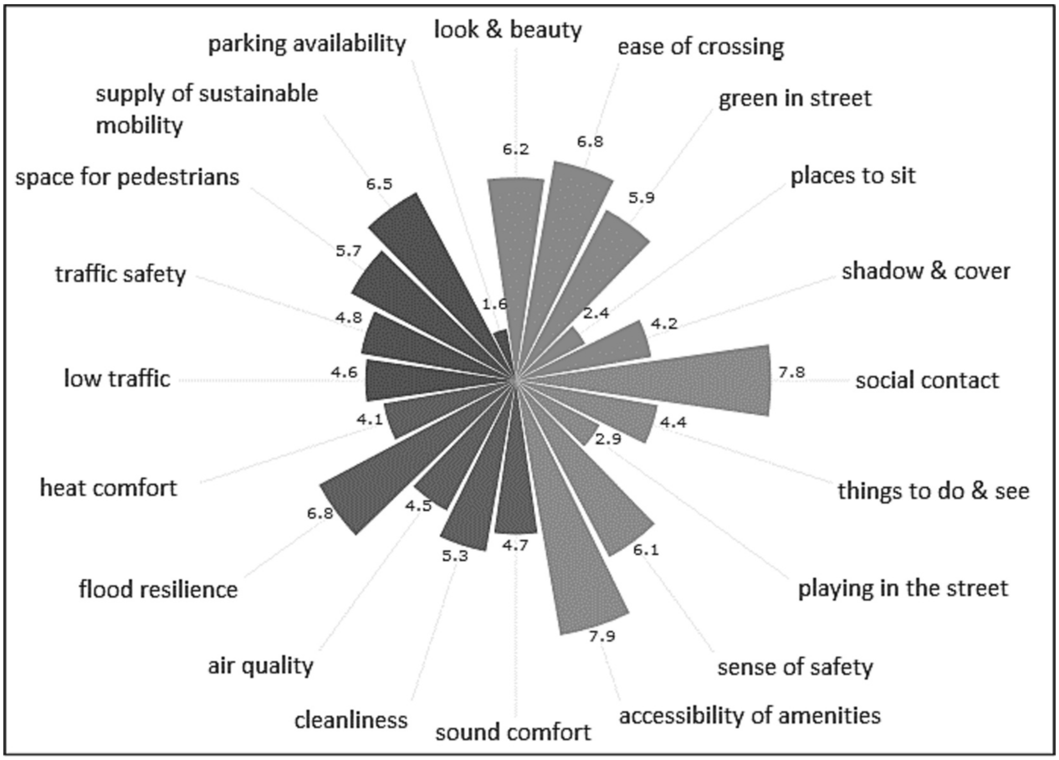


**Fig. 1.** Straat-O-Sfeer 'liveability rose' (example: Wetstraat, Antwerp; based on scoring by 22 residents).

Appleyard & Lintell, 1972) lots of empirical material on the impact of motorised traffic on street liveability has been collected. Also in more recent times, researchers apply the liveable streets toolbox in a variety of contexts (Hart & Parkhurst, 2011; Mahmoudi, Ahmad, & Abbasi, 2015; McAndrews & Marshall, 2018; Sanders, Zuidgeest, & Geurs, 2015; Wiki, Kingham, & Banwell, 2018). Relatedly, walkability scores have gained prominence as indicators at the neighbourhood level (Wang & Yang, 2019). Notwithstanding the variety in definitions, a liveable street is generally understood as 'a place where many people know each other because they spend time out-of-doors […], thus creating a sense of community and belonging. A liveable street is also a place that residents know very well, take care of, and identify with.'(Bosselmann, Macdonald, & Kronemeyer, 1999, p.170). The corresponding message is that residential streets should not be seen as traffic arteries, but as public spaces, as 'streets for people' (Bertolini, 2020). This implies a more local focus at the street level and the immediate neighbourhood. Existing modal split studies at the city-level or regional level lack this fine-grained information to assess how changes in the composition and intensity of the traffic affects the liveability of streets.

*Imagined subjects*- in line with the citizen science approach and the liveable streets paradigm, subjects are active residents who participate in initiatives to understand and improve their living environment. Some authors see citizen science as a way to implement the right to participate in scientific research (Mann, Porsdam, & Donders, 2020; Vayena & Tasioulas, 2015). Such an approach might bring research closer to citizens, and may challenge the monopoly of experts in scientific discovery. Citizen science has thus potential for the democratisation of knowledge production by discussing methodologies, analyses and results with a varied group of participants. It can thus also be part of struggles for epistemic justice (Anderson, 2012; Irwin, 2015), and encompasses an idea of scientific citizenship. This view corresponds well with the liveable streets paradigm that emphasises participation and democracy (Francis, 2016).

## 5. Discussion and conclusion

A framework based on the literature on ecological indicators was employed to compare modal split indicator uses, and to explore the relationship between factors such as underlying policy paradigms, rather technical issues, as well as the actors involved. Although a specific case was discussed, some general findings have emerged.

In transport research and policy, modal split figures were initially used by experts to predict and forecast transport flows using the standard four-stage transport model (Salter, 1974). Such an intermediate step in an analysis was mainly a technical issue. The idea of an optimal modal split was added to this, and although there is inevitably a normative dimension to such a figure, it was something that could be produced using a rigorous method (Tyson, 1977). The envisaged role in the supposedly linear policy process was instrumental, providing information to decision makers to enable them to take rational decisions. Especially with the rise of the sustainable mobility paradigm, the modal split indicator, which was available as a result of its previous uses, became more symbolic as a general indicator of sustainable mobility. As is often the case with popular indicators and concepts, their vagueness and interpretational flexibility goes hand in glove with their popularity as different actors can appropriate the indicator or concept. This opens also more possibilities for contestation and interpretive struggles, as the case of the citizen science project Straatvinken illustrates. While mainstream sustainability mobility discourse points to individual behaviour change as main solution to unsustainable mobility at the city level, the more participatory approach of the citizen science project reframed the issue in line with the liveable streets paradigm, which is closer to the experiences of citizens, and attributes a more democratic role to them. The liveable streets approach also downplays the role of relative numbers, which are central in modal shift policies, and employs traffic intensity data instead (which are absolute numbers), together with data on experienced liveability. Paradoxically, absolute numbers seem also to be more relevant for environmental sustainability since these are more closely linked to concepts such as planetary boundaries.

The mainstream use of modal split figures, for example in city rankings and comparisons, is to promote best practices as well as to emphasise that policies need to influence the modal choice of individual travellers (Bergman et al., 2017; Mössner & Gomes de Matos, 2019). The case illustrates that especially environmental agencies and researchers warn that relative numbers need to be complemented by absolute figures of, in particular, vehicle kilometres (see also Boussauw & Vanoutrive, 2017; Heinen & Mattioli, 2019a, 2019b). Modal split indicators are at best incomplete measures of sustainable mobility. To illustrate, with on average 2.42 trips made per day per person, of which 65.01 % by car, a 50/50 modal split can be obtained in the region of Flanders when 73 % of the residents makes each day an additional trip of at least 100 m by bike or on foot, without any reduction in car travel (figures based on the Flemish regional household travel survey OVG 5.5; 1/2019–1/2020, (MOW, 2022)).

This contribution reports also on a citizen science project that started as a way to monitor the modal split targets set in an agreement with the government. Interestingly, the measurement strategy and interpretation of the modal split indicators was done quite some time after the indicators and targets were communicated, and this is both the case for the official targets of the government in the Pact for the Future, and the citizen science project under study. This confirms that indicator projects are iterative processes, and illustrates how indicators such as modal split figures are rather constructs, practices and processes which get meaning during data collection, processing, analysis and communication (Freistein & Koch, 2014; Kitchin et al., 2015).

Most will agree that the deliberate misuse or abuse of indicators is morally wrong. However, there are several reasons why unintended misuse, as well as non-use, of indicators occurs. First of all, organisations and individuals have limited resources and capacities to find, select, develop, understand and interpret indicators (Lyytimäki et al., 2013). Furthermore, the development of indicators is an iterative learning process that starts with awareness raising and agenda setting, i.e. actors need to be convinced that an issue is important enough to pay attention to. Hence, the instrumental role can only emerge after an initial conceptual phase (Gasparini & Mariotti, 2023). As a result, it is logical that crude measurements of a vaguely defined indicator are used and somewhat misused in early phases of indicator development or the reconceptualization of an existing one. Vagueness and interpretive flexibility also perform a function since these allow different actors with different views to develop a common language (Holden, 2013). The downside is that this might cause conceptual confusion and that a concept acts as an empty signifier. Given that indicators are necessarily simplifications and translations of a more complex reality, reconceptualization and the development of new indicators is a continuous process. Likewise, several community-based indicator projects 'took the process of choosing and building the conceptual framework and the indicators to be far more important than the indicators per se' (Moreno Pires et al., 2017, p.1315).

Such community data initiatives have the potential to bring the analysis closer to the life of citizens (Moreno Pires et al., 2017). In the citizen science project Straatvinken that counts traffic in streets (Straatvinken, 2023), modal split measurement is brought back from abstract modelling to an experienced reality at street level, and is complemented and linked to ideas of liveable streets. While modal split figures and absolute volumes are still used in communication, the importance of the traffic counts is increasingly framed as being a way to monitor liveability. Especially with the launch of a liveability survey, the tools are also seen as a useful methodology to be applied in the context of street redesign processes, which was highlighted during a webinar in December 2022 (Straatvinken, 2023). In general, the citizen science project brings more abstract debates on sustainable mobility and infrastructure planning permeated with abstract indicators closer to the living and social environment of citizens. This methodological and conceptual innovation strengthens traditional, survey-based, modal split measurements and models for the monitoring of urban and regional mobility trends in at least two areas: documenting fine-grained street-level mobility patterns, and linking them with experiences and perceptions of street liveability.

Perhaps, it is no coincidence that the liveable streets paradigm fits well with citizen science and participation. This can also be observed in other projects on street mobility which take a participatory approach and address issues such as community severance (the barrier effect: heavily trafficked streets that form barriers to slow transport and divide communities; Anciaes, Boniface, Dhanani, Mindell, & Groce, 2016; Anciaes, Jones and Mindell, 2016; Mindell et al., 2017). The early literature on liveable streets already stated that streets 'are actually controlled by agencies and ordinances that are remote from the residents', and that 'streets are dangerous, noisy, polluted, and impersonal domains, about which residents feel able to do little' (Appleyard, 1980, p.107). Recent work reemphasises the importance of participation (Appleyard, Ferrell, Carroll, & Taecker, 2014; Francis, 2016), and discusses experiments of street redesign (Bertolini, 2020), including experiments in which citizens design and furnish streets themselves, although it remains a challenge to deal with tensions between users with different needs and views (Van Wymeersch, Oosterlynck, & Vanoutrive, 2018). Notwithstanding such difficulties, participation in knowledge production on traffic, liveability and street design using citizen science seems to be promising for both research and practice.

Being involved in citizen science projects forces experts to look at their field of research with the eyes of citizens. Although the perspectives of citizens are varied and cannot be interpreted without ambiguity, the idea of citizen science as a way to facilitate the participation of people in knowledge generation about their living environment is worth further study and discussion. However, in many transport policy documents 'There is some consideration of people as subjects whose behaviour affects sustainability (primarily through uptake), but little thought of the public as stakeholders, knowledge providers, or partners in shaping the future.' (Bergman et al., 2017, p.169). In contrast, citizen science explicitly frames citizens as knowledge producers and participants (Irwin, 2018; Vayena & Tasioulas, 2015). It seems that the application of citizen science in the field of transport can be strengthened (Storme et al., 2022), as it was recently stated that: 'Beyond the currently dominating environmental domain, the potential is high for extending Citizen Science activities to a number of other areas (health, energy, urban management, transport, agriculture, etc.), where co-creation is key to effective policy making and societal impact.'(Manzoni, Vohland, & Schade, 2021, p.14). Likewise, citizen science is seen as having potential to connect citizens to general issues that operate at a broad scale, for example in the context of the Sustainable Development Goals (Dörler, Fritz, Voigt-Heucke, & Heigl, 2021).

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## CRediT authorship contribution statement

**Thomas Vanoutrive:** Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Huib Huyse:** Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

No data was used for the research described in the article.

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