Using impact chains for a feasibility assessment of sufficiency policies in the mobility sector

Carina Zell-Ziegler
Oeko-Institut
Borkumstr. 2
13189 Berlin
Germany
c.zell-ziegler@oeko.de

Johannes Thema
Wuppertal Institute
Döppersberg 19
42103 Wuppertal
Germany
johannes.thema@wupperinst.org

Kaya Dünzen
Oeko-Institut
Merzhauser Straße 173
79100 Freiburg
Germany
k.duenzen@oeko.de

Keywords

energy sufficiency, mobility, decarbonisation, emission reduction policy analysis, domestic policies and measures, impact chains, feasibility assessment

Abstract

Energy savings through modal shift and demand reduction (avoid) are key to decarbonising the transport sector. This is the aim of transport sufficiency policies. Some of them are already implemented and serve as best practice examples, and there are many planned and proposed policies, e.g., in the National Energy and Climate Plans (NECPs) of EU Member States and in the literature on decarbonisation of the transport sector.

The European Sufficiency Policy Database of the Energy Sufficiency junior research group (EnSu) currently contains 120 sufficiency policies for passenger transport, grouped into seven different policy strategies and covering different types of policy instruments. In this paper, we take a closer look at 74 of them.

Methodologically, we refer to the concept of impact chains as developed by Zell-Ziegler and Thema (2022) and analyse the chain from policy stimulus to impact with a particular focus on those factors that seem relevant to the feasibility of policy implementation. In our feasibility assessment, we seek to answer the following questions: 1) How do particular policy instruments work from cause to effect and what can we learn from them for implementation feasibility? 2) Within a particular policy strategy, how do individual policy instruments differ in terms of implementation feasibility? 3) Does implementation feasibility vary between instrument types?

Regarding the first question, we take the impact chain of the good practice example of "superblocks" in Barcelona – neighbourhoods with restricted car access – as an example of a policy that could also be implemented in cities in Germany as well. We conclude that this can work well if good public transport is available and administrations are flexible in their urban planning. However, barriers and risks such as the risk of gentrification or protests from local shopkeepers should not be neglected and must be taken seriously. All of the other 73 impact chains, which cannot be described in such detail, are provided in a supplementary table.

Regarding the second question, we focus our analysis on the enabling and hindering factors of policy instruments. We find that policies with many supporting factors often also have many barriers and risks. This is mainly because they are meta-level policies with more diverse relevant factors. The policy strategy "Reduce trips: local supply" has the most risks and the promotion of active transport has the least, suggesting a no-regret policy. Another pattern we see is that pull policies (such as incentives or infrastructure) have fewer barriers than push policies (such as banning air travel and converting road space to cycling and walking).

On the third question, we find out that regulatory instruments do not have the most risks (but do have the most barriers) and even have the most supporting factors compared to economic and fiscal instruments. In conclusion, this analysis supports a detailed consideration of decarbonisation options for passenger transport and paves the way for further research on a comprehensive policy mix in this sector.

Introduction

The transport sector in Germany is not on track to reduce GHG emissions (BReg 2023). Decarbonisation options also include sufficiency policy targets such as reducing travel distances and shifting to public transport or active mobility. To reach those targets, a broad set of policy instruments exists and can e.g. be found in the European Sufficiency Policy Database (Zell-Ziegler et al. 2024, see explanation in methods section).

We apply the definition from the latest IPCC report for our analysis: "Sufficiency policies are a set of measures and daily practices that avoid demand for energy, materials, land and water while delivering human wellbeing for all within planetary boundaries" (IPCC 2022).

The discussion on policy instruments, and in particular on regulatory instruments such as car-free city centres, short-haul flight bans or speed limits, is highly controversial and often emotional. We thus aim to analyse the implementation feasibility of sufficiency policies by increasing transparency of the effects, impacts, required inputs and associated factors that ease or hinder proposed sufficiency policies. We aim for an evidence-based discussion that helps to identify feasible instruments to achieve sector decarbonisation. We therefore carry out a qualitative assessment of individual policy instruments using the impact chain method to discuss the feasibility of each policy instrument and, for example, how to overcome barriers. This method is often used as standard in policy evaluation, see for example Schlomann et al. (2020). Our research questions are:

1. How do particular policy instruments work from cause to effect and what can we learn from them for implementation feasibility?
2. Within a particular policy strategy, how do individual policy instruments differ in terms of implementation feasibility?
3. Does implementation feasibility vary between instrument types?

In addition, we test whether the impact chain model (Zell-Ziegler and Thema 2022) can be applied to policy proposals that are partly at a meta-level, instead of the application to locally implemented policies as in the original source.

Material and Methods

IMPACT CHAIN CONCEPT

We apply the concept of impact chains developed in Zell-Ziegler and Thema (2022), see Figure 1, and set up impact chains for transport sufficiency policies with a focus on Germany. In addition to the main chain from stimulus-activity-output and outcome to impact, several factors were identified as being of high importance for the implementation feasibility of a policy instrument: supporting factors, barriers and risks (referred to as "factors" in the following). We define the factors as follows:

- Supporting factors: Circumstances and other factors that (can) contribute to the success of the policy. This can also be already implemented other policy instruments.
- Barriers: Contrary to risks, barriers can lower the effectiveness of the policy but will not lead to its failure.
- Risks: Could potentially lead to a failure of the policy.

Examples on the factors are given in the subchapter "Methods". In addition to factors, inputs and revenues can be relevant at different stages of the chain. Inputs are defined as "all relevant, mainly project-internal means to reach the intended effect". We differentiate administrative, financial, staff, material (physical) and other input. Revenues are defined as government revenues, e.g. higher or new tax revenues.

For an aggregated view on the policies, we qualify the input into *high–medium–low,* in the results figures we show the highest rating a policy has for any of its inputs.

DATA AND SOURCES

Our data basis is the *European Sufficiency Policy Database* of the *Energy Sufficiency junior research group* (EnSu) by Zell-Ziegler et al. (2024). This database is continuously updated. We use a fixed version from June 6, 2023. By this date, it included 110 sufficiency policy instruments in the transport sector. The policy instruments are either already implemented in at least one European country, region or city, or proposed in the literature. They are grouped into seven targets or policy strategies, disaggregated to measures/actions. Individual policy instruments are classified by nine different instrument types according to United

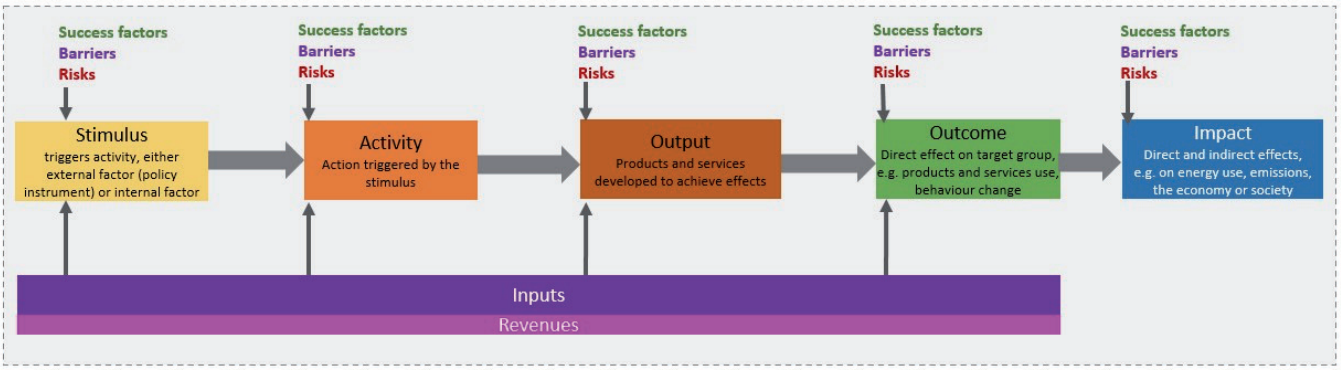

Figure 1. Impact chain model adapted from Zell-Ziegler and Thema (2022).

Nations Framework Convention on Climate Change (2000). As an example, the policy strategy "Reduce motorized individual transport" includes the measures/actions "Reduce parking in public space", "Disincentivise car acquisition/ownership" and eleven other measures/actions. 32 individual policy instruments are listed for this policy strategy in the database, additionally categorised by sufficiency type based on the ASI framework ("avoid–shift–improve", see e.g. GIZ 2016). The structure of the database and the definition of the sufficiency types including examples is explained in Best et al. (2022).

From the 110 policies we excluded eleven due to their very indirect impacts, unspecific descriptions, or because they were too closely interlinked with other policies, which did not justify a separate impact chain. We also excluded 10 policies of instrument type categories with a very low number of entries (e.g. voluntary agreements), that would not allow for a reliable comparison. This left 89 policies for our analysis base. For this paper, we were able to analyse a sample of 83 % (74 entries), and six of the seven policy strategies fully or to a very large extent (>70 % of entries within a strategy). 12 of the analysed policies are of economic instrument type, 32 are fiscal and 30 are regulatory. We consider these shares to be sufficiently large to draw conclusions for the overall policy strategy or instrument type categories.

METHODS

For setting up the impact chains including their relevant factors that we used for their feasibility comparison, we proceeded as follows:

- One team member as expert in sufficiency and/or transport policies filled the impact chain template with the first draft, for each of the 74 impact chains based on the information given in the European Sufficiency Policy Database and the literature cited there.
- Additional information on the policy was added from a literature search (peer-reviewed, grey literature, news articles on existing implementation examples) by another person, the cause–effect–chain and factors were revised accordingly in joint author sessions. We list substantiating literature in the link provided to our impact chains and not in the reference section of this article as it is very extensive.
- We discussed all aspects of individual impact chains in detail in meetings and revised them with respect to number, level of detail and weighting of factors to ensure consistency. We applied a four or even six-eye principle.

To compare policies as to their feasibility following from enabling and hindering factors, we analyse their respective number. However, not all factors are equally important. We therefore systematically apply weighting factors. For supporting factors, we use the weighting factors *importance* with the selection options *high-medium-low.* Additionally, we assess whether the *factor is typically in place* with the options *yes-partially-no*.

Factors of *high* importance play an important role for the successful implementation of the policy instrument. For instance, an existing frequent public transport is highly important to enable a mode shift when car access to cities is restricted. Factors with *medium* importance play a medium important role. An example are existing taxation or incentive schemes to support mode shift, with price signals often being insufficient to lead to behaviour change. Factors with *low* importance play a subordinate role for the successful implementation of the policy instrument like policies being promoted in media campaigns by NGOs.

A factor is typically in place (selection of "*yes*") when found in many places such as parking management in most of German cities. A factor is *partially* typically in place when e.g. good practice examples exist – without being the standard – like car-free city centres in some German or other European cities. A factor is *not* typically in place if it does not exist so far, such as the perception of mobility provision as a common good.

For barriers and risks we use an assessment of *influence* and *occurrence probability* with the options *high–medium–low* for weighting. Barriers or risks with high influence are very relevant hindering factors for the implementation of the policy instrument. An example for a barrier with a *high* influence is the limited availability of (road) space for a conversion to infrastructure for other modes. An example for a risk with a *high* influence is the non-availability of staff for construction of local supply structures. Barriers or risks with *medium*/*low* influence are medium relevant/subordinate hindering factors for the implementation of the policy instrument. An example for a barrier with a *medium* influence is bureaucratic obstacles, with a *low* influence is difficulties in setting up a company-internal sharing platform for mobility management. An example for a risk with a *medium* influence is opposition by workers and trade unions, if there are no good alternative plans, with a *low* influence the risk of displacement of flights if no global policy exists.

Barriers or risks with high/medium/low occurrence probability will occur with a high/medium or low likelihood. An example for a *high* occurrence probability of barriers is political opposition against policies that limit car or air transport. A *medium* occurrence probability of barriers is a low population density because this exists in rural areas in Germany. A *low* occurrence probability of barriers is wild parking on the streets when reducing obligatory parking spaces per apartment. An example for a *high* occurrence probability of risks is the lack of long-term financing for some policy instruments. A *medium* occurrence probability of risks is a rebound effect that e.g. reduces the net positive impacts due to resource needs for home office equipment. A *low* occurrence probability of risks is that no good long-distance alternatives to air transport exist.

To operationalise the comparison of different policy instruments by using their weighted factors, we translate the qualitative assessment into representative quantified weights (1–0.67–0.33). Combinations of weighting factors are shown as an example for supporting factors in Table 1. For barriers and risks the same approach applies. The overall rating for each of the three types of factors (supporting factors, barriers, risks) is the weighted sum of all factors. We show these in the results figures as positive (supporting factors) or negative (barriers, risks) bars.

Results

We present our results in three sections: 1) we introduce a filled-in impact chain sheet for one example, explaining general findings and issues when applying our method, and analyse

Table 1. Results of the combination of weighting factors, shown here for supporting factors.

		Importance		
	×	High (1)	Medium (0.67)	Low (0.33)
Factor typically in place/true	Yes (1)	1	0.67	0.33
	Partially (0.67)	0.67	0.45	0.22
	No (0.33)	0.33	0.22	0.11

how this policy could be implemented in Germany, and which supporting factors, barriers and risks exist. 2) We show implementation feasibility results of single policies, for each policy strategy and compare policy strategies; and 3) finally briefly analyse differences between policy instruments.

PRESENTATION OF AN EXEMPLARY CAUSE-EFFECT CHAIN

The data basis of this analysis are the 74 filled-in sheets with impact chains of single transport sufficiency policy instruments. The full set of impact chains including the literature used to set them up is available in a supplementary table[1]. We briefly outline the structure of the sheet and the content results for one good practice policy instrument – Superblocks in Barcelona, ID 330 in the *European Sufficiency Policy Database* (Zell-Ziegler et al. 2024) – that could be implemented in another country such as Germany (Figure 2).

The upper part covers the chain from the policy stimulus (here "introduction of superblocks") to impacts (here GHG and energy savings, quality of life improvements in terms of air, noise and green spaces as well as less accidents), in a narrative description. The activity is the planning and implementation of superblocks which needs administrative input in urban planning and design as well as financial and material means to create the superblocks (mainly revitalise the streets and public spaces e.g. by city outdoor furniture and plants), we qualify the extent of the required input as medium (see middle part in Figure 2).

The output is threefold: Restrictions to car pass-through, revitalised public spaces and improved cycling and walking infrastructure. As an expected outcome, people use this revitalised space for leisure and walking/cycling and car use becomes more unattractive so that a mode shift is induced which leads to the mentioned impacts. We find three main supporting factors for the implementation of this policy in Germany (see lower part of Figure 2): 1) Residents partially demand better quality of life in their neighbourhoods and 2) superblocks already exist in Barcelona – both factors are of medium importance. What is most important is 3) an existing access and network of public transport which is not always the case in German cities. Qualitative ratings in Figure 2 and weights in Table 1 yield the weighted sum. Overall, the supporting factors are thus rated with 1.6.

The barriers and risks comprise resistance from local shop owners to the restriction of car pass-through with a high influence and community resistance due to concerns regarding gentrification, rising property values, and residents' displacement with a medium influence and occurrence probability. With a low occurrence probability but a high influence, we see a risk of potential congestion issues if car traffic is not reduced substantially on the then fewer transit streets. Overall, the barriers are rated with 1.1 and the risks with 0.3.

In those German cities where the supporting factor is given (public transport well developed) and where the administrations are capable to adapt the concept into their urban planning, superblocks seem to be favourable and there are more (weighted) arguments in favour than against. We can observe this in some districts of Berlin that adopted the concept and call these areas "Kiezblocks"[2].

Policies vary in depth of detail and specificity, depending on the specific proposals and descriptions in the literature source, some are more generic and on a meta-level, others very specifically target existing regulations or e.g. propose the amount of a mobility fund. We tried to streamline the impact chains, aiming for a minimum level of specificity.

In our sample, the highest rating of weighted supporting factors is 4.5 (ID 288 "Quit legal prioritisation of cars over cycling/walking", regulatory instrument), of barriers 5.9 (ID 292 "Prioritise public transport", regulatory instrument) and of risks 3.8 (ID 249 "Legal obligation for public transport availability", regulatory instrument). 35 % of all policies need a high input, 15 % low and 7 % no input at all, while 17 generate a revenue.

COMPARISON OF IMPLEMENTATION FEASIBILITY BY POLICY STRATEGY

In this section, we present results of the analysis of supporting factors, barriers and risks for all analysed impact chains, in separate figures that group policies following one policy strategy. Figures 3–8 display weighted supporting factors as positive bars, weighted barriers and risks as negative bars. In addition, the rating of the inputs (low–high) is displayed as dot and on the right vertical axis. Single policies are grouped by instrument type (E/economic, F/fiscal, R/regulatory; separated by vertical lines). Policies that generate additional revenues are labelled with an asterisk (*).

Figures can be interpreted as an assessment of the implementation feasibility of single policy measures. They are *not* a cost-benefit analysis because impacts are not quantified, and absolute levels of bars cannot be interpreted. However, figures allow to compare policies: the relative location on the positive and negative side indicates a tendency towards which policies are easier implementable than others. A direct recommendation for policy selection cannot be drawn, as this would require an assessment of impacts and contrasting them with the implementation feasibility and possible options to overcome barriers and risks.

In general, we observe a tendency for policies with a high number of supporting factors to also have a higher number of

1. All the impact chains used in this analysis can be found in this table: https://docs.google.com/spreadsheets/d/1uLAty7v1vLXsdeojIQER5hi0fL9vzkWm/edit?usp=sharing&ouid=104807890568630557993&rtpof=true&sd=true.

2. https://www.kiezblocks.de/

ID EnSu policy DB	330						
Title policy instrument	Car access restriction to city quarters ("Superblocks")						
Sector, policy strategy, measur	Transport	Reduce motorized indiv	Car-free city centers				
Instrument type	fiscal						
Check social / gender impact							
Impact chain	**Stimulus**	**Activity**	**Output**	**Outcome**	**Impact**	Evaluation (high - medium - low)	
Definition	*Triggers activity, either external factor (policy instrument) or internal factor*	*Action triggered by the stimulus (administrative part)*	*Products and services developed to achieve effects*	*Direct effect on target group, e.g. products and services use, behaviour change (+indirect effects on other affected groups)*	*Direct and indirect effects, e.g. on energy use, emissions, the economy or society*		
Chain line 1	Introduction of Superblocks (e.g. of a 3×3 grid) in cities	Planning, implementation of superblocks	Restriction to car pass-through	People use revitalised space for leisure and walking/cycling	GHG saving		
Chain line 2			Revitalised public space	Car use becomes more unattractive -> mode shift	Energy saving		
Chain line 3			Improved cycling and walking infrastructure		Quality of life in blocks improved (air, noise, green spaces)		
Chain line 4					Less accidents		
Chain line 5							highest rating of inputs
Administrative Input		Urban planning and design				medium	medium
Financial Input		Budget to create the superblocks (revitalise the streets and public spaces)				medium	
Staff Resources							
Material Input (Physical)		City outdoor furniture, plants				medium	
Other Input							
Revenue							
Supporting factor line 1	Residents demand better quality of life in their neighbourhoods	Existing access and network of public transport					1.6
Importance	medium	high					
Factor typically in place/true	partially	partially					
Supporting factor line 2	Existing examples in Barcelona						
Importance	medium						
Factor typically in place/true	partially						
Barrier line 1	Resistance from local shop owners						1.1
Influence	high						
Occurrence probability	medium						
Barrier line 2	Community resistance due to concerns regarding gentrification, rising property values, and residents' displacement						
Influence	medium						
Occurrence probability	medium						
Risk line 1				More superblocks means fewer transit streets: potential congestion issue if car traffic is not reduced substantially			0.3
Influence				high			
Occurrence probability				low			

Figure 2. Example for impact chain: ID 330 Car access restrictions to city quarters ("Superblocks").

barriers and risks; in addition, these tend to have a higher need for inputs. A reason for this could be that most of them are rather meta-level policies and less detailed or specified than others, with factors being more diverse.

We analysed 18 individual policies that all pursue the strategy "Improve public transport and multi-modality" (Figure 3). Two of the economic policies generate additional revenues for public budgets. The third economic proposal (introduction of a company fee to finance local public transport, as already implemented in Paris) is expected to lead to a high resistance if the fee is not limited to an acceptable level. Therefore, it scores high concerning barriers. The first fiscal policy, introducing a €365 year ticket, is expected to be very costly in the long term and if not financed sufficiently, public transport quality will not suffice to lead to a substantial mode shift. This leads to barriers and risks for this policy. The second fiscal measure (ticket reform, price reduction) that subsidises public transport prices is also likely to be costly and bears the risk of not being able to reduce prices to levels competitive enough with air to lead to a substantial mode shift. We thus also observe significant barriers and risks. The last fiscal measure of implementing park & ride and mobility hubs results with the highest balance of supporting factors vs. barriers/risks, indicating easiest implementation feasibility. The two analysed regulatory instruments (right side of Figure 3) have high numbers of supporting factors, barriers and risks. A legal obligation for full geographical coverage of public transport is expected to have many supporting factors, but there are issues with the availability of driving staff, sufficient rolling stock and high financing needs. The reactivation of closed rail lines is more advanced in terms of planning, but also requires substantial inputs.

13 policies follow the strategy of promoting active modes (Figure 4). The first fiscal measure of shifting national and departmental funds from road to active modes is expected to encounter severe opposition from car lobbies and risks with long-term financing. Especially regulatory "push" measures that take away preferential treatment of cars in legal frameworks are expected to lead to barriers through stronger oppositions. However, we did not identify risks for any of the regulatory policies. "Pull" measures like active mode infrastructure expansion (fiscal policies) are expected to be easier implementable, however with some associated risks and high inputs.

We find barriers and risks that outweigh limited supporting factors for the introduction of additional aviation carbon taxation and a moratorium on the expansion of airports (Figure 5). For air travel bans, barriers and risks are even higher (opposition from business and frequent flyers, potential displacement of flights to neighbouring countries if not well designed), but

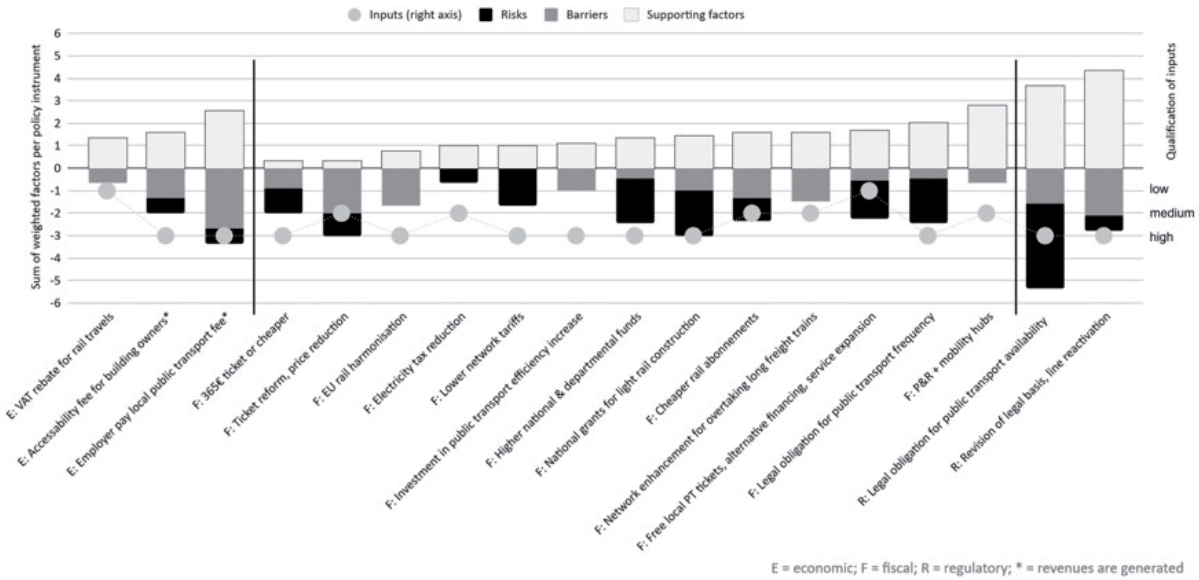

Figure 3. Policies within the strategy "Improve public transport and multi-modality".

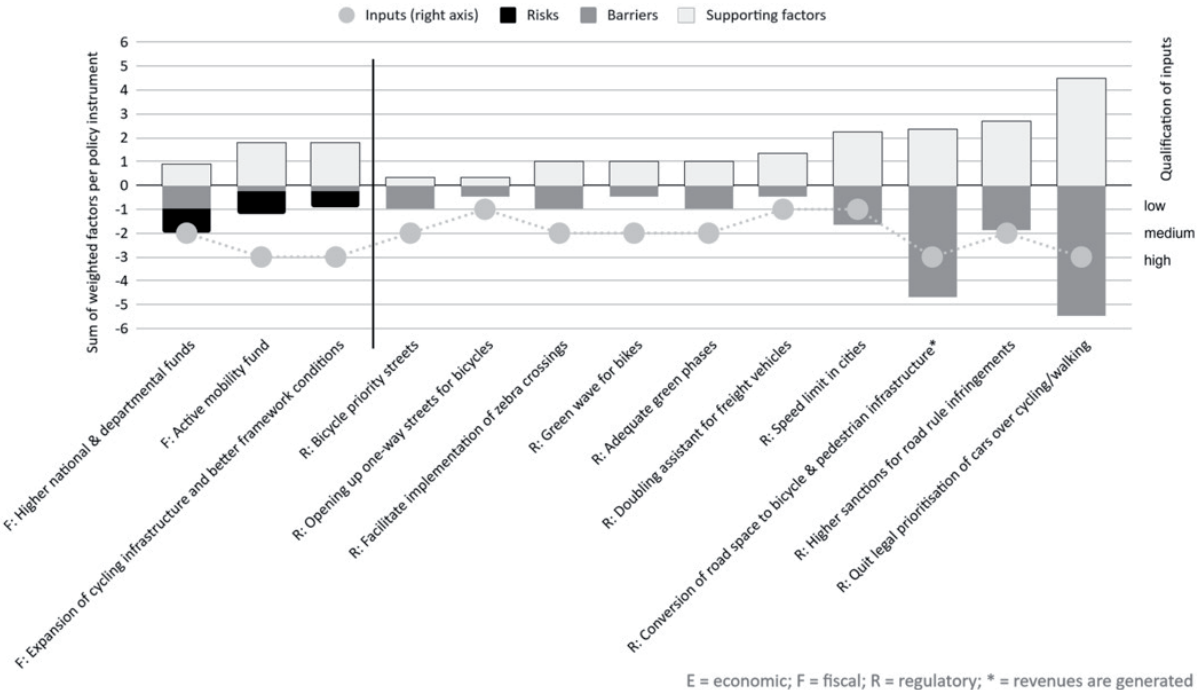

Figure 4. Policies within the strategy "Promote active modes".

the latter have high supporting factors. All policies in the air transport reducing strategy have low expected inputs.

Given the dominance of cars in passenger transport, the policy strategy to reduce motorised individual transport is key. It covers in total 23 instruments in this analysis (Figure 6). Interestingly, there is a significant number of policies (mostly economic, but also others) that are expected to generate additional revenues or reduce state expenses. There are some policies that appear especially easy to implement such as mobility vouchers, car-free days, or a restriction on surface sealing. Some policies have high barriers, risks and inputs like road charges or a systematic prioritisation of public transport – however, could still be expected to have high impacts. Other potentially high-impact policies like car-access restrictions appear to have no associated risks.

The policy strategy to reduce trips by improving local supply is a genuine sufficiency enabling strategy: reduced mobility needs render trips dispensable. However, we find (Figure 7) that they all have significant barriers and risks associated to costs, staff, and material, which challenges implementation. The support of local childcare and decentral shops, medical and elderly care are among the more feasible policy options in this strategy.

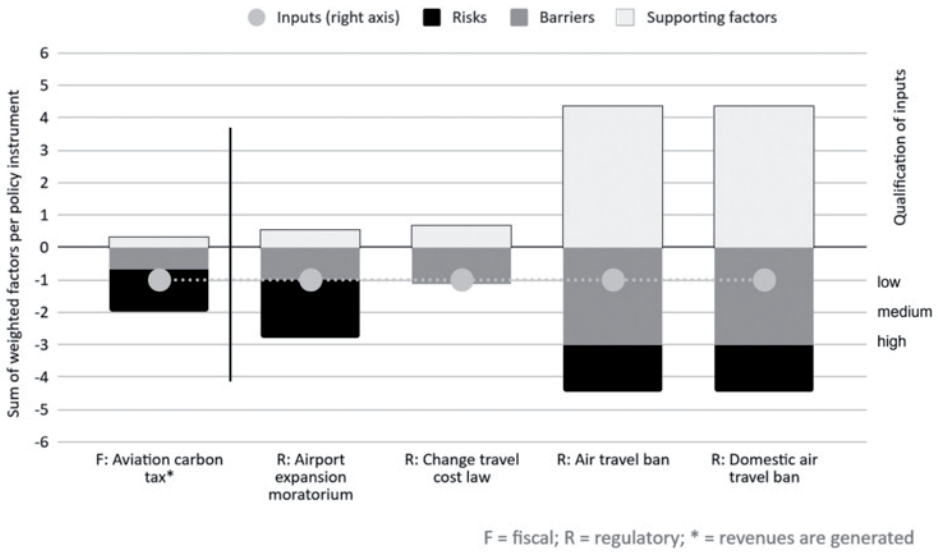

Figure 5. Policies within the strategy "Reduce air transport".

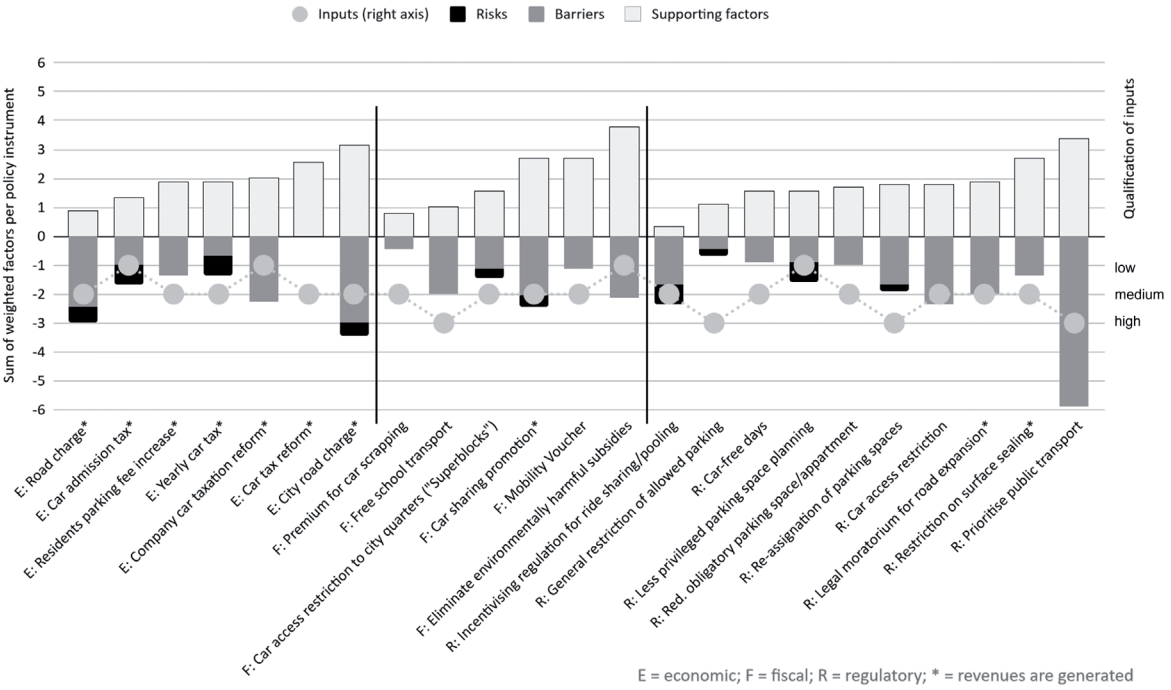

Figure 6. Policies within the strategy "Reduce motorised individual transport".

Reducing work trips has been found to have high impacts, Figure 8 shows our analysis. Especially the right to work from home seems to have a comparative advantage with many supporting factors and limited barriers and risks. The expectedly high-impact cancellation of commuter tax allowances also has limited barriers and risks (although significant opposition) and low inputs needed.

In addition to the analysis of implementation feasibility of individual policies, we compare average feasibility of policy strategies (averaging weighted number of factors, see Figure 9). We find that on average, there is no strong difference in supporting factors by strategies, with air and motorised individual transport reduction having slightly more supporting factors due to the co-benefits. Also, barriers do not vary substantially, with somewhat less for public transport and multi-modal improvement. Risks, however, are unevenly distributed: the "reduce trips through local supply" strategy has most risks, followed by "work trip reduction". Thus, it seems like genuine sufficiency policies aiming at an absolute reduction of travelled distances are most difficult to implement, substitution policies aiming at a mode shift like public transport improvement and air transport reduction bear less risks. The "promotion of active

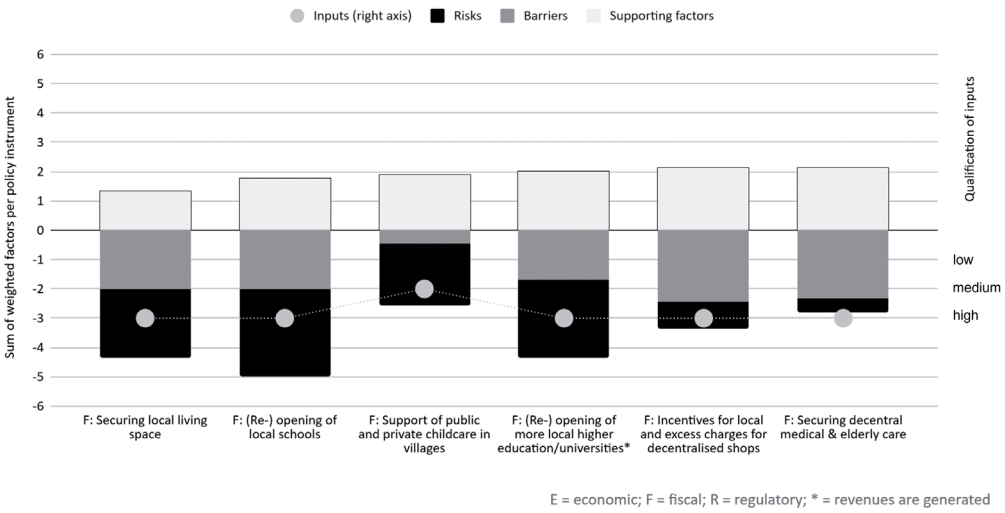

Figure 7. Policies within the strategy "Reduce trips through local supply".

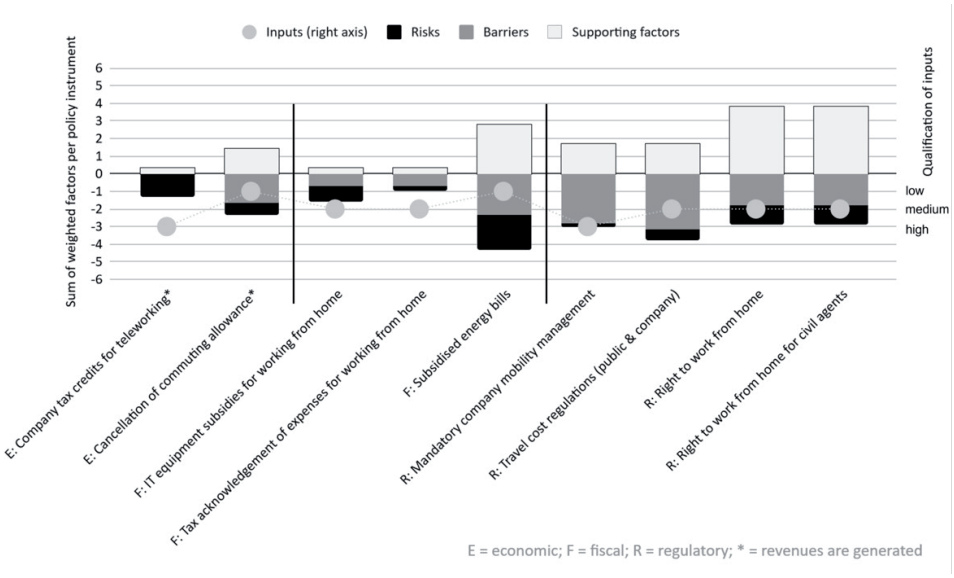

Figure 8. Policies within the strategy "Reduce work trips".

modes" and "motorised individual transport reduction", both strategies including a mixture of push and pull policies, are associated with the lowest number of risks.

We conclude that there is no clear pattern for supporting factors, barriers/risks and inputs over the proposed transport policies, policy strategies and instrument types. For each policy strategy, different policies need to be compared and policy mixes need to be set up which can support each other, e.g. the investment in public transport frequency/quality will remove barriers and risks for car access restrictions.

COMPARISON OF IMPLEMENTATION FEASIBILITY BY INSTRUMENT TYPE

We also analysed the variation in terms of feasibility between different instrument types of proposed policies. We find that fiscal instruments have fewer supporting factors and a higher number of risks than the other instrument types, often related to the required funds that need to be secured in the long term (Figure 10). We further find that regulatory instruments have, on average, more supporting factors than the other instrument types, but also more barriers (that can however be overcome), and a limited number of risks. This finding contrasts with discussions on regulatory instruments in politics and media, where barriers and risks dominate the discourse, with little focus on supporting factors (keyword German Buildings Energy Act).

Discussion of Results and Limitations

The presented results show no easily interpretable patterns for favourable or less favourable proposed transport policies. Moreover, assessed factors are not necessarily fixed, but can be dependent on the implementation of other policies. Especially barriers can likely be reduced through the simultaneous implementation of other policies which will modify the results. Research on a favourable policy mix and on a combination of this qualitative assessment with quantitative data on the GHG emission reduction potential per policy is needed to draw more concrete policy recommendations.

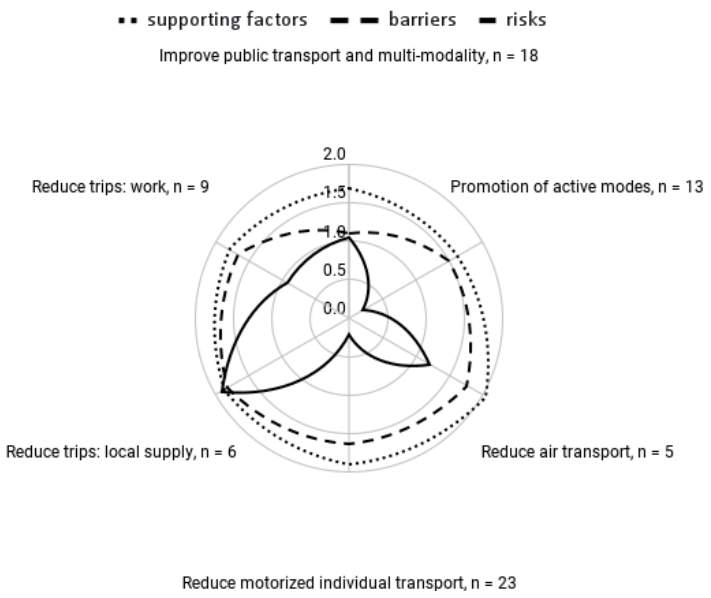

Figure 9. Overview of policy strategies by average number of supporting factors, barriers and risks.

At this stage, we can, however, draw findings on single policies, policy strategies and instrument types:

- Good practice examples like the Barcelona superblocks can be analysed with our method to stimulate fact-based discussions on the implementation feasibility of decarbonisation policies in the transport sector, detailing the necessary inputs and factors that support or hinder their implementation. This is helpful to compare policy options.
- Policies with many supporting factors often also have many barriers and risks; in addition, these tend to have a higher need for inputs. This is often because they are more abstract, high-level policies with more diverse relevant factors and more diverse or structural input needs.
- "Pull" policies such as incentives or infrastructure have less barriers than "push" policies such as an air travel ban or the conversion of road space to cycling and walking. However, "pull" policies in most cases require higher financial and other input.
- The genuine sufficiency policy (avoid) strategy "reduce trips by improving local supply" with the aim to reduce the absolute amount of travelled distance has most risks, the "promotion of active modes" and the "reduction of motorised individual transport" strategy least. A low number of risks hints at no-regret policies and leads to the conclusion that mode shift policies are more easily feasible.
- From the comparison of instrument types, we find that regulations seem comparatively feasible to implement: they have the most supporting factors compared to economic and fiscal instruments, while they do not have the most risks (but most barriers). This can be explained by a relatively high public support which was also concluded by Lage et al. (2023).

The specific policy proposals and their descriptions in the literature vary in depth of detail and specificity. Some are more generic and on a meta-level, others very specifically target existing regulations. We tried to streamline the impact chains, aiming for a minimum level of specificity. However, as mentioned above, the more meta-level policies often have a higher number of positive and negative factors.

Furthermore, our comparison of policies by policy strategy and instrument type relies on the factors identified in the impact chain analysis. We tried to streamline all impact chains in terms of detail and applied a four to six eye principle for all entries to reduce subjective bias and increase robustness of our results. We are however aware that the mindset of the group of authors and the two students who supported us, may subjectively bias the results. We think that the most important mindsets which should be kept in mind by readers are that all authors are working in scientific institutions, partly for years, and that they are concerned of climate change and living within planetary boundaries and think that we need a socio-economic transformation. This more higher-level scientific view can make it difficult to identify barriers and risks associated with actual implementation. The findings in this work are therefore preliminary. As a next step, expert interviews with transport modelers and policy experts will be carried out to validate the impact chains and increase their robustness.

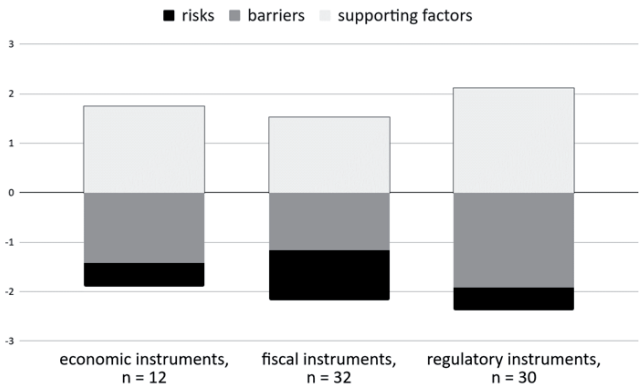

Figure 10. Average number of supporting factors, barriers and risks by instrument types.

Conclusions and future research need

We analysed 74 different policy instruments to decarbonise the transport sector with the concept of sufficiency impact chains by Zell-Ziegler and Thema (2022). We showed that the framework can be used for encompassing sets of meta-level policies and policy proposals. This is a new application relative to the initial application (in Zell-Ziegler and Thema (2022)) to local level policies that are already implemented. We show that policies can be analysed in a transparent and fact-based manner using information from literature and by setting up transparent open-access impact chain tables. We assess the impact chains with associated factors for single policies to analyse the feasibility of implementing proposed policies in Germany. We can also compare different policies based on supporting factors, barriers, risks, inputs and revenues and give recommendations on policies which seem to be implementable with very limited inputs or barriers/risks. On a more aggregate level, we can point out which policy strategies or instrument types seem favourable in terms of the mentioned factors.

Follow-up research should look more into interactions between the policies: One or several policies can reduce barriers and risks for other policies and boost their effectiveness. We therefore need a suitable policy mix and appropriate research for the decarbonisation of the transport sector – there is no single solution. Quantitative impacts of the policies like GHG and energy savings also need to be integrated into the analysis to approach a "cost-benefit" or rather barrier/risk and input vs. impact analysis of the policies. This is however difficult for not yet implemented and only proposed policies, as the implementation details like amount of funding, extent of car-free zones etc. are not known from our data basis (*European Sufficiency Policy Database*). Policy recommendations hinge on the expected saving potential being included in the analysis. Assumptions on these implementation details thus seem favourable, but ex-ante assessments may be challenging.

Furthermore, future research can build on this effort and add e.g. gender and social inequality issues to the published impact chains.

References

Best, Benjamin et al. (2022): Building a database for energy sufficiency policies. In: F1000Research 11, p. 229. https://doi.org/10.12688/f1000research.108822.2

BReg (2023): Projektionsbericht 2023 für Deutschland. Gemäß Artikel 18 der Verordnung (EU) 2018/1999 des Europäischen Parlaments und des Rates vom 11. De-zember 2018 über das Governance-System für die Energieunion und für den Klimaschutz, zur Änderung der Verordnungen (EG) Nr. 663/2009 und (EG) Nr. 715/2009. Hg. v. Umweltbundesamt (UBA). Umweltbundesamt (UBA) (Climate Change, 39/2023). Available online at https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/39_2023_cc_projektionsbericht_2023.pdf, last accessed on 24.11.2023.

GIZ (ed.) (2016): Sustainable Urban Transport: Avoid-Shift-Improve (A-S-I). Available online at https://ledsgp.org/app/uploads/2016/01/SUTP_GIZ_FS_Avoid-Shift-Improve_EN.pdf, last accessed on 11.03.2024.

IPCC (ed.) (2022): Climate Change 2022. Mitigation of Climate Change. Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

Lage, Jonas; Thema, Johannes; Zell-Ziegler, Carina; Best, Benjamin; Cordroch, Luisa; Wiese, Frauke (2023): Citizens call for sufficiency and regulation – A comparison of European citizen assemblies and National Energy and Climate Plans. In: Energy Research & Social Science (104). Available online at https://doi.org/10.1016/j.erss.2023.103254.

Schlomann, Barbara et al. (2020): Methodikleitfaden für Evaluationen von Energieeffizienzmaßnahmen des BMWi (Projekt Nr. 63/15 – Aufstockung). Im Auftrag des Bundesministeriums für Wirtschaft und Energie (BMWi). Hg. v. Fraunhofer ISI, Institut für Energie- und Umweltforschung Heidelberg (ifeu), Prognos und Stiftung Umweltenergierecht. Karlsruhe / Heidelberg / Basel / Würzburg. Available online at https://www.bmwi.de/Redaktion/DE/Downloads/M-O/methodik-leitfaden-fuer-evaluationen-von-energieeffizienzmassnamen.pdf?__blob=publicationFile, last accessed on 09.08.2023.

United Nations Framework Convention on Climate Change (ed.) (2000): UNFCCC guidelines on reporting and review. Review of the implementation of commitments and of other provisions of the convention. FCCC/CP/1999/7. Available online at http://unfccc.int/resource/docs/cop5/07.pdf, last accessed on 11.08.2023.

Zell-Ziegler, C.; Best, Benjamin; Thema, J.; Wiese, Frauke; Vogel, B.; Cordroch, Luisa (2024): European Sufficincy Policy Database. [Data set]. Energy Sufficiency Research Group. Available online at https://energysufficiency.de/policy-database/.

Zell-Ziegler, Carina; Thema, Johannes (2022): View of Impact chains of energy sufficiency policies: A proposal for visualization and possibilities for integration into energy modeling | TATuP – Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis. In: TATuP – Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis Vol 31, No 2, pp. 40–47. Available online at https://www.tatup.de/index.php/tatup/article/view/6970/11734, last accessed on 07.06.2023.

Acknowledgements

We thank Diah Putri and Lola Delfosse who supported the literature research and discussion of impact chains during their respective internships at Oeko-Institut. We thank Mahsa Bagheri and Leila Siebke from Fraunhofer ISI for the discussions on the impact chain concept during the application of the method to the buildings sector for Leila's master's thesis. We thank our colleagues Frauke Wiese, Benjamin Best, Jonas Lage and Luisa Cordroch from the EnSu project for their inputs to this research strand as well the members of our doctoral colloquium, Prof. Stefan Heiland from TU Berlin and Katja Schumacher from Oeko-Institut for inputs at different stages of this analysis.

We thank the German Federal Ministry of Education and Research (BMBF) for funding the EnSu junior research group within which this analysis was conducted (grant numbers 01UU2004B and 01UU2004C).