The relevance of causal chains for planning and evaluating sustainable transport policies

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Abstract

Policy planners often lack guidance in their approach to meet sustainability goals in transportation. Considering the multiplicity of actors involved and challenges to be met, as well as the intertwined impacts of transportation, a more widespread use of causal chain analysis seems relevant to improve the decision-making process. This paper illustrates the usefulness of the causal chain approach for 1) transport-related policy integration, 2) for visualizing, comparing and choosing the most promising strategies aiming at achieving sustainable transportation goals, and 3) for identifying and selecting the best performance indicators to be used for monitoring and evaluation purpose.

Key words

Sustainable transportation, Policy, Causal chain, Impact assessment, Transport planning

Highlights

- The causal chain approach provides a comprehensive view of the issues at stake in sustainable transportation and their interactions
- Causal chains help select the most efficient strategy to achieve sustainability in transportation
- The causal chain approach is suitable for the development of an indicator framework for decision-support
Introduction

Sustainability in transport has become one of the major challenges of the 21st century in most countries, due to the scope and the magnitude of its impacts on the environment, the economy and human populations. Among other things, transport consumes large surfaces of land and huge amount of natural resources, contributes to climate change, jeopardizes health, safety and quality of life, creates congestion, damages landscapes, endangers biodiversity, and entails tremendous costs.

In this context, policy planners have to decide which strategies are best to meet sustainable goals, whether it is a decrease in oil consumption, a reduction in GHG emissions, a safer and more accessible transportation system, a better air quality, a stronger economic competitiveness, an enhanced quality of life for communities, or a more efficient land-use development. Moreover, turning strategies into actions requires a good understanding of the links between problems, objectives, interventions and outcomes. Causal chains and their diagrams have proved themselves to be very useful to illustrate those links, especially in complex causal systems, thus providing decision-makers with a comprehensive view of the issues at stake.

A causal chain has been defined by Joumard and Gudmundsson (2010) as “an ordered sequence of events or issues, in which any one event or issue in the chain causes the next one”. These authors also stated that each causal chain depends on the society where it takes place, so there is no unique diagram for a particular situation. They extend the causal framework developed by the European Environment Agency (EEA, 2011) to the concept of causal chain. This framework – called the DPSIR model – describes the interactions between society and the environment: Driving forces, Pressures, States, Impacts, Responses.

The use of causal chains has recently been proposed in health impact assessment (Joffe and Mindell, 2002, 2006) in order to take into account the systemic nature and the complexity of the problems, allowing an overall integration of causes and consequences, not only distally – along the length of the causal chain – but also laterally – across different problems, interventions and outcomes – sectorally – across different policy areas and administrations – and then spatially and temporally (Briggs, 2008).

Considering the multiplicity of challenges to be met in the field of transportation and how they interact with each other to produce a set of intertwined impacts, the causal chain approach seems particularly relevant here. For instance, the reliance on car driving has an impact on oil dependence, congestion, CO2 emissions, and air quality. Addressing one of these issues might affect the others as well. Transport is not an isolated activity; it is deeply interconnected with land-use development, other human activities and the environment. Richardson (2005) has proposed a series of causal frameworks for sustainable transport, providing an overview of the interactions taking place, and warning against a one-dimensional problem solving approach, since addressing one policy option will have an impact on the others dimensions as well.
One of the main efforts to consider causal chains in transport policy planning has been made in the U.K. under requirements for the preparation of local transport plans, as expressed under the Transport Act 2000. Following government guidance, local authorities were asked to produce a vision document linking objectives, measures, and outcomes for the planning and evaluation of transportation in their region every five years, using causal chain diagrams to illustrate those links (Essex 2001; North Lincolnshire 2001). Not only the vision document would clarify in a logical manner the causal pathways between objectives, measures and outcomes, but it would also provide authorities with an integrated strategy of transport-related policies, and help choose the best indicators for monitoring the performance of the system.

1 Objectives

The aim of this paper is to highlight the usefulness of the causal chain approach 1) for transport-related policy integration, 2) for visualizing, comparing and choosing the most promising strategies aiming at achieving sustainable transportation goals, and 3) for identifying and selecting the best performance indicators to be used for monitoring and evaluation purpose.

2 Clarifying the concepts

In transport strategy documents, there is sometimes confusion between challenges, objectives and strategies, as well as between strategies and interventions, or between challenges and impacts. Similarly, there can also be confusion between categories of impacts, whether they are intermediate, indirect or final, which usually depends on the goal to be achieved. This confusion can lead to a wrong interpretation of causal links and possibly favour the adoption of wrong policy options, thus compromising the decision-making process. The logical sequence is presented in figure 1.
Figure 1. The logical pathway of the causal chain

The steps of the sequence can be defined as follows:

*Challenge*
A challenge is the issue encountered and requiring a solution.

*Objective and goal*
An objective is what helps achieve a goal but it is not an end in itself, while a goal is what society ultimately aims at, in order to address a challenge.

*Strategy*
A strategy is the general orientation taken to reach the objective.

*Intervention*
Operationalizing a strategy, an intervention is the specific measure put in place to reach the objective.

*Indirect outcomes*
An impact (or outcome) is said to be indirect if it is not directly pursued by the objectives. For instance, promoting transit use in order to reduce congestion will have as indirect outcome to increase walking among commuters, since a segment of the trip will be made on foot. Another indirect outcome will be a reduction in CO\(_2\) emissions, since there would be fewer cars on the road.

*Intermediate and key outcomes*
An intermediate outcome is a proxy measuring progress towards the final impact (which are also called key outcome). Among the intermediate impacts in the above example
would be the increase in the number of transit users, while the final impact would be the observed reduction in congestion.

At each step of the sequence can be associated one or more indicators aiming at measuring the progress towards the objectives to be reached and/or the impacts of the measures implemented, whether it is part of the monitoring process or of the impact assessment.

**Input and output indicators**
Indicators can be categorized into input and output indicators – both related to the interventions – input indicators concerning costs and other resources used to implement output elements. In the above example, an output indicator would be the number of new busses or bus lines put in service.

**Outcome indicators**
Indicators used for determining the impacts of the interventions are called outcome indicators. Usually, input and output indicators are considered in the monitoring process while outcome indicators help evaluate the impacts.

### 3 The relevance of causal chains

#### 3.1 Causal chains for policy integration

Since transport is at the core of most human activities, involving all kind of resources and having a large scope of impacts, policies aiming at improving its sustainability should be part of a broad framework taking simultaneously into account the contributions of all the actions taken to achieve the pursued goals, and their intertwined consequences.

Sustainable transport requires actions in different policy sectors such as land-use planning, environment and health, which makes policy integration a key element of success when dealing with causes and consequences belonging to other sectors. Measures taken in one sector should not compromise other aspects of sustainability, as it was the case with the production of ethanol from corn and other food stocks in order to decrease the reliance on fossil fuels. Moreover, impacts occurring far beyond the geographic limits of areas where new measures are implemented also have to be taken into account, as in the case of GHG emissions. Causal chain analysis has been presented as a useful technique for policy integration (Stead, 2004).

Causal chains can have, for starting point, the challenges to be met, the objectives to be achieved, or the measures implemented. The three approaches have been used in the provision of local transport plans in the U.K. Beginning with a challenge or an objective allows decision-makers to consider all the available options – and their multiple impacts – to reach the sustainable goal pursued (figure 2).
On the other hand, when the starting point is the intervention to be carried out, the causal chain illustrating the impacts of the measure implemented will provide some insight into all the objectives that could be met with this intervention. In the case illustrated here, pedestrian facility improvements is one of the contributors to four among six objectives set in the North Lincolnshire Local Transport Plan (figure 3).
Figure 3. Causal chain based on the intervention (pedestrian facility improvements)

The causal chain approach will provide a comprehensive view of the issues at stake and their interactions, allowing planners to integrate the three dimensions of sustainability in their decision process. If the emphasis is to be put on one dimension such as the environment, causal chain diagrams will also illustrate other aspects of sustainability of concern, and help show how they can be taken into account. Thus, aiming at reducing dependence on fossil fuels and curbing global warming could also result in a better air quality and its effects on population health through a reduction of respiratory problems, leading then to a decrease in hospitalizations for asthma among vulnerable populations and their associate medical costs. Still too often, these possible impacts are overlooked because planners have only one aspect of sustainability in mind at a time. This example shows how addressing one dimension of sustainability can have a positive impact on the others dimensions as well, if the appropriate solution is pushed forward. In this perspective, decision-makers from different policy sectors would benefit from measures taken in a single area.

Such win-win strategies for sustainable transportation have been reviewed extensively by Todd Litman (2011a) at the Victoria Transport Policy Institute. The author shows how environmental, social and economic goals are not necessarily in conflict: for instance, increase neighbourhood walkability does not have to be a threat to economic vitality.
Providing a broad range of benefits, win-win strategies can help achieve multiple planning objectives, and thereby increase transportation system efficiency.

3.2 Selecting the best strategies

Once the environment in which transportation takes place is well understood, causal chains allows comparison between the strategies available to achieve the pursued objectives. Relating policies to their impacts, causal chains help select the most efficient strategy, i.e. the one with greater positive impacts and lesser negative consequences, at the best cost possible. The following example (Table 1) illustrates four available – but not exhaustive – options to reach two sustainable transport goals: a reduction of GHG emissions and oil dependence.

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Strategies</th>
<th>Change energy source</th>
<th>Optimize vehicle occupancy rate</th>
<th>Operate a modal transfer (for persons)</th>
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<td>gas (oil)</td>
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<td>GHG emissions</td>
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<td>congestion</td>
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<td>transport costs (global)</td>
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<td>transport costs (households)</td>
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<td>noise pollution</td>
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Table 1. Strategies aiming at reducing oil dependence and GHG emissions.

Range of effects
It is obvious at first glance that some options have a larger range of effects, and on more than one dimension of sustainability. Among the four options illustrated, a modal transfer seems to offer more potentialities than the others, addressing not only the two issues at
stake (GHG emissions reduction and oil dependence), but helping meet other challenges such as congestion, accessibility, physical activity, safety, air pollution, and so on. After mapping all the possible impacts of the available strategies, policy-makers might decide to opt for one providing multiple benefits, as long as its implementation is realistic and does not incur phenomenal costs. This approach will also help discard an option bearing unwanted consequences.

**Timeframe**

Another aspect to be considered in the causal chain is the timeframe, since not all impacts will occur at the same speed. If there is a sense of urgency to reach a specific goal, it will influence the decision-making process, and finally, the option favoured. Nevertheless, one should keep in mind that long-term consequences are inherent to the definition of sustainability (Brundtland, 1987). In the example illustrated above, a modal transfer to walking and cycling would have an immediate impact on daily physical activity, but a delayed impact on obesity and on the occurrence of other health problems. Moreover, since these impacts are multi-causal, the share attributed to transport is not easily determined. Similarly, some measures require less time to be implemented than others, which may also influence the decision-making process. For instance, although land-use development is recognized as a strong determinant of transport demand, a change in land use would require more time to implement than measures aiming at inducing a modal transfer.

**Scale of impacts**

Finally, the causal chain should refer to the scale of impacts, whether they occur at the local, metropolitan or national level. A systemic approach will ascertain that the problem to be solved is not just transferred to another area, as might be the case sometimes for congestion reduction.

### 3.3 Developing an indicator framework

In the context of the DISTILLATE project (Marsden et al, 2005; May, 2009) carried out at the University of Leeds in the U.K., a causal chain approach has been proposed by Marsden and Snell (2009) for the development of an indicator framework for decision-support regarding sustainable transportation. Since indicators are a critical part of the monitoring and the evaluation process, it is essential they are developed in close connection with the objectives to be reached; otherwise, they might not be used to support the decision-making process. Linking indicator systems to policy making was pointed out by Gudmundsson (2003) as one of the major issues to consider in order to incorporating adequately sustainability goals.

The following steps were recommended for developing a coherent indicator framework suitable for decision-support in transport planning (Marsden and Snell, 2009):

- Define the objectives to be reached;
- Link objectives and key outcomes;
At this step, select the key outcome indicators used to assess progress towards the achievement of the objectives.

- Link key outcomes and intermediate outcomes;
  o Intermediate outcomes and their indicators depend on the strategies adopted to meet the objectives. They represent proxies or milestones towards key outcome targets, and often, decision-makers have to rely on them because key outcomes may take a longer time to occur, or cannot be measured directly, or are subject to many other influences besides transport, as it is the case for health outcomes, for instance. Moreover, an intermediate outcome might be linked to several key outcomes, and a key outcome might have several intermediate outcomes.

- Link outputs and intermediate outcomes;
  o Once the strategies have been identified, output indicators are selected in order to estimate the implementation of strategies. Output indicators also depend on the strategies chosen.

- Prioritize indicators;
  o At this step, it is recommended to consider indicators required by national or regional authorities, as well as indicators with a pre-existing time series. It is also suggested to include indicators from all categories (process, inputs, outputs and outcomes).

According to Marsden and Snell (2009), causal chain analysis is useful for setting up the linkages between indicators; this approach would also make the indicator set more suitable for the decision-making process. Too many indicators, however, may reduce the ability to use the information effectively. Nevertheless, in a sustainability perspective, the indicator list must include those characterizing indirect (desirable and unwanted) outcomes. Ideally, causal links should be based on empirical evidence. But the scarcity (and the quality) of data often limits the choice of relevant indicators.

A list of principles has been set out for guiding the selection of indicators. These principles have been reviewed by Litman (2011b): 1) indicators should be comprehensive, reflecting various impacts and transport activities, 2) data collection should reflect high quality standards, 3) indicators should allow comparison between jurisdictions and times, 4) they must be easy to understand by decision-makers and the general public, 5) they must be accessible and transparent, 6) they must be cost effective to collect, 7) they should differentiate between net impacts and shifts of impacts to different locations and times, and 8) they must be suitable for establishing usable performance targets.

4 Conclusion
Seeing policy integration as “an essential precondition for achieving more sustainable development”, the United Nations Economic Commission for Europe recently pointed out the “great need to integrate the principles of sustainable development into transport policies” (UNECE, 2008). Too often, policies aiming at achieving sustainability in transportation fail to do so because they are not based on an integrated model, and therefore neglect considering some crucial dimensions, thus compromising the balance between economic, environmental and social goals. A causal chain approach provides a valuable tool facilitating the adoption of a comprehensive vision of transportation, and illustrating its interconnections with the whole environment where it takes place. Without such a system-oriented approach, there is a risk that sustainability policies fail (Goldman and Gorham, 2006). For the environmental sector only, 49 independent causal chains illustrating the impacts of the transport system have been identified (Joumard, 2011).

Beyond its contribution to policy integration, causal chain analysis helps clarify the links between objectives, interventions and impacts, allowing a better understanding of all the issues at stake. When pursuing sustainability goals, there is always a risk of emphasizing one dimension – such as the environment, or even more specifically energy – at the expense of others like social or health issues. Taking into account all possible links, causal chains are particularly appropriate for studying multidimensional problems.

A causal chain approach does not guarantee either that policy-makers from different sectors are going to work in synergy, but it can be used as a tool facilitating collaboration between stakeholders having sometimes conflicting interests and priorities regarding transport policies and impacts. This approach might help raise awareness of some authorities on issues not specific to their field and also avoid considering a narrow definition of sustainable transport, unable to capture its multivariate nature. As stated by Litman and Burwell (2006), such a narrow definition “tends to overlook many relationships between issues and opportunities for coordinated solutions”. Focusing too narrowly on one policy option without considering other dimensions of sustainability might exacerbate other problems.

References


