Component 1: Draft Conceptual Design

Introduction

The purpose of this design draft is to create a model proposal which demonstrates the changes in commuting transport choice in the Sheffield with the introduction of new schemes by the Sheffield City Council. It will be used to assess the effectiveness of each of these schemes over a 22 year period, with the overall goal of increasing the proportion of cycling commuting journeys from 2% of the working population to 11%. There are currently three options to consider:

- Construct cycle routes that are separate to the road infrastructure.
- Increase the amount of road space dedicated to cyclists.
- Invest in subsidised pay-per-use docked electric bicycles that require less cycling effort on Sheffield's hills.

The model shall be an agent based model, with decisions made by the agents corresponding with population choices in transport methods. The model shall attempt to incorporate to a sufficiently accurate level aspects of everyday life which impact normal commuting choices, as well as the above detailed schemes to simulate the effects they have. The model shall be based on existing research, relating to the choices made by commuters as well as statistics collected by other studies that, although not reflective of Sheffield as an individual city, should still be considered.

Existing Research Analysis

Sheffield City Region Transport Strategy 2018-2040

The SCR Region Transport Strategy document provides a useful background of information for this model. It offers a selection of relevant data which could be used to calibrate and test the model, as well as less obvious but still relevant data topics which could be incorporated into the model to improve accuracy and give a larger set of simulation parameters. It also outlines a set of policies which would suggest that the above mentioned schemes are viable options and are worth modelling and simulation.

This document provides an outline of the proportions between common transport methods and the distances used for them - (page 27) namely cycling, walking, cars (both driving and passenger), bus and other for trips between 0.5km and 5km in 0.5km increments. This may be a useful data set, as it provides an initial starting data point for a model which considers how cycling journey frequency varies against distance. However, by the document's own admission, this data has been "captured across a limited geographical area and time period". As a result, this data may want cross checking against other sets of the same or similar metrics to confirm its validity across Sheffield.

The Strategy also presents a graph showing that the number of people killed or seriously injured in road collisions has fallen. This drop is implied to have been caused by the introduction of legislation improving the safety of pedestrians and cyclists, for example a ban on mobile phone use whilst driving which came into force in 2005. However, this trend is starting to plateau, presumably as the new laws are more widely accepted and taken up by drivers. This might be relevant to the model as any data used to compare the model accuracy taken from this time period should account for the decrease in traffic incidents and as such public confidence in cycling would have grown. It should also be noted that the model should potentially allow for the influence of any new legislation to be introduced which may continue this trend in the simulation.

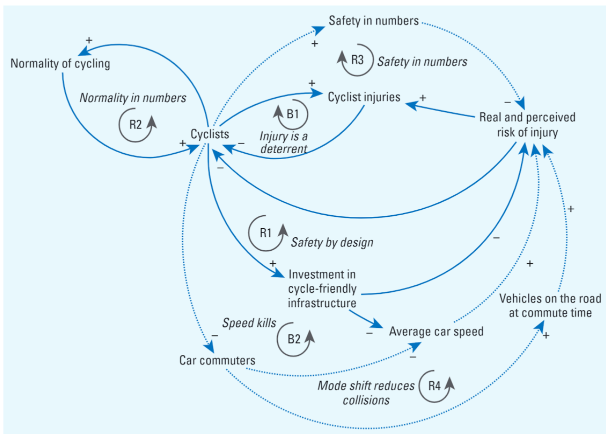
s The Strategy identifies potential improvements to cycling-related infrastructure, specifically attempts to increase perception of safety on the streets though more street lighting and "cycling facilities" to persuade more people to walk or cycle to their destinations. This will be done to identified major cycling routes into main urban areas.

The Societal Costs and Benefits of Commuter Bicycling: Simulating the Effects of Specific Policies Using System Dynamics Modeling

This document outlines building a model which simulates commuter cycling in Auckland, New Zealand, and looks at the costs and benefits to society - in particular the impact on public health spending. It used the effects of large scale policies as input parameters and system dynamics modelling to run the model, in a similar way to how the model for this project may work.

It was built using a combination of primary and secondary data sets to build quantitative relationships between the identified modelled stakeholders. The primary data was a set of 16 interviews of people the researchers thought represented the groups in their model. They took qualitative data in the form of possible causal relationships and potential model stakeholders and quantitative data in the form of the interviewees opinions regarding the strengths of these relationships which were rated numerically. This method would be a good way to incorporate experienced opinions into the model without the need to find and comprehend all of the relevant data sets as a researcher who may not be experienced in the subject of interest. However, with smaller sample sizes it is not as accurate; small biases from individuals based on relatively rare events such as roadside collisions might bias the model and skew the results. This effect may be more pronounced if this opinion were to bereplicated across thousands of simulated agents in non-linear feedback loops. The secondary data was taken from national census and survey data and was used to quantify other relationships in the model. This method would be far less susceptible to biases of individuals. However, due to them being national and regional surveys the opinions are not specific to an area. This would make this method far less accurate when applied to local instances, such as in this project which is concerned with the city of Sheffield.

The document outlines the exact structure of the finalised relationships in the model through a diagram. This makes it very simple to understand the model, as well as easy to see why such a model requires in-depth simulation rather than a cursory glance at a set of data.



The input parameters of the model - for example the simulated policies - would impact the weightings of the relationships between the stakeholders whilst the model was being simulated. Again, this was based on qualitative and quantitative research adapted to the specific locations required - in this case, Auckland. The simulation was run enough times to create high and low confidence limits of the scenarios, which allowed for best and worst case estimates of the effects to be created.

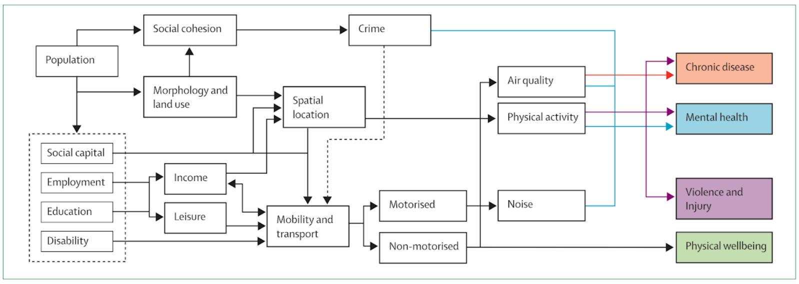
With the results of the project, the researchers found the equations modelling the policies could be quite ill-conditioned - such that small variations in the input gave large variations in the outputs. They also found the system was very sensitive to their “safety in numbers” equations. This would imply that for this project, careful research and testing should be performed in calibrating any equivalent functions.

Shaping cities for health: complexity and the planning of urban environments in the 21st century

This paper provides an overall and very general analysis of factors that affect and influence the health of the population with respect to urban living. There are only two sections with cycling as a focus: the first provides a brief analysis into the motivations of active modes of transport such as walking and cycling. This section states that people who choose active modes of transport are mainly those of low to mid socio-economic status, as it tends to be that families might have to switch to active modes of transport for purely financial reasons rather than from a freedom of choice perspective. However, location within the city also plays a role in this decision As the lowest cost housing is further away from the city and hence further from the centre of employment, those who live too far out are forced to use inactive forms of transport despite the cost, for the sole reason of being able to access employment.

This document also lists the perception of safety and crime as another reason for choosing not to walk or cycle, especially for parents when choosing how their children might get to school through a less safe neighbourhood. In higher income countries, urban density is shown to positively affect active transport time. However, this is due to the close proximity of conveniences such as shops, and does not apply to commuting journeys. On the other hand, sprawling cities are shown to promote inactive transport use regardless of income levels, as the need to travel relatively long distances arises as a result of this city layout.

The second relevant section of this paper references several case studies of effects of policies on active transport modes. One case study focuses on Bogota in Columbia, which began shutting roads to motorised transport on Sundays from 1974. This allowed people to use active forms of transport more easily, and produced an uptake of active transport modes even when the roads returned to normal operation. It has since been linked with an uptake in a more active lifestyle, with 41% of adults in the population participating in three hours of daily exercise in the lower traffic periods.



Model Proposal Overview

From this research, I have decided that the following set of features should be included as a minimum for simulation:

1. Perceived road safety parameter: This metric would tie in to the first two proposed policy changes of creating separate cycle routes and increasing road space available for cyclists, ass both would reduce the perceived risk of a road collision with cars. It was also named as being a fairly important metric for transport choice in the Auckland-specific study. The Auckland study also shows that more work could also

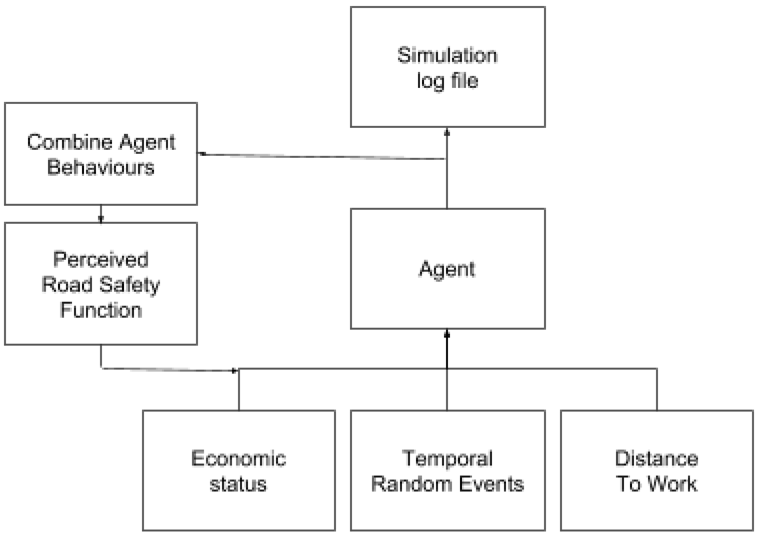
be done in modelling the safety-in-numbers positive feedback loop, and the bike to bike collisions.

2. Socio-economic status parameter: As multiple papers have suggested, income level is a key metric for deciding to actively commute to work. It is also a firm metric, as the chances of dramatic economic position changes amongst the agents are low, whilst the need for agents to keep commuting is high. The consistency of this factor shows the importance of using this as a core parameter of the model. This also links with the third potential policy change of introducing pay-per-use electric bikes, as low earners may not want to invest in a bike, so would see a pay-per-use system as a major benefit. It would be easy to simulate as census data could give an idea of the distribution of socio-economic standing.
3. Distance to work parameter: This was a key factor in deciding the style of commute in SCR Transport Strategy. This would also be easy to simulate in the model as it involves looking at places of work and residence across the city.
4. Configurability:The model should be easy and clear to configure parameters linked to policies to avoid ambiguity when analysing and comparing the results.
5. Logging:All data produced by the model simulation should be logged to an output file for later analysis.

The model could be written such that if there were enough time, the following features might also be added:

1. Safety-in-numbers positive feedback loop and a bike to bike collisions function, as these might provide a more realistic simulation of the perceived road safety metric.
2. An increase in perceived road safety due to technological factors such as progression of car safety, based on existing data.

Model Explanation



This model shall be executed as an agent based model, where each agent represents a commuter, or a small cluster of commuters with similar characteristics - for example, location or economic status. The agents shall take inputs in the form of population-wide effects such as the policies implemented during the simulation, as well as local inputs such as location of work and residence; economic status; a random component to account for agent decision-making in response to temporal events such as weather or illness, and the perception of how safe it is to actively travel to work in Sheffield. The output of each agent will be the choice made of the transport method - such as cycling or not cycling - which will be logged as the program's output. The program will also include several feedback loops based on a set of parameters combined into a universal measure of perceived travel safety.

Bibliography

Sheffield City Region & ARUP, Sheffield City Region Transport Strategy 2018-2040: Draft for Consultation, 2017.

Macmillan A, Connor J, Witten K, Kearns R, Rees D, Woodward A. The societal costs and benefits of commuter bicycling: simulating the effects of specific policies using system dynamics modeling. Environmental Health Perspectives 2014;122(4):335-344.

Rydin Y, Bleahu A, Davies M, Dávila J, Friel S, et al. Shaping cities for health: complexity and the planning of urban environments in the 21st century. Lancet 2012;379:2079-2108.