Complementarity and substitution between public transport and bicycles

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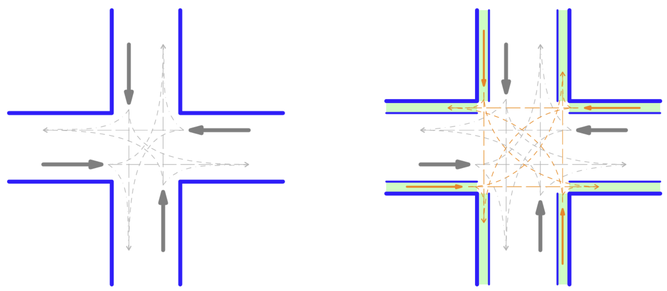
Background

To enhance public transport, particularly buses, it is crucial to improve their attractiveness by creating dedicated lanes and increasing service frequencies. While fare reforms, such as free public transport, have a limited effect on reducing private car use. Active modes like bicycling can either complement or substitute public transport, depending on the stations accessibility. This analysis is based on a microsimulation approach that takes into account highly detailed factors such as traffic lights, station locations, crosswalks, etc.

Objectives

- What is the extent to which bicycles and buses are substitutes or complements?
- Develop a microsimulation model, integrating the mode transportation choice based on the users generalized cost.
- Analyze different scenarios to determine which one will make public transportation more appealing.
- Evaluate the impact of each scenarios on congestion and greenhouse gas emissions.

Bus lanes and the complexity of the intersections



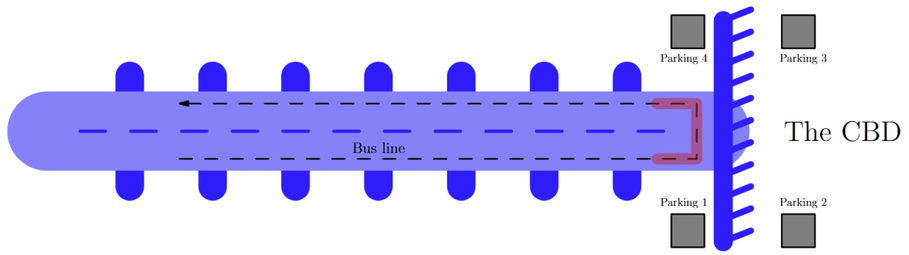
Left figure : simple intersection Right figure : An intersection with bus lanes

Demand & transport flows

- Population : 3,000 users with daily trip home-to-work.
- 20 % trips are generated from the main axis, corresponding to the share of households living there, or from the secondary roads linking the main residential areas.
- transport Modes : car, bus, bike and walk. In the base scenario, bicycling is excluded due to safety issues in mixed traffic.

Mono-centric city

In this analysis, we consider a parametric city model. The main links are nine kilometers long and intersect with secondary roads at eight equidistant points, where traffic flows are generated. Travel speeds are set to 50 km/h on the primary roads and 30 km/h on the secondary roads. All intersections are controlled by traffic lights operating on a 90-second cycle. In the baseline scenario, the primary roads feature three lanes in each direction, while the secondary roads have one lane per direction. All three lanes on the primary roads are shared among all transport modes.



The base-case scenario

Modal share (%)			User cost (€)			CO_2 (kg/car)
Car	Bus	walk	Ring 1	Ring 2	Ring 3	
68.4	8.4	23.5	10.8	33.7	41.4	13.4

Different scenarios illustrating the substitutability and complementarity between bus and bicycle

Scenario		S_1'''	S_2'''	S_3'''	S_4'''	S_5'''	S_6'''
Modal share *(%)*	Car	47.0	37.0	37.5	35.0	22.0	22.9
	Bus	6.0	15.0	4.6	15.7	36.0	25.2
	$b-$Bus	6.0	7.0	16.2	8.0	16.0	26.2
	Bike	35.0	36.0	35.9	36.0	23.0	23.5
	Walk	6.0	5.0	5.6	5.3	1.7	2.2
User Cost *(euros)*	Ring 1	10.9	10.0	9.4	11.1	9.1	9.5
	Ring 2	22.3	21.4	21.5	21.4	13.9	13.8
	Ring 3	32.4	27.1	26.4	26.5	13.0	13.3
	All	23.4	20.9	20.6	20.7	12.4	12.7
CO_2 *(kg/car)*		6.13	5.28	5.15	5.21	3.02	3.1

S_1''': Cycle-paths and users allowed to combine the bicycle and the bus; S_2''': S_1''' and dedicated bus-lane; S_3''': S_1''' and large spacing between bus stations (five stations instead of eight); S_4''': S_2''' and free public transport; S_5''': S_3''' and high frequency bus S_6''': S_5''' and high frequency bus services.

Main findings

- Different scenarios to limit road congestion, reduce user costs and GHG emissions: road infrastructure, modal shift to cycling and/or intermodality (bike-bus), public transport fares, fuel price increases, and the frequency and number of bus stops.
- Substitutability: Bus and bicycle are substitutes in densely populated areas, where the modal shift between the two modes is high, especially if dedicated lanes are available.
- Complementarity: Bus and bike become complementary when bus stops are spaced out, allowing users to combine the two modes to reduce walking and improve accessibility.

Study for the city of Dunkirk (BENNAYA & KILANI)

- This study presents an illustration to be applied to the city of Dunkirk in order to study the complementarity and the substitutability between bus (the only public transport mode) and bicycle in dense and suburban areas
- Building on this study and the cost function developed in this paper, alternative scenarios, such as a bike-sharing system combined with free public transport, will be examined to determine their effectiveness in Dunkirk.

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