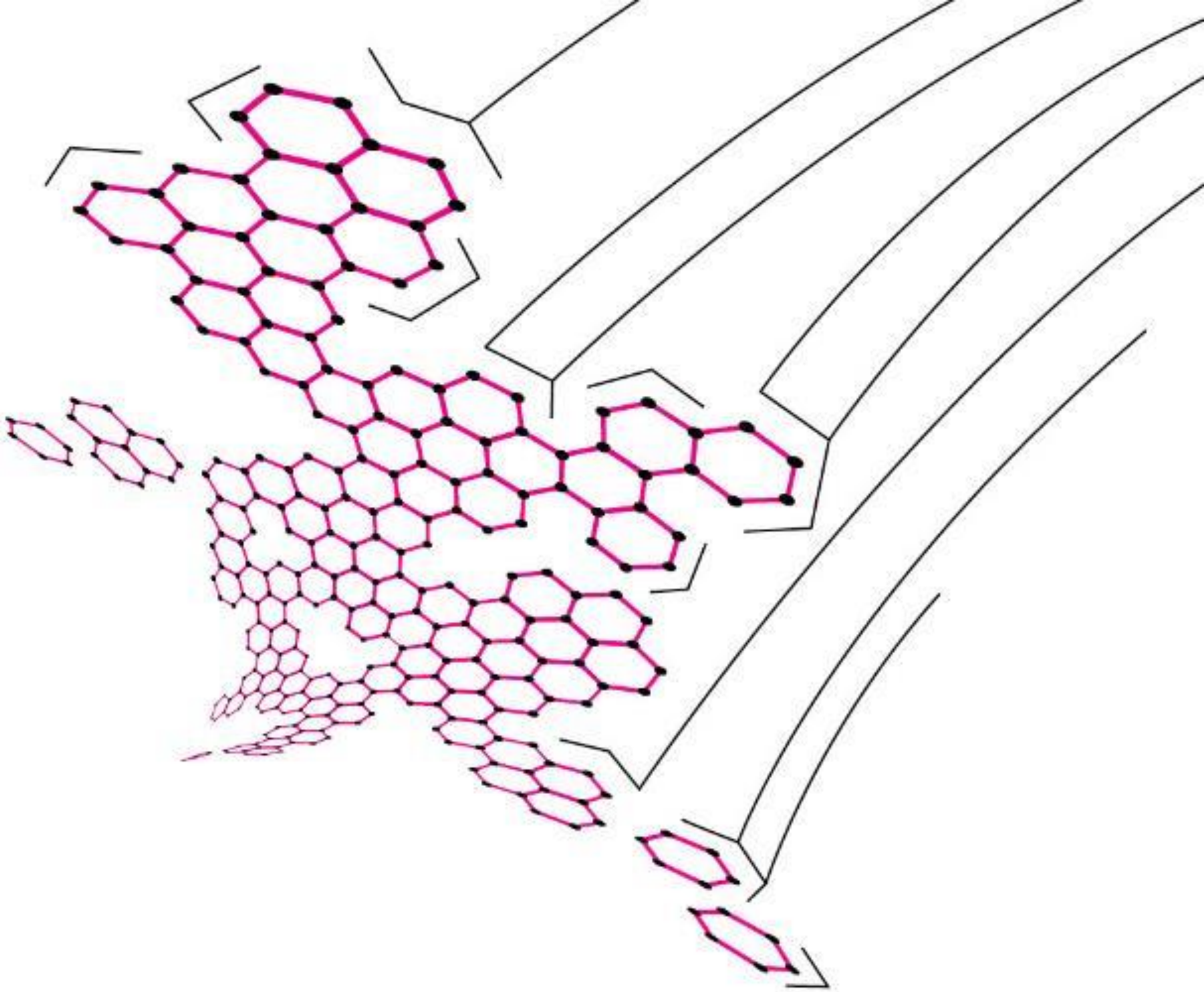
HEALTH BENEFITS FROM ACTIVE MOBILITY: EFFECT ON PRICING AND DESIGN OF PUBLIC TRANSPORT SERVICES



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QUESTIONS

1. Are there quantifiable health benefits from active mobility?
   - Are these benefits internal or external?

2. If so, what is the effect of these health benefits on the optimal design of transport systems:
   a) Prices and subsidies
      - Walking
      - Cycling (private bikes and shared bikes)
      - Public transport
      - Cars
   b) Public transport design: frequency of service, distance between bus stops or stations

HEALTH BENEFITS FROM ACTIVE MOBILITY

1. Health benefits from physical activity
   - Reduced mortality
   - Reduced probability of coronary heart disease, stroke, hypertension, diabetes, colon and breast cancer.
   - Improved mental health
2. For a person that cycles 5 km (one day), 5 days a week, 46 weeks a year, for 40 years: average life expectancy gain is 1.2 years (Rabl and de Nazelle, 2012)
   - Average value of a life year (VOLY): 43800 euros
   - Health benefit monetised as 1300 euros per year
   - Result: health benefit monetised as 0.56 euro/km of cycling
3. In case of serious illness, there are real economic costs as well: healthcare costs and production losses, which are also quantified (Statens Vegvesen, 2021)

https://transportation.ucla.edu/blog/biking-your-way-better-health

Rabl, A., de Nazelle, A. (2012) Benefits of shift from car to active transport. Transport Policy *19*(1), 121-131.
Statens Vegvesen (2021) Konsekvensanalyser. V712 i Statens vegvesens håndbokserie

INCLUSION OF HEALTH BENEFITS IN POLICY SETTING?

- If active mobility has positive externalities due to health benefits, welfare economics theory would suggest that walking or cycling should be subsidized as a first-best policy.

- In practice, there are indeed some cases around the world of policies that directly or indirectly subsidize cycling
  - Belgium: subsidy of up to 0,27 €/km for commuting by bicycle, car commuting can receive a 0.15 €/km subsidy and public transport is usually for free for commuters.
  - The Netherlands: commuting subsidy up to 0.23 €/km, regardless if the person travels to work by walking, bicycle, public transport or private car.
  - Colombia: public servants have the right to a half day free of work every 30 days that they commute by bicycle.
  - Norway, France, Germany, the Netherlands, Portugal, Spain, etc: subsidies acquisition electric bicycles, either for personal mobility or for freight transport.
  - HOWEVER, In most of these cases, the bike subsidies are motivated by (efficient?) modal choice away from congested car use

Question: are these optimal or reasonable levels of subsidy for active mobility, in multimodal context in which active mobility competes with motorized modes?

HEALTH BENEFITS: INTERNAL OR EXTERNAL?

- Survey in Stockholm: 52% of cyclist state that exercise was the most important reason to choose cycling (Börjesson and Eliasson, 2012)
- If travelers consider the health effects when making travel decisions (Börjesson and Eliasson, 2012)
  - Health benefits will be in consumer surplus – both as increased demand for cycling and as a lower value of cycling time.
  - Adding health benefits to CBA would be (partially) double-counting.
  - In spite of this, some exercises consider 100% health benefits as external in CBA, e.g., Standen *et al.* (2019)
- However, reduced healthcare cost and production loss are external.

- Börjesson, M., & Eliasson, J. (2012). The value of time and external benefits in bicycle appraisal. Transportation Research Part A: policy and practice, 46(4), 673-683.
- Standen, C., Greaves, S., Collins, A. T., Crane, M., & Rissel, C. (2019). The value of slow travel: Economic appraisal of cycling projects using the logsum measure of consumer surplus. Transportation Research Part A 123, 255-268.

HEALTH BENEFITS FROM ACTIVE MOBILITY

Table 5-21 Reduced healthcare costs for new pedestrians and cyclists (2020-kr) (Norwegian Directorate of Health 2014 and 2017)[14].

Reduced costs	Kr/km
Short-term sick leave for pedestrians	3,55
Short-term sick leave for cyclists	1,83
Serious illness for pedestrians (real economic costs (healthcare costs and production losses) + the welfare effect)	23,17
Serious illness for cyclists (real economic costs (healthcare costs and production losses) + the welfare effect)	14,67

- The health effect depends on the activity level already present in the population, and the intensity and duration of the activities.
- As there is no information on trip lengths for individual users, calculations are based on changes in total active travel distance.
- Estimated health benefits should not be used for minor route changes (length or intensity) for those already walking or cycling.

1 NOK = 0,085 Euro

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MULTIMODAL TRANSPORT PLANNING AND PRICING FOR GIVEN LOCATIONS

$$Social\ Welfare(SW) = Users\ benefit + Surplus\ transport\ providers + Health\ Benefits\ - External\ Costs$$

(1) (2) (3) (4)

- q_a: car demand
- q_b: bicycle demand
- q_w: walking demand
- q_{bs}: bike-sharing demand
- q_{pt-i}: public transport demand, multi modal access by $i \in \{w, b, bs\}$

- Active mode have health benefits, modelled in a per-km basis

MULTIMODAL TRANSPORT PLANNING AND PRICING

$$Social\,Welfare(SW) = Users\ benefit + Profit\ transport\ providers + Health\ Benefits\ - External\ Costs$$

(1) (2) (3) (4)

$$SW = B\left(q_a, q_b, q_w, q_{bs}, q_{pt-w}, q_{pt-b}, q_{pt-bs}\right) - q_a c_a - q_w[c_w - l_w H_w] - q_b[c_b - l_b H_b] - q_{bs}[c_{bs} - l_{bs} H_{bs}] - q_{pt-bs}\left[c_{pt-bs} - l^a_{pt-bs} H_{bs}\right] - q_{pt-w}\left[c_{pt-w} - l^a_{pt-w} H_w\right]$$

$$c_a = c_a\left(q_a, q_{pt}, f_{pt}, K_{pt}, S_{pt}\right)$$

$$c_{pt} = c_{pt}\left(q_a, q_{pt}, f_{pt}, K_{pt}, S_{pt}\right)$$

$$c_{bs} = c_{bs}(q_{bs})$$

- q_a: car demand
- q_b: bicycle demand
- q_w: walking demand
- q_{bs}: bike-sharing demand
- q_{pt-i} : public transport demand, access by $i \in \{w, b, bs\}$

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MULTIMODAL TRANSPORT PLANNING AND PRICING

$$Social\ Welfare(SW) = Users\ benefit + Profit\ transport\ providers + Health\ Benefits\ - External\ Costs$$

(1) (2) (3) (4)

Optimal first-best solution: prices τ

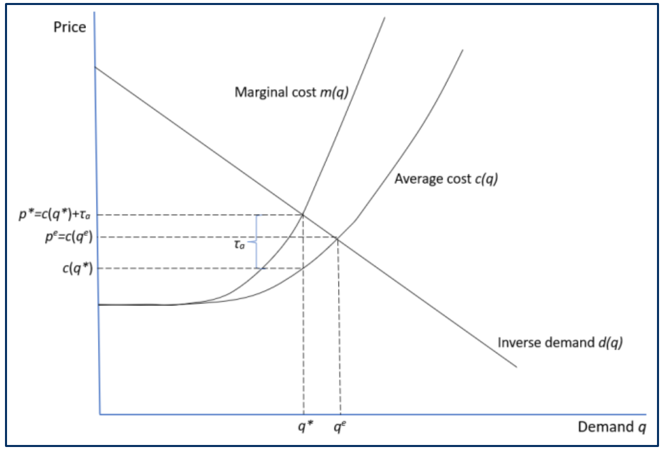
Cars $\tau_a = q_a \frac{\partial c_a}{\partial q_a}$

Public transport $\tau_{pt} = c_{pt}^o + q_{pt} \frac{\partial c_{pt}}{\partial q_{pt}} - l_{pt}^a H_{acc}$

Bicycles $\tau_b = -l_b H_b$

Walking $\tau_w = -l_w H_w$

- q_i: demand mode *i*
- c_i: cost mode *i*
- c_{pt}^o: operator cost bus
- l_i: trip length mode *i*
- H_i: monetized health benefits mode *i*



Marginal Operator cost + external crowding cost - Health benefit

MULTIMODAL TRANSPORT PLANNING AND PRICING

$$Social\,Welfare(SW) = Users\ benefit + Profit\ transport\ providers + Health\ Benefits\ - External\ Costs$$

(1) (2) (3) (4)

Optimal number of bus stops

- Increases with bus route length
- Decreases with the health benefits of walking H_{acc}
- Increases with total patronage
- decreases with frequency

Optimal bus frequency

- Increases with discomfort
- Increases with waiting time
- Decreases with bus costs

- q_i: demand mode *i*
- l_i: trip length mode *i*
- H_i: monetized health benefits mode *i*

Optimal number of bus stops

$$S_{pt} = \sqrt{\frac{\frac{P_a L}{2 v_w} - q_b H_{acc} \frac{L}{2}}{c_1 f_b \frac{t_s}{q_b} + P_v \frac{l_b}{L} t_s + \frac{c_2}{q_b}}}$$

- P_a: Value access time savings
- P_v: Value in-vehicle time savings
- v_w: walking speed
- f_b: service frequency
- t_s: boarding/alighting time
- L: bus route length
- c_1, c_2 : unit operator costs bus

APPLICATION: OPTIMISATION
BUS LINE OSLO

- Modal choice: bus, car, bicycle, walk
- Demand choice calibrated for Oslo
- PT supply: bus line 37 (18 km)
- Environmental externalities and health benefits from active mobility as monetised in Norway
- Optimisation (Max SW)
    - Bus frequency
    - Bus size
    - Bus stop spacing
    - Bus fare
    - Pricing alternative modes

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HEALTH BENEFITS AND EXTERNAL COSTS

1 NOK = 0,085 Euro

S1 = reduction of health car costs and production losses
S2 = maximal interpretation, including
Health benefits mostly internalised

Table 3: Unit values for external costs and health benefits and avg. trip lengths of active mo

Parameter	*Car*	*Public transport*	*Cycle*	*Walk*
Avg. distance of active transport per trip (km)	0.0	Endogenous	4.3	1.4
Monetised benefits, S1 (NOK/km)	0.0	10.8	4.6	10.8
Monetised benefits, S2 (NOK/km)	0.0	26.7	16.5	26.7
External costs (NOK/km)	1.2	3.5	0	0

1 NOK = 0,085 Euro

RESULTS 1 FIRST BEST

SO = No H benefits | S1 =with H benefits | S2 = max H benefits

BUS

Table 4: Characteristics of the no. 37 bus service in the benchmark equilibrium and first best scenarios S0-S2

	Benchmark	S0	S1	S2
Capacity	110	110	110	110
Frequency	12	18	18	17
Pax/bus (no)	48	40	39	38
Stops (no)	68	66	40	39
Access dist. (m)	408	415	615	618

BUS features
Higher frequency in first best

Less bus stops

Table 5: Current and optimal prices (NOK2020) for transport per trip

PRICES

	Benchmark	S0	S1	S2
Car	23.0	42.7	41.8	38.9
Bus	13.0	5.6	-1.5	-1.6
Cycle	0.0	0.0	-19.6	-71.0
Walk	0.0	0.0	-15.1	-37.4

PRICES
Higher car tolls in optimum S0 without
Health benefits (corridor dependent)
But no higher tolls from S0 to S1

Subsidized bus, cycle and walk

RESULTS 1ST BEST

Market shares do not change much: mainly less car use

Table 6: Market shares (trips) in the benchmark and first best scenarios S0-S2

	Benchmark	S0	S1	S2
Car	27	23	21	20
Bus	43	50	48	40
Cycle	5	5	7	12
Walk	25	22	24	28

Welfare +2%

	Benchmark	S0	S1	S2
Welfare	3 002	3 117	3 176	3 272
Consumer surplus	3 048	3 169	3 156	3 118
Operator profit	23	-5	-31	-29
External costs	26	25	25	24
Health benefits	0	0	63	222
Active transport subsidy	0	0	-43	-176

Health benefits are generated
By lower prices bus and subsidies for walking and cycling

2^{ND} BEST: SB1 = BUS FARE >0
SB2=BUS FARE >0 + NO SUBSIDIES WALK +CYCLE

	Scenario	FB	SB1	%Δ from FB	SB2	%Δ from FB
Welfare	**S0**	3 117	3 117	0,00 %	3 117	0,00 %
	S1	3 176	3 176	0,00 %	3 172	-0,13 %
	S2	3 272	3 272	0,00 %	3 232	-1,22 %
Access distance	**S0**	415	415	0,00 %	415	0,00 %
	S1	615	606	-1,46 %	615	0,00 %
	S2	618	607	-1,78 %	618	0,00 %
Car toll	**S0**	43	43	0,00 %	43	0,00 %
	S1	42	42	0,00 %	46	9,52 %
	S2	39	40	2,56 %	50	28,21 %
Bus fare	**S0**	6	6	0 NOK	6	0 NOK
	S1	-1	0	1 NOK	2	3 NOK

REDUCTION OF BUS STOPS AND WELFARE GAINS REMAIN UNDER SECOND BEST RESTICTIONS ON SUBSIDIES

DISCUSSION – NEXT STEPS

- More research is needed to disentangle internal from external health benefits.
- Effect of health benefits on the value of travel time savings.
- Relationship between pricing (bicycle subsidies) and infrastructure (cycleways) incentives to cycling.
- Extension to bike-sharing and integration bike-sharing – public transport.
- Accessibility issues for disabled people.
- Alternative ways of promoting health exercises (sports at work,at conferences) may be more efficient and may crowd out the health benefits of active mobility