Quantifying the Benefits of Sustainable Transport for the Urban Economy
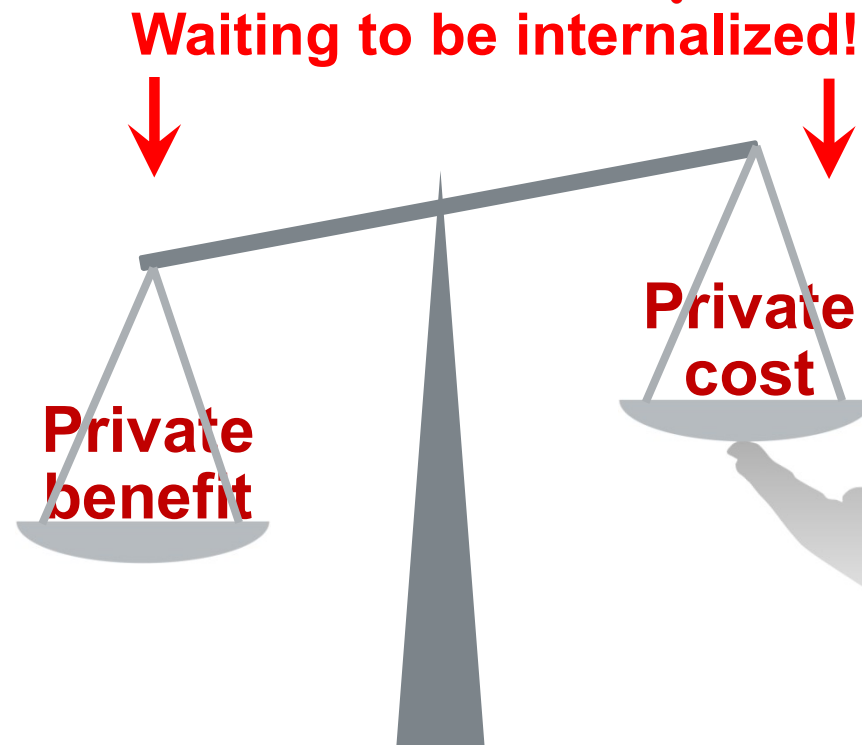
Impact of modal split on external agglomeration effects and productivity.

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Main reasons for market failure in the transport sector

- **External cost (health- and environmental cost, external accident- & congestion cost)**

- **Positive health effects (walking & cycling)**
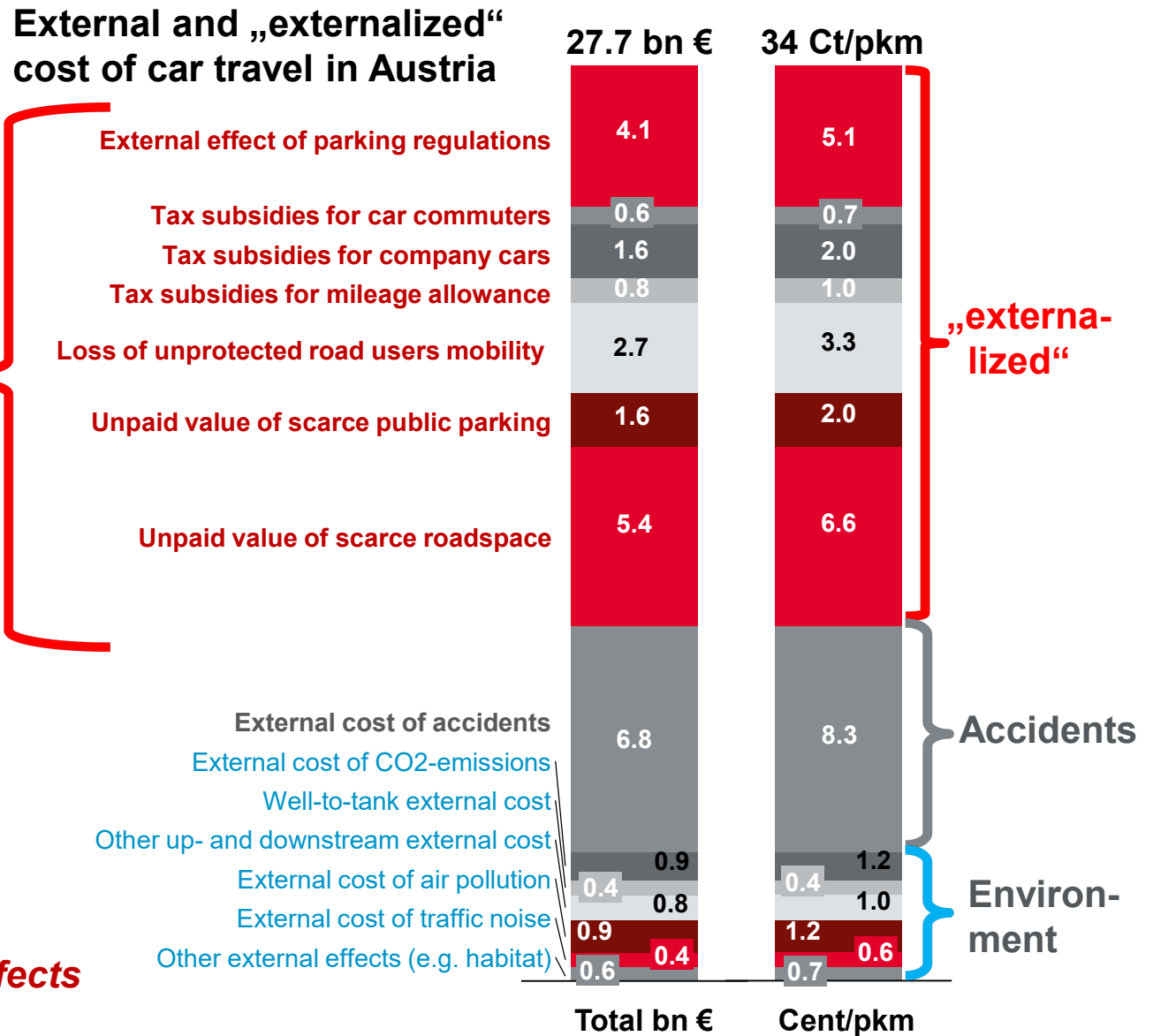
- *Impact on agglomeration externalities*

Waiting to be internalized!

Active interventions waiting to be eliminated:

Private benefit

Private cost

- **Infrastructure subsidies and regulations (e.g. parking requirements)**
- **Direct subsidies and tax subsidies**

The Elephant in the Room: „Externalized" Cost of Transport

External and „externalized" cost of car travel in Austria

27.7 bn €   **34 Ct/pkm**

Label	Total bn €	Cent/pkm
External effect of parking regulations	4.1	5.1
Tax subsidies for car commuters	0.6	0.7
Tax subsidies for company cars	1.6	2.0
Tax subsidies for mileage allowance	0.8	1.0
Loss of unprotected road users mobility	2.7	3.3
Unpaid value of scarce public parking	1.6	2.0
Unpaid value of scarce roadspace	5.4	6.6
External cost of accidents	6.8	8.3
External cost of CO2-emissions	0.9	1.2
Well-to-tank external cost		
Other up- and downstream external cost		
External cost of air pollution	0.4	0.4
External cost of traffic noise	0.8	1.0
Other external effects (e.g. habitat)	0.9	1.2
	0.6	0.7
	0.4	0.6

„externa-lized"

Accidents

Environ-ment

Total bn €   **Cent/pkm**

Still missing in this picture: impact on agglomeration effects
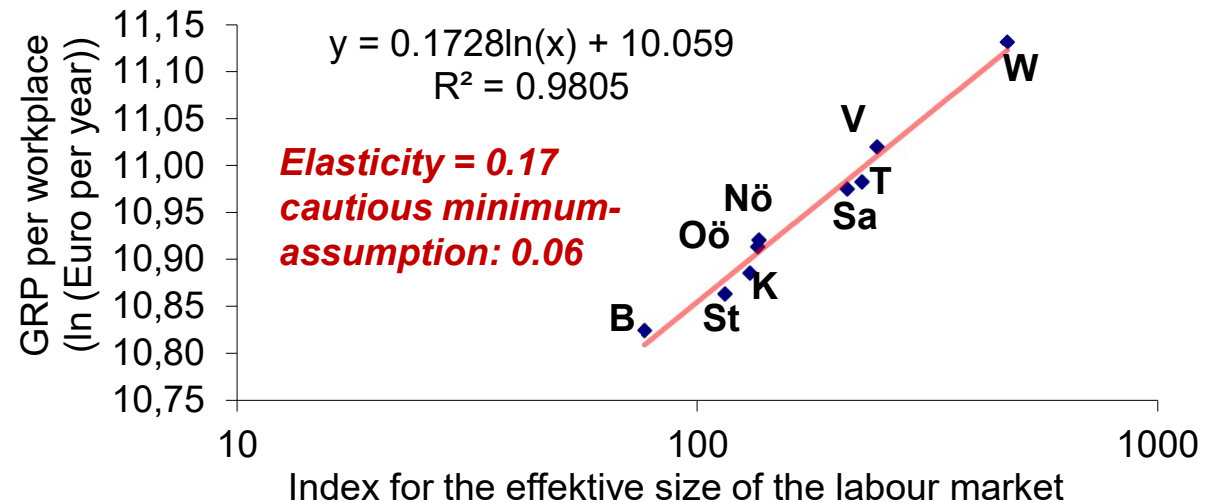
Productivity is promoted by agglomeration effects

„The hypothesis put forward here —and tested— is that the efficiency of the transport system (in short: speed) and the relative location of jobs and homes (in short: sprawl), which are the output of transport policies and urban policies respectively, combine with city size to determine the effective size of the labor market. ==This effective size of the labor market —the number of jobs that can, on average, be reached in less than t minutes — in turn is a major explanation of labor productivity.=="

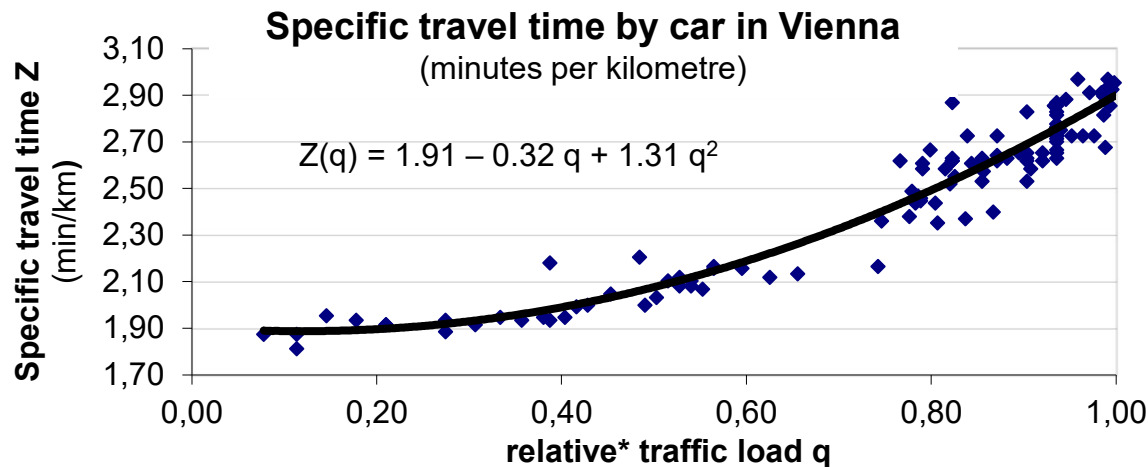Prud'homme R., Lee C., 1999, Size, Sprawl, Speed and the Efficiency of Cities

- As census data till 2001 did include commuting times the above hypothesis could be successfully tested for the Austrian Federal States as well.

- The test supports the estimate of Prud'homme and Lee for the elasticity of productivity with regard to effective labour market size of 0.18.

Productivity increases with labour market size
(comparison of Austrian federal states)

$y = 0.1728\ln(x) + 10.059$
$R^2 = 0.9805$

Elasticity = 0.17 cautious minimum-assumption: 0.06

GRP per workplace (ln (Euro per year))

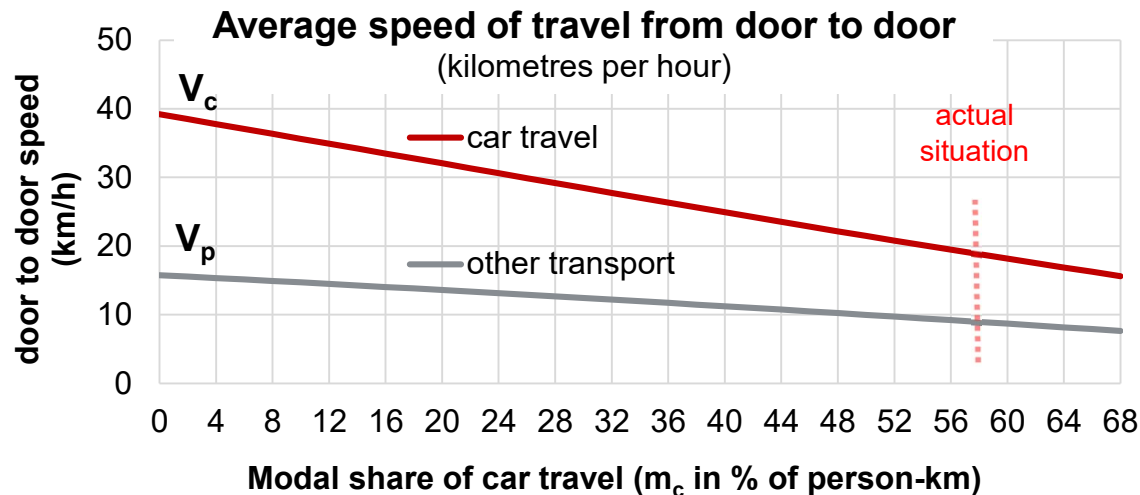Index for the effektive size of the labour market

Source: W. Rauh (2008) / Dissertation an der TU-Wien, Einfluss der Verkehrsmittelwahl auf Bevölkerungsdichte und externe Agglomerationseffekte in Großstädten

Basic properties of the transport infrastructure network

Specific travel time by car in Vienna
(minutes per kilometre)

$$Z(q) = 1.91 - 0.32\,q + 1.31\,q^2$$

Specific travel time Z (min/km)

relative* traffic load q

Rauh W, Staukosten – ein starkes Argument für den Öffentlichen Verkehr, Der Nahverkehr 7/8, Hamburg 2010, p.21-24

Average speed of travel from door to door
(kilometres per hour)

V_c

car travel

actual situation

V_p

other transport

door to door speed (km/h)
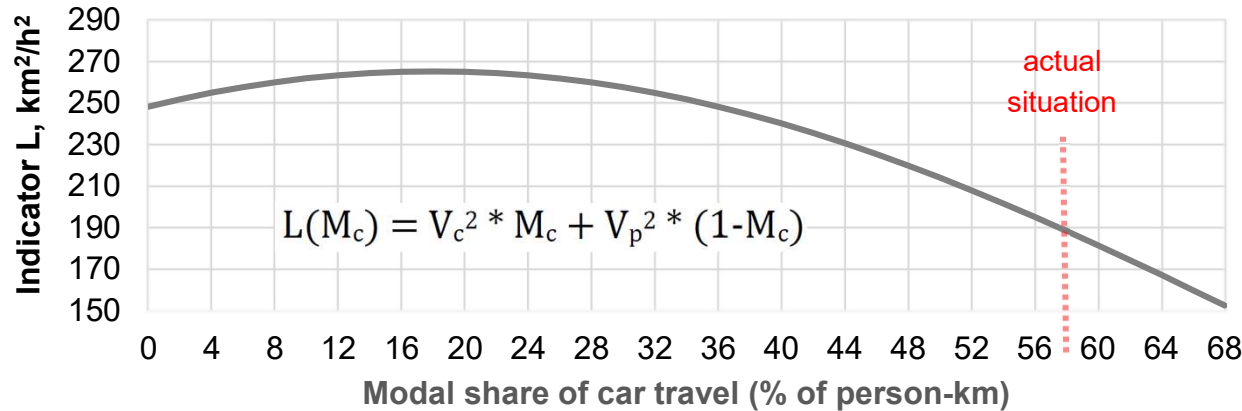
Modal share of car travel (m_c in % of person-km)

Rauh W., Impact of the modal split on the density of population and on the economies of agglomeration in metropolitan areas, doctoral thesis, Technical University Vienna 2008, p. 41, recalculated

- A model for changes in the effective size of the labour market is based on the average **speed-flow relationship** within the urban road network. This relationship was determined empirically by GPS-tracking a taxi-fleet at different traffic loads.

- Based on the speed flow relationship, the impact of changing modal split on the average road traffic speed during peak hours can be modelled. Additional data from mobility surveys leads to **door-to-door speed by car V_c**

- Further data from mobility surveys (walking times to and from stations etc.) leads to the average **speed of travel by a mix of other means of transport** (walking, cycling, bus, tram, subway) V_p
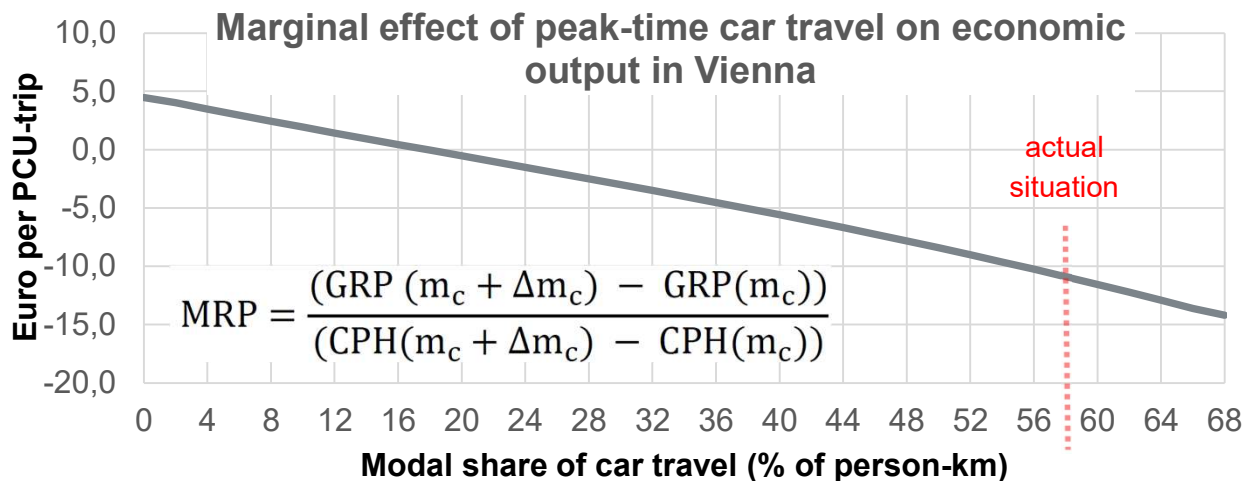
* relative to peak time traffic

Impact of modal split on labour market and productivity

Impact of car travel on the effective size of the labour market

Indicator L, km²/h² (y-axis: 150, 170, 190, 210, 230, 250, 270, 290)

actual situation

$$L(M_c) = V_c^2 * M_c + V_p^2 * (1-M_c)$$

Modal share of car travel (% of person-km) (x-axis: 0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68)
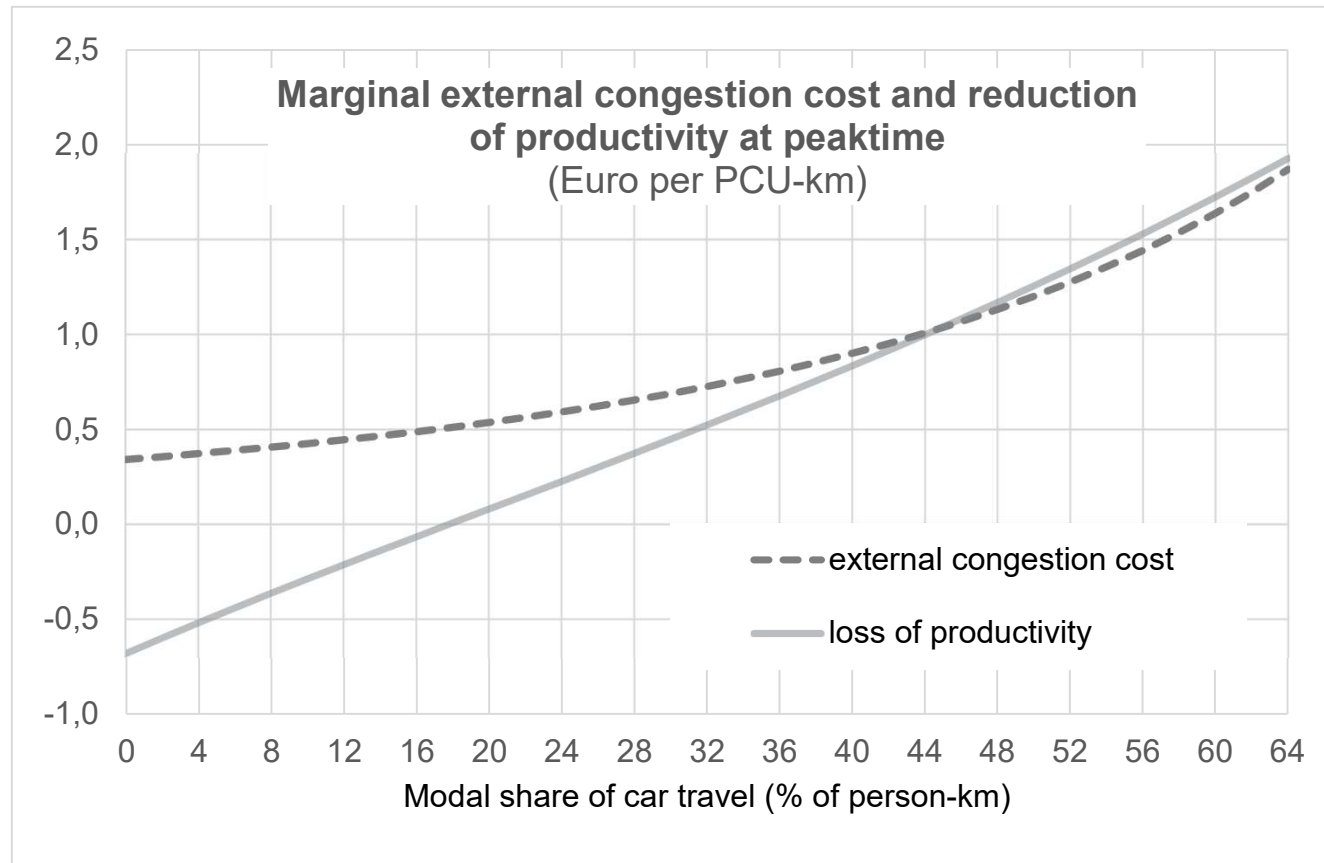
Rauh W., Impact of the modal split on the density of population and on the economies of agglomeration in metropolitan areas, doctoral thesis, Technical University Vienna 2008, p. 72 ff.

Marginal effect of peak-time car travel on economic output in Vienna

Euro per PCU-trip (y-axis: 10,0 5,0 0,0 -5,0 -10,0 -15,0 -20,0)

actual situation

$$MRP = \frac{(GRP\ (m_c + \Delta m_c)\ -\ GRP(m_c))}{(CPH(m_c + \Delta m_c)\ -\ CPH(m_c))}$$

Modal share of car travel (% of person-km) (x-axis: 0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68)

Rauh W., Impact of the modal split on the density of population and on the economies of agglomeration in metropolitan areas, doctoral thesis, Technical University Vienna 2008, p. 72 ff., updated to 2019 for inflation and changes in GRP.

- Based on door-to-door speed of car and other transport (V_c and V_p) and its dependency on the modal split an indicator $L(M_c)$ showing the impact of modal share of car trips M_c on the size of the labour market can be derived.

- Via the elasticity* of labour productivity with respect to the size of the labour market an estimate of changes in economic output can be given.

- By means of numeric differentiation the marginal effect **MRP** per **additional car trip CPH** on **gross regional product GRP** can be estimated.
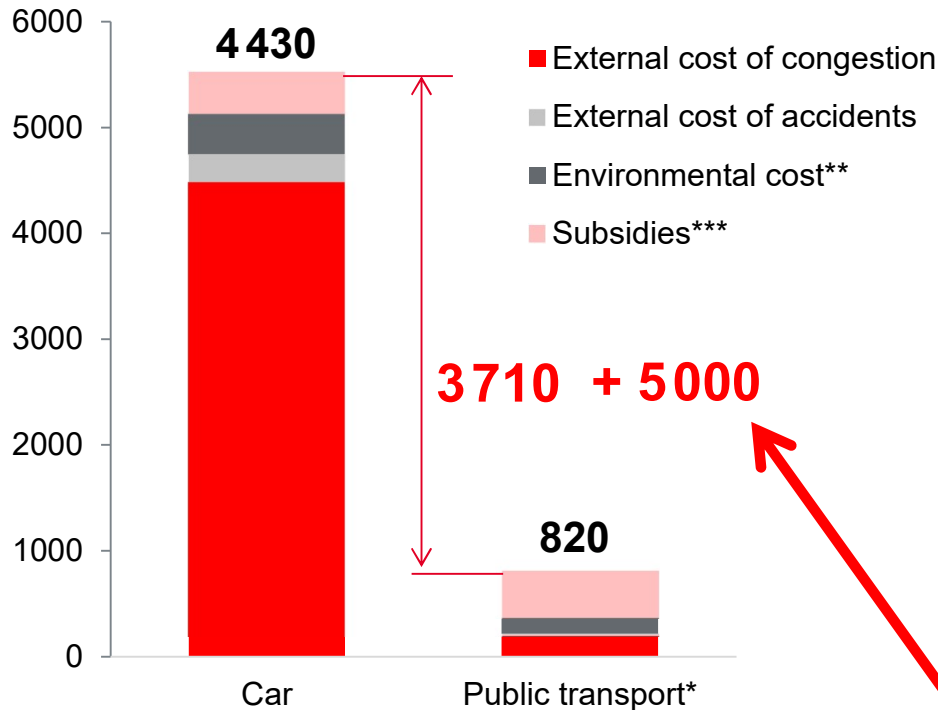
* For a cautious approach the minimum assumption of **0.06 or 6%** is chosen.

Similar magnitute of congestion cost and loss of producitvity

Marginal external congestion cost and reduction of productivity at peaktime
(Euro per PCU-km)

Modal share of car travel (% of person-km)

- - - - external congestion cost

—— loss of productivity

How businesses profit from sustainable urban transport

Vienna: external cost and subsidies
(Euro per commuter per year)

- External cost of congestion
- External cost of accidents
- Environmental cost**
- Subsidies***

4 430

3710 + 5000

820

Car   Public transport*

*   Train, subway, bus, tram

**   Cost of noise, pollution and other external effects.

*** tax subsidies for car-commuting + company parking lots, subsidies for public transport.

Source: Rauh W./ Staukosten – ein starkes Argument für den öffentlichen Verkehr, „Der Nahverkehr" 7-8, Hamburg 2010

Less congestion cost + higher benefits of agglomeration:

- In Cities like Vienna, **congestion** causes by far **the largest component of external cost** of transport**.**

- An **additional** commuter switching from car to public transport reliefs people living and / or working in Vienna as well as businesses from a **net-total of 3 710 Euro** per year in external cost. About **50%** of this relief benefits the urban **business sector.**

- In addition to the cost it causes directly congestion also reduces the effective **size of the labour market** which in turn leads to a **reduction of productivity.**

- Urban businesses profit from an increase of productivity which can be estimated at another **5 000 Euro** per year per **additional** commuter switching from car to sustainable means of transport.