Accessing the overall impact of last mile transport on the traffic situation in cities: Research results and recommendations

Thesis

- The e-commerce business models provide the opportunity to adequately supply people living in peripheral locations
- Distance selling reduce the number of stationary retail
- Markets can be accessed independently of location
- E-commerce could reduce costs
  - through enabling companies to choose locations at low real estate cost
  - through new logistic delivery concepts
- E-commerce could reduce the number of individual motorised shopping trips through substitution by delivery traffic

Research to traffic generation by home delivery

- Concentrating on tele-shoppers
  Tacken 1990; Handy/Yantis 1997; Gould 1996; Gould/Golob 1997; Gould/Golob/Barwise 1998; Luley et al. 2002
- Conceptional analyses and ideas about the plausibility of correlations between e-commerce and traffic
  Mokhtarian 2003, Mokhtarian/Salomon 2002; Janz 2001
- Projections of the trips generated by e-commerce:
  - onto the entire commercial traffic volume
    TLN 2000
  - onto the need of fleet and the efficiency of distribution process
    INVENT 2004
- Concentration on home delivery of one group of goods, mostly on groceries:
  - (extensive) simulation of real and precisely defined areas
    Cairns 1998, 2003; Punakivi/Saranen 2001, Punakivi/Holmström 2001
  - emissions caused by the “last mile” in different distribution concepts
    Orremo et al. 1999, 2000; Flämig 2001

Alternative Concepts for Last Mile

- **personal transfer**

V2
  - direct delivery to household

- **personal transfer via transfer station**
  - (convenience)-stores (e.g. Kiala)

V3a
  - depots

V3b
  - office

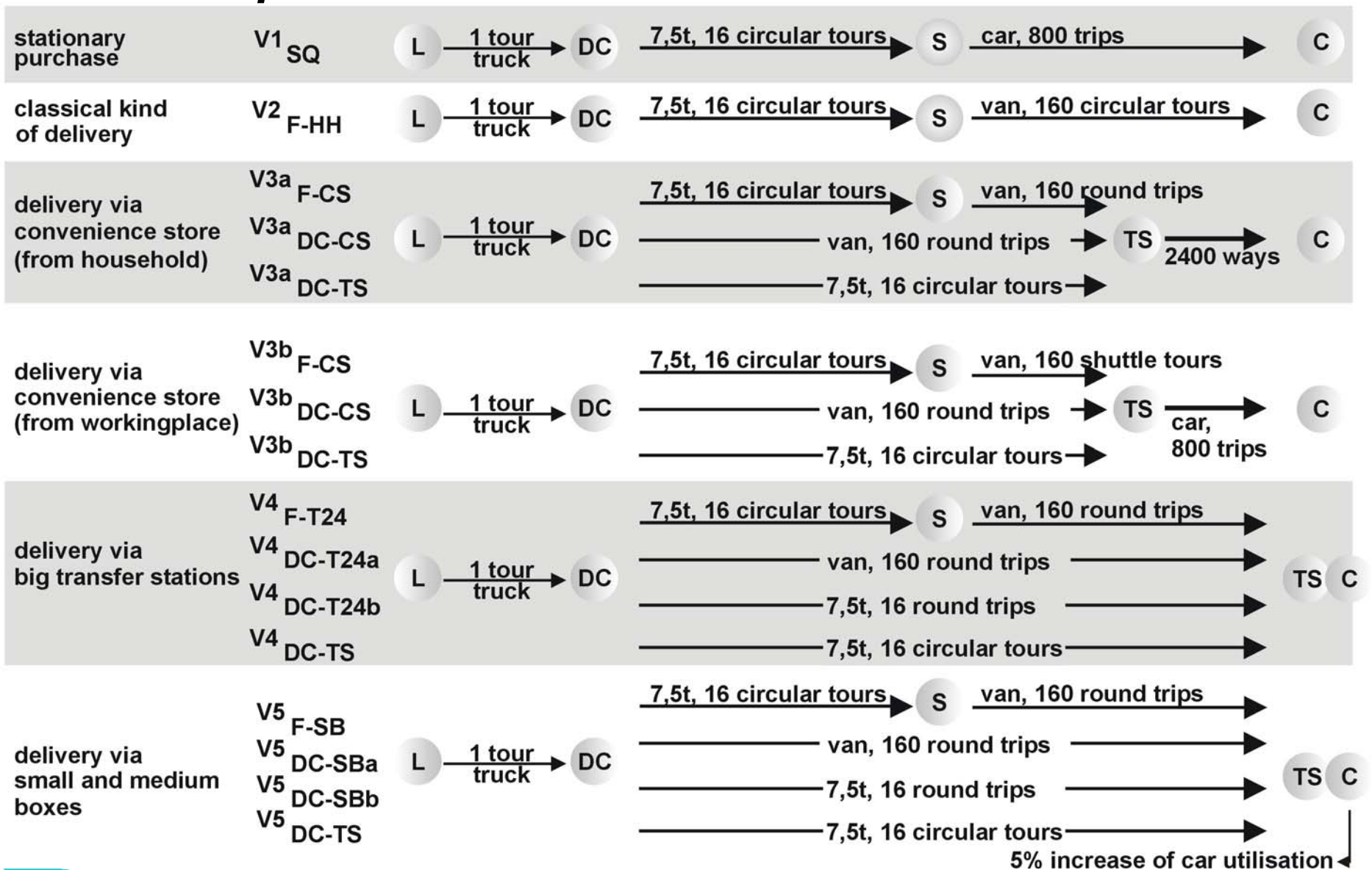
- **transfer stations**

V4
  - big box-systems (e. g. Tower 24)

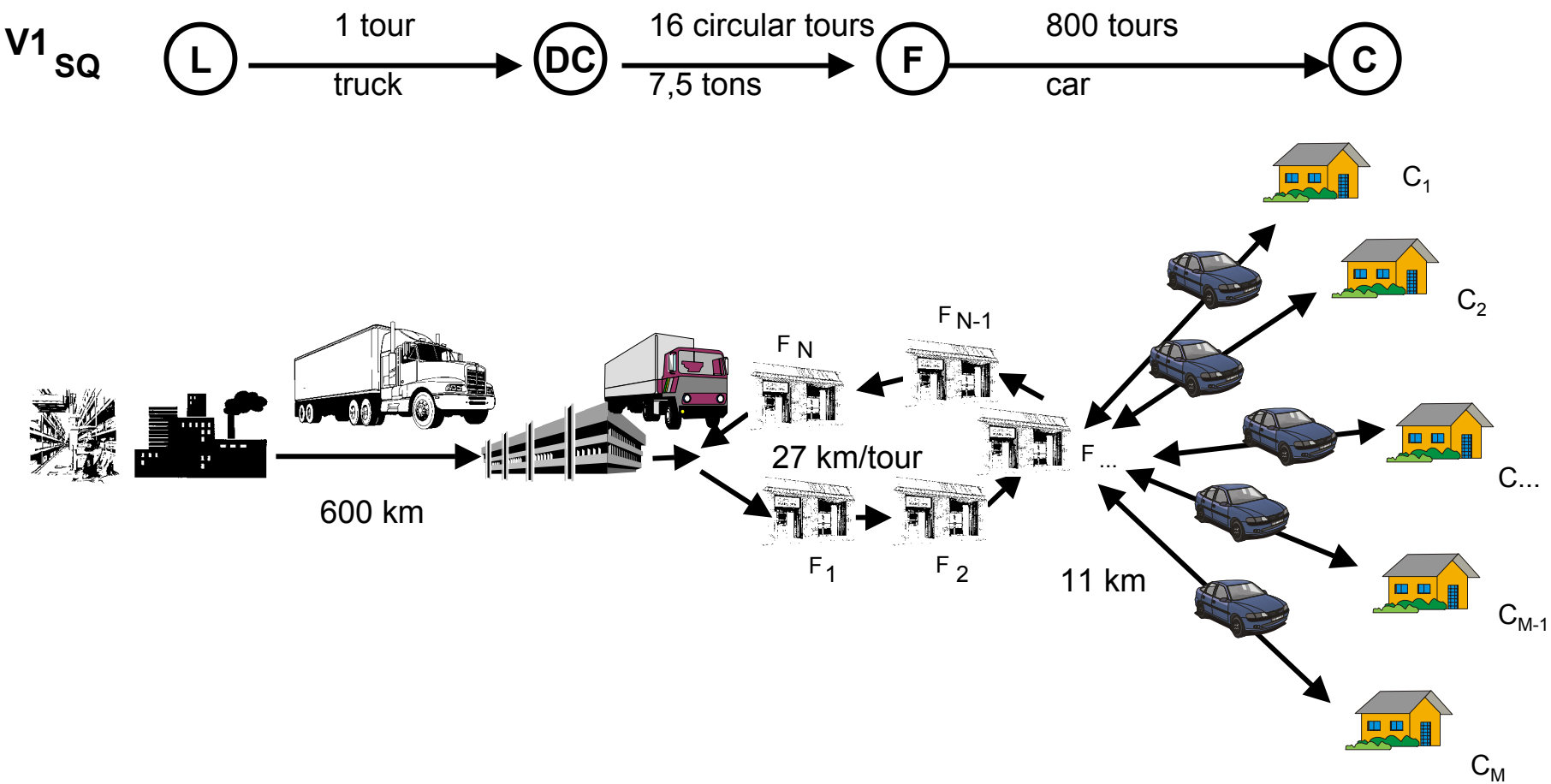
V5
  - Small and middle box-systems (e. g. Packstation)

Which is the most environmental friendly delivery/last mile concept?

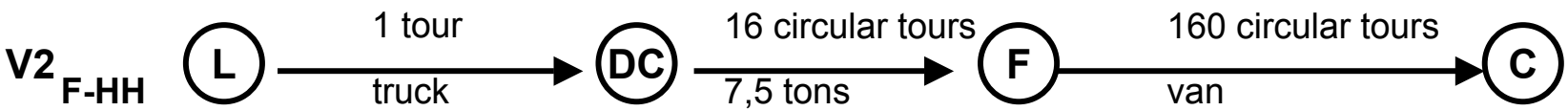
Transportation Chains of the scenarios: Overview

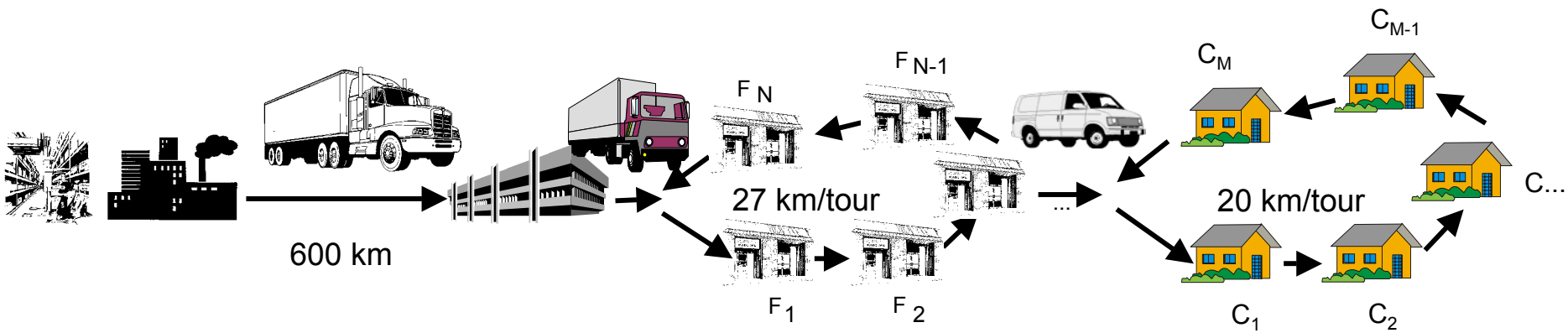


Shopping trip



Home delivery services



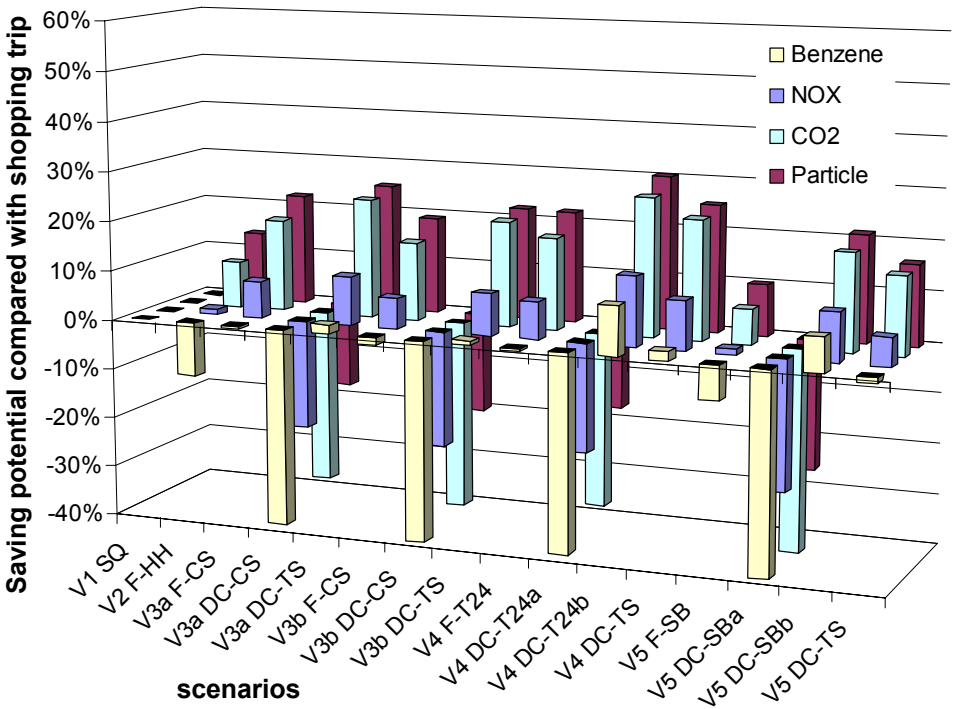


The ecological role of population density – Assumptions

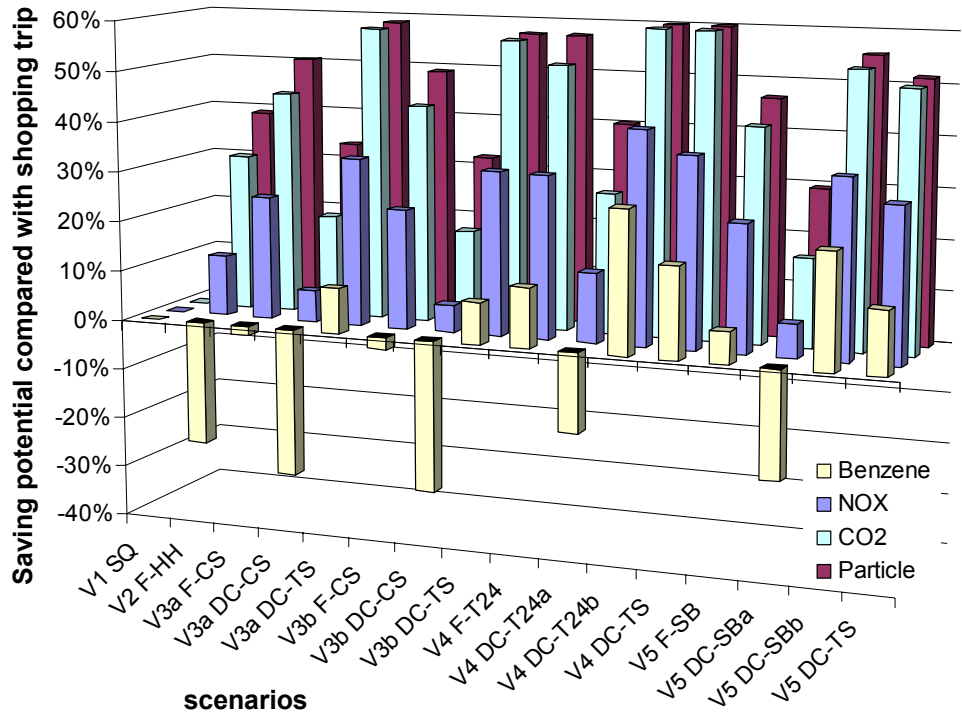
- The status-quo scenario $V1_{SQ,}$ served as the **starting point**.
- To begin with, in the first calculations was assumed that **all shopping trips** are car-based and **can be fully substituted by delivery trips**.
- The conversion factor is **one shipment unit** which represents one customer's shopping process.
- The **average shopping load** was assumed to be 30 kg for the distance trade and 10 kg for the stationary trade.
- The **average loading factor** of the vehicle types used have been assumed to be identical.
- The **distance covered by the customer** was varied and influences the distances covered at other distribution levels.
- For this, **three area types** are defined, the reference area, the urban area and the rural area.
- The research on environmental impacts has been limited to air pollutants and are calculated with the Mobilev emission model (Mobilev 1997).

Saving-potentials of delivery chains – 100 % substitution

urban area

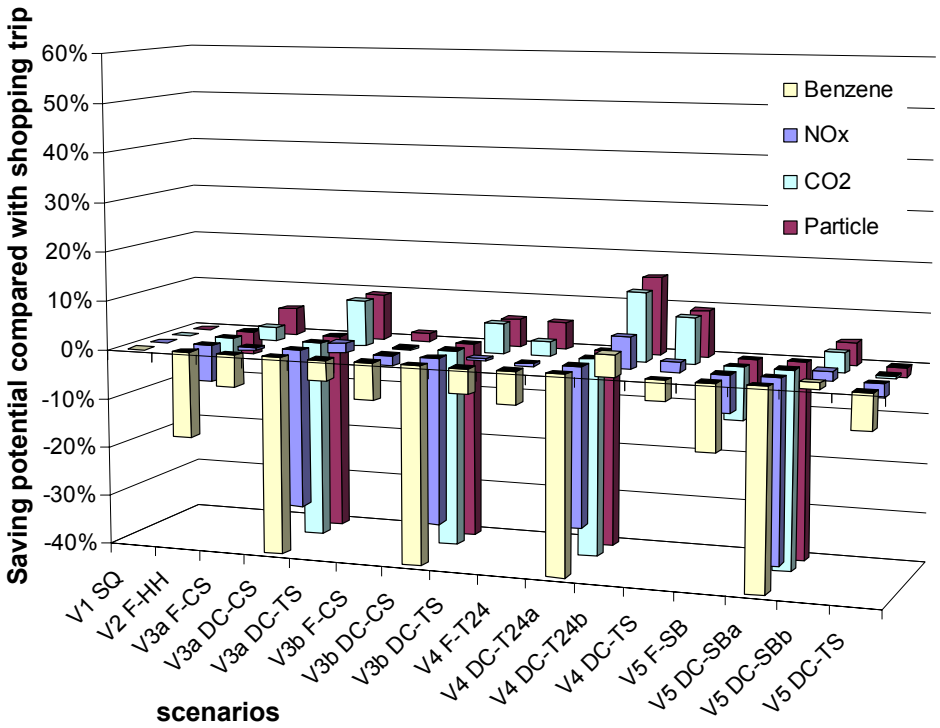


rural area

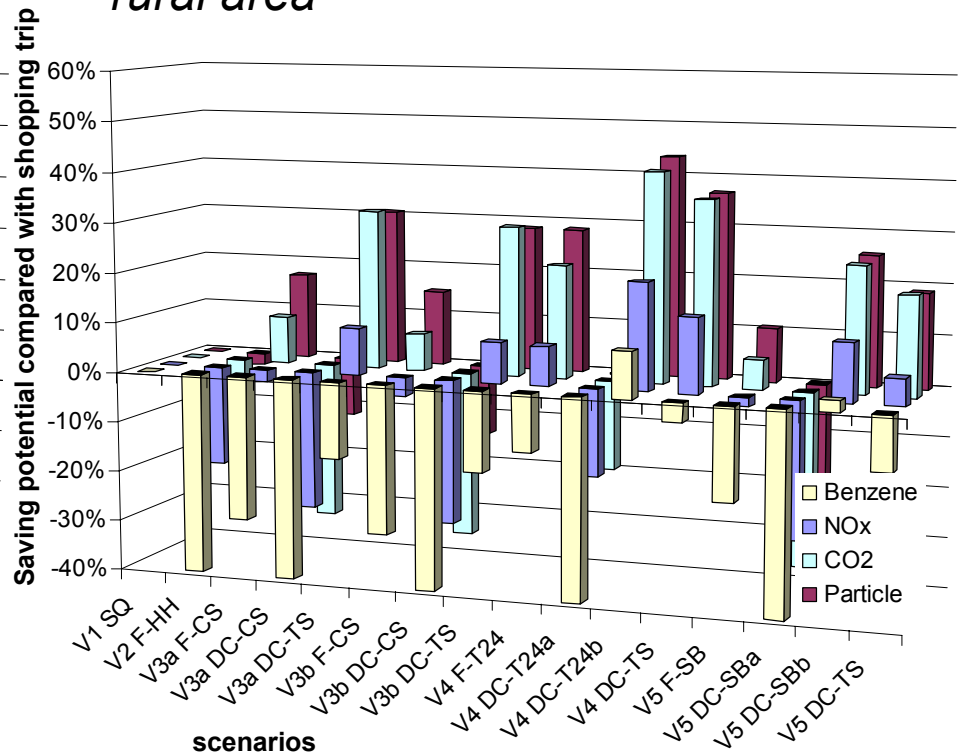


Saving-potentials in consideration of a substitution potential of 42 %

urban area

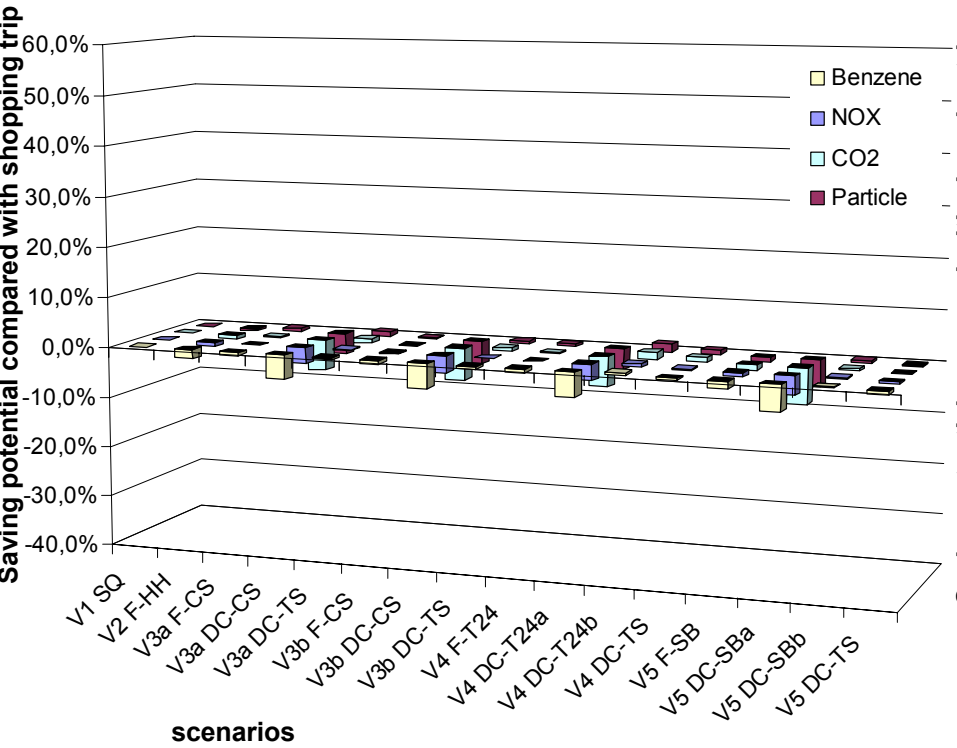


rural area

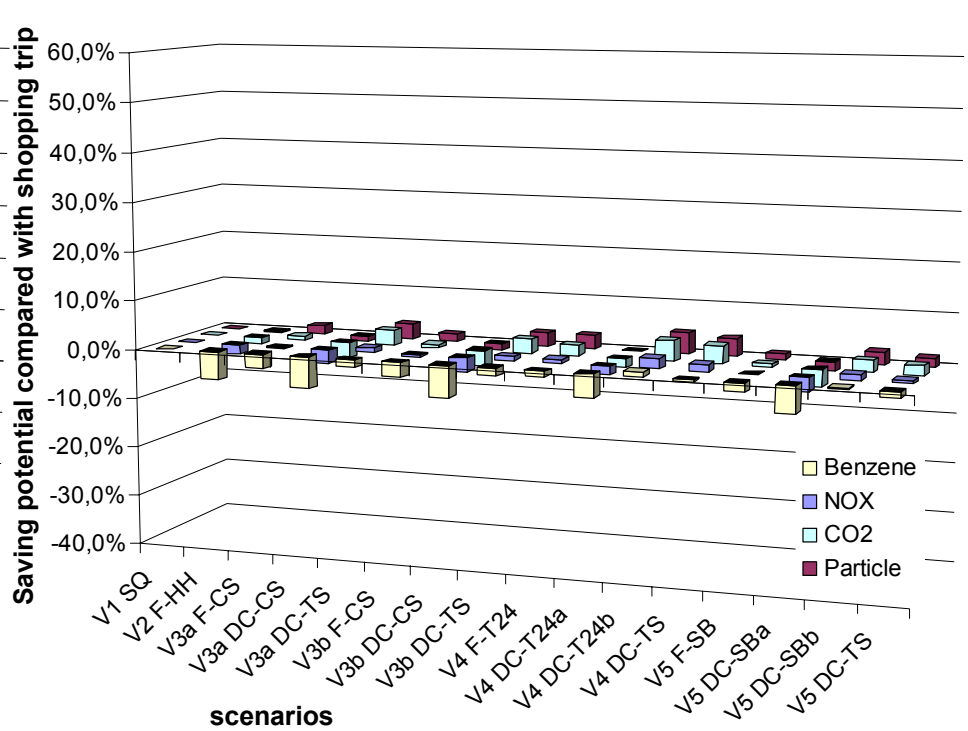


Saving-potentials in consideration of 42 % substitution-potential and 10 % share of e-commerce

urban area



rural area



Mileage per shipment of delivery chains

First calculation 100 % substitution-potential :

- Depending on the type of area, **reductions** in mileage per shipment are possible in a range between **33 and 92 per cent**.
- Still, some scenarios in the urban area lead to an **increased** number of kilometres driven per shipment of up to **70 per cent**.

Consideration of 42 % substitution-potential and 10 % share of e-commerce:

- Depending on the type of area, **reductions** in mileage per shipment are possible in a range between **49 and 82 per cent**.
- Still, some scenarios in the urban area lead to an **increased** number of kilometres driven per shipment of up to **176 per cent**.

But:

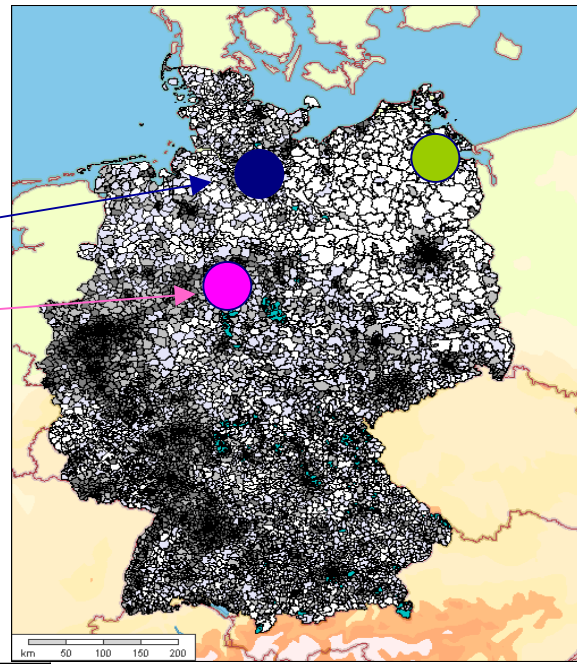
- High dependence from several assumptions!
- And: e-commerce is not the major parameter but the behaviour of the consumer/drivers.

Parameters/Assumption which influenced the traffic generation and environmental impacts

- Stops per tour
  - Numbers of customers
  - Shipments per stop
- Distances between stops
- Distances between the basis (DC) and the first/last customer
- Time restrictions (working hours)
  - driving time between two stops
  - delivery time per shipment
- Vehicle type (and its emissions)
- Costumer behaviour: buying and driving (Substitution factor)
- Product group
- Technical optimisation

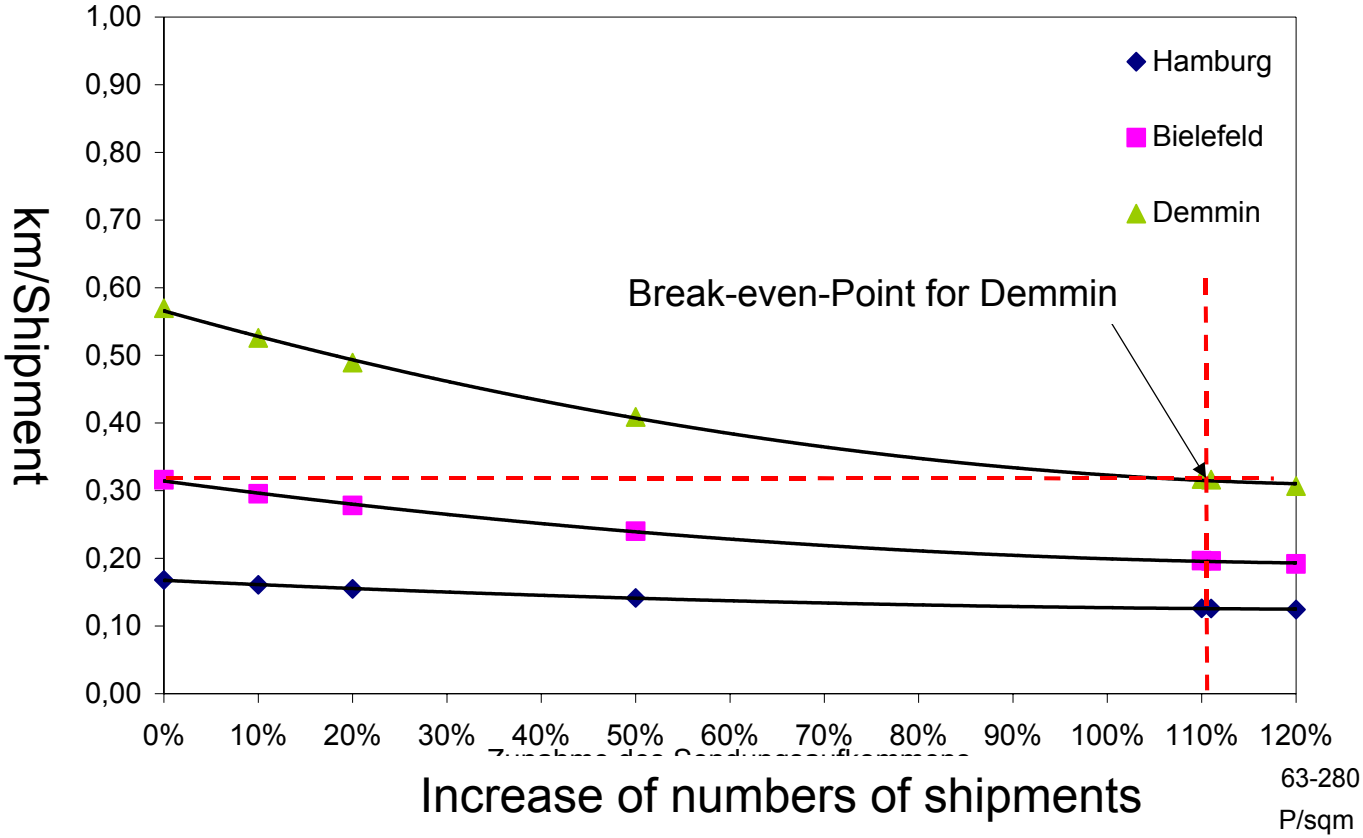
Population density

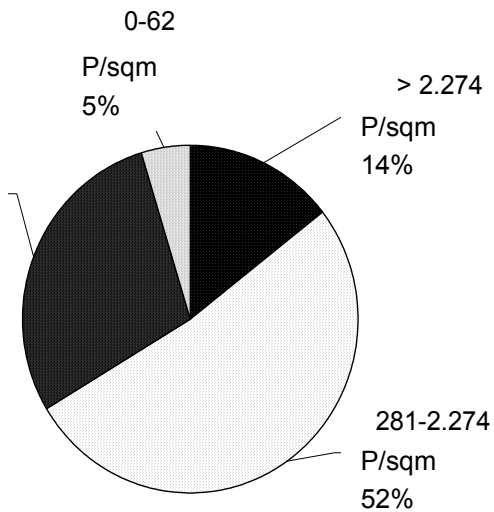
- *When is e-commerce economically effective, or: how many "E-commerce-customers" do you need?*
  - Comparing the tours of CEP industry
    - in "high"-density areas (Hamburg)
    - in "middle"-density areas (Bielefeld)
    - in "low"-density areas (Demmin)



Location of depot	Distribution area [km²]	Population density [P/sqm]	Length of tour [km]
Hamburg	755	2.257	34 – 50
Bielefeld	10.231	281	63 – 113
Demmin	10.686	63	114 – 165

Increase of efficiency through e-commerce at parcel services

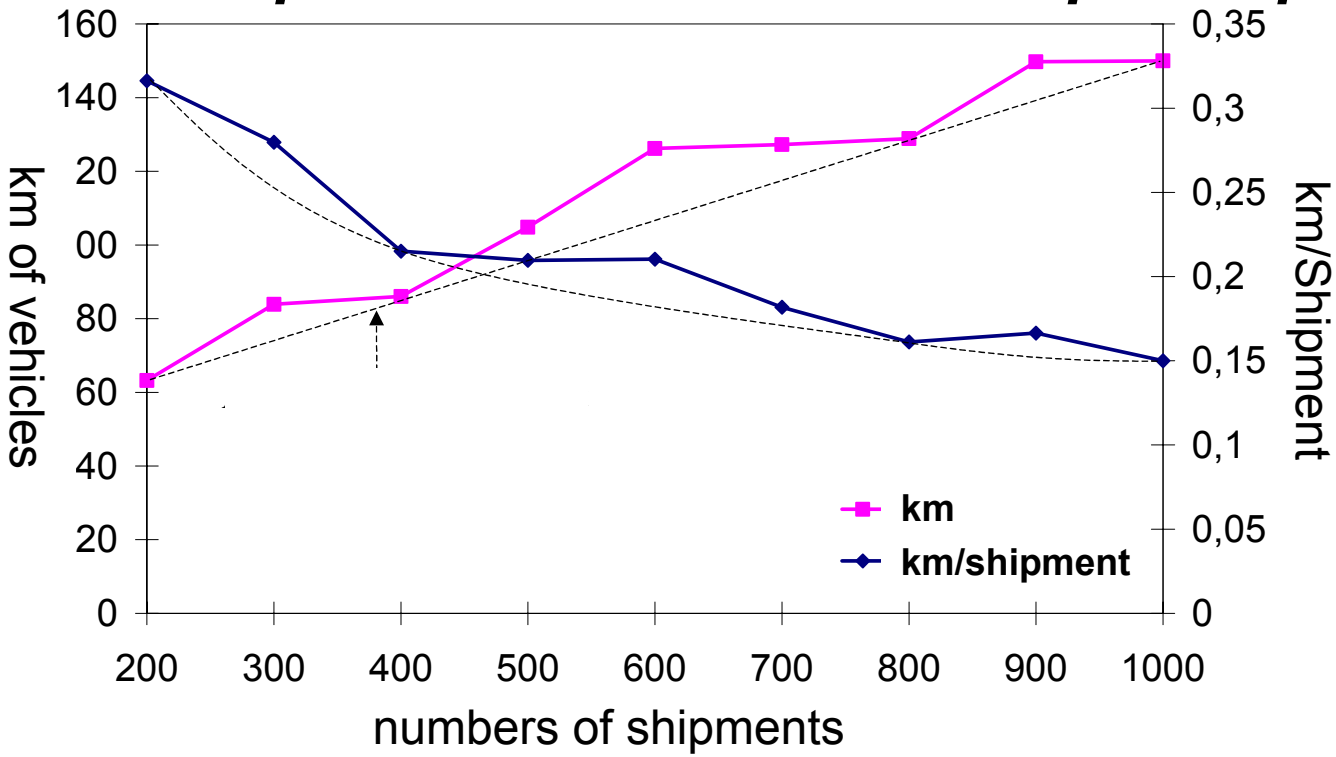




- 70 % of German inhabitants can be served economically.
- The number of shipment in rural areas has to be doubled.

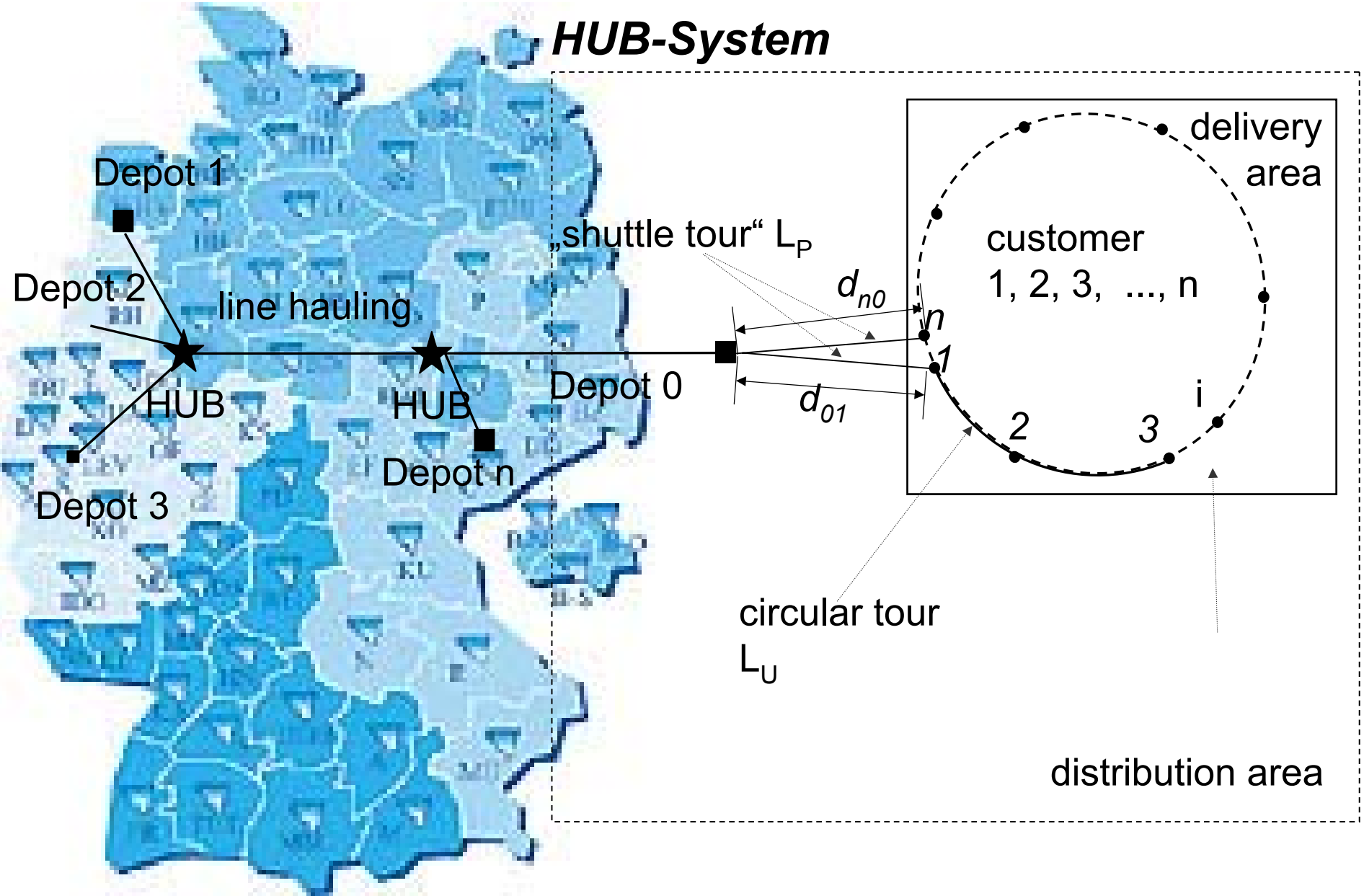
Source: Data from 31.12.1999
Statistisches Bundesamt

The development of total km and km per shipment



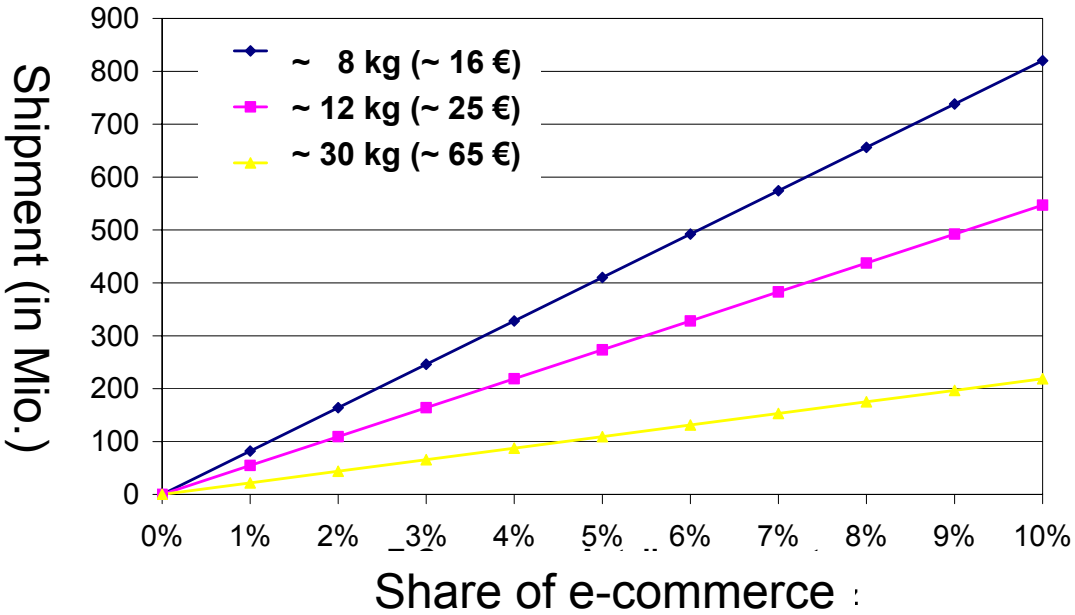
- An increase of shipments / an increase of e-commerce:
  - Improves the efficiency of deliveries of the CEP-Industry.
  - Reduces the numbers of kilometres per shipment.
  - but: increases the total mileage!

HUB-System



Source:
Hermes Versand Service

Traffic generation: The example of home delivery of groceries



- E-commerce related traffic impact (given 10 % market share of e-commerce in grocery) could be nearly 0.5 % based on the total truck mileage in 1999.

		1 per cent	5 per cent	10 per cent
1)	**Number of shipment: 8 kg Parcel (~ 16 €)**	109,2 Mio.	546 Mio.	1.092 Mio.
2)	**Number of shipment: 25 € Invoice**	72,8 Mio.	364 Mio.	728 Mio.
3)	**Number of shipment: 65 € Invoice**	29,1 Mio.	145,6 Mio.	291,2 Mio.
4)	**Traffic [kilometre per vehicle]**	9,6 Mio.	61,8 Mio.	336,8 Mio.
5)	**Increase of total truck km in Germany**	0,013 %	0,1 %	0,46 %

Categories of product groups

category	Product group	Concerned Products	personal needs	Logistics needs
C 1	**Food**	Fresh and ultra-fresh, frozen, etc.	short-term needs	- daily delivery frequency - small shipment sizes - short covered distance
C 2	**Food**	Dry food, etc.	short-term needs	- daily delivery frequency - large shipment sizes - long covered distance
C 3	**Clothing & Footwear**	clothing, footwear, gifts, etc.	medium-term needs	- weekly delivery frequency - large shipment sizes - long covered distance
C 4	**1-person delivery items**	smaller electrical items like irons, mixer; hi-tech objects like computers, TVs; other household/leisure items like sports equipment, etc.	medium-term needs	- weekly delivery frequency - large shipment sizes - long covered distance
C 5	**Postable items**	Music, Books, Software, etc.	medium-term needs	- daily/weekly delivery frequency - large shipment sizes - long covered distance
C 6	**2-person delivery items**	furniture, bed equipment, gardening, heavy white and brown goods, etc.	long-term needs	- monthly delivery frequency - large shipment sizes - long covered distance

Verification of thesis: E-commerce bears chances and risks for sustainability

- The e-commerce business models provide the opportunity to adequately supply people living in peripheral locations
  > social benefit
  But: high economic cost
- Distance selling reduce the number of stationary retail
  > social disadvantage
  But: revalue of the small shops (against: concentration, chain stores growing)
- Markets can be accessed independently of location
  > growing distance between the company and the customer
- E-commerce could reduce costs
  - through enabling companies to choose locations at low real estate cost
  - through new logistic delivery concepts
  > no clear picture of the impacts on traffic and environment
- E-commerce could reduce the number of individual motorised shopping trips through substitution by delivery traffic
  > no clear picture of the impacts on traffic and environment

Recommendations for Cities

- Saving logistical space for urban distribution centre and for pick up-points
- Logistical architecture by building new residential areas and shopping spaces
- Loading zones in residential areas
- Last but not least: Against the background of current forecast of further growth of shipments and traffic volume, certain transport and economy policies are required to ensure long-term quality of life in city centres!

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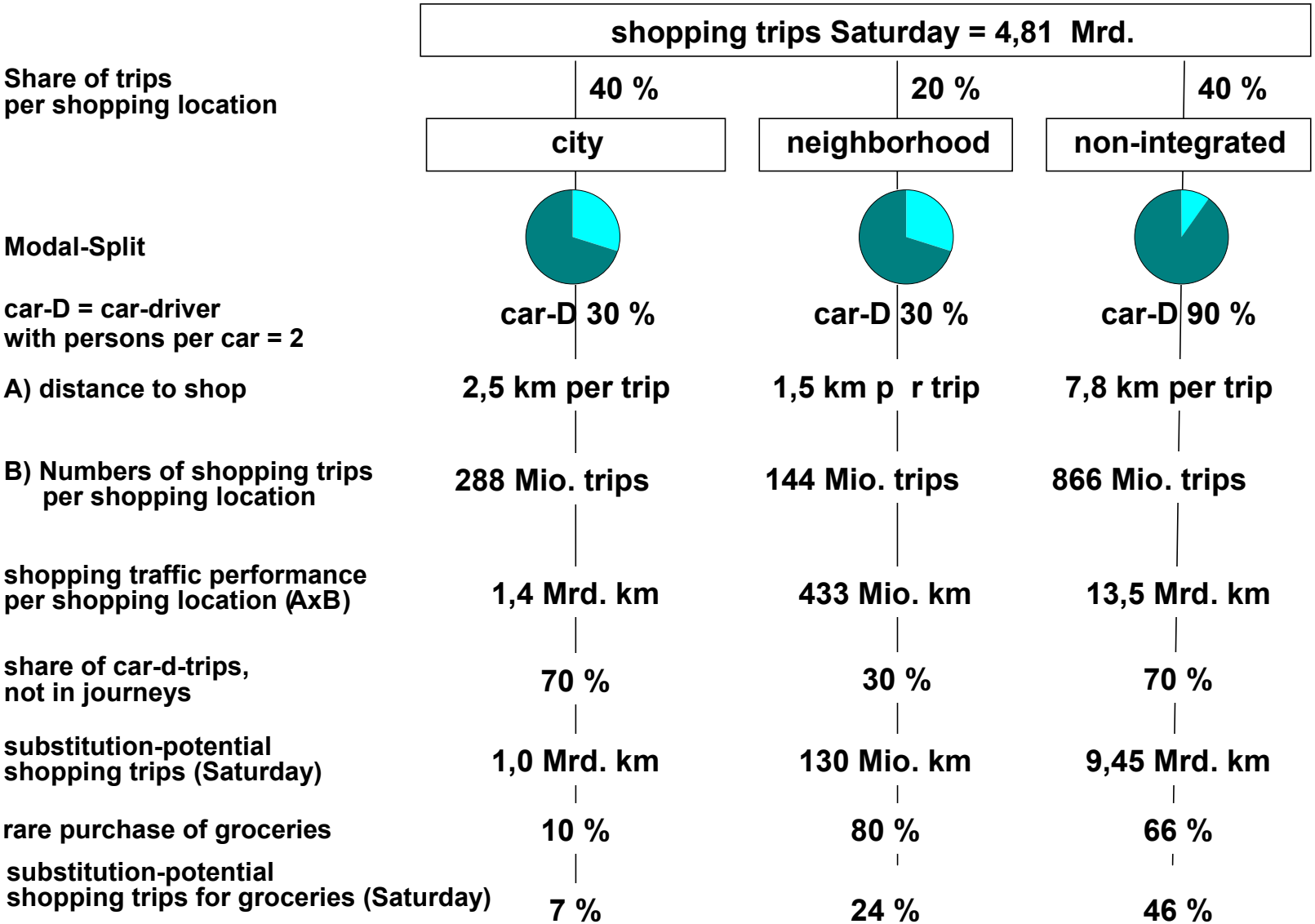
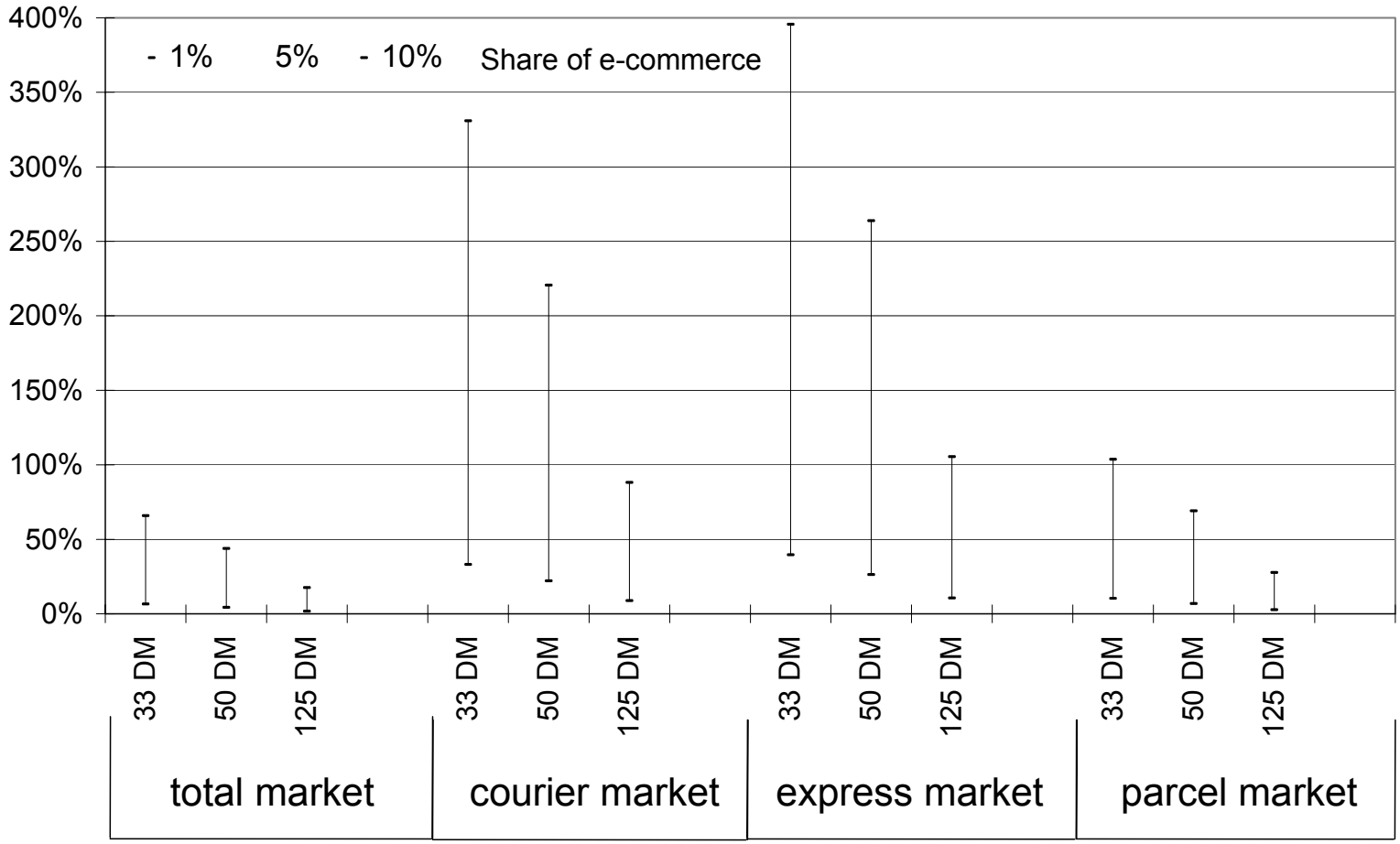
Maximum substitution-potential of shopping trips



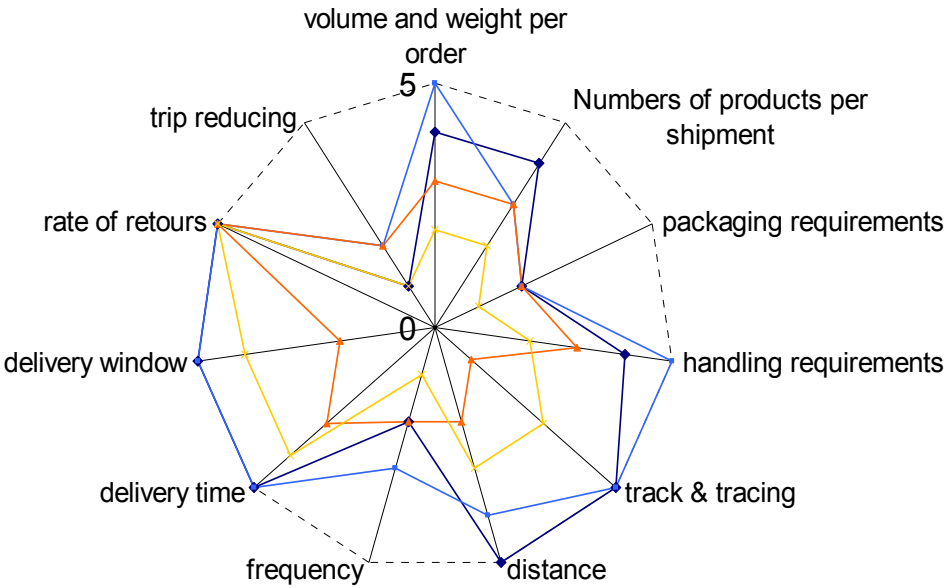
The problems of the value of variables - e. g. volume of shipment



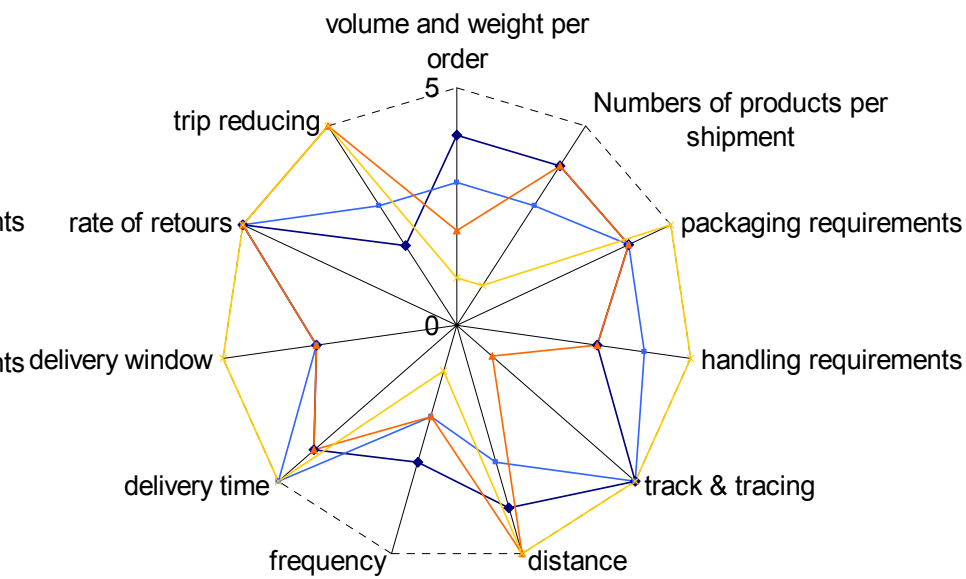
Own calculation. Market data based on MRU

The perspective of the logistics professionals

Groceries



Music



trad. Retail (2000)
trad. Retail (2010)
E-C (2000)
E-C (2010)

Remarks - Product Groups from the logistics professional perspective

evaluation raster	bad = 1 point	good = 5 points
volume and weight per order	low	high
Numbers of products per shipment	low	high
packaging requirements	high	low
handling requirements	high	low
track & tracing	no	yes
distance	high	low
frequency	high	low
delivery time	long	short
delivery window	large	small
rate of retours	high	low
tripreducing	impossible	possible

- Step 1: All product groups have been judged based on 11 criteria. For each criteria a scale from 1 to 5 points have been used.
- Step 2: Comparison based on the total number of points.

- Note: All criteria have the same weight.

Saving-potentials of various delivery chains - first calculation

Urban area	NO_x	Particle	Benzene	CO_2
V4 DC-T24b	14%	30%	10%	28%
V3a DC-TS	10%	25%	2%	24%
V4 DC-TS	10%	25%	2%	24%
V3b DC-TS	8%	22%	1%	21%
V5 DC-SBb	10%	21%	7%	19%
V3a F-CS	7%	22%	0%	18%
V4 F-T24	7%	22%	0%	18%
V3b F-CS	6%	19%	-1%	16%
V5 DC-TS	6%	16%	-1%	16%
V2 F-HH	1%	14%	-11%	9%
V5 F-SB	1%	10%	-7%	7%
V3a DC-CS	-22%	-17%	-39%	-35%
V4 DC-T24a	-22%	-17%	-39%	-35%
V3b DC-CS	-23%	-20%	-40%	-37%
V5 DC-SBa	-26%	-26%	-42%	-43%

Rural area	NO_x	Particle	Benzene	CO_2
V4 DC-T24b	42%	66%	28%	64%
V4 DC-TS	37%	62%	18%	61%
V3a DC-TS	33%	59%	9%	58%
V3b DC-TS	32%	57%	8%	57%
V5 DC-SBb	35%	56%	23%	54%
V4 F-T24	32%	57%	12%	52%
V5 DC-TS	30%	52%	13%	51%
V3a F-CS	25%	50%	-2%	44%
V3b F-CS	24%	49%	-2%	43%
V5 F-SB	25%	47%	6%	42%
V2 F-HH	12%	39%	-24%	31%
V4 DC-T24a	14%	40%	-16%	28%
V3a DC-CS	6%	33%	-29%	20%
V3b DC-CS	5%	32%	-30%	19%
V5 DC-SBa	7%	29%	-21%	18%

Example: Home delivery service (V2)

- In urban areas CO_2-emissions decrease of 9 %.
- In rural areas CO_2-emissions decrease of 31 %.

Saving-potentials in consideration of a substitution potential of (only) 42 %

Urban area	NO_x	Particle	Benzene	CO_2
V4 DC-T24b	6%	16%	4%	14%
V3a DC-TS	2%	9%	-4%	9%
V4 DC-TS	2%	9%	-4%	9%
V3b DC-TS	0%	6%	-5%	6%
V5 DC-SBb	2%	4%	1%	4%
V3a F-CS	-1%	5%	-7%	3%
V4 F-T24	-1%	5%	-7%	3%
V3b F-CS	-2%	2%	-8%	0%
V5 DC-TS	-3%	-2%	-7%	-1%
V2 F-HH	-8%	-5%	-17%	-8%
V5 F-SB	-7%	-9%	-13%	-11%
V3a DC-CS	-32%	-42%	-48%	-60%
V4 DC-T24a	-32%	-42%	-48%	-60%
V3b DC-CS	-34%	-46%	-49%	-63%
V5 DC-SBa	-37%	-53%	-51%	-70%

Rural area	NO_x	Particle	Benzene	CO_2
V4 DC-T24b	21%	44%	9%	41%
V4 DC-TS	15%	37%	-4%	36%
V3a DC-TS	9%	31%	-15%	32%
V3b DC-TS	8%	28%	-16%	30%
V5 DC-SBb	12%	26%	2%	25%
V4 F-T24	8%	28%	-11%	22%
V5 DC-TS	5%	19%	-11%	20%
V3a F-CS	-2%	17%	-29%	9%
V3b F-CS	-4%	15%	-29%	7%
V5 F-SB	-2%	11%	-18%	6%
V2 F-HH	-20%	-2%	-57%	-12%
V4 DC-T24a	-17%	0%	-46%	-18%
V3a DC-CS	-27%	-12%	-64%	-31%
V3b DC-CS	-29%	-14%	-64%	-33%
V5 DC-SBa	-27%	-18%	-53%	-34%

Example: Home delivery service (V2)

- In urban areas CO_2-emissions increase of 8 %.
- In rural areas CO_2-emissions increase of 12 %.

Saving-potentials in consideration of 42 % substitution-potential and 10 % share of e-commerce

Urban area	Nox	Particle	Benzene	CO_2
V4 DC-T24b	0,6%	1,6%	0,4%	1,4%
V3a DC-TS	0,2%	0,9%	-0,4%	0,9%
V4 DC-TS	0,2%	0,9%	-0,4%	0,9%
V3b DC-TS	0,0%	0,6%	-0,5%	0,6%
V5 DC-SBb	0,2%	0,4%	0,1%	0,4%
V3a F-CS	-0,1%	0,5%	-0,7%	0,3%
V4 F-T24	-0,1%	0,5%	-0,7%	0,3%
V3b F-CS	-0,2%	0,2%	-0,8%	0,0%
V5 DC-TS	-0,3%	-0,2%	-0,7%	-0,1%
V2 F-HH	-0,8%	-0,5%	-1,7%	-0,8%
V5 F-SB	-0,7%	-0,9%	-1,3%	-1,1%
V3a DC-CS	-3,2%	-4,2%	-4,8%	-6,0%
V4 DC-T24a	-3,2%	-4,2%	-4,8%	-6,0%
V3b DC-CS	-3,4%	-4,6%	-4,9%	-6,3%
V5 DC-SBa	-3,7%	-5,3%	-5,1%	-7,0%

Rural area	Nox	Particle	Benzene	CO_2
V4 DC-T24b	2,1%	4,4%	0,9%	4,1%
V4 DC-TS	1,5%	3,7%	-0,4%	3,6%
V3a DC-TS	0,9%	3,1%	-1,5%	3,2%
V3b DC-TS	0,8%	2,8%	-1,6%	3,0%
V5 DC-SBb	1,2%	2,6%	0,2%	2,5%
V4 F-T24	0,8%	2,8%	-1,1%	2,2%
V5 DC-TS	0,5%	1,9%	-1,1%	2,0%
V3a F-CS	-0,2%	1,7%	-2,9%	0,9%
V3b F-CS	-0,4%	1,5%	-2,9%	0,7%
V5 F-SB	-0,2%	1,1%	-1,8%	0,6%
V2 F-HH	-2,0%	-0,2%	-5,7%	-1,2%
V4 DC-T24a	-1,7%	0,0%	-4,6%	-1,8%
V3a DC-CS	-2,7%	-1,2%	-6,4%	-3,1%
V3b DC-CS	-2,9%	-1,4%	-6,4%	-3,3%
V5 DC-SBa	-2,7%	-1,8%	-5,3%	-3,4%

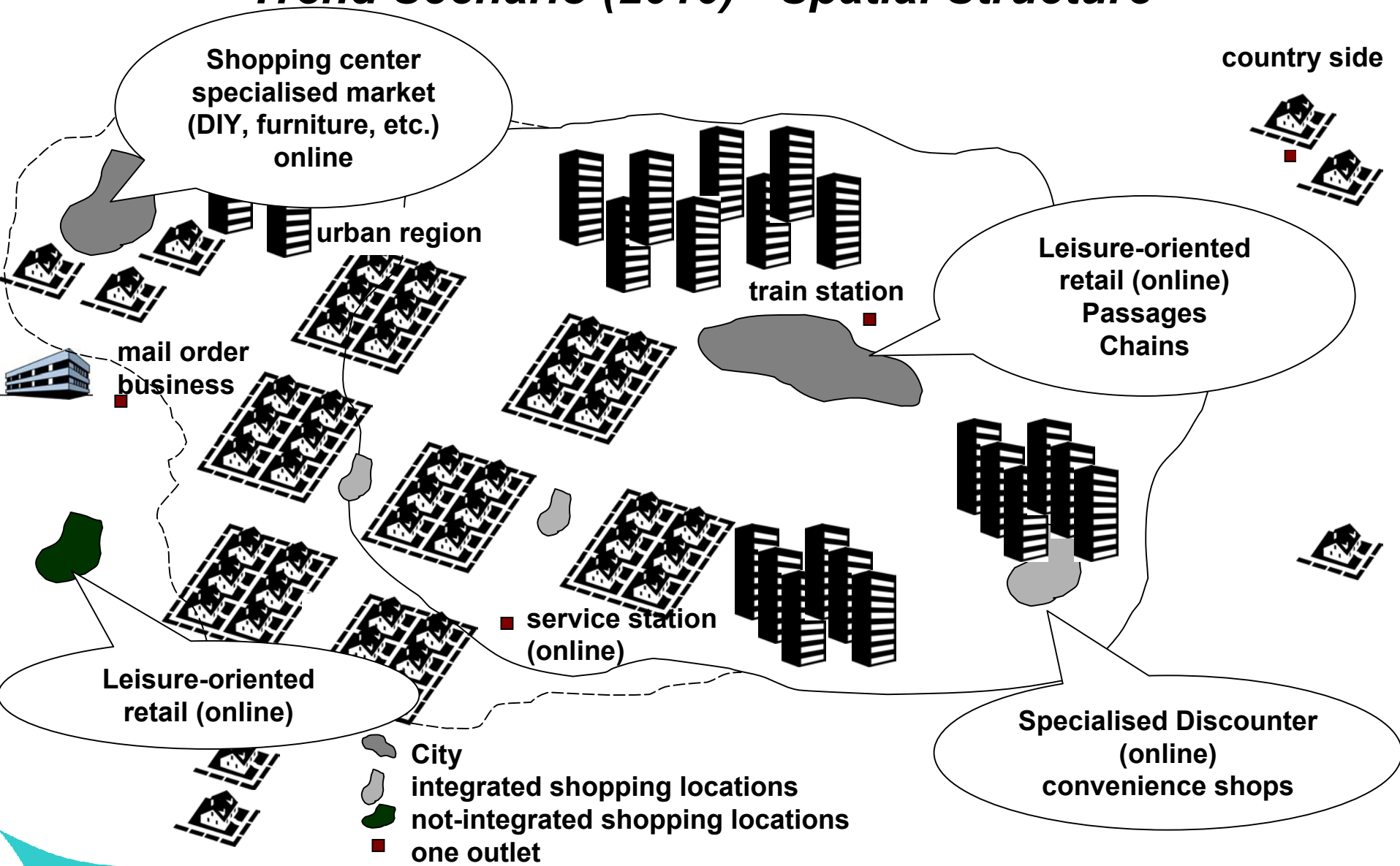
Example: Home delivery service (V2)

- In urban areas CO_2-emissions increase of 0.8 %.
- In rural areas CO_2-emissions increase of 1.2 %.

Conclusions

- An increase of shipments / an increase of e-commerce:
  - improves the efficiency of deliveries,
  - reduces the numbers of kilometres per shipment,
  - but: increases the total mileage!
- Various delivery chains create a different amount of exhaust gas pollutions.
- The degree of air pollution depends on the population density:
  - Rural areas: Delivery creates less pollutions than “motorised shopping trips”
  - Urban areas:The impacts of delivery on air pollution are not clear.
- ***But:***
- High dependence from several assumptions!
- And: e-commerce is not the major parameter but the behaviour of the consumer/drivers.
- Last but not least: Against the background of current forecast of further growth of shipments and traffic volume, certain transport and economy policies are required to ensure long-term quality of life in city centres!

Trend Scenario (2010) - Spatial Structure



EC-Scenario (2020) - Spatial Structure