Estimating CO_2 emissions generated by tourism in European cities

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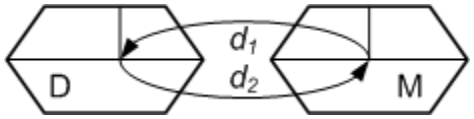
Gunter, U., & Wöber, K. (2021): *Estimating transportation-related CO_2 emissions of European city tourism*. Journal of Sustainable Tourism 30 (1): 145-168, DOI: 10.1080/09669582.2021.1939708.

Gunter, U., & Wöber, K. (forthcoming): *Reassessing transportation-related CO_2 emissions of European city tourism: The impact of the COVID-19 pandemic and the contribution of DMOs in improving the precision of CO_2 estimates*. In: Maxim, C., Morrison, A. M., Coca- Stefaniak, J. A., Day, G J. (Eds.): Handbook of sustainable urban tourism. Edward Elgar Publishing, Cheltenham, UK and Northampton, MA.

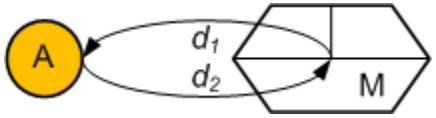
Objectives and motivation

Stefan Gössling, Daniel Scott, Michael Hall (2015): *Inter-market variability in CO_2 emission-intensities in tourism: Implications for destination marketing and carbon management*, Tourism Management, 46, pp. 203-212

CO_2 emissions in tourism calculated based on the distances flown of all tourists from a specific **source market** to a specific **destination** times CO_2 emission factors per flight distance



The primary objective of the TourMIS project is to create **more precise estimates** of CO_2 emissions of European **city tourism**



In order to achieve this objective, **not only the travel distance** (as typically done) but also the **chosen transportation mode(s)** and the particularities of the different cities' **source markets** are considered

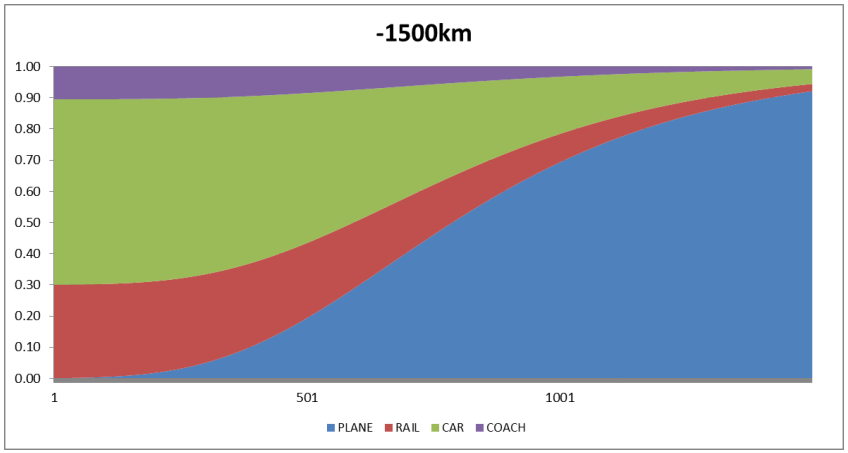
Four steps

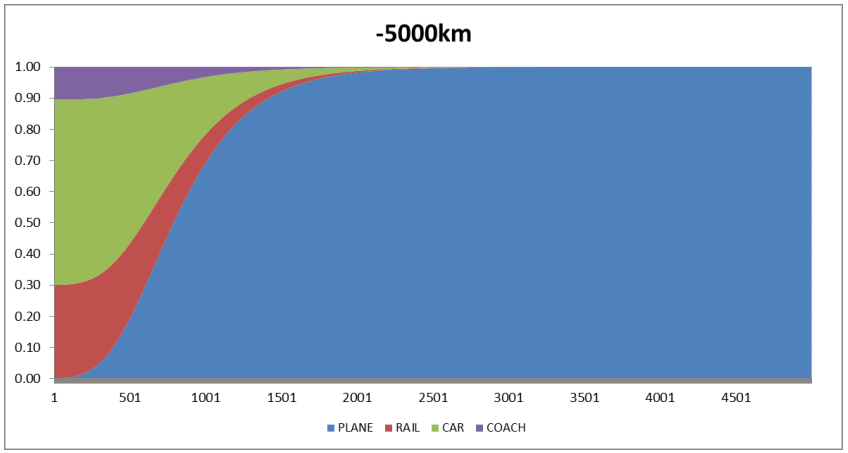
1. Calculation of travel distances in km between European cities and their source markets based on their geographical coordinates (population centers) as reported by the Socioeconomic Data and Applications Center (SEDAC) by NASA
2. Calculation of share of travel mode (air, rail, car, coach)
   a) Entered by TourMIS inputter (information from guest surveys)

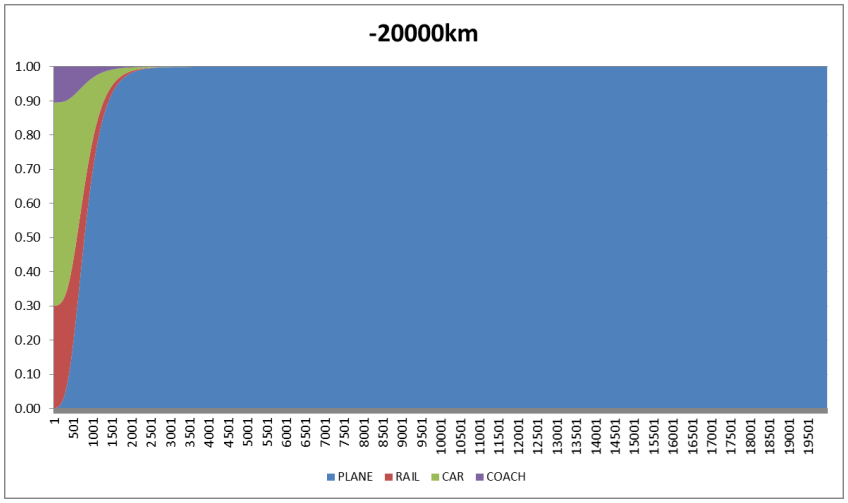
   or

   b) Estimated (by TourMIS)
3. Calculation of CO_2 emissions by multiplying distance by travel mode with average CO_2 emissions by travel mode
4. Incorporating multiple trips and average length of stay

Estimating travel mode by travel distance







The probability of choosing a certain transportation mode is approximated by a Gompertz function in travel distance (PLANE) and a growth function in travel distance (RAIL), with the remaining probability (i.e., 100% – Pr(PLANE) – Pr(RAIL)) being distributed on CAR (85%) and COACH (15%), respectively

Estimating CO2 emissions

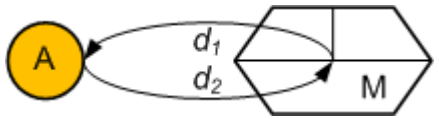
- Travel distances per transportation mode are calculated by multiplying the travel distance in km per destination and source market by Pr(PLANE), Pr(RAIL), Pr(CAR), and Pr(COACH), respectively
- CO2 emissions per tourist arrival are calculated by multiplying the travel distances per transportation mode by the average CO2 emissions per transportation mode according to Peeters et al. (2007):

Table 11.2 Emission factors for tourism transport modes in the EU context

Mode	CO_2 factor (kg/pkm)	Occupancy rate/load factor (%)
Air < 500 km	0.206	–
500-1,000 km	0.154	–
1,000-1,500 km	0.130	–
1,500-2,000 km	0.121	–
> 2,000 km	0.111	–
Air world average [a]	0.129	75
Rail	0.027	60
Car	0.133	50
Coach	0.022	90

(a) This value is calculated in Section 11.1.2.1.

Source: Peeters, P. et al. (2007b)



$$CO_2 = \sum f^T(d_1) * kg/pkm^T + \sum f^T(d_2) * kg/pkm^T$$

New feature: Trend analysis

1000 | 0,0% | Visual Graph

Cities - Nights and arrivals - Annual data
CityDNA-J17: transportation-caused CO2

Destination: Vienna (48.220, 16.380)
Arrivals in all forms of paid accommodation in greater city area
Benchmark: All Cities
Mode of transport: Estimate by TourMIS
Number of visited cities: = 1 (no roundtrips)
Domestic: Yes
Considers the average length of stay when calculating the total CO2 emissions
Period: 2017-2022

		All Cities				Vienna				in %	
Period	Number	Arrivals	(1)	CO2 kg/pP	Total CO2 t	Arrivals	(1)	CO2 kg/pP	Total CO2 t	Arrivals	Total CO2	TDI
2017	58	150,062,017	1.2	202	30,338,521	7,638,785	0.9	253	1,938,098	5.1	6.4	1.3
2018	59	157,536,305	1.2	199	31,443,213	8,099,113	0.8	253	2,056,746	5.1	6.5	1.3
2019	58	151,455,501	0.7	215	32,671,366	8,565,170	0.9	251	2,152,163	5.7	6.6	1.2
2020	52	41,388,398	0.7	110	4,561,449	2,203,719	1.6	141	312,151	5.3	6.8	1.3
2021	54	55,357,209	0.8	87	4,869,437	2,293,768	2.2	98	226,554	4.1	4.7	1.1
2022	55	113,899,151	1.1	134	15,337,298	5,996,048	1.8	153	918,879	5.3	6.0	1.1

(1) Unspecified in %
Travel distance indicator (TDI): <1 = local; 1 = average; >1 = far
CO2 emissions (Peeters et al. 2007):
Air: <500 km: 0.206 kg/pkm; 500-1,000 km: 0.154 kg/pkm; >1,000-1,500 km: 0.130 kg/pkm; >1,500-2,000 km: 0.121 kg/pkm; >2,000 km: 0.111 kg/pkm
Rail: 0.027 kg/pkm; Car: 0.133 kg/pkm; Coach: 0.022 kg/pkm
NA = Bednights in all forms of paid accommodation in city area only
NG = Bednights in hotels and similar establishments in city area only
NZ = Bednights in all forms of accommodation incl. VFR in city area only
NAS = Bednights in all forms of paid accommodation in greater city area
NGS = Bednights in hotels and similar establishments in greater city area
NZS = Bednights in all forms of accommodation incl. VFR in greater city area

Table: CityDNA-J17 (tab_j17)

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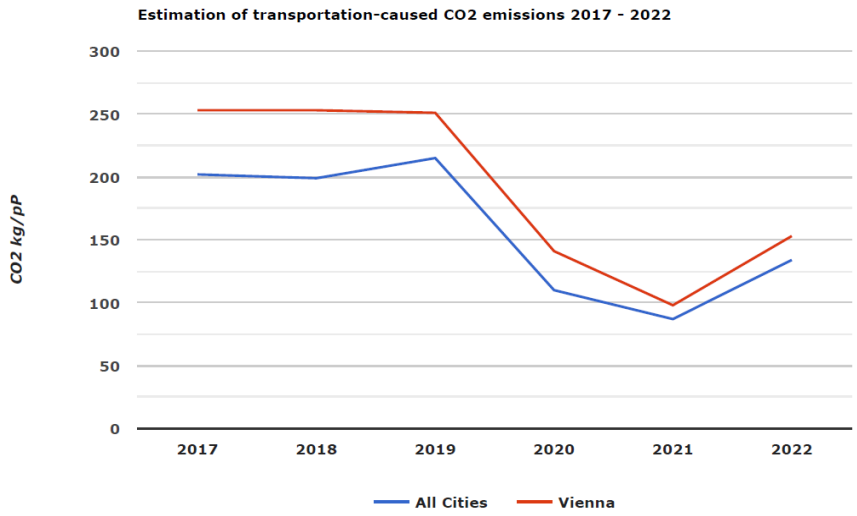

Limitations and future research

- Differences in transportation mode preferences across European countries have not been considered
  - Eurostat data on the terrestrial modal split of passenger transport as well on passenger flights could be incorporated in the future
- Only (direct) CO_2 emissions from transportation from the source markets to the destinations are considered
  - More information is needed on the other (indirect and induced) CO_2 emissions of tourists to and within European cities