Estimating CO_2 emissions generated by tourism in European cities and countries

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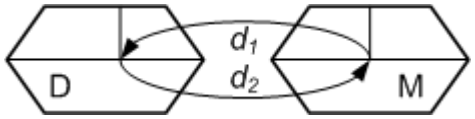
Gunter, U., & Wöber, K. (2021): *Estimating transportation-related CO_2 emissions of European city tourism*. Journal of Sustainable Tourism 30 (1): 145-168, DOI: 10.1080/09669582.2021.1939708.

Gunter, U., & Wöber, K. (2024): *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 (pp. 396-414). Edward Elgar Publishing, Cheltenham, UK and Northampton, MA.

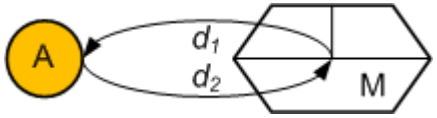
Objectives and motivation

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**

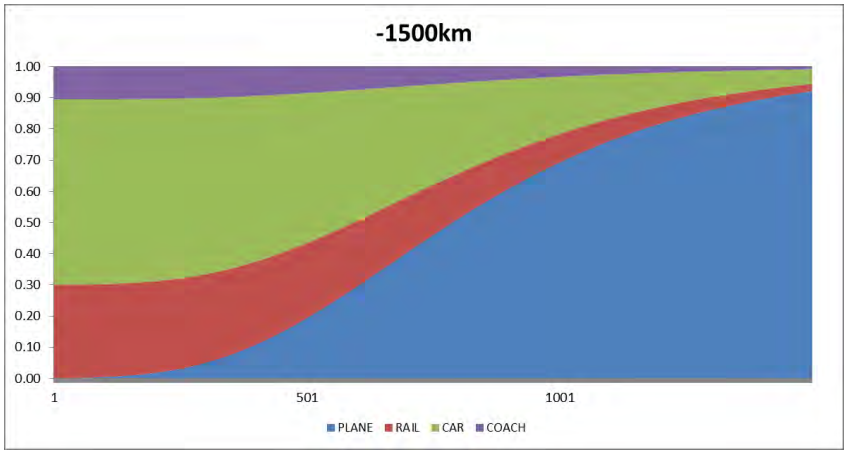


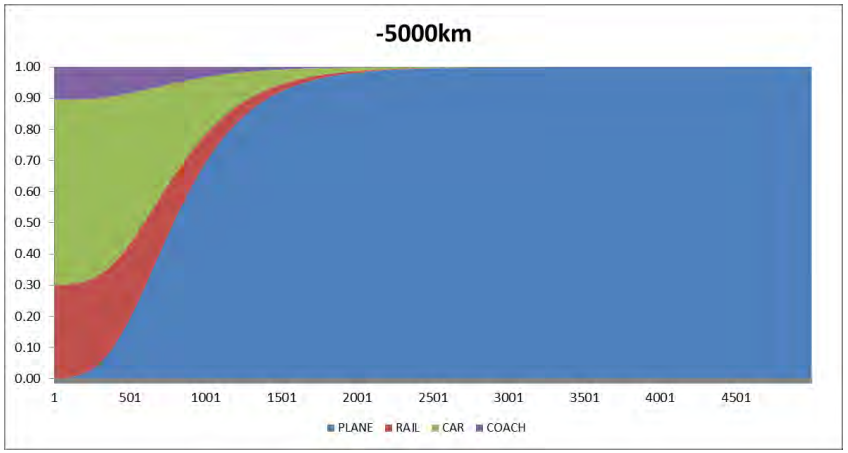
In order to achieve this objective, **not only the travel distance** (as typically done) but also the **chosen transportation mode(s)** and the particularities of the different cities' **source markets** are considered

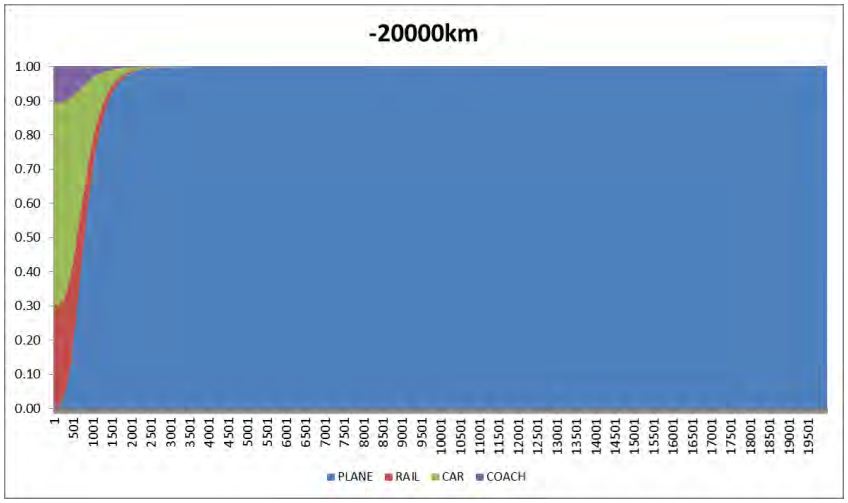
Four steps

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 CO_2 emissions

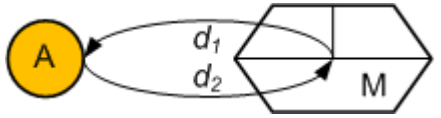
- Travel distances per transportation mode are calculated by multiplying the travel distance in km per destination and source market by Pr(PLANE), Pr(RAIL), Pr(CAR), and Pr(COACH), respectively
- CO_2 emissions per tourist arrival are calculated by multiplying the travel distances per transportation mode by the average CO_2 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 #1: 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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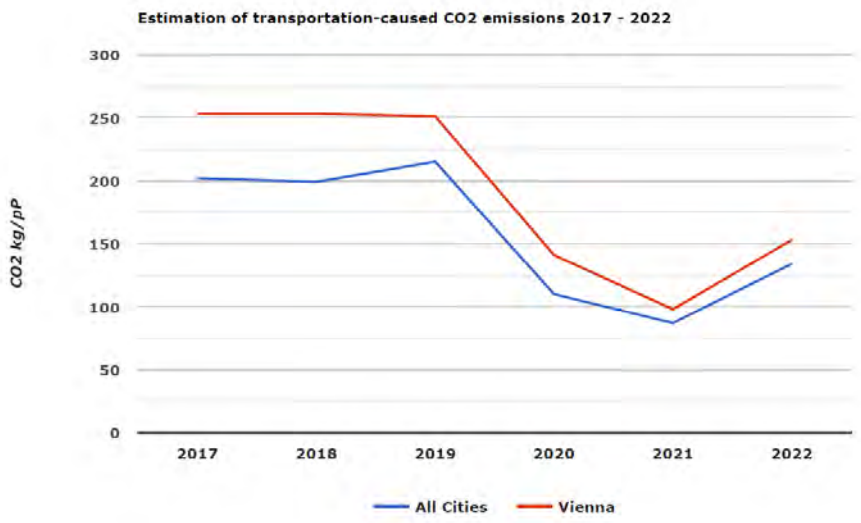

New feature #2: Application to countries

European Countries >> Nights and arrivals >> Annual data

For one destination

	1 or 2 year(s)	Trend
Nights and arrivals	ETC-J3: for various markets	ETC-J4: for a market
	ETC-J7: for various markets and benchmark	ETC-J9: for a market and benchmark
		ETC-J1: for all definitions
Length of stay	ETC-J12: for various markets	ETC-J14: for on market and several years
Sustainability	ETC-J22: Sustainability indicators	ETC-J17: transportation-caused CO2
	ETC-J16: transport and CO2 emissions	

For one market

	1 or 2 year(s)	Trend
Nights and arrivals	ETC-J2: in all destinations	ETC-J11: in all destinations
Length of stay	ETC-J13: in all destinations	
Density & intensity	ETC-J20: in all destinations	ETC-J21: for a destination and benchmark

Combining markets and destinations

- ETC-J10: Portfolio Analysis: Market volumes and shares for selected destinations
- ETC-J15: Comparison of the diversity of the guest mix
- ETC-J8: All markets versus all countries (arrivals or nights)

Destination: Austria
Benchmark: All — Edit

Mode of transport
- ☐ Data provided by the destination for the selected year, or
- ☐ Latest available data provided by the destination, or
- ☐ Average of all destinations' data and selected year, or
- ☐ Average of all destinations' latest available data, or
- ☑ Estimate by TourMIS

Number of other visited destinations
- ☐ Data provided by the destination for the selected year, or
- ☐ Latest available data provided by the destination, or
- ☐ Average of all destinations' data and selected year, or
- ☐ Average of all destinations' latest available data, or
- ☑ = 1 (no roundtrips)

CO2 emissions

		kg/pkm
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
Rail		0.027
Car		0.133
Coach		0.022

Minimum: 40 markets
Domestic: ◉ Yes ○ No
Length of stay: ○ Yes ◉ No
Period: 2018 - 2023

OK

1000 | 0,0% | Visual Graph

European Countries - Nights and arrivals - Annual data
ETC-J17: transportation-caused CO2

Destination: Austria (47.516, 14.550)
Arrivals in all forms of paid accommodation
Benchmark: All European Countries
Mode of transport: Estimate by TourMIS
Number of other visited destinations: = 1 (no roundtrips)
Domestic: Yes
Period: 2018-2023

		All European Countries				Austria				in %		
Period	Number	Arrivals	(1)	CO2 kg/pP	Total CO2 t	Arrivals	(1)	CO2 kg/pP	Total CO2 t	Arrivals	Total CO2	TDI
2018	14	473,189,434	0.6	188	89,432,256	44,848,762	2.7	235	10,558,850	9.5	11.8	1.2
2019	20	667,334,332	0.6	233	155,631,834	46,195,388	2.6	239	11,063,356	6.9	7.1	1.0
2020	19	271,629,365	0.4	89	24,313,808	25,030,207	1.3	118	2,973,534	9.2	12.2	1.3
2021	19	317,392,832	0.4	89	28,497,421	22,144,098	1.3	100	2,228,670	7.0	7.8	1.1
2022	19	502,406,078	0.6	162	81,494,303	39,794,088	2.0	154	6,137,278	7.9	7.5	1.0
2023	19	558,364,922	0.7	207	115,593,985	45,212,567	2.7	189	8,587,353	8.1	7.4	0.9

(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

Table: ETC-J17 (tab_j17)

Generated 2024-09-12 (08-52-50)

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