CO_2 emission profiles for mobility behavior in Austria

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- Political goal: decrease CO_2 emissions by 80% (1990- 2050)
- Mobility is a highly valuable good for people and increases living standards
- On average, every fourth way in Austria is a way related to work.

Modal split

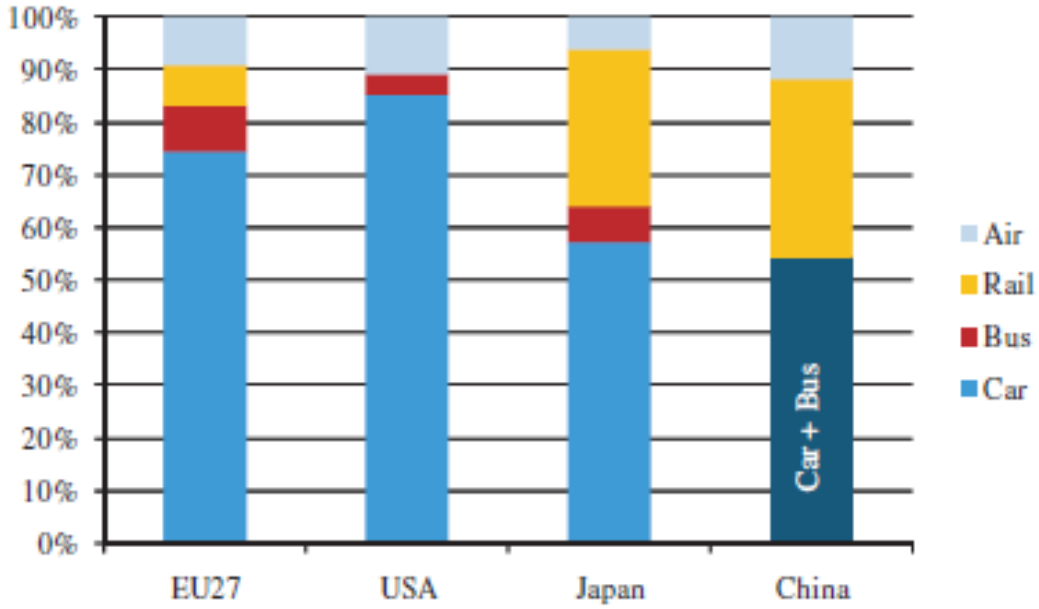

Figure: Modal split of passenger in terms of pass-km in 2005, source: GEA 2010 based on EU 2010

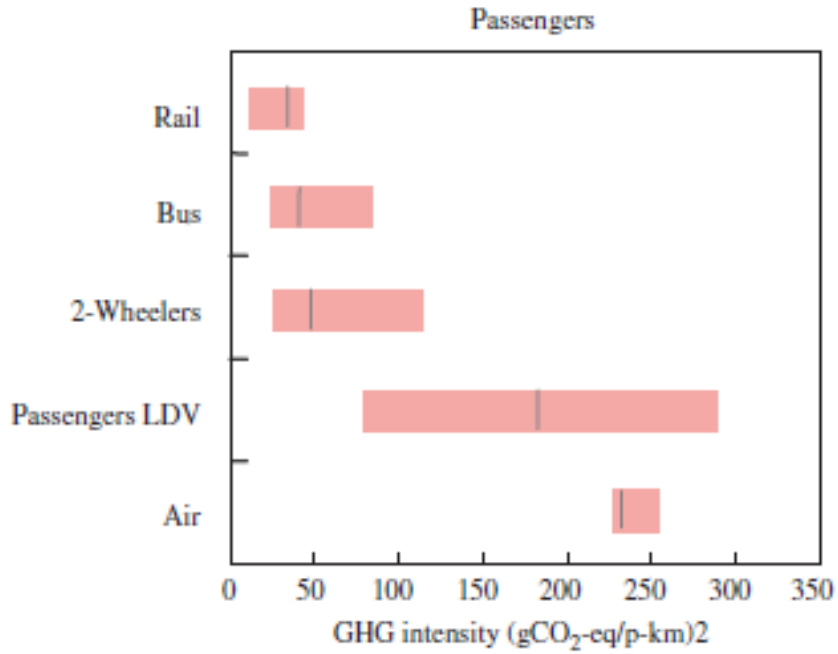

Figure: GHG intensity per mode, source: GEA 2010 based on IEA 2009

Drivers of mobility

Figure: Historical relationship between vehicle ownership and GDP per capita, source: GEA 2010, Chapter 9 based on World Bank 2010

Drivers of mobility

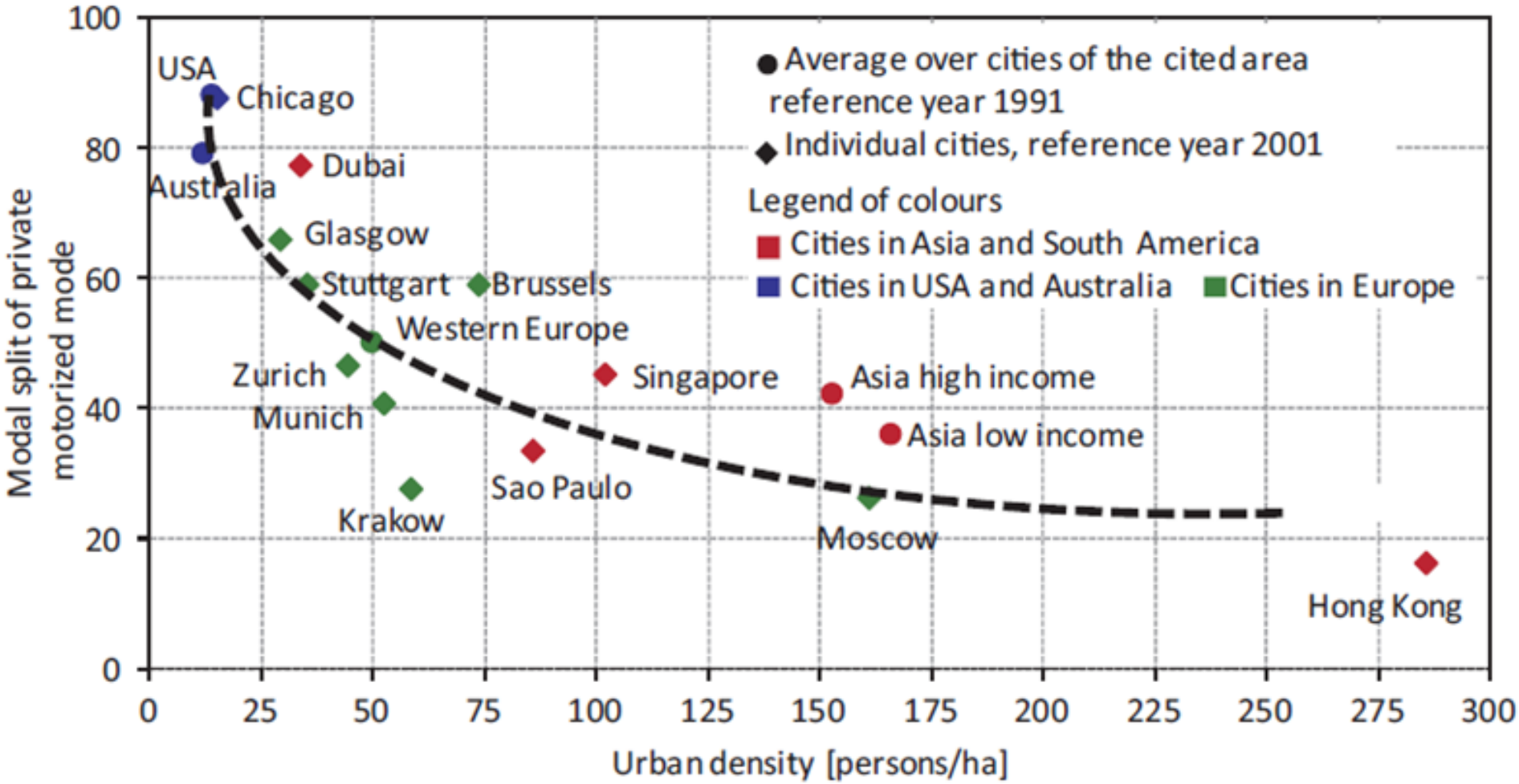

Figure: Relation of urban density and share of private motorized transport modes for individual cities and regional average cities. Source: GEA 2010, Chapter 18

Mobility patterns

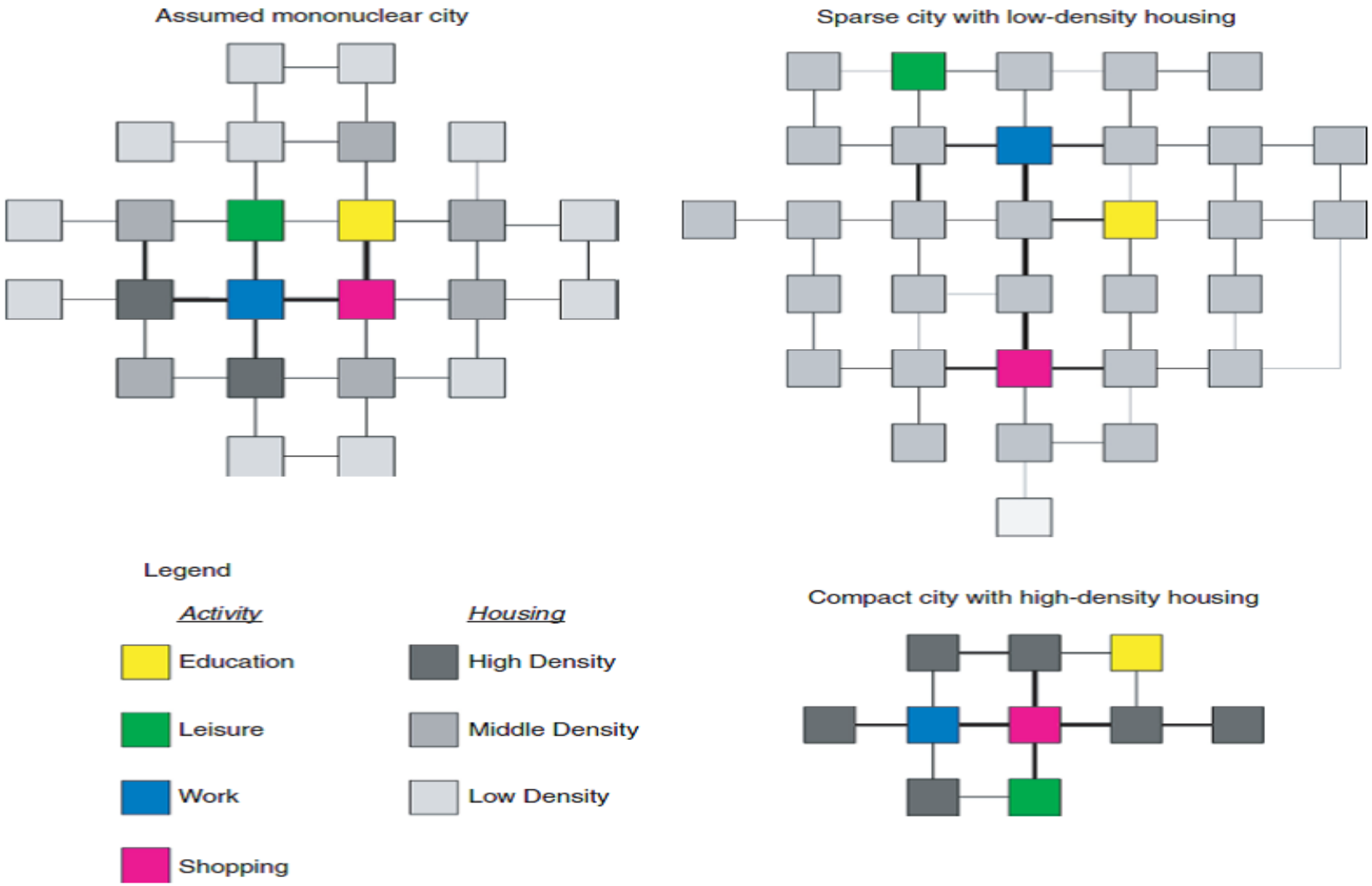

Figure: Urban layouts, source: GEA 2010, Chapter 18

Research Question

- Which CO_2 emission patterns generated by mobility can be observed in Austria?
  - Do we observe the same CO_2 emission patterns as in the US with some suburban households having higher carbon footprints than rural households?

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  - Do we observe the same CO_2 emission patterns as in the US with some suburban households having higher carbon footprints than rural households?
- To which extent are transport-related CO_2 emissions driven by household characteristics (preferences, behavior) and structural factors?

Mobility data

Austrian household survey

- EU FP7 project DEFINE: Development of an Evaluation Framework for the Introduction of Electromobility, `https://www.ihs.ac.at/projects/define/index.html`

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- web-based survey conducted by a German commercial subcontractor (GfK) in February 2013
- 1449 respondents
- Representative for gender, age, educational attainment, employment status, federal state
- Focus lies on typical trips and annual car usage

Mobility pattern in Austria

Means of transportation	Walking	Car	Bus	Train & Municipal railway	Bike	Under-ground & Tram
0 - 1km	51%	22%	10%	1%	5%	11%
1 - 5km	19%	56%	4%	1%	9%	11%
6 - 10km	5%	73%	3%	2%	7%	10%
11 - 20km	5%	77%	5%	4%	1%	8%
21 - 50km	0%	86%	2%	8%	2%	2%
More than 51 km	0%	78%	1%	18%	1%	2%

Figure: Relation between main trip distance and transport mode, source: IHS 2013

Mobility pattern in Austria

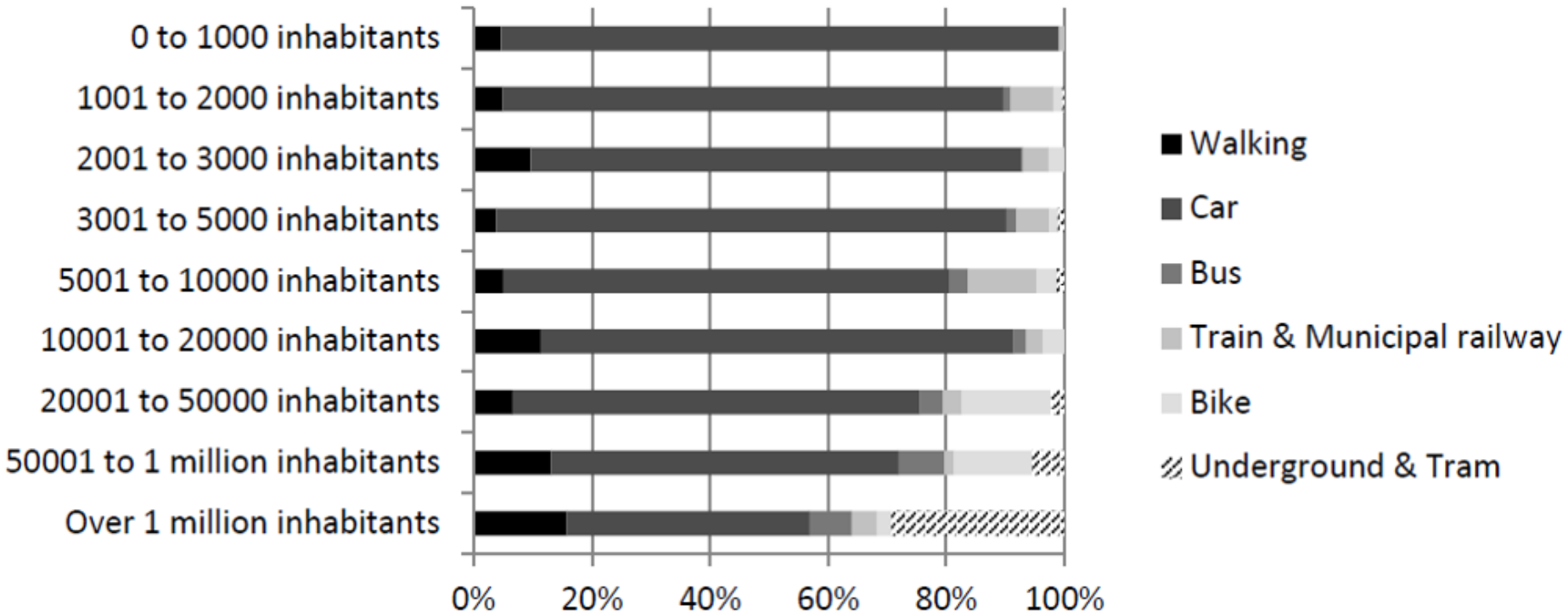

Figure: Relation between population density and transport mode, source: IHS 2013

Indicators for CO_2 emissions

CO_2 emissions (main trip) = CO_2 emission intensity (energy intensity(transport mode)) * km(main trip)

CO_2 emissions (main trip) = CO_2 emission intensity (fuel economy(car ownership)) * km(main trip)

CO_2 emissions (car usage)= CO_2 emission intensity (fuel economy(car ownership)) * km(car usage p.a.)

- Transport modes: walking, car, bus, train and municipal railway, bicycle, underground and tram, motorcycle
- Distance
- Assumptions on fuel economy and CO_2 emission intensity

Model specification

- CO_2 emissions for main trip

$$CO2(maintripp.day) = \alpha + \beta \ln(Inc) + \gamma Z + \eta Agg + \zeta Mob + \lambda Att + \varepsilon \quad (1)$$

- CO_2 emissions for annual car usage

$$CO2(km) = \alpha + \beta \ln(Inc) + \gamma Z + \eta Agg + \zeta Mob + \lambda Att + \varepsilon \quad (2)$$

Z ... socioeconomic variables (gender, age, occupation, nb of household members, educational attainment, family status, car driver)
Agg ... agglomeration size
Mob ... mobility features (commuter, purpose of main trip and car usage)
Att ... attitude

Estimates of CO_2 emissions for main trip 1

CO2 emissions (g) for main trip p. day	ols	nbreg	zinb
	(1)	(2)	(3)
Age	1.006	0.998	1.002
Personal income ln	1.128	1.585***	1.535***
Gender	1.109	1.042	1.053
Aggl 1,001-2000ln	0.723	0.965	0.859
Aggl 2,001-3000ln	0.760	0.981	0.935
Aggl 3,001-5,000ln	0.809	1.249	1.025
Aggl 5,001-10,000ln	0.513**	0.874	0.775
Aggl 10,001-20,000ln	0.693	1.528	1.110
Aggl 20,001-50,000	0.535*	0.444**	0.480**
Aggl 50,001-1 million ln	0.379***	0.455**	0.487**
Aggl over 1 million-Vienna	0.220***	0.711	0.570*
Occupation_working	0.468***	0.615**	0.728
Occupation_education	1.542	1.314	1.369
Occupation_student	0.631	0.849	0.928
Education_secondary	1.144	0.875	0.965
Education_tertiary	1.024	0.532**	0.704
Commuter	2.222***	2.648***	2.394***
Persons/hh = 2	1.033	1.243	1.040
Persons/hh = 3	1.063	1.261	1.048
Persons/hh = 4	0.869	0.961	0.874
Persons/hh = 5 and more	0.869	0.985	0.941
Driver = 1	1.554	1.704**	1.092
Constant	57.37***	6.219*	21.91***
Inflate			
Frequency of car use			1.919***
Constant			0.0295***
Observations	820	969	969
R-squared	0.437		

*** p<0.01, ** p<0.05, * p<0.1

Constant: female,rural, unemployed/maternity leave/pension/working in hh, primary educ. degree, 1 p hh, co-driver/no driver licence, purpose main trip and car is private, no car ownership

Estimates of CO_2 emissions for main trip 2

CO2 emissions (g) for main trip p. day	ols (1)	nbreg (2)	zinb (3)
Mtrip_purpose_work	1.226		
Mtrip_purpose_bus	5.004***		
Mtrip_purpose_edu	0.523		
Mtrip_purpose_shop	0.823		
Mtrip_purpose_tran	1.635*		
Mtrip_purpose_leis	1.526*		
Car for work	4.436***	3.678***	3.121***
Car for business	1.314*	2.697***	2.284***
Car for training	1.163	1.415	1.376
Car for shopping	0.784	0.756	0.632**
Car for transport	1.163		
Car for leisure	1.050		
Att_environ.consciousness	1.075	1.019	
Att_environ.protect.important	1.049	1.046	
Att_environ.exaggerate	0.988	1.010	0.980
Att_regional.products	0.965	0.988	
Att_purchase.organic.products	0.991	0.965	
Att_job.losses.for.environ.meas.	1.014	1.041	1.014
Att_limits.to.growth	1.127**	1.182***	1.169***
Att_environ.footprint.important	0.967	0.980	
Private garage	1.199	1.739**	1.384
Parking permit	1.051	1.046	0.831
Observations	820	969	969
R-squared	0.437		

*** p<0.01, ** p<0.05, * p<0.1

Constant: female,rural, unemployed/maternity leave/pension/working in hh, primary educ. degree, 1 p hh, co-driver/no driver licence, purpose main trip and car is private, no car ownership

Estimates of CO_2 emissions for car usage 1

CO2 emissions (kg) for annual car usage	ols (1)	ols (log) (2)
Age	-31.38	-0.0422**
Personal income ln	-17.48	-0.187
Interaction Age/Income ln	4.113	0.00565**
Gender	261.6**	0.132***
Urbanisation (intermediate)	-39.49	-0.00665
Urbanisation (thinly)	311.1**	0.132**
Occupation pensionist	-141.3	-0.130*
Education secondary	339.9***	0.191***
Education tertiary	142.2	0.0771
Commuter.allow.small	304.9*	0.122*
Commuter.allow.large	648.5***	0.215***
Driver = 1	-616.8***	-0.254***
Mtrip_purpose_bus	1,029***	0.277***
Mtrip_purpose_edu	204.7	-0.142
Mtrip_purpose_shop	99.89	0.00501
Mtrip_purpose_tran	249.8	0.166**
Mtrip_purpose_leis	230.6	0.0961
Observations	902	902
R-squared	0.335	0.364

*** p<0.01, ** p<0.05, * p<0.1

Constant: female, in densely populated areas,primary educ. degree, no commuters, co-driver/no driver licence, main trip for private purpose, frequency of car use is never or up to once/month or no license

Estimates of CO_2 emissions for car usage 2

CO2 emissions (kg) for annual car usage	ols (1)	ols (log) (2)
Car for work	135.0	0.0849
Car for business	370.6***	0.136**
Car for training	189.2	0.104
Car for shopping	-95.15	-0.0599
Car for transport	58.46	0.0343
Car for leisure	234.3**	0.131**
Frequency of car use daily	554.3	0.345
Frequency of car use sev times/week	124.8	0.176
Frequency of car use sev times/month	-107.1	0.0292
Vignette	614.6***	0.345***
Age of car	21.85**	0.0139***
Trips p. day	170.7***	0.0734***
Att_environ.exaggerate	-96.68**	-0.0342**
Att_purchase.organic.products	68.04*	0.0248
Observations	902	902
R-squared	0.335	0.364

*** p<0.01, ** p<0.05, * p<0.1

Constant: female, in densely populated areas,primary educ. degree, no commuters, co-driver/no driver licence, main trip for private purpose, frequency of car use is never or up to once/month or no license

Concluding remarks

- Both household characteristics and external factors drive mobility behavior
- Habits such as car driving behavior and socioeconomic characteristics such occupation status and educational background affect CO_2 emissions
- External factors such as infrastructure availability, agglomeration size and distribution of economic activity influence individual mobility pattern
- Personal attitudes towards environment only marginally affect CO_2 emissions

Concluding remarks

- Long-term perspective: support the concept 'city of short ways' and multiple land-use
- Consider population density thresholds to enable the availability and quality of public transport
- Provide safe and appealing infrastructure for low-carbon transport modes

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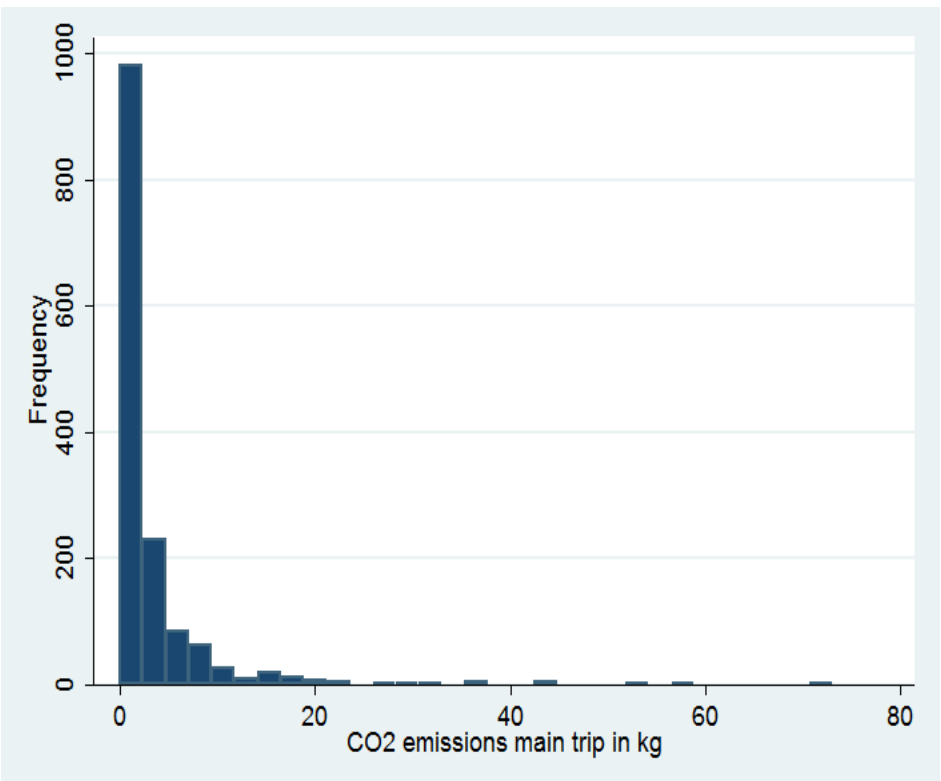
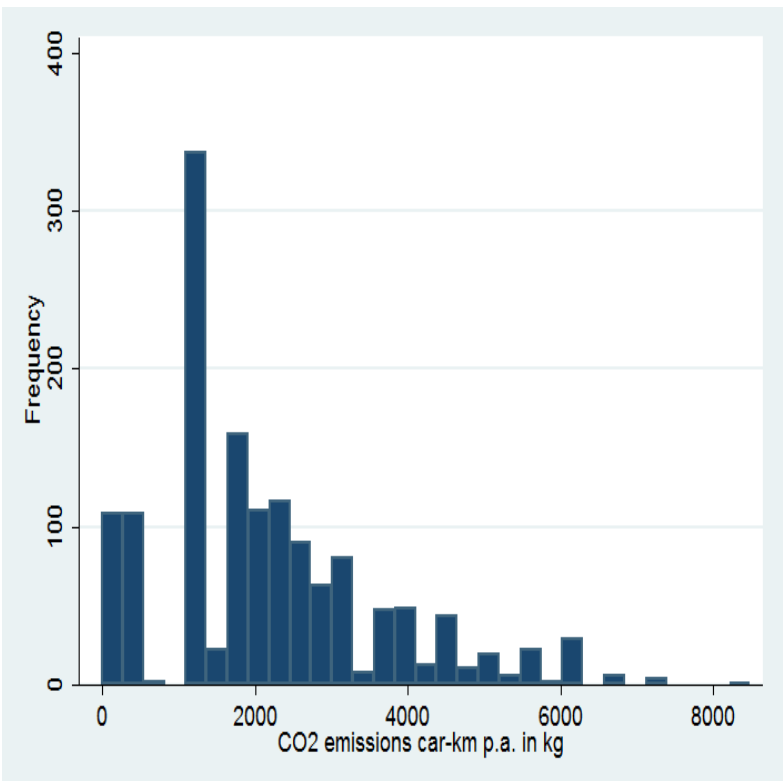
Thank you for your attention.

Distribution of CO_2 emissions

CO2 emissions in kg	Median	Mean	Std.Dev.
For main trip	1.20	3.02	7.17
For main trip p. Day	0.42	1.52	3.39
For annual car usage	1,828	2,136	1,481





Mobility pattern in Austria

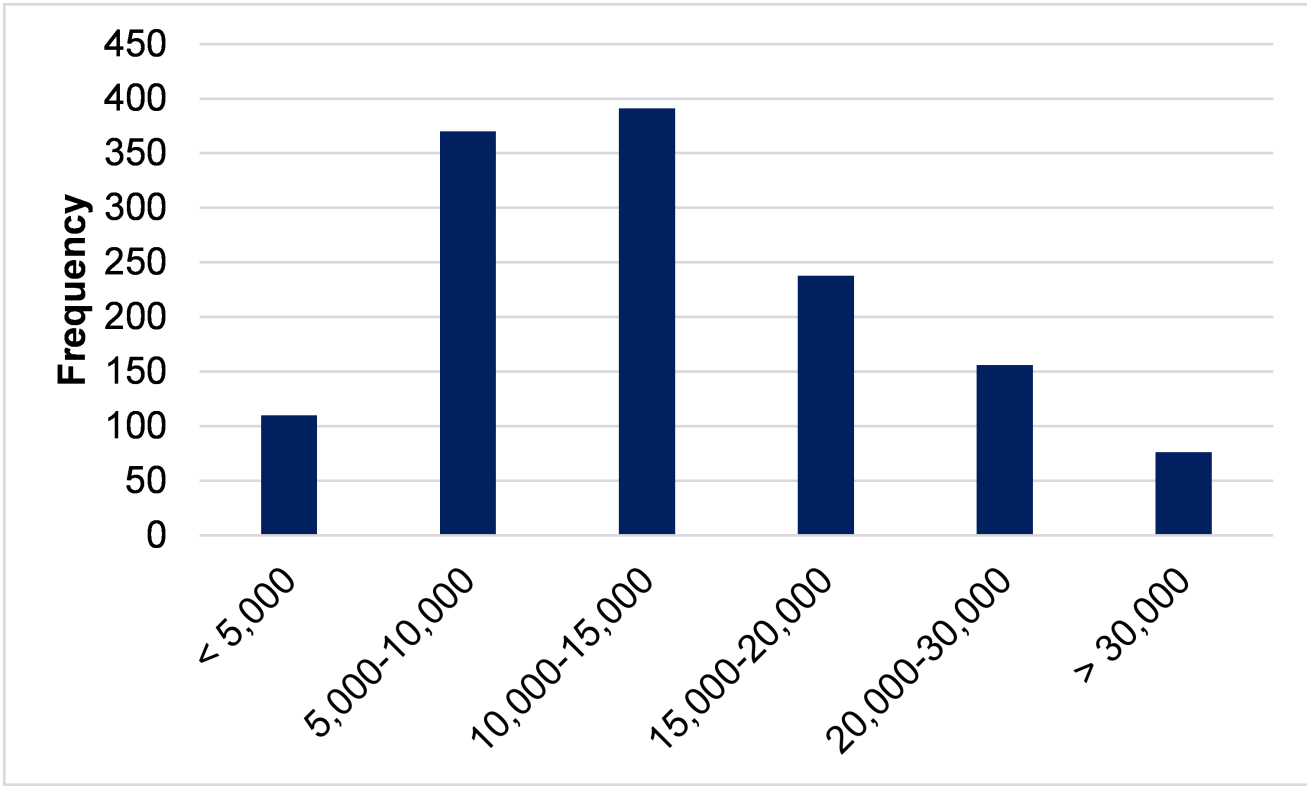


Figure: Frequency of annual kilometers driven with car, source: IHS 2013

Drivers of mobility

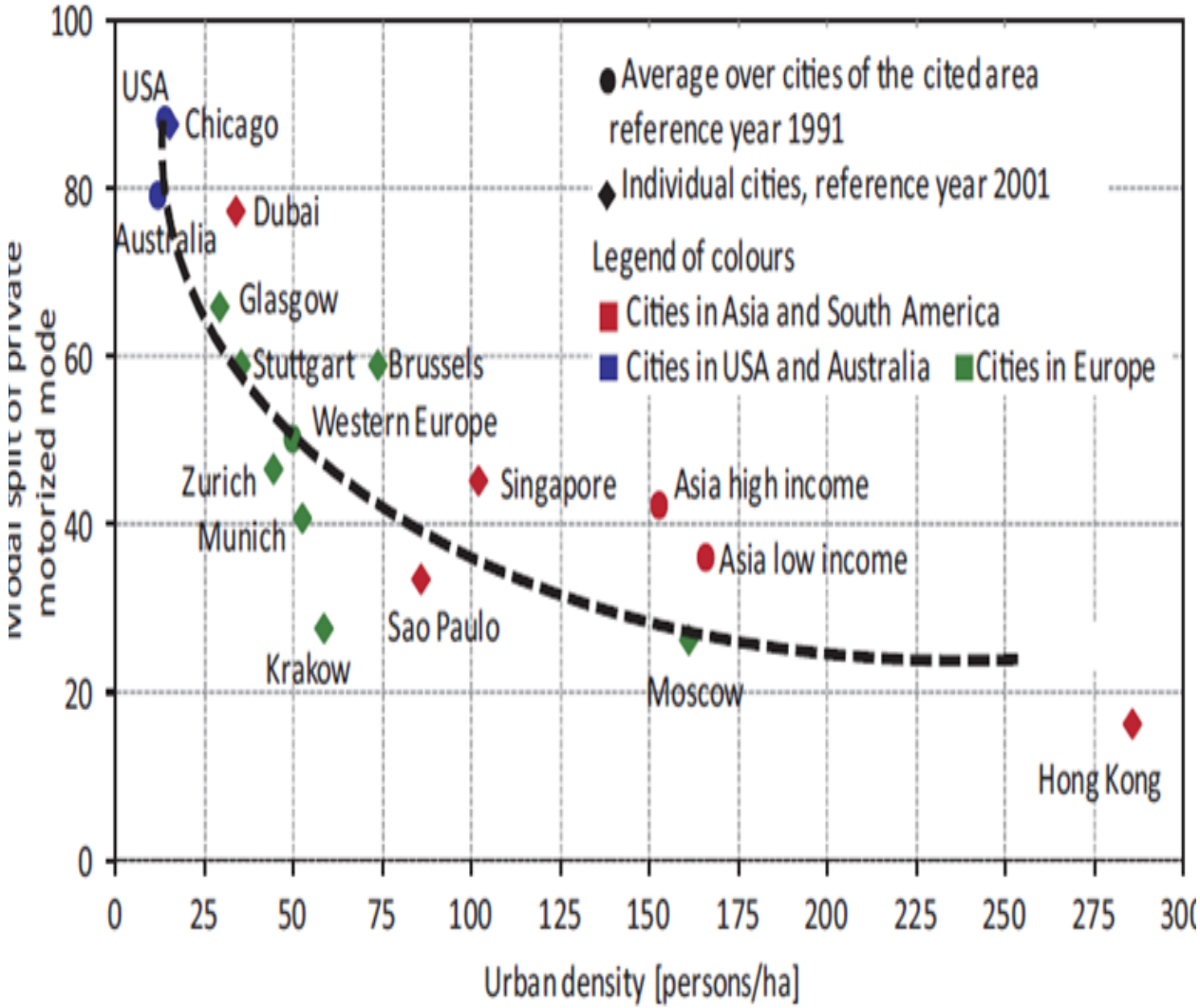


Figure: Relation of urban density and share of private motorized transport modes for individual cities and regional average cities. Source: GEA 2010, Chapter 18 based on various sources Kenworthy et al., 1999 ; Kenworthy and Laube, 2001 ; Vivier, 2006

Comparison to other studies

MiD 2008 Survey	km	CO2 kg per day	CO2 g / km
Private motorized mode	46.9	6.4	136
Public transport (regular customers)	53.6	5.6	104
Public transport no car)	26.7	2	75

Figure: Comparison of CO_2 emissions for different transport mode, source: MiD 2008

Assumptions-car

European car segment defined by EU Commission	l/100km	CO2g/km
mini car (A)	5.85	146.25
small car (B)	6.24	146.25
medium car (C)	6.87	146.25
large car (D)	7.95	177.50
executive or luxury car (E, F)	9.40	177.50
multi-purpose car (M)	8.75	177.50
sports utility car (J).	8.80	242.59

Figure: Car segements, fuel economy and CO_2 emissions, source: Lichtblau and Pötscher 2013

Assumptions-bus, train and tram

Transport mode	unit	
CO2 emissions bus	g / pass-km	60
CO2 emissions train	g / pass-km	10
Electricity demand tram & underground	kWh / pass-km	0.08
CO2 emissions tram & underground	g / kWh	52.63

Figure: Car segements, fuel economy and CO_2 emissions, source: Umweltbundesamt 2007, BMVIT 2012