UNIVERSITY OF BIRMINGHAM

The Environmental Value of Sustainable Transport Infrastructure

Nikos Kalyviotis
Ph.D.(cand) Civil Engineering

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Introduction

There is an ongoing debate on infrastructure investment priorities related to: Energy, Water, Transport, Waste, Communication

(*Hall et al., 2016; iBUILD, 2015; Liveable Cities, 2015; National Infrastructure Plan, 2013*)

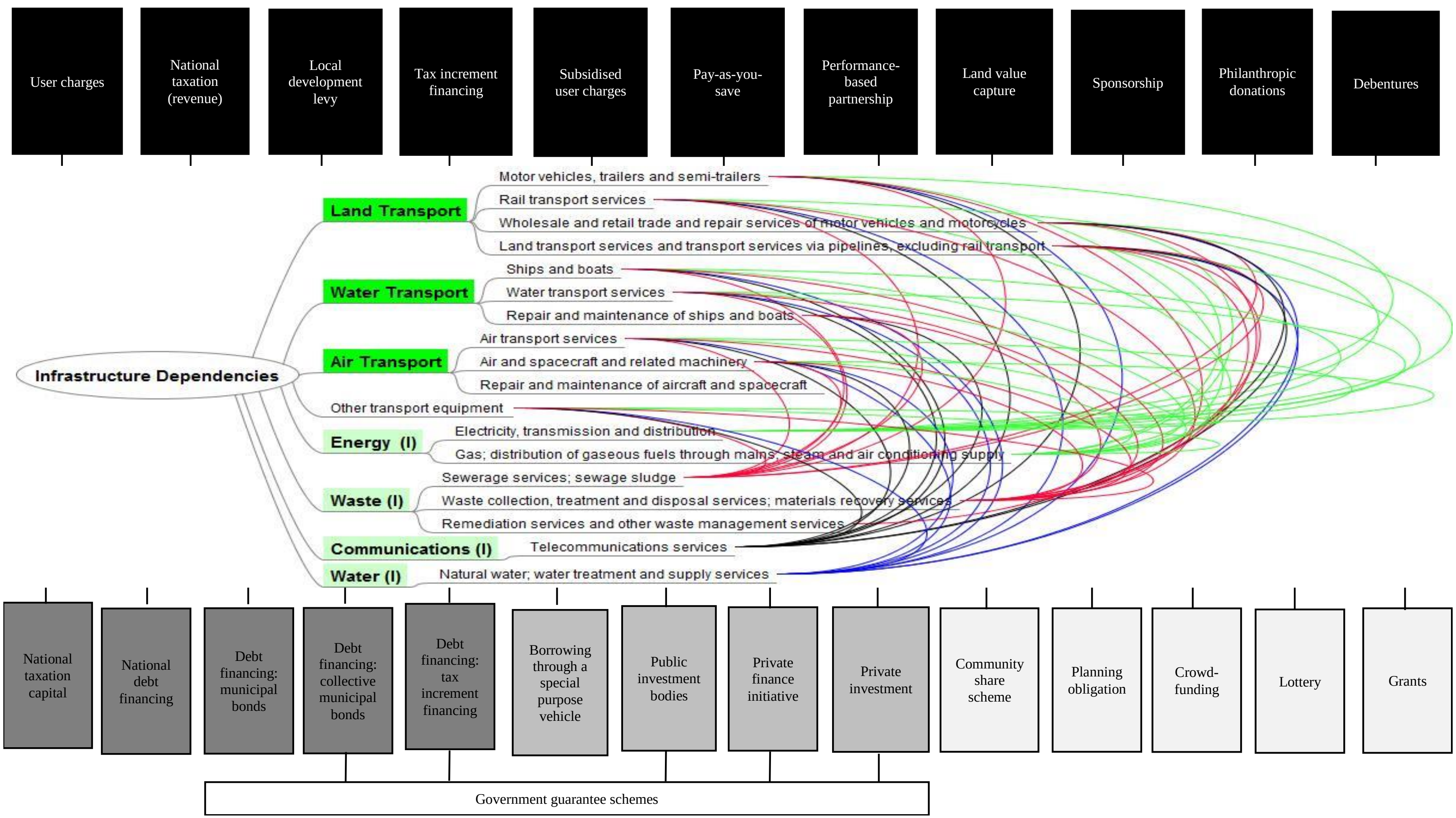
Aims and Objectives (aligning with iBUILD & Liveable Cities projects)

- *Understand the Environmental Value Interdependencies of Transport Infrastructure*
- *Devise a new Transport Business Model that takes account on these interdependencies*

Briefly
Target Explanation

Environmental interdependencies

Figure 1: Infrastructure business models



Introduction

From ancient times until now:

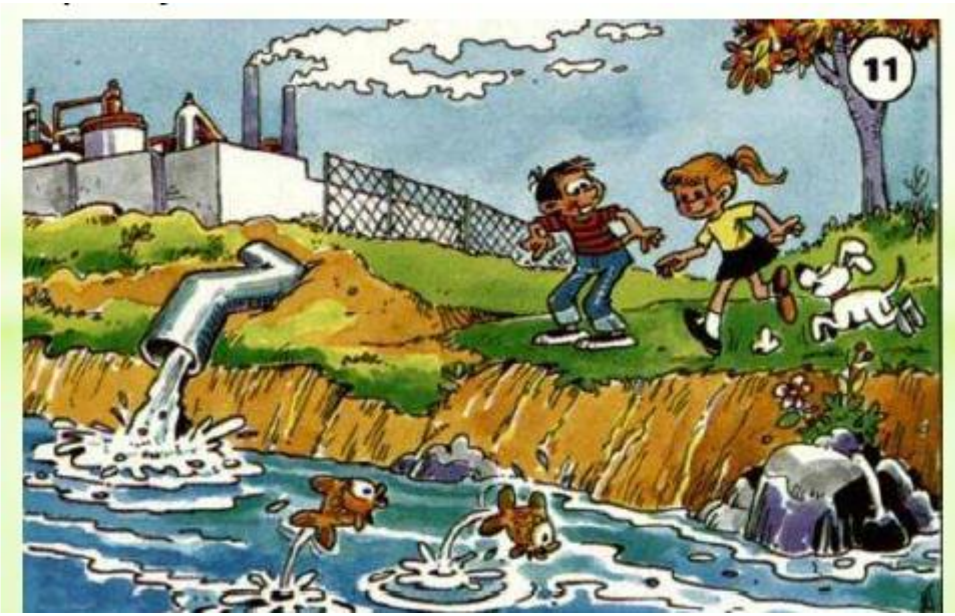
- Use of the natural resources to cover human needs

What the environment offers:

- Raw materials
- Receiving the waste

of human activities

- Life
- Recreation



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Introduction

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Environment affects us all but.... not everyone is concerned about it

Introduction

Causes of the environmental crisis:

- Natural Resource Scarcity
- Environmental Ethics
- Institutional Framework of Environmental Impact
- Economic value
- Unsaturated human needs (social value)

Theoretical Methodology

Sustainable Development Definition (1987):

"…is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

Key- concepts:

- "…needs…"
- "…without compromising the ability of…" (limitation)

Theoretical Frame of Reference

Environmental Value

- Environmental value may be defined by the natural and anthropogenic factors and elements which interact and influence the ecosystem, the quality of life, human well-being and human health (Riffat et al, 2016; Khatri & Tyagi, 2015; Summers et al, 2012).

- Environmental damaging actions may be considered or expressed with the followings: environmental pollution, environmental degradation, environmental contamination extraction of natural resources which causes depletion of natural resources etc. (FAO, 2017)

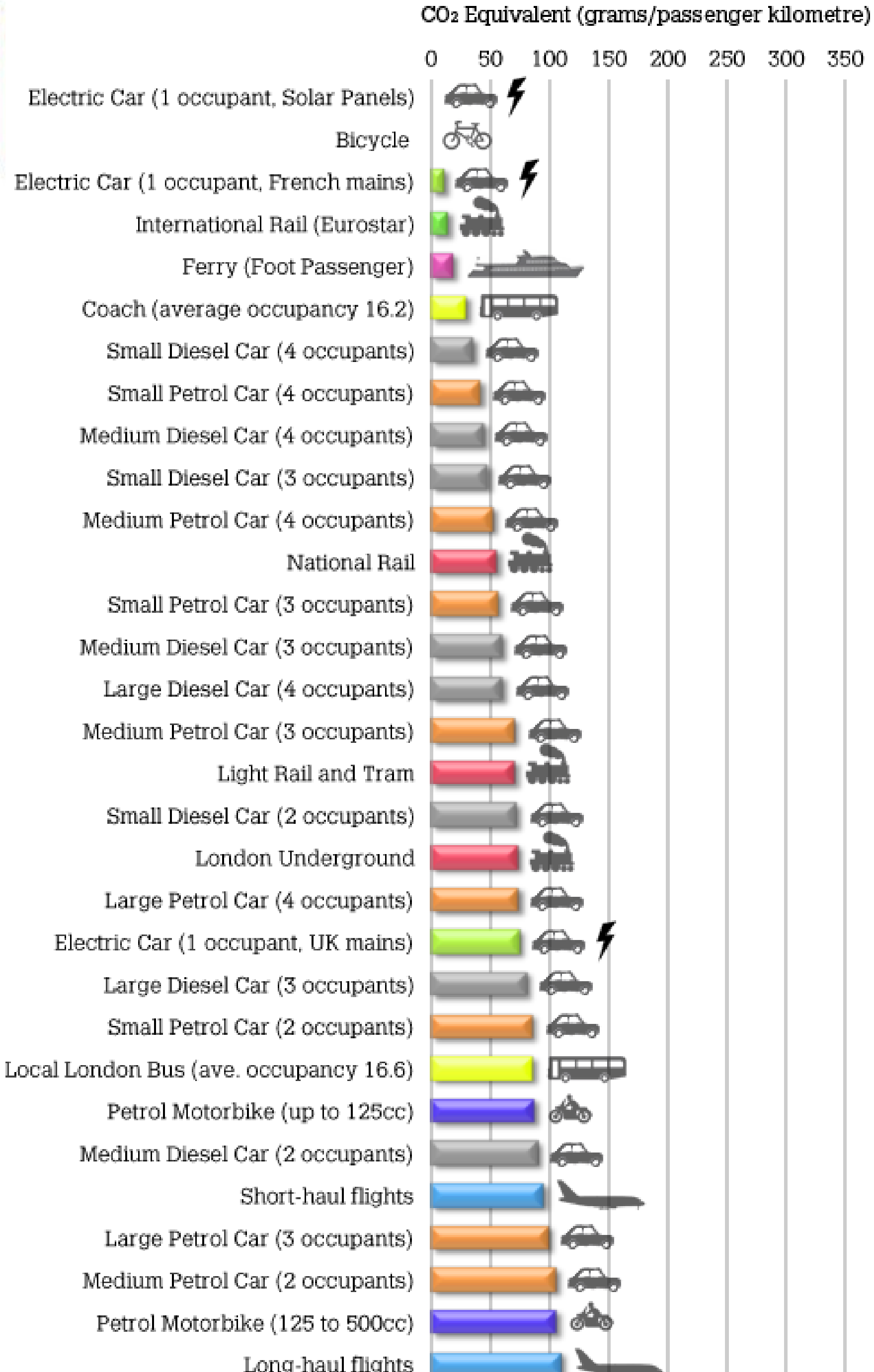
Theoretical Frame of Reference

Research proposition: Environmental Value

- Emissions are the wide accepted way to “calculate” the environmental damaging actions. Emission addresses the production of pollutants and the waste placement into the environment (FAO, 2017).

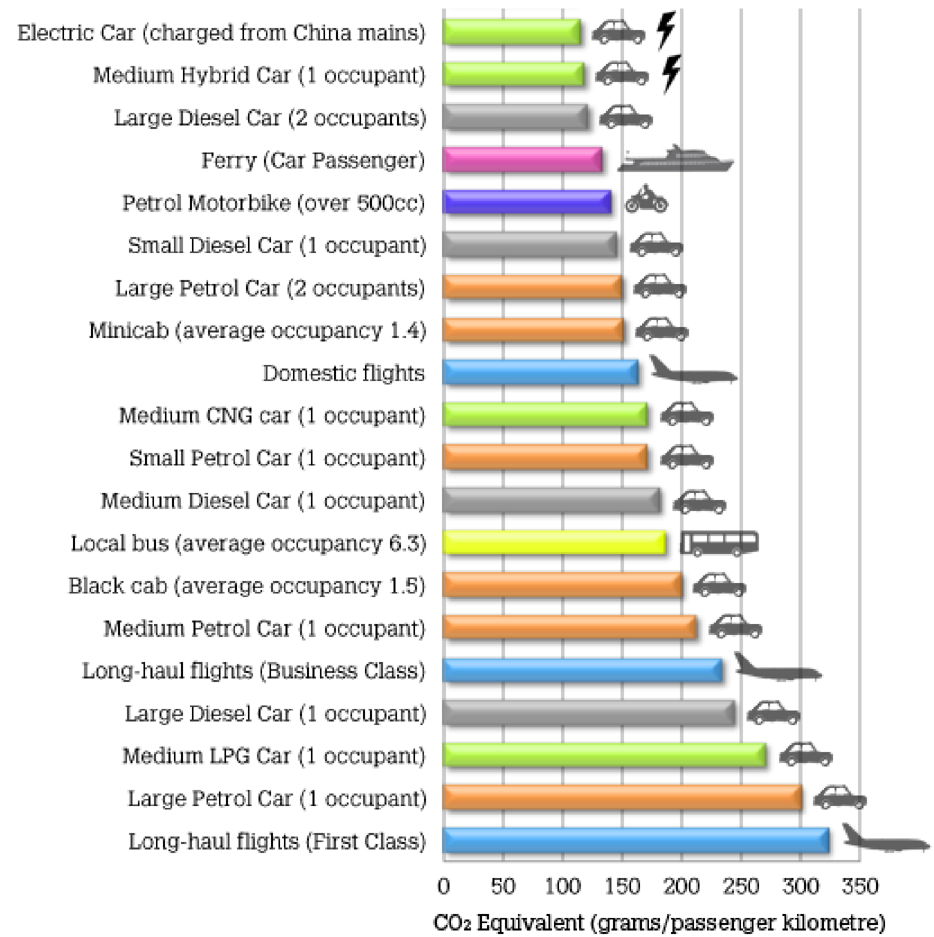
Methodology:

- Correlate data of Input –Output tables EXIOBASE 3 (Stadler et al., 2018)
- Why is it difficult to use primary data?



Buenos Aires to London

(Source: http://www.beagleybrown.com)



Primary data Methodology

- Questionnaire:

300 individuals

1											Evaluation												
Postcode	Age	Ethnic	Gend.	Indiv.	Cars/ Veh.	Income (x1000)	Distan (Km)		Percent	Goods	Main	Walking	Cycling	Rail	Bus	Car	Taxi		Travel Time	Excess Time	Travel Cost	Confort & Conven.	Safety & Security
Birmingham B191L	20-29	White	F	2	0	0-10	7	Walking	15	x	Bus	4	-1	3	3	5	5	Walking	2	5	5	4	4
								Cycling										Cycling	0	4	1	-3	-3
								Rail										Rail	3	3	2	4	3
								Bus	80									Bus	3	4	4	-1	-1
								Car										Car	3	5	-1	4	4
								Taxi	5									Taxi	4	5	-2	4	4
Adjust to society:			Yes	Main reason:		Time			Trips	Distan													
Never cross the street if there is no zebra line								Air	1	311	General	Air			Water			Air	5	-1	0	4	4
								Water	4	186		4			4			Water	3	2	2	3	5

- The distance is not accurate
- We do not have data enough data for the car types
- Missing data from other transport modes too
- Worst case scenario assumption

Primary data Methodology

Automobile emissions in the UK

Type of Vehicles	Emissions
Small motorbike/moped/scooter up to 125cc: 100000 km	10.19 tonnes of CO_2e
Medium motorbike over 125cc up to 500cc:	12.41 tonnes of CO_2e
Large motorbike over 500cc: 100000 km	16.28 tonnes of CO_2e
Average petrol car (half full average car)	18.57 tonnes of CO_2e
Average petrol hybrid car	11.79 tonnes of CO_2e

Primary data Methodology

This study		Worst case scenario	(£ 12.90 incl. 20% VAT per tonne)
Walking	Walking: 100000 km	0 tonnes of CO2e	£ 0
Cycling	Cycling: 100000 km	0 tonnes of CO2e	£ 0
Rail	Tube / Subway: 100000 km	7.52 tonnes of CO2e	£ 97.01
	Tram: 100000 km		
	International rail: 100000 km		
	National rail: 100000 km		
Bus	Coach: 100000 km	10.26 tonnes of CO2e	£ 132.35
	Bus: 100000 km		
Car	Average petrol car	18.57 tonnes of CO2e	£ 239.56
Car (Hybrid)	Average petrol hybrid car	11.79 tonnes of CO2e	£ 152.09
Taxi	Taxi: 100000 km	15.62 tonnes of CO2e	£ 201.5
Air	Short-haul flight	28.54 tonnes of CO2e	£ 368.17
	Long-haul flight		
	Domestic flights		
Water		0.61 tonnes of CO2e	£ 7.89

Primary data Methodology

Survey	Day (Km)	Year (Km)/300	Year (%)	Cost (£) /10^5Km	Year (Km) Metropolitan areas	Cost (£) Metropolitan areas/Year
Walking	489.7	178740.5	5.27%	0	0	0
Cycling	357.9	137791.5	4.05%	0	0	0
Rail	1273.1	464681.5	13.69%	97.01	50426240412.65	48918495.82
Bus	810.9	295978.5	8.72%	132.35	32118952439.42	42509433.55
Car	4392.1	1603116.5	47.23%	239.56	?	?
Hybrid	?	?	?	152.09	?	?
Taxi	79.3	28944.5	0.85%	201.5	3140995102.29	6329105.13
Air	-	676412	19.93%	368.17	73402780463.61	270247016.8
Water	-	8658	0.26%	7.89	939547603.02	74130.31
Total	7403	3394323	100%	-		?

Methodology

EXIOBASE 3 (Stadler et al., 2018):

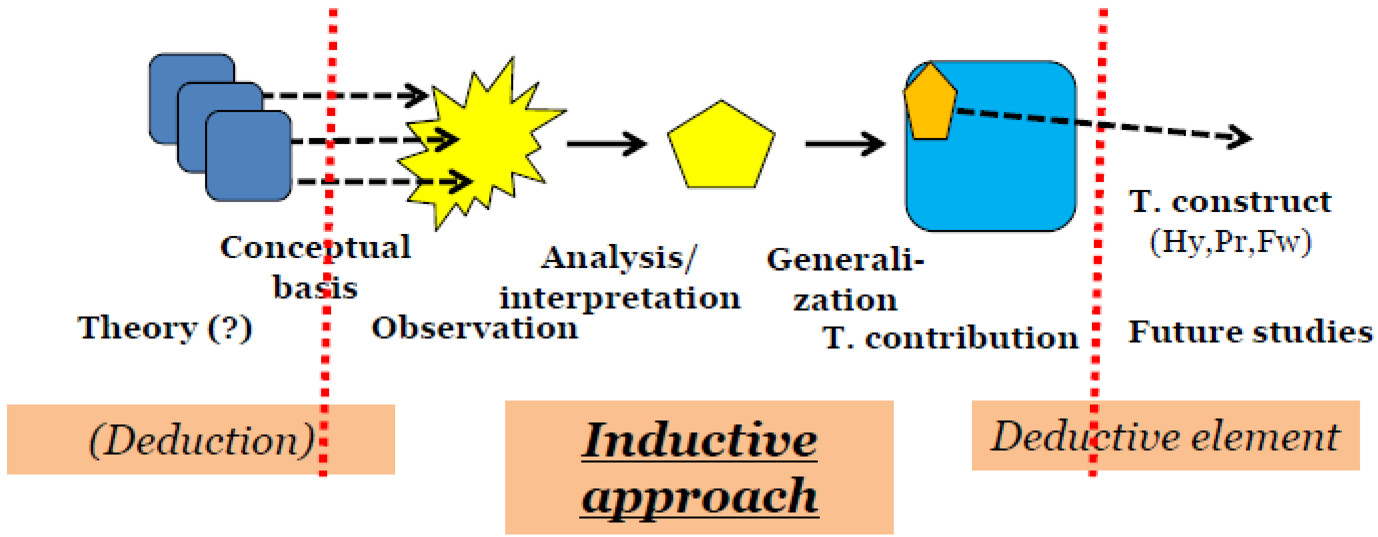
- 85 types of emissions (air & water) per demand in euros
- 44 countries (28 EU member plus 16 major economies)
- Same year 2007 (2018 under issue):

48 counties/areas x 85 emission

Methodology

Inductive approach:

- Based on the observation only 29 emission are produced by the industries of interest



Environmental Value

Transport		GB	GB	GB	GB	GB	GB
Combustion	/M.EUR	Transport via railways	Other land transport	Transport via pipelines	Sea and coastal water transport	Inland water transport	Air transport
CO2	kg	111343.9	75817.3	71681.49	1108655.203	1.83E+07	1862350.55
CH4	kg	6.238257	4.54647	4.298415	78.72147886	1256.948296	14.3246283
N2O	kg	42.21357	28.65806	27.09408	73.19358565	4603.169686	53.2051471
SOx	kg	17.04783	1.969464	1.861975	17143.43579	152268.3867	568.83487
NOx	kg	1811.144	519.2538	490.9285	25327.8992	408003.4647	6118.75415
NH3	kg	0.270514	1.05822	1.000488	0.05264327	0.047646388	0.17962125
CO	kg	371.9159	178.2455	168.5243	2609.062487	41939.39313	11860.3205
Benzo(a)-pyrene	kg	0.001062	0.00117	0.001106	6.13E-05	5.55E-05	0.0020887
Benzo(b)-fluoranthene	kg	0.001836	0.004233	0.004003	0.007221654	0.113501983	0.00240859
Benzo(k)-fluoranthen	kg	9.78E-04	6.61E-04	6.25E-04	2.80E-05	2.54E-05	1.22E-04
Indeno(1,2,3-cd)pyrene	kg	6.25E-04	4.27E-04	4.04E-04	0.003532855	0.056681484	6.18E-05
PCDD_F	kg I-TEQ	2.70E-09	2.46E-09	2.33E-09	1.13E-10	1.02E-10	4.57E-10
NMVOC	kg	160.2165	28.55117	26.99358	844.7898495	13600.89201	435.243209
PM10	kg	50.23377	30.27385	28.62203	2122.43322	18402.08881	12.4706341
PM2.5	kg	47.76662	27.92559	26.40159	2122.333157	18402.00751	57.8458301
TSP	kg	53.38177	44.33343	41.91496	2123.055043	18402.64132	14.1566342
As	kg	0	0	0	154.8712546	1086.557878	0
Cd	kg	3.51E-04	2.74E-04	2.59E-04	9.292351941	65.21871018	9.31E-05
Cr	kg	0.001817	0.003572	0.003377	0.063771562	0.574430091	7.68E-04
Cu	kg	0.06095	0.092727	0.087669	154.87521	1086.561458	0.02219303
Hg	kg	0	0	0	6.197080476	43.62924232	0
Ni	kg	0.002449	0.001726	0.001632	9.294917712	65.42838692	6.47E-04
Pb	kg	0.009344	0.006423	0.006072	0.066397099	0.784160389	0.00138649
Se	kg	3.51E-04	3.02E-04	2.85E-04	0.132253666	1.567866517	9.63E-05
Zn	kg	0.035647	0.047423	0.044836	0.301652597	3.70419127	0.01178429
NMVOC (non combustion)	kg	94.03963	117.3346	1.142945	11.18485141	22.71792767	44.9018179

Environmental Interdependencies

Correlation using SPSS software:

Transport
Waste
Water
Energy
and Communication

WLPaper - WLWood	**0.888**	**W-W**
WIOil - WLMetal	0.887	W-W
WIFood - WIPaper	0.874	W-W
WLTextile - WLWood	0.872	W-W
EnergyCoal - EnergyDistrib	0.846	E-E
EnergyTransm - NWaterDistrib	0.841	E-N
EnergyCoal - EnergyTransm	0.828	E-E
WWFood - WWOther	0.816	W-W
TManufMotor - TPipelines	0.803	T-T
EnergyNuclear - EnergyWind	0.767	E-E
EnergyDistrib - NWaterDistrib	0.761	E-N
WLPaper - WLPlastic	0.753	W-W
WLFood - WLPlastic	0.750	W-W
EnergyOcean - WCPaper	0.731	E-W
TSaleFuel - Communic	0.725	T-C
WLPlastic - WLTextile	0.715	W-W
EnergyCoal - NWaterDistrib	0.707	E-N
TRail – Communic	0.617	T-C
EnergyPetrol - TAir	0.598	T-E
WWFood - WLFood	0.591	W-W
TSea - WIPlastic	0.591	T-W
TSea - WITextile	0.591	T-W
EnergyGeoth - TPipelines	0.589	E-T
WWFood - WLPaper	0.579	W-W

Next steps:

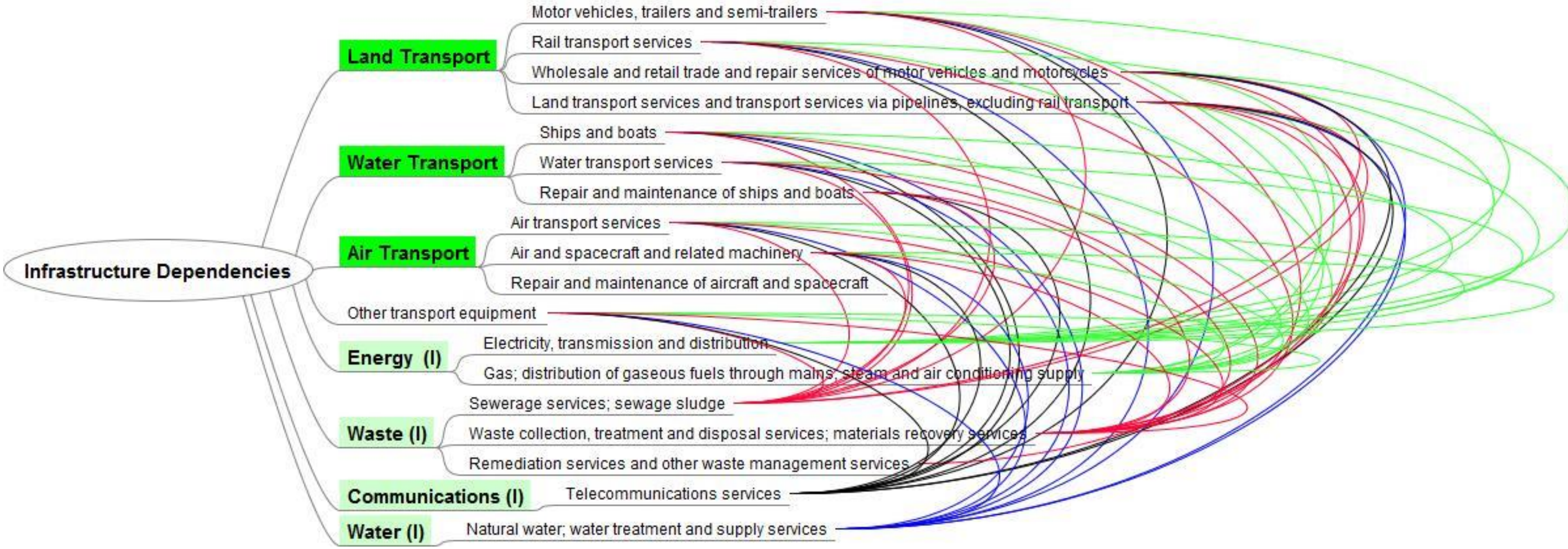
- Exclude zeros and missing values
- Exclude same type of input

Environmental Interdependencies

Emission	Transport Dependency	Other Dependency
CO_2	Energy-Transport; Communication-Transport (Pipelines, Rail); Water-Transport; Waste-Transport	Energy-Water; Water-Waste; Energy-Communication; Energy-Waste
CH_4	Energy-Transport; Communication-Transport (Manufacture)	Energy-Water; Energy-Communication
N_2O	Energy-Transport; Communication-Transport	Energy-Water; Water-Waste
SO_x	Energy-Transport; Communication-Transport (Pipelines); Water-Transport (Sales); Waste-Transport	Energy-Waste
NO_x	Waste-Transport (Sales; Transport through Water with Wastewater)	
NH_3	Communication-Transport; Energy-Transport; Waste-Transport	Energy-Water; Water-Waste;
etc	(The rest 23 are calculated now)	

Next step

Create a model of the interdependencies



ibuild

Liveable Cities

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Infrastructure Management:

Devise of a Business Model for Transport Infrastructure Interdependencies Management

Nikos Kalyviotis
Ph.D.(cand) Civil Engineering

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