URBAN SUSTAINABILITY ASSESSMENT

EURO PhD Summer School on MCDA/MCDM

Chania, Greece

July 23 - August 3, 2018

Group 7

The case assessed in this presentation is fictional. Any relation to cities and organizations as well as preference elicitations are made solely for the purpose of completing the case study of the EURO PhD Summer School on MCDA/MCDM. The intended audience for this presentation are fellow students of the summer school and evaluators.

OUR PURPOSE

- Professionals in decision aiding
- Providing decision aiding services for our clients

Group 7:	
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Børge Heggen Johansen	Norwegian University of Science and Technology, Norway
Esra Adiyeke	Boğaziçi University, Turkey
Fuqi Liang	Delft University of Technology, Netherlands
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Lysimachos Evangelinos Maltoudoglu	Democritus University of Thrace, Greece
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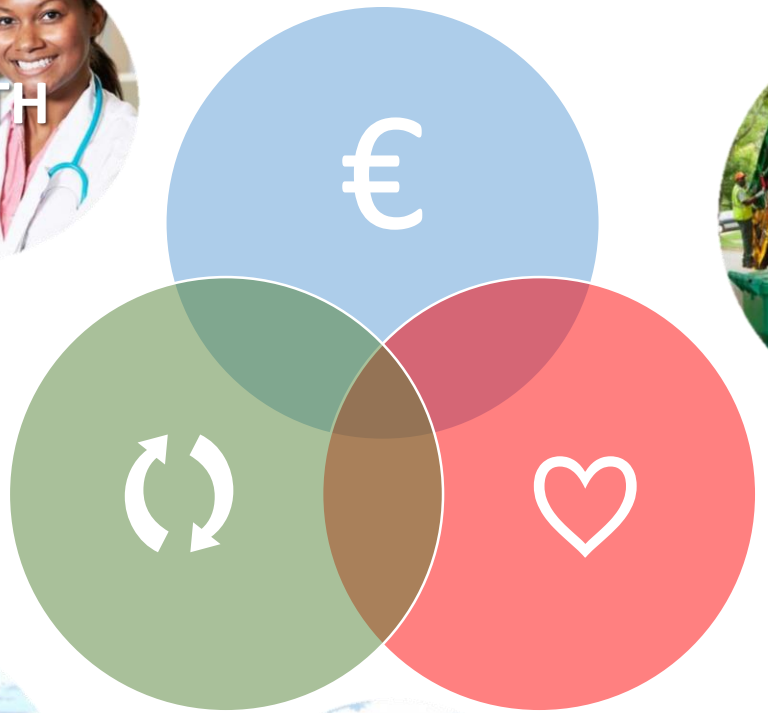
SUSTAINABLE CITIES

Urban Sustainability Assessment
Group 7, MCDA Summer School 2018

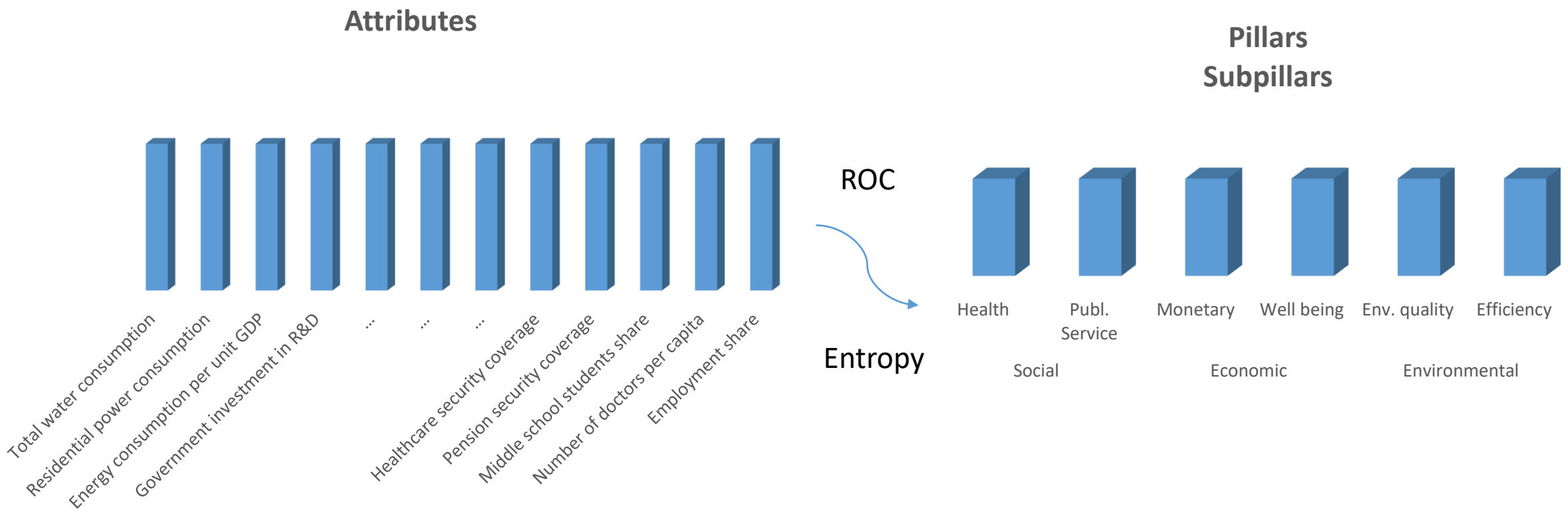


MISSION

- Global Compact Cities Programme
- Influencing city governments (DM) to take action for more sustainable cities and urban areas
- Existing sustainability measurement schemes for cities provide multiple indicators
- Difficult for DMs to relate to multiple indicators and consider trade-offs when considering policy implementation and investment projects

- **Group 7s - mission:**
  - Assist in creating overreaching sustainability dimensions
  - Aid in prioritization of criteria within dimensions
  - Make a global ranking of cities – providing DMs an overview of their sustainability performance

GENERAL IDEA
Part 1

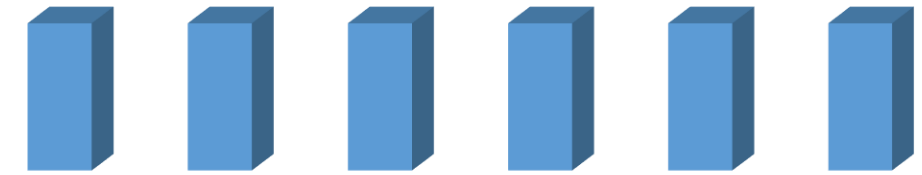


Original Data

Performance Matrix

GENERAL IDEA
Part 2

Pillars
Subpillars

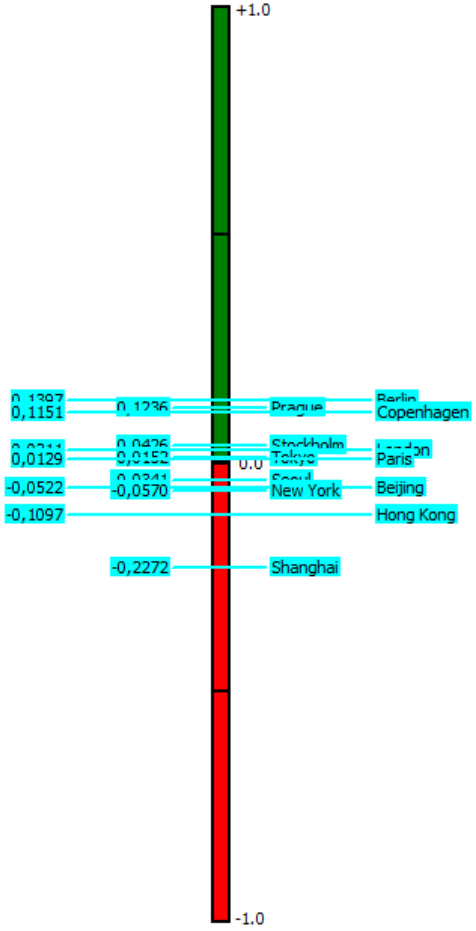


Health | Publ. Service | Monetary | Well being | Env. quality | Efficiency

Social | Economic | Environmental

Performance Matrix

PROMETHEE II



Ranking

TAXONOMY

Pillar		Social		Economic		Environmental	
subpillar	dir	health	publ. service	monetary	well being	env quality	efficiency
Employment_share	↗				high		
Number_of_doctors_per_capita	↗	high					
Middle_school_students_share	↗				mid		
Pension_security_coverage	↗				high		
Healthcare_security_coverage	↗	high					
Concentration_of_NO2	↘					mid	
Concentration_of_SO2	↘					mid	
Concentration_of_PM10	↘					mid	
Industrial_air_pollution_SO2	↘						high
Air_qualified_days_per_year	↗					high	
Wastewater_treatment_rate	↗		high				
Domestic_waste_treated	↗		high				
Urban_population_density	↗		mid				
Passengers_using_public_transit	↗		low				
Coverage_of_public_green_space	↗		low				
Public_water_supply_coverage	↗		high				
Household_access_to_Internet	↗		mid				
Disposable_income_per_urban_capita	↗			mid			
Service_share_in_GDP	↗			mid			
Government_investment_in_RandD	↗			high			
Energy_consumption_per_unit_GDP	↘						high
Residential_power_consumption	↘						high
Total_water_consumption	↘						high

WEIGHTING ROC

- Rank Order Centroid (ROC) method $w(r_k)$

$$w_1 \begin{cases} g_1 \\ g_2 \\ g_3 \end{cases}$$

$$w_2 \begin{cases} g_3 \\ g_4 \end{cases}$$

$$w_{\dots} \begin{cases} g_{\dots} \\ g_{\dots} \end{cases}$$

With:

$w_1 > w_2 > w_{\dots}$

$$w(r_k) = \frac{1}{n} \sum_{j=k \dots n} \frac{1}{j}$$

WEIGHTING ENTROPY

Entropy is a measure that uses probability theory to measure the uncertainty of information. It shows that the more **dispersive the data**, the **more useful** the data is.

1. Entropy **value** from information

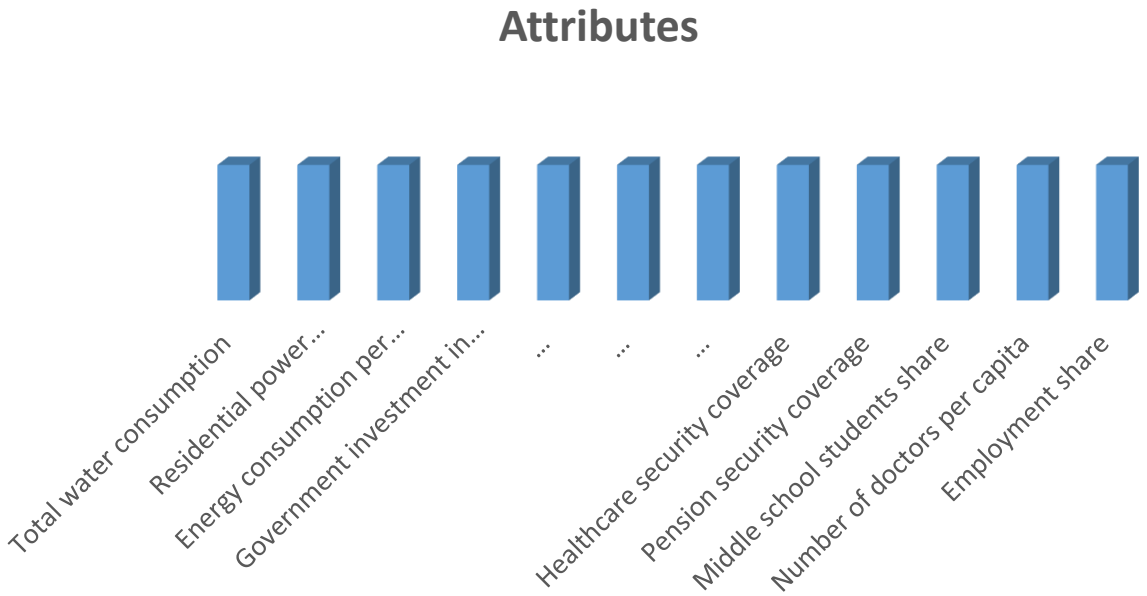
$$E_j = -K \sum_{i=1}^{m} r_{ij} ln r_{ij}$$

2. Difference degree

$$G_j = 1 - Ej$$

3. Entropy **weight** w:

$$w_j = G_j / \sum_{j=1}^{m} G_j$$



Normalized
Attribute matric

Beijing
Berlin
...
...
Tokyo

Matrix A

Attributes importance for each sub-pillar

ROC

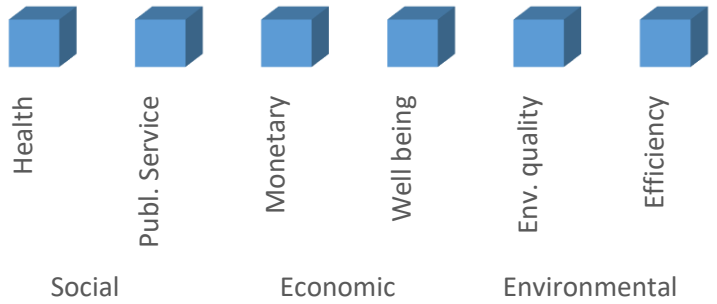
DM preference

Entropy

Data driven preference

Aggregate weights

Pillars
Subpillars



Matrix B

AGGREGATED WEIGHTS

Pillar		Social		Economic		Environmental	
subpillar		health	publ. service	monetary	well being	env quality	efficiency
indicator	dir	w	w	w	w	w	w
Employment_share	↗				0.37		
Number_of_doctors_per_capita	↗	0.64					
Middle_school_students_share	↗				0.35		
Pension_security_coverage	↗				0.28		
Healthcare_security_coverage	↗	0.36					
Concentration_of_NO2	↘					0.23	
Concentration_of_SO2	↘					0.15	
Concentration_of_PM10	↘					0.16	
Industrial_air_pollution_SO2	↘						0.21
Air_qualified_days_per_year	↗					0.46	
Wastewater_treatment_rate	↗		0.15				
Domestic_waste_treated	↗		0.14				
Urban_population_density	↗		0.13				
Passengers_using_public_transit	↗		0.13				
Coverage_of_public_green_space	↗		0.10				
Public_water_supply_coverage	↗		0.14				
Household_access_to_Internet	↗		0.20				
Disposable_income_per_urban_capita	↗			0.24			
Service_share_in_GDP	↗			0.31			
Government_investment_in_RandD	↗			0.45			
Energy_consumption_per_unit_GDP	↘						0.23
Residential_power_consumption	↘						0.26
Total_water_consumption	↘						0.30

PERFORMANCE MATRIX [P]

Normalized
Attribute matric

Aggregate
weights

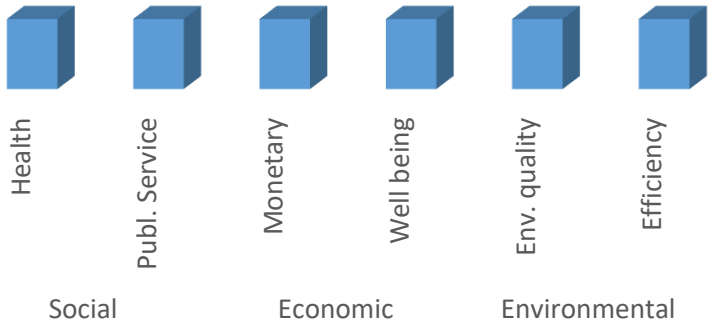
Subpillars

$[P] = [A] \times [B] =$

Beijing
Berlin
…
…
Tokyo

Matrix A

×



Matrix B

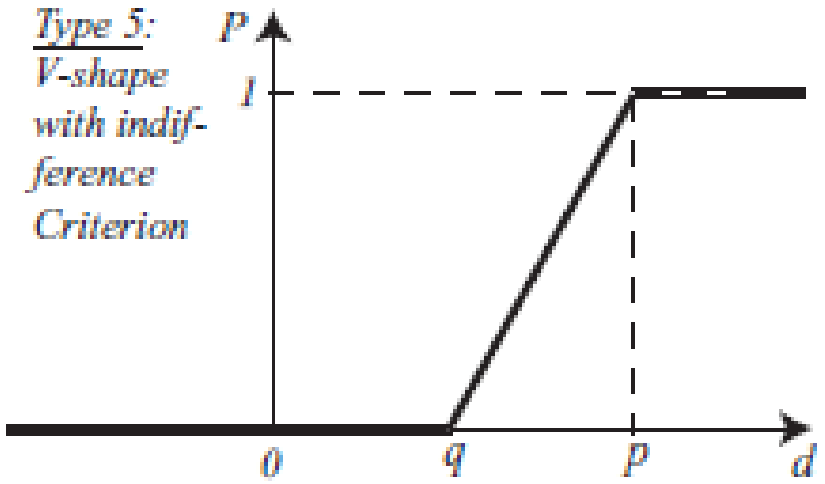
PERFORMANCE MATRIX [P]

[P] = [A] × [B] =

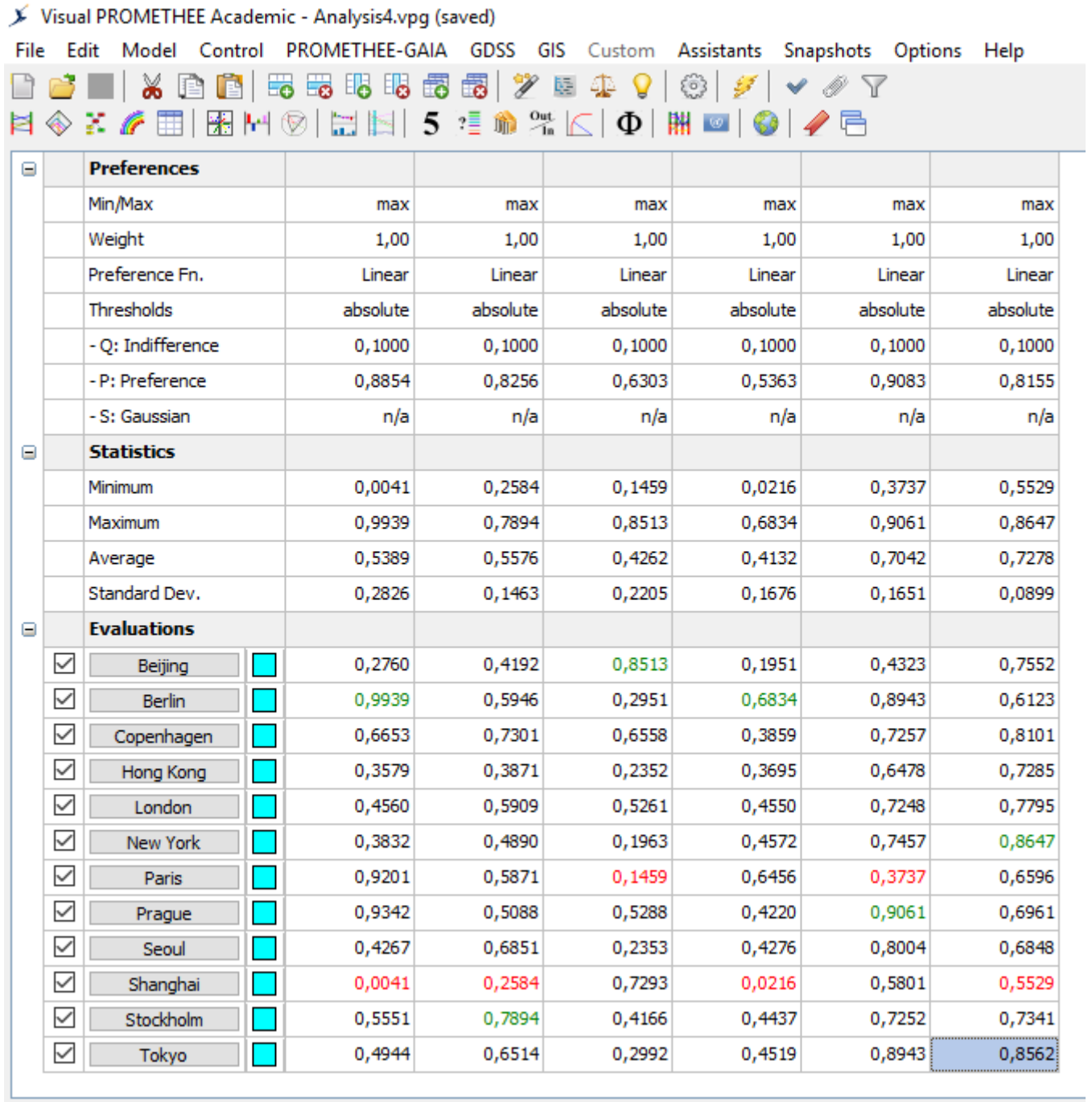
Pillar	Social		Economic		Environmental	
subpillar	health	publ. service	monetary	well being	env quality	efficiency
Beijing	0.2825	0.4737	0.8795	0.2147	0.5861	0.7291
Berlin	0.9915	0.7023	0.2698	0.6786	0.9245	0.6449
Copenhagen	0.7394	0.7963	0.6643	0.4796	0.7846	0.8218
Hong Kong	0.5000	0.4187	0.1848	0.4129	0.6682	0.7606
London	0.5764	0.6770	0.5034	0.5230	0.8599	0.7968
New York	0.4747	0.6340	0.1605	0.5408	0.7796	0.8741
Paris	0.9340	0.6801	0.1180	0.7500	0.1817	0.6753
Prague	0.9488	0.5967	0.5284	0.5051	0.9621	0.7333
Seoul	0.5385	0.7680	0.1843	0.4336	0.8425	0.7323
Shanghai	0.0032	0.3058	0.7765	0.0153	0.7213	0.4953
Stockholm	0.6535	0.8159	0.4411	0.5204	0.7608	0.7577
Tokyo	0.6063	0.7136	0.2426	0.5153	0.9245	0.8742

PROMETHEE II

V-Shape with indifference Criterion

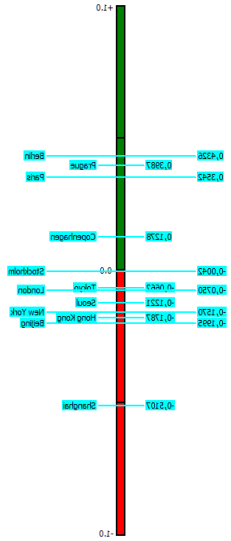


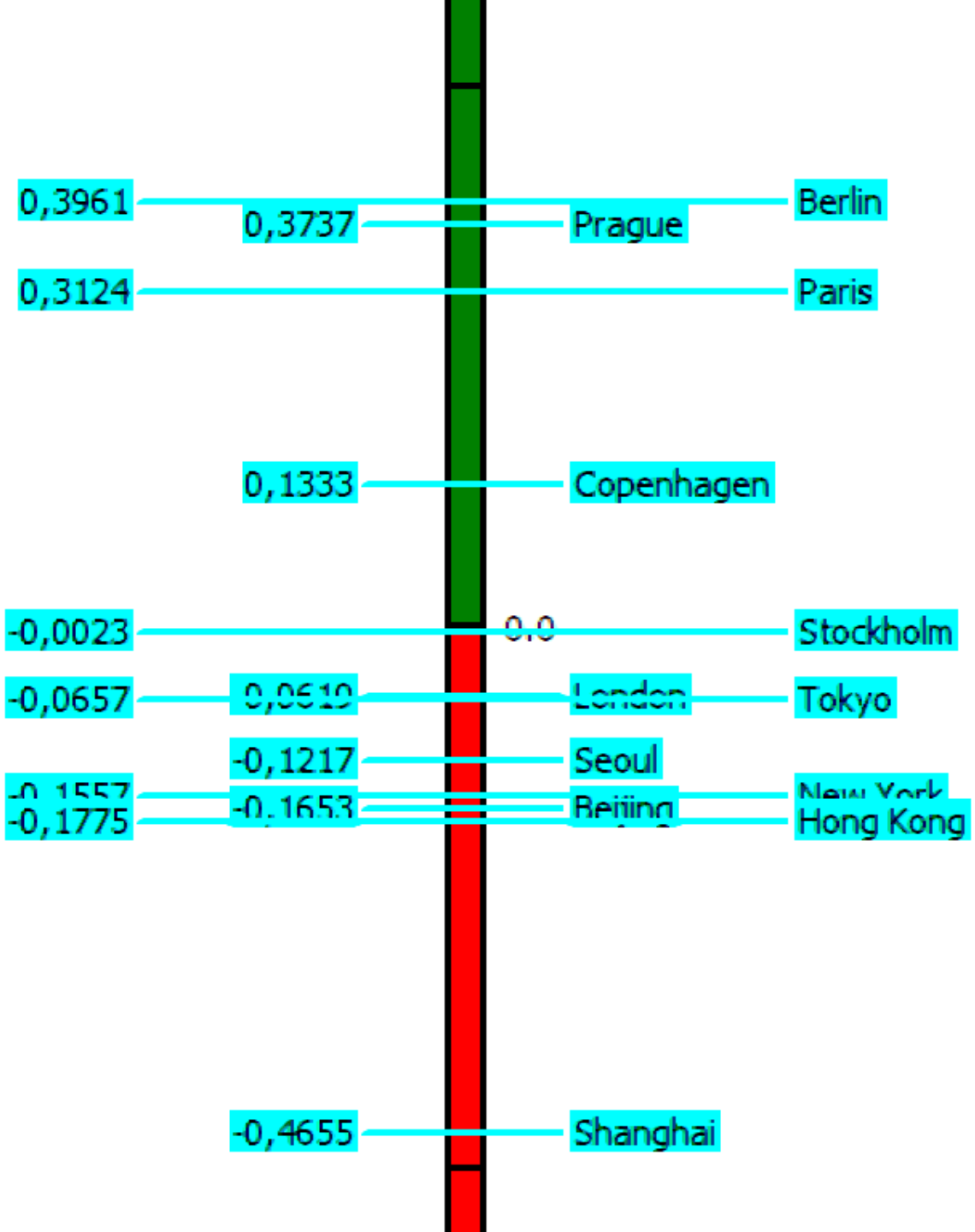
$$P(d) = \begin{cases} 0 & d \leq q \\ \frac{d-q}{p-q} & q < d \leq p \\ 1 & d > p \end{cases} \qquad p, q$$



Preferences							
Min/Max		max	max	max	max	max	max
Weight		1,00	1,00	1,00	1,00	1,00	1,00
Preference Fn.		Linear	Linear	Linear	Linear	Linear	Linear
Thresholds		absolute	absolute	absolute	absolute	absolute	absolute
- Q: Indifference		0,1000	0,1000	0,1000	0,1000	0,1000	0,1000
- P: Preference		0,8854	0,8256	0,6303	0,5363	0,9083	0,8155
- S: Gaussian		n/a	n/a	n/a	n/a	n/a	n/a
Statistics							
Minimum		0,0041	0,2584	0,1459	0,0216	0,3737	0,5529
Maximum		0,9939	0,7894	0,8513	0,6834	0,9061	0,8647
Average		0,5389	0,5576	0,4262	0,4132	0,7042	0,7278
Standard Dev.		0,2826	0,1463	0,2205	0,1676	0,1651	0,0899
Evaluations							
☑	Beijing	0,2760	0,4192	0,8513	0,1951	0,4323	0,7552
☑	Berlin	0,9939	0,5946	0,2951	0,6834	0,8943	0,6123
☑	Copenhagen	0,6653	0,7301	0,6558	0,3859	0,7257	0,8101
☑	Hong Kong	0,3579	0,3871	0,2352	0,3695	0,6478	0,7285
☑	London	0,4560	0,5909	0,5261	0,4550	0,7248	0,7795
☑	New York	0,3832	0,4890	0,1963	0,4572	0,7457	0,8647
☑	Paris	0,9201	0,5871	0,1459	0,6456	0,3737	0,6596
☑	Prague	0,9342	0,5088	0,5288	0,4220	0,9061	0,6961
☑	Seoul	0,4267	0,6851	0,2353	0,4276	0,8004	0,6848
☑	Shanghai	0,0041	0,2584	0,7293	0,0216	0,5801	0,5529
☑	Stockholm	0,5551	0,7894	0,4166	0,4437	0,7252	0,7341
☑	Tokyo	0,4944	0,6514	0,2992	0,4519	0,8943	0,8562

RANKING

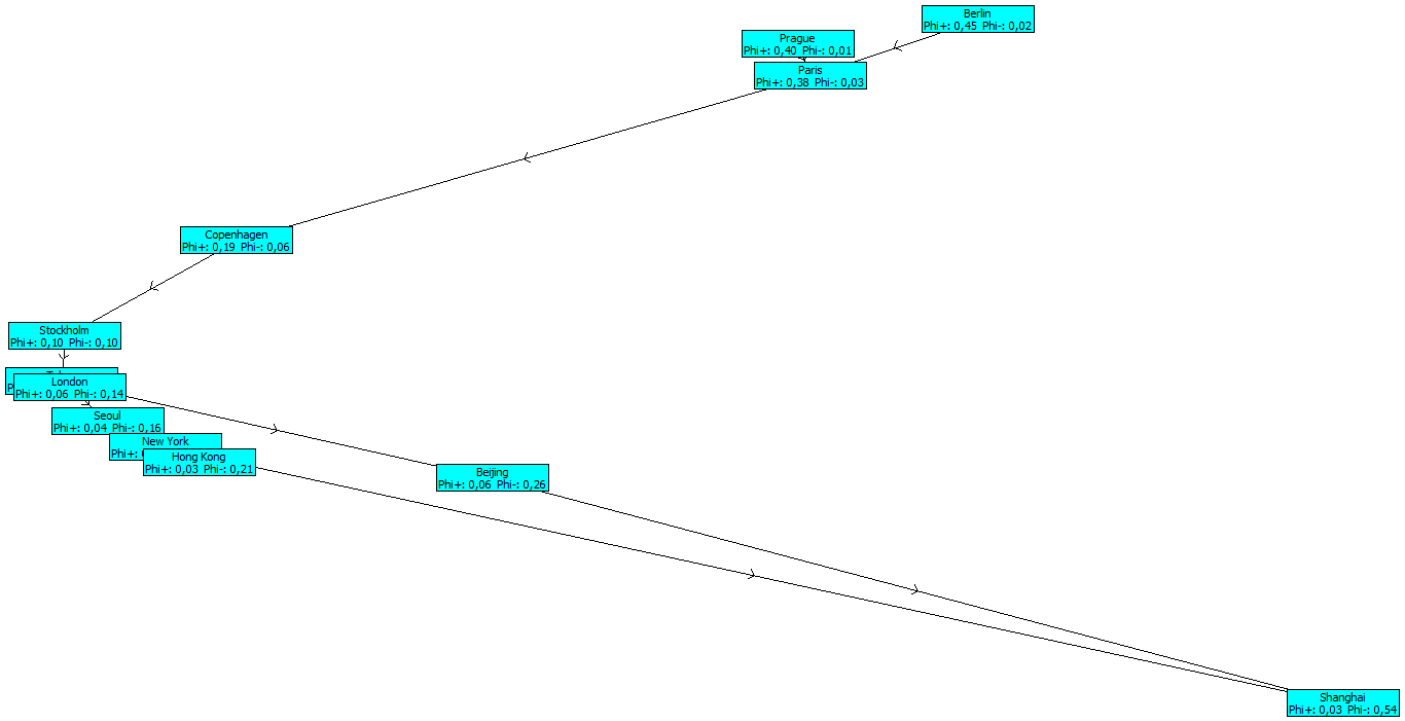



0,3961
Berlin
0,3737
Prague
0,3124
Paris
0,1333
Copenhagen
-0,0023
0.0
Stockholm
-0,0657
Tokyo
-0,1217
Seoul
-0,1775
Hong Kong
-0,4655
Shanghai

PROMETHEE FLOW TABLE

PROMETHEE Flow Table

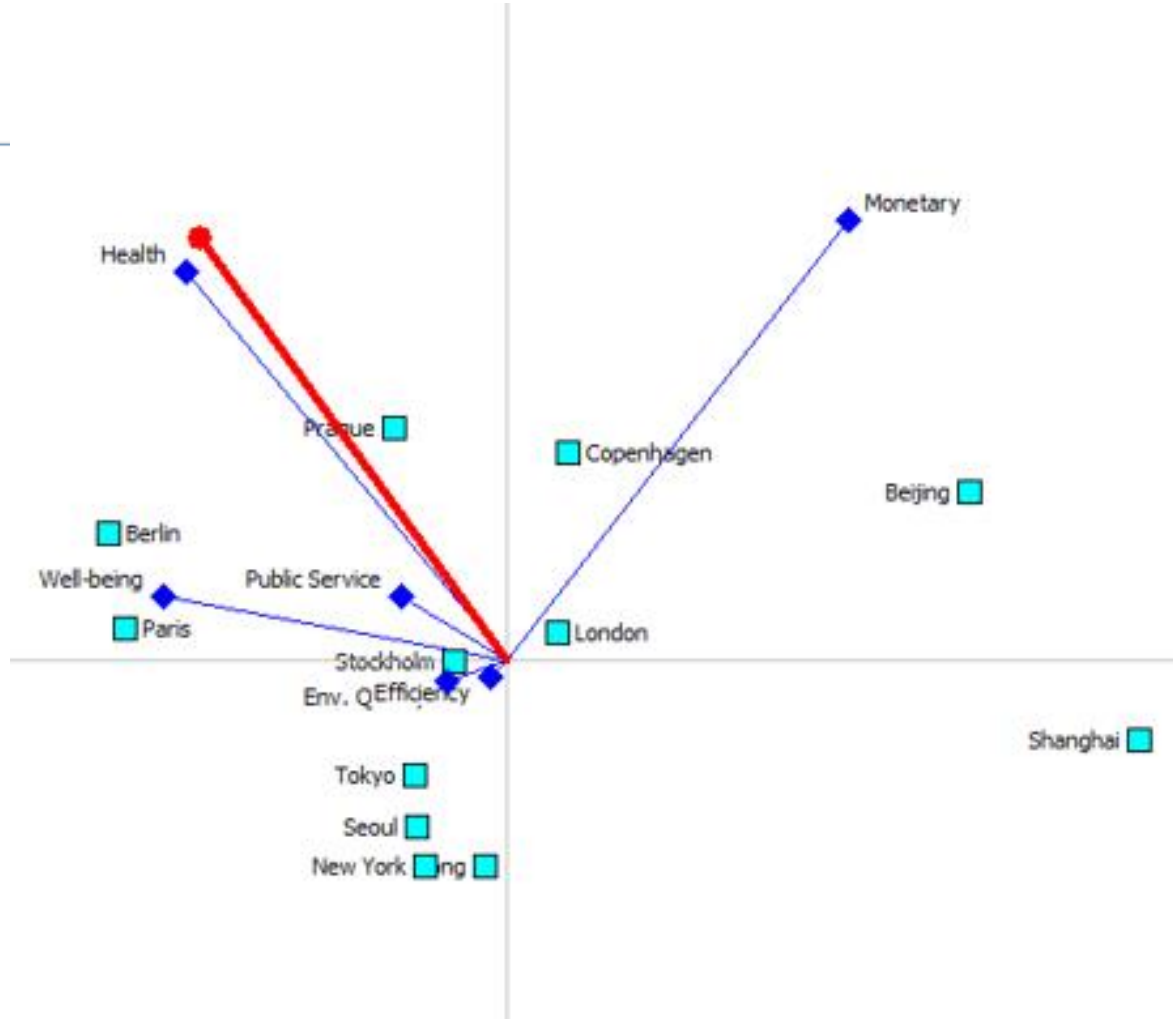
Rank	action	Phi	Phi+	Phi-
1	Berlin	0,4326	0,4484	0,0159
2	Prague	0,3987	0,4048	0,0062
3	Paris	0,3542	0,3845	0,0303
4	Copenhagen	0,1278	0,1865	0,0587
5	Stockholm	-0,0042	0,0951	0,0992
6	Tokyo	-0,0662	0,0637	0,1298
7	London	-0,0750	0,0604	0,1354
8	Seoul	-0,1221	0,0425	0,1646
9	New York	-0,1570	0,0336	0,1906
10	Hong Kong	-0,1787	0,0277	0,2064
11	Beijing	-0,1995	0,0606	0,2601
12	Shanghai	-0,5107	0,0307	0,5414



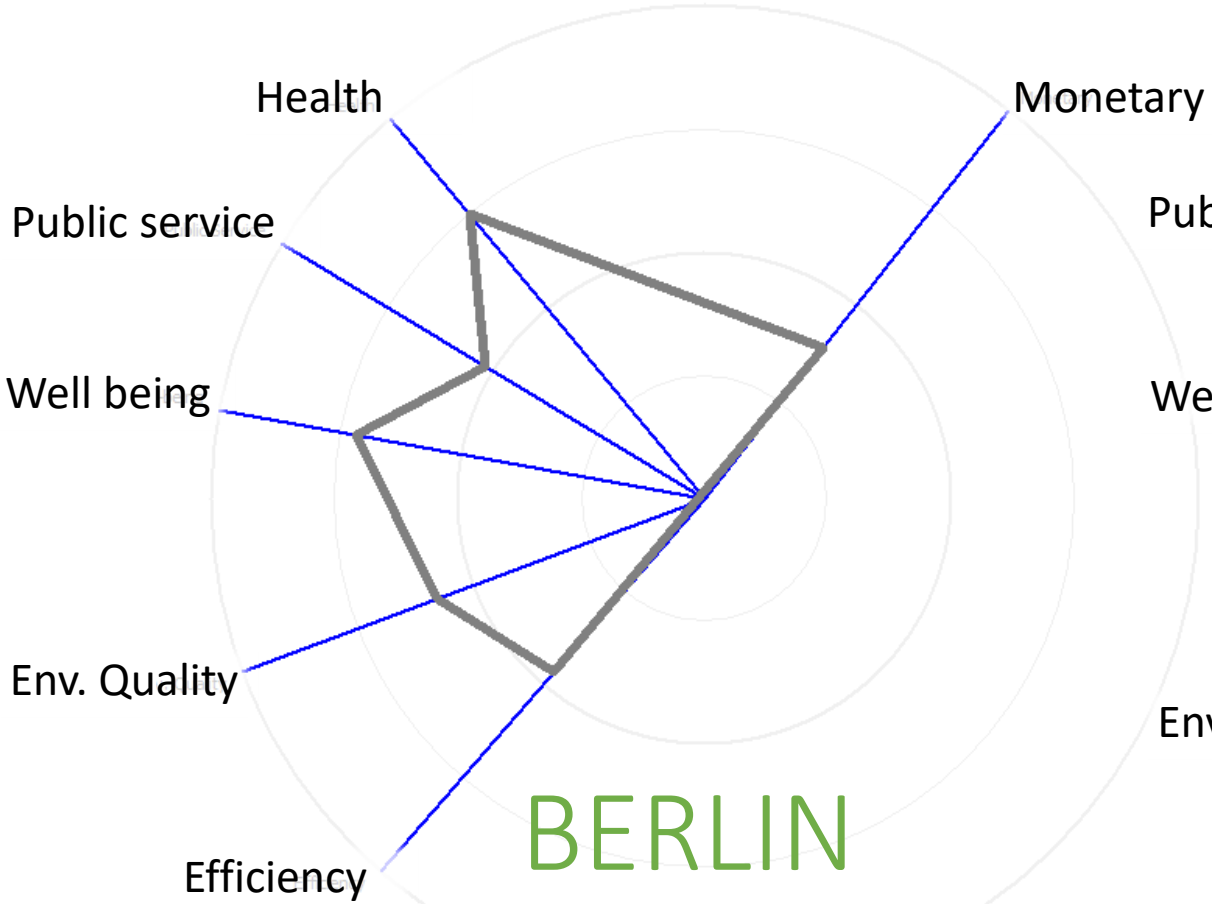
PREFERENCE FLOWS - GAIA

Φ Preference Flows

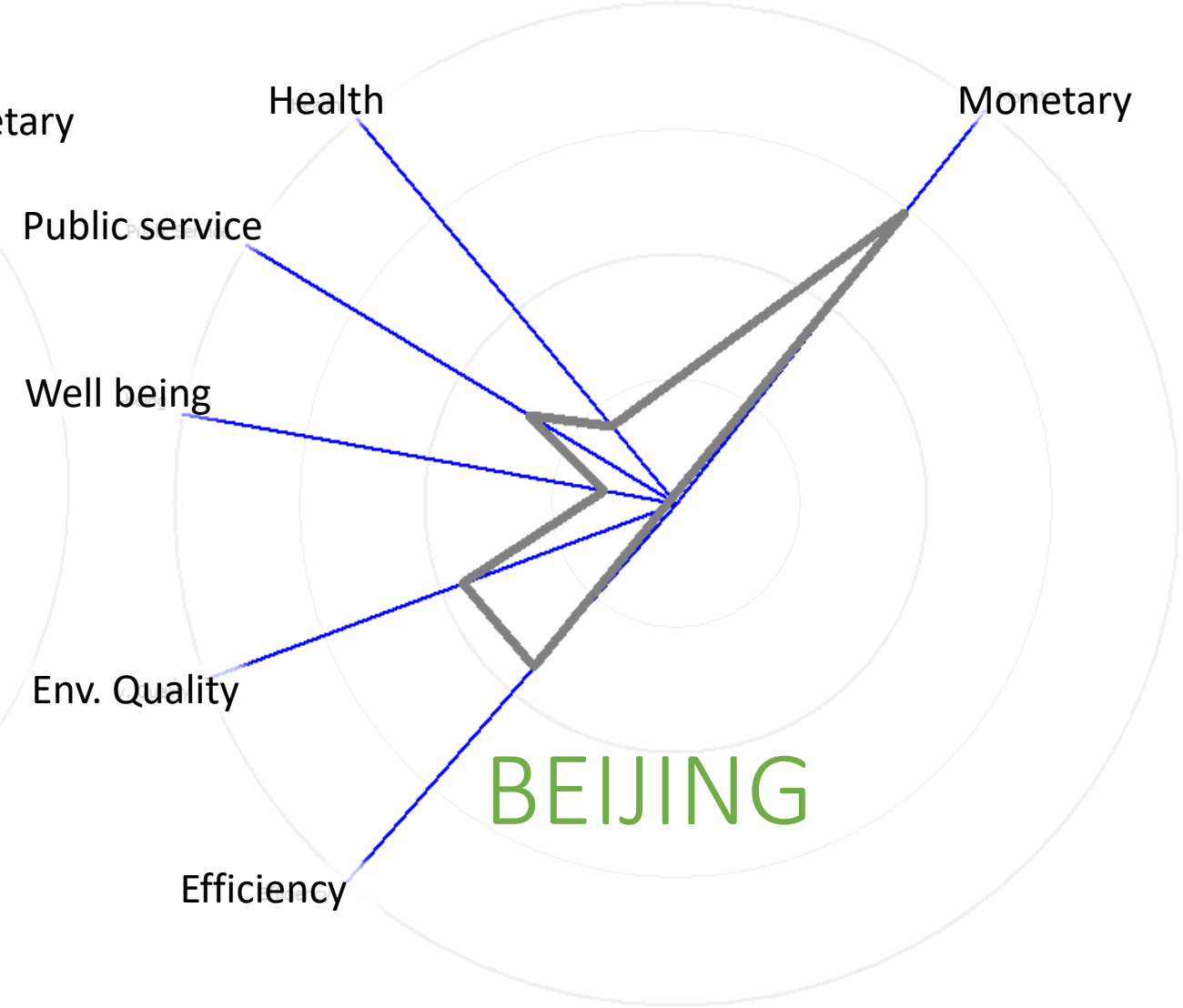
	Health	Public	Monetary	Well-being	Env. Quality	Efficiency
Beijing	-0,2631	-0,1169	0,6687	-0,3578	-0,2611	0,0171
Berlin	0,5003	0,0369	-0,2208	0,4332	0,1574	-0,0689
Copenhagen	0,1177	0,1511	0,3477	-0,0004	0,0308	0,0438
Hong Kong	-0,1808	-0,1521	-0,2909	-0,0141	-0,0241	0,0035
London	-0,0993	0,0341	0,1373	0,0572	0,0301	0,0272
New York	-0,1594	-0,0470	-0,3271	0,0590	0,0442	0,0882
Paris	0,4319	0,0315	-0,3874	0,3623	-0,3270	-0,0337
Prague	0,4450	-0,0312	0,1419	0,0297	0,1686	-0,0126
Seoul	-0,1229	0,1076	-0,2908	0,0343	0,0857	-0,0184
Shanghai	-0,5947	-0,3120	0,4737	-0,7055	-0,0924	-0,1321
Stockholm	-0,0076	0,2158	-0,0370	0,0477	0,0304	0,0064
Tokyo	-0,0671	0,0823	-0,2154	0,0546	0,1574	0,0796



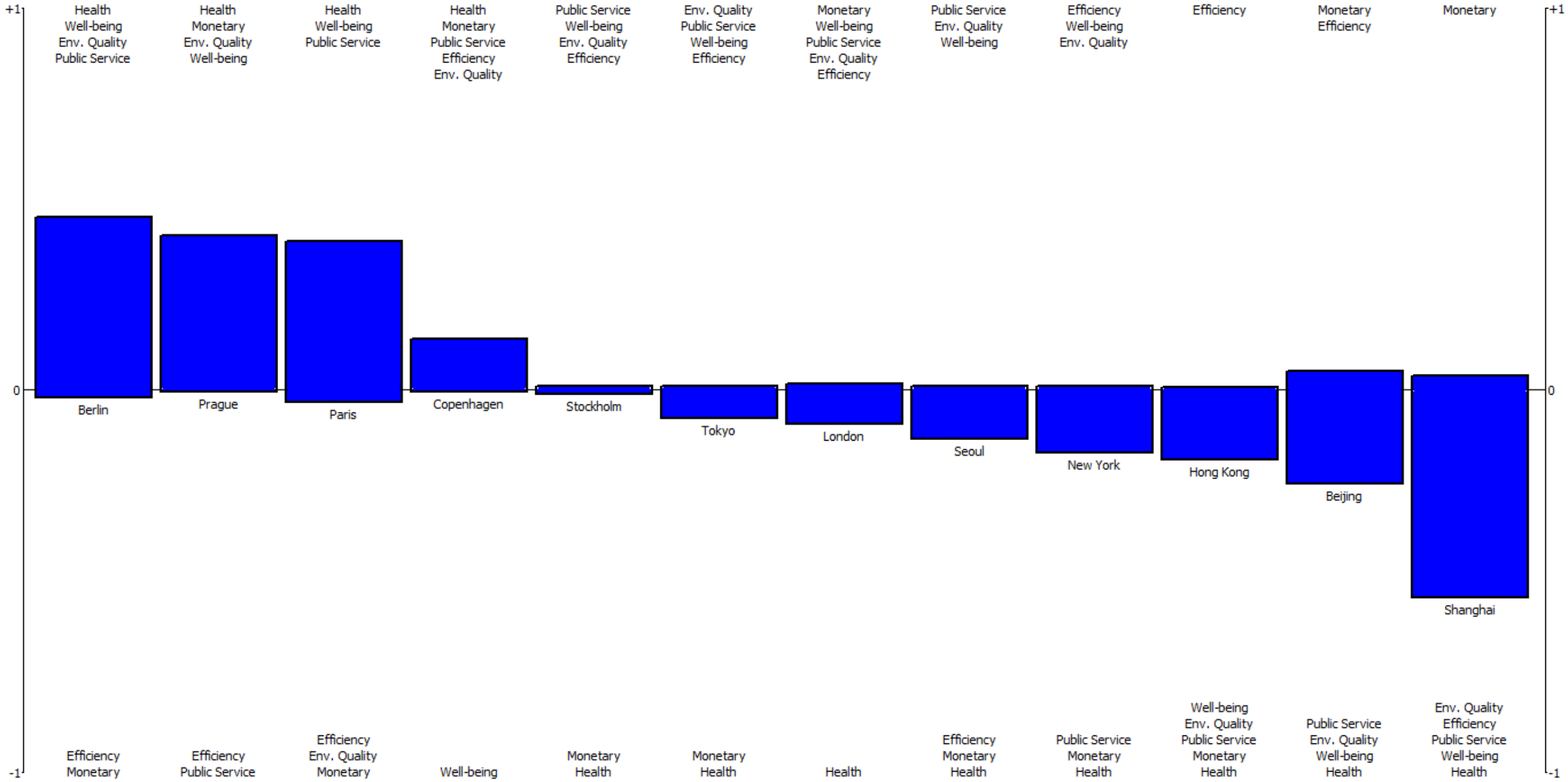
COMPARISON



BERLIN



BEIJING


+1
0
-1
Health
Well-being
Env. Quality
Public Service
Health
Monetary
Env. Quality
Well-being
Health
Well-being
Public Service
Health
Monetary
Public Service
Efficiency
Env. Quality
Public Service
Well-being
Env. Quality
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Efficiency
Monetary
Berlin
Prague
Paris
Copenhagen
Stockholm
Tokyo
London
Seoul
New York
Hong Kong
Beijing
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Efficiency
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Public Service
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Env. Quality
Monetary
Well-being
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Monetary
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Public Service
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Health
Well-being
Env. Quality
Public Service
Monetary
Health
Public Service
Env. Quality
Well-being
Health
Env. Quality
Efficiency
Public Service
Well-being
Health

THANK YOU FOR YOUR ATTENTION!

QUESTIONS?