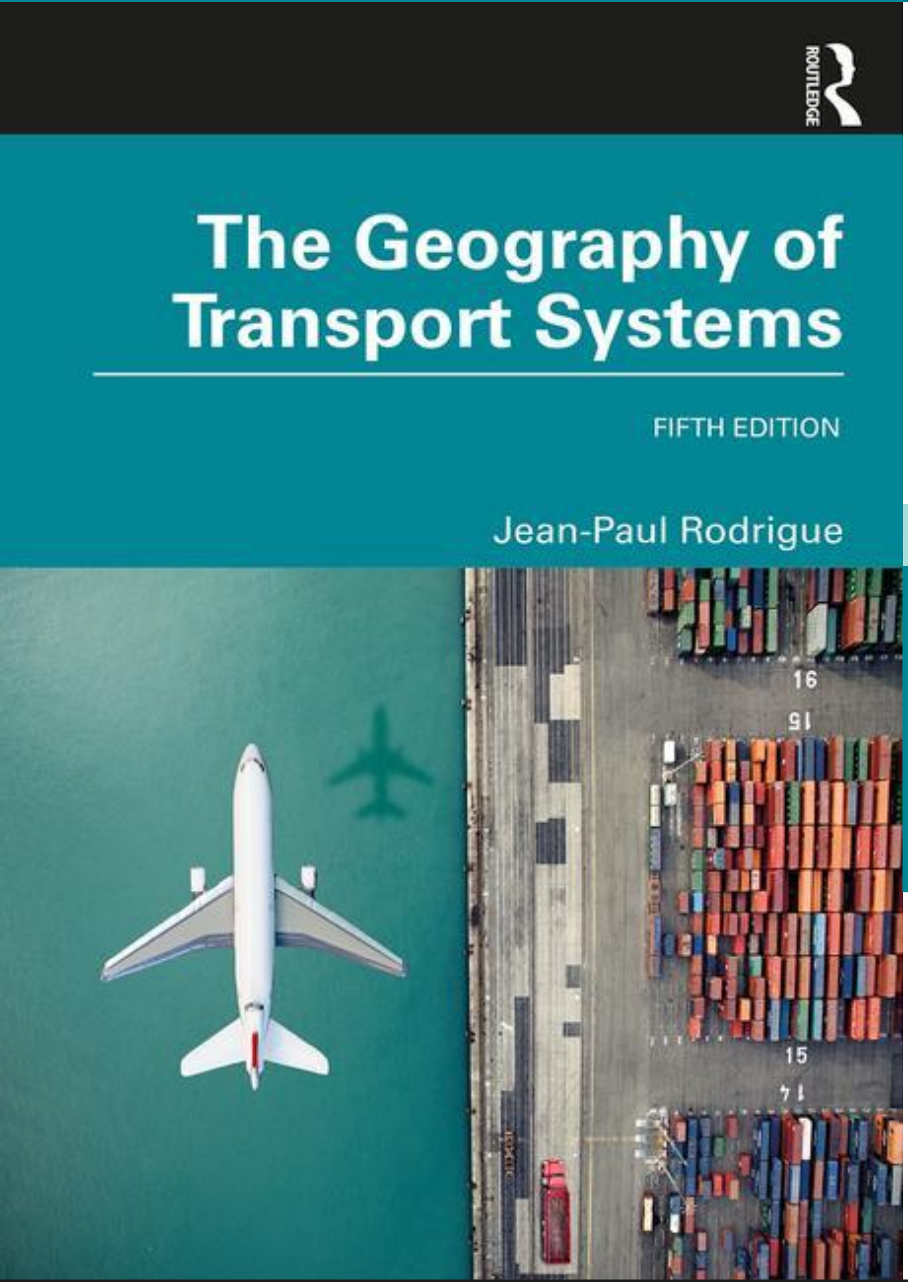

Methods in Transport Geography

APPENDIX A

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For more information: https://transportgeography.org/

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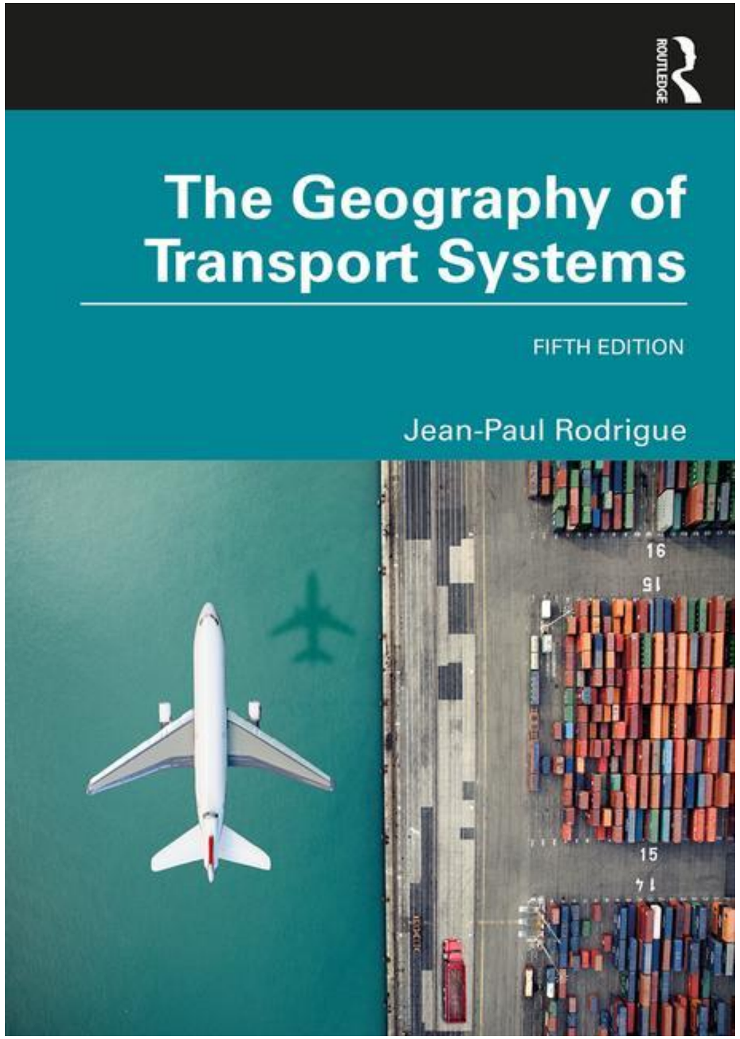
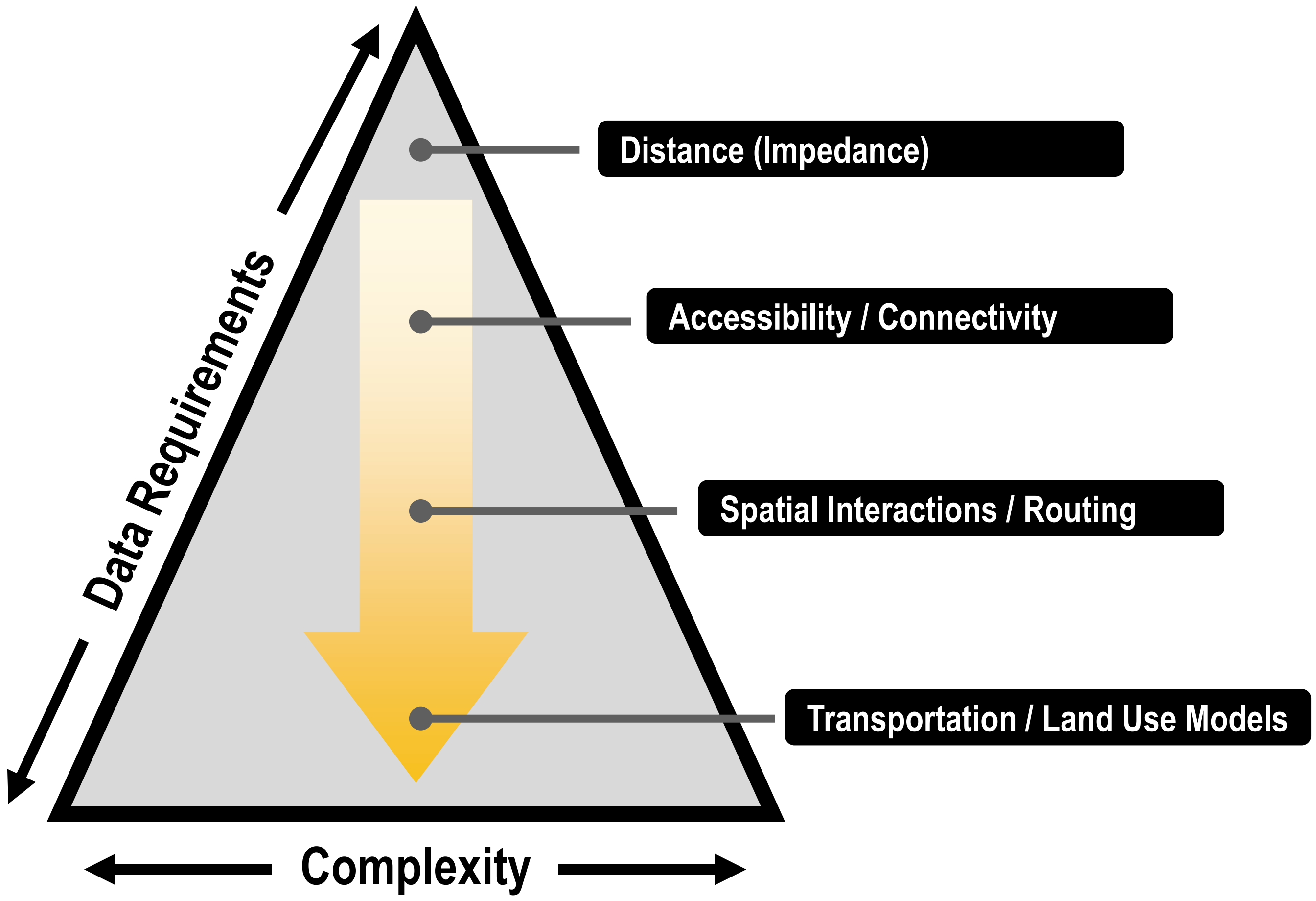


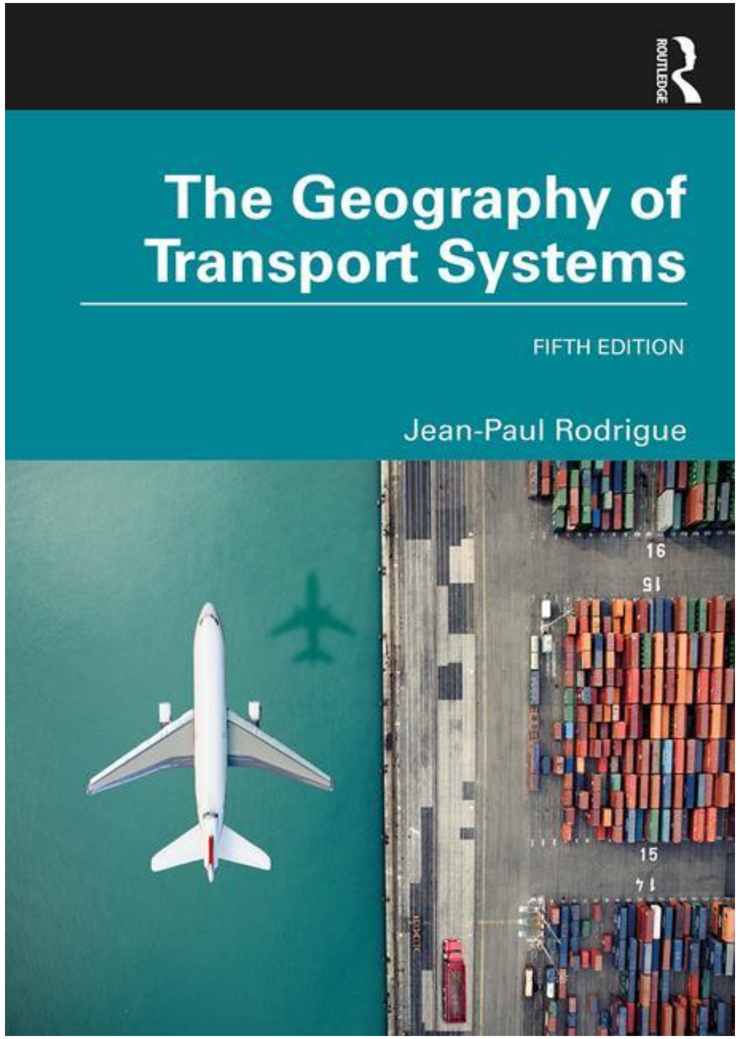
An Overview of Methods in Transport Geography

Models in Transport Geography



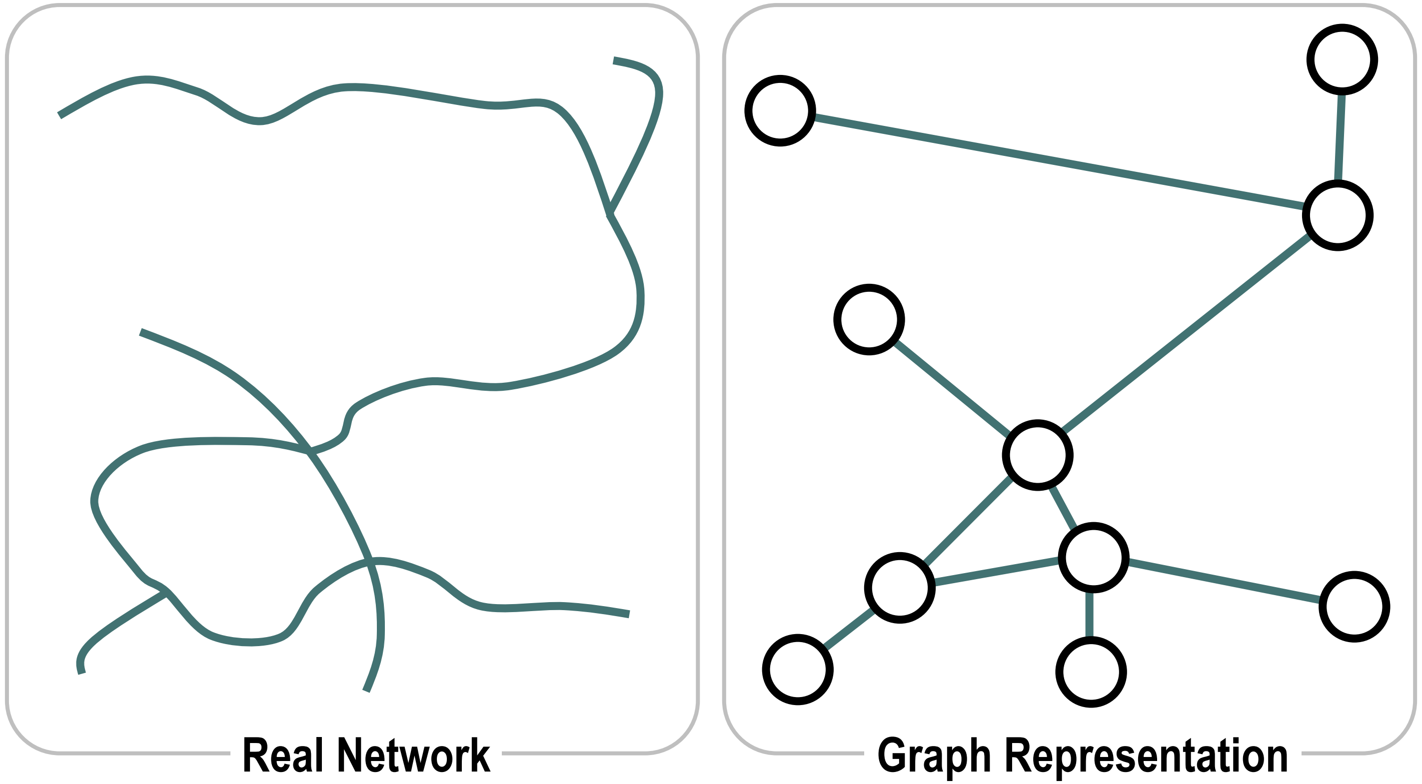
Taxonomy of Transport Geography Methods

	Transport Related	Multidisciplinary
Geography Related	• Network Analysis (Graph Theory). • Land Use / Transportation Interactions. • Flow/Location Allocation Models.	• Cartography / Geographic Information Systems. • Descriptive Statistics, (e.g. Gini Coefficient).
Multidisciplinary	• The Four-Stage Urban Transportation Model. • Travel / Traffic Surveys.	• Questionnaires / Interviews. • Big data. • Graphs and Charts. • Inferential Statistics. • Impact Assessment. • Risk Assessment. • Policy Analysis.

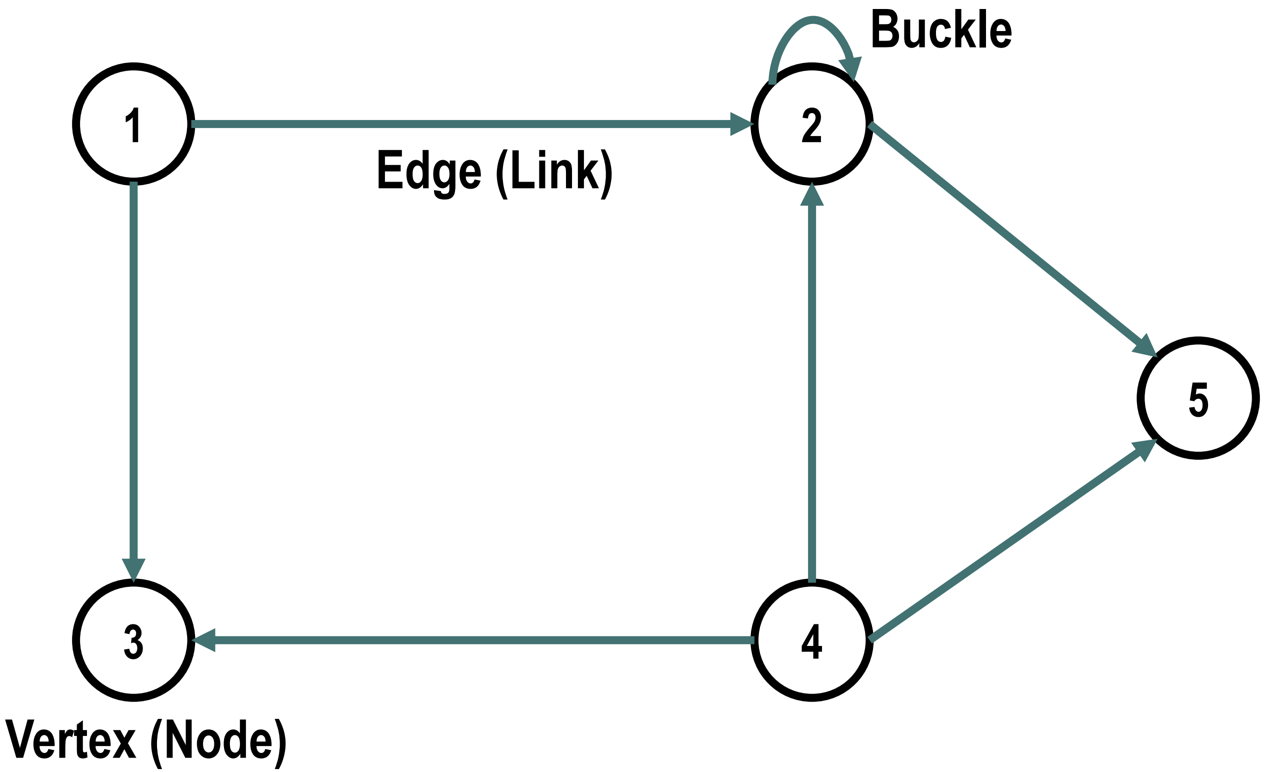


Graph Theory: Definition and Properties

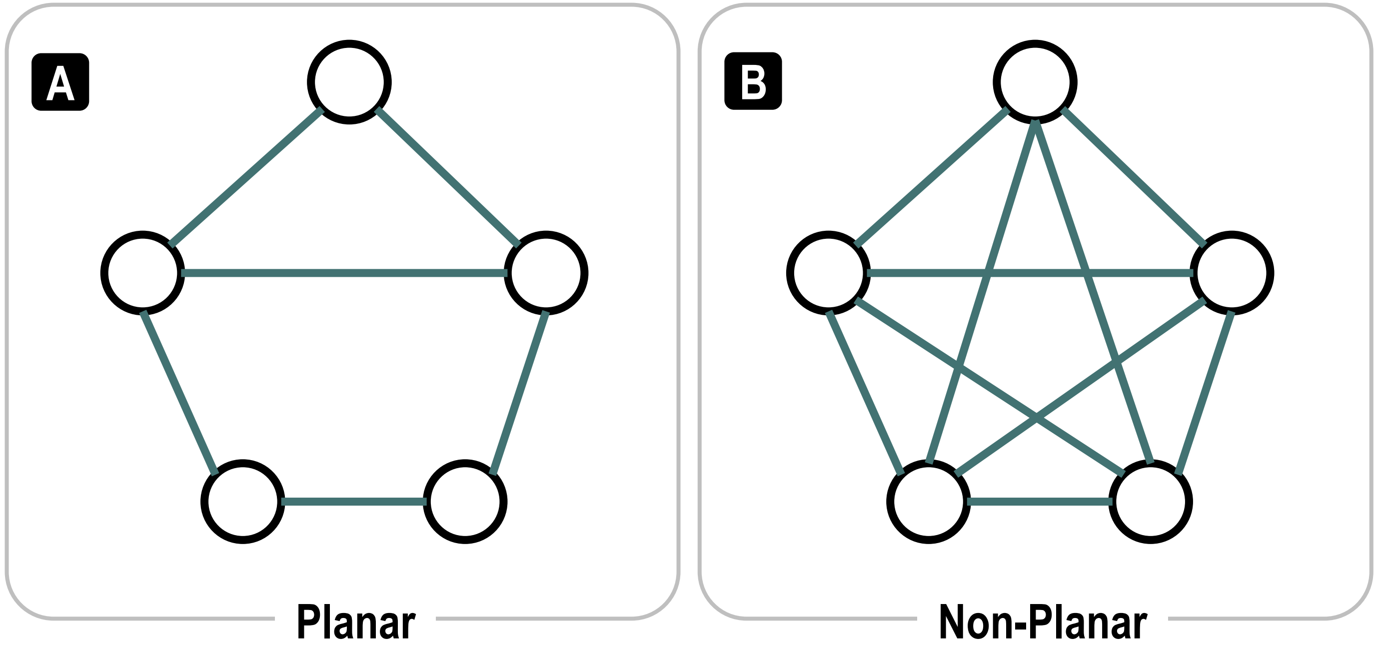
Graph Representation of a Real Network



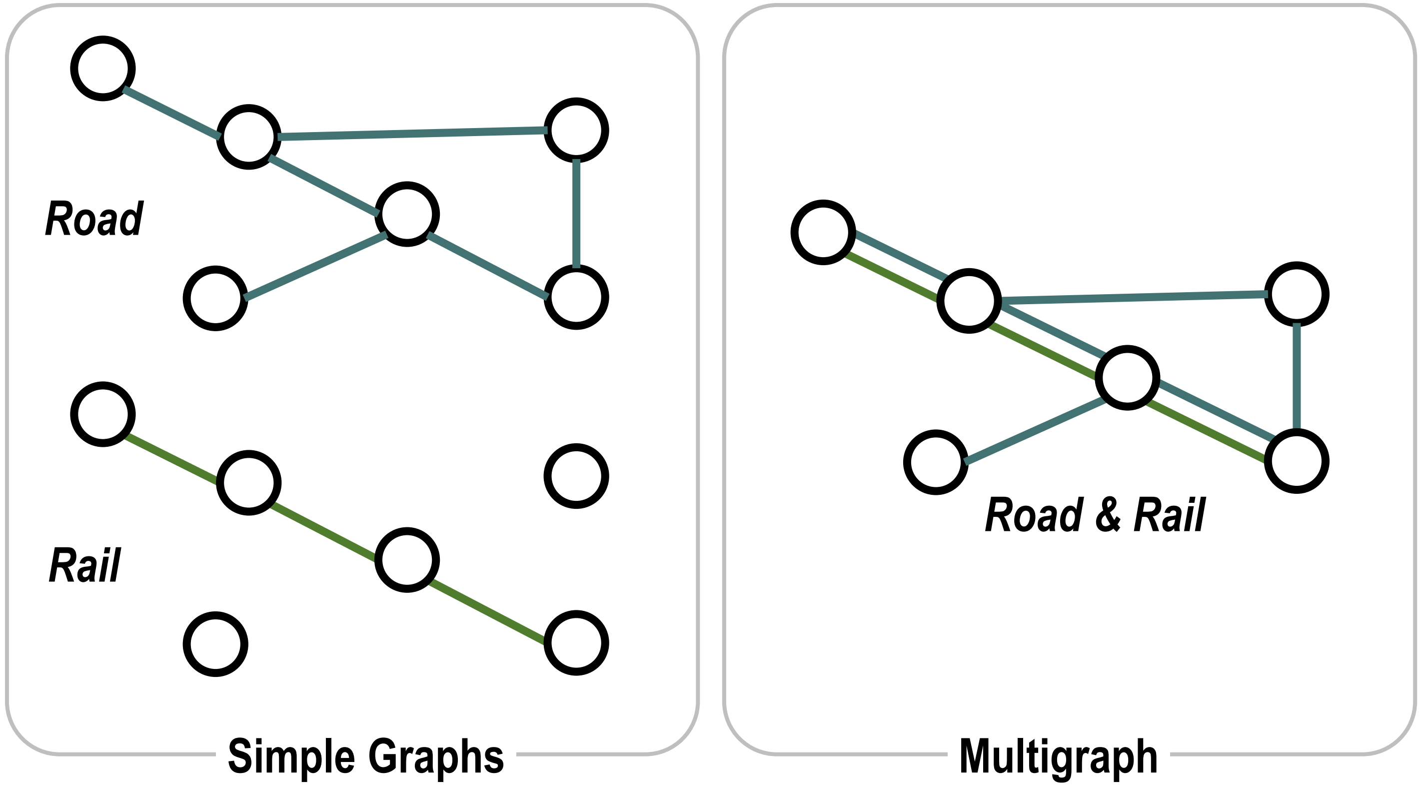
Basic Graph Representation of a Transport Network



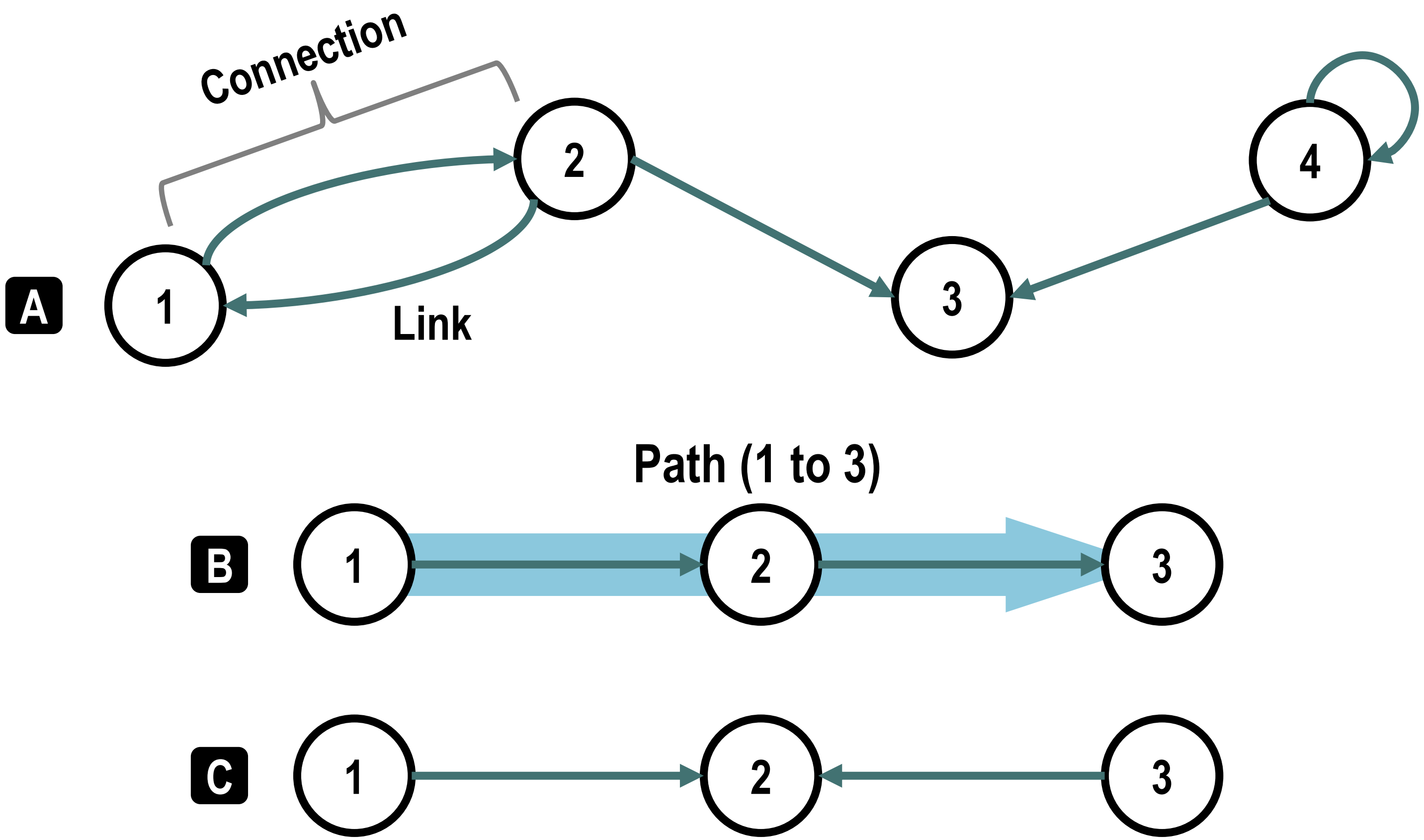
Planar and Non-Planar Graphs



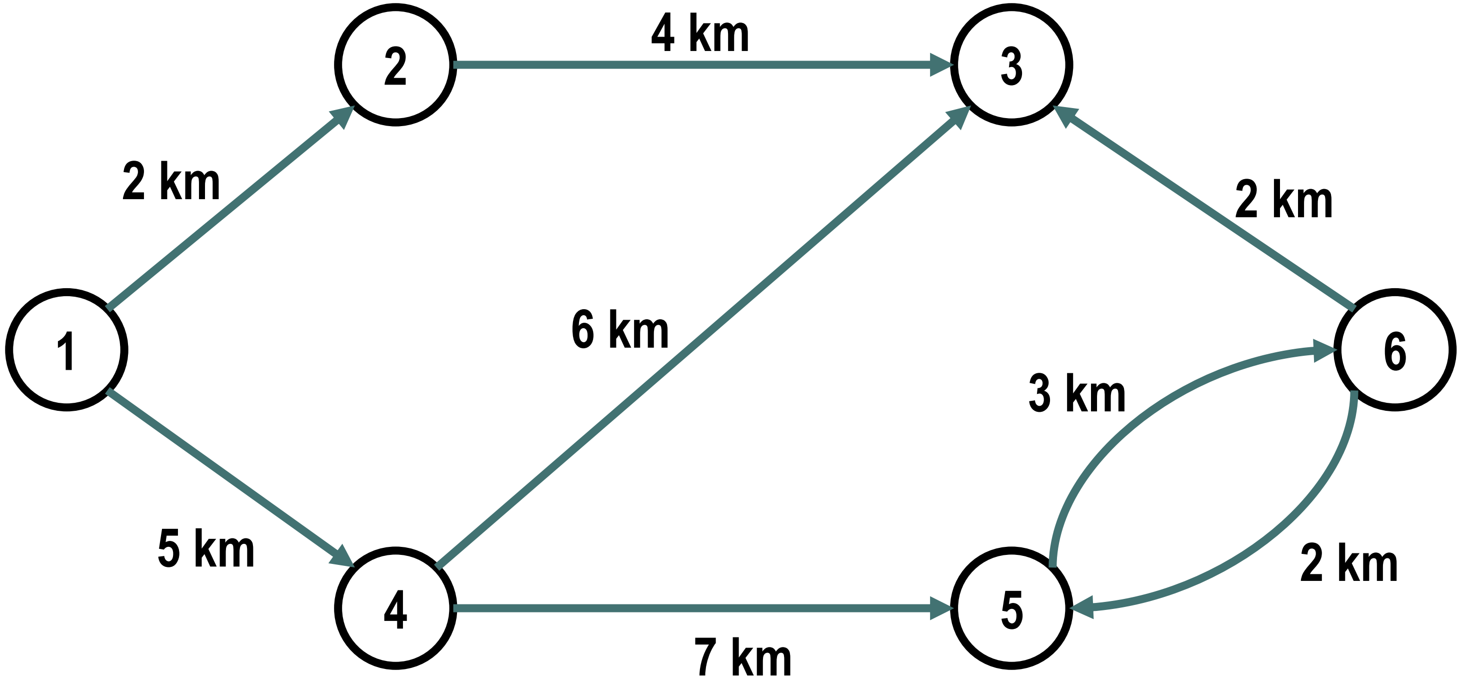
Simple and Multigraph



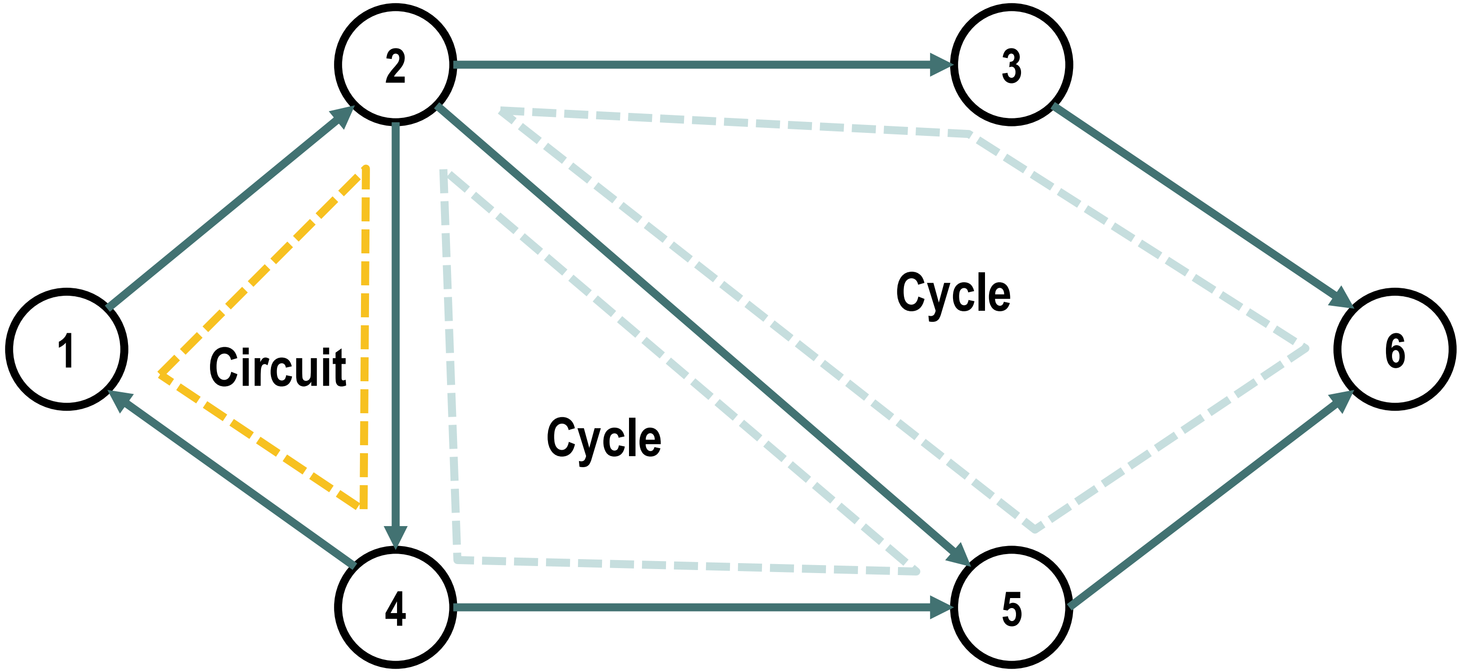
Connections and Paths



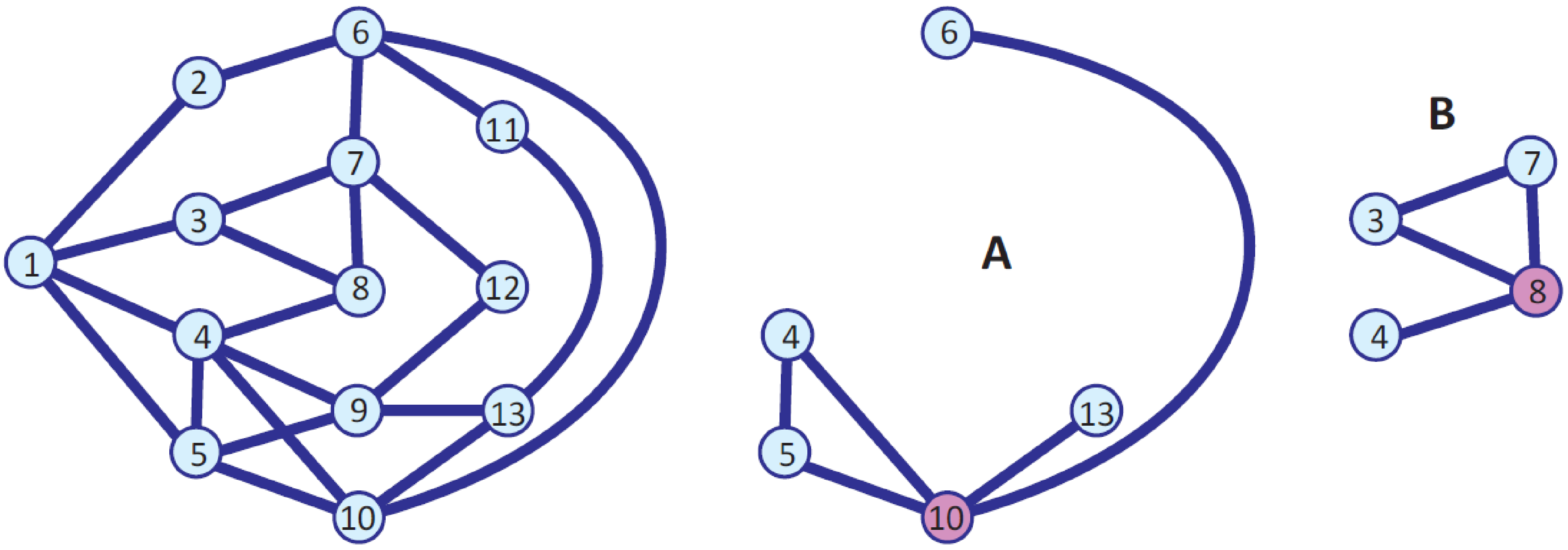
Length of a Link, Connection or Path



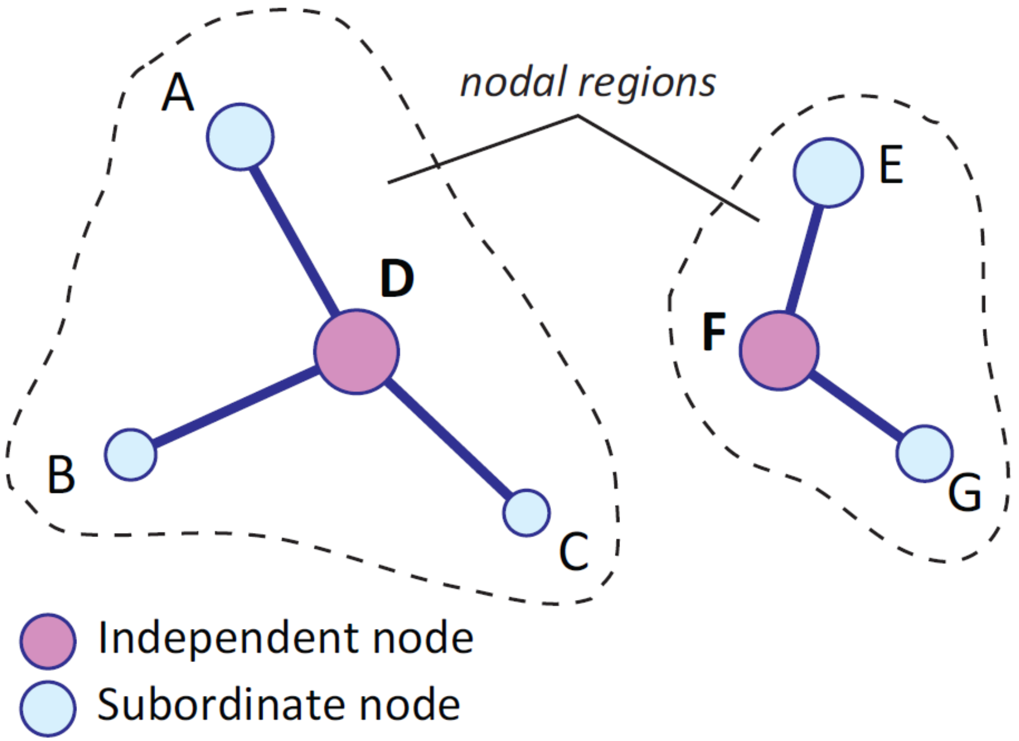
Cycles and Circuits



Ego Network

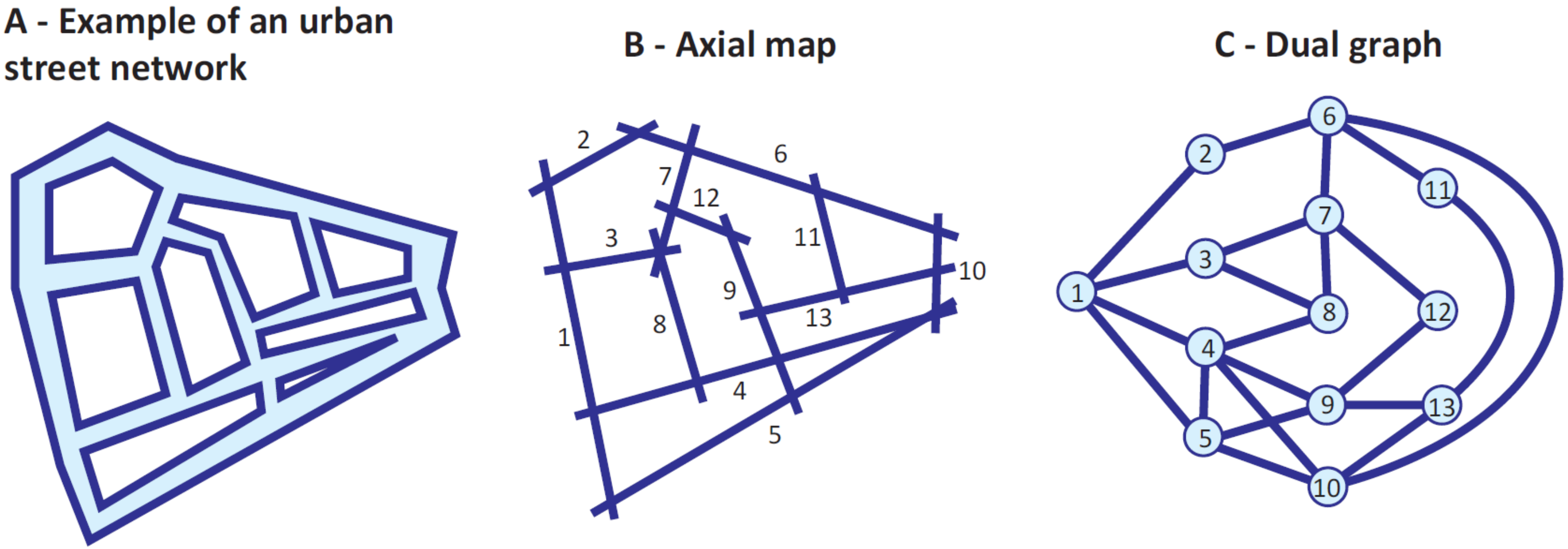


Nodal Region

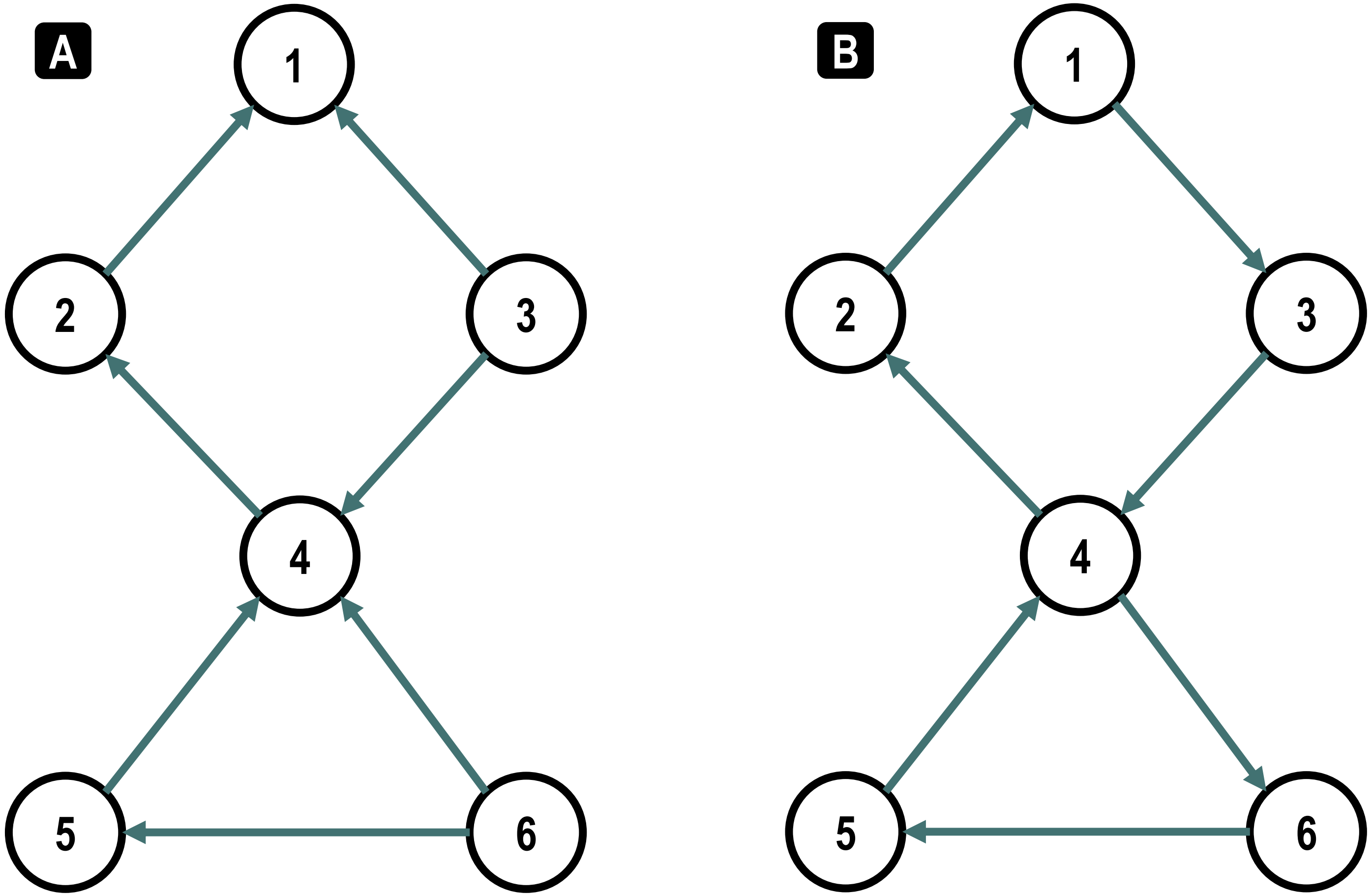


	A	B	C	D	E	F	G	Total
A		15	5	***35***	5	10	5	75
B			5	***15***	1	5	5	31
C				***10***	1	5	1	17
D					20	25	10	55
E						***40***	15	55
F							***20***	20
G								0
Total	0	15	10	55	27	90	56	253

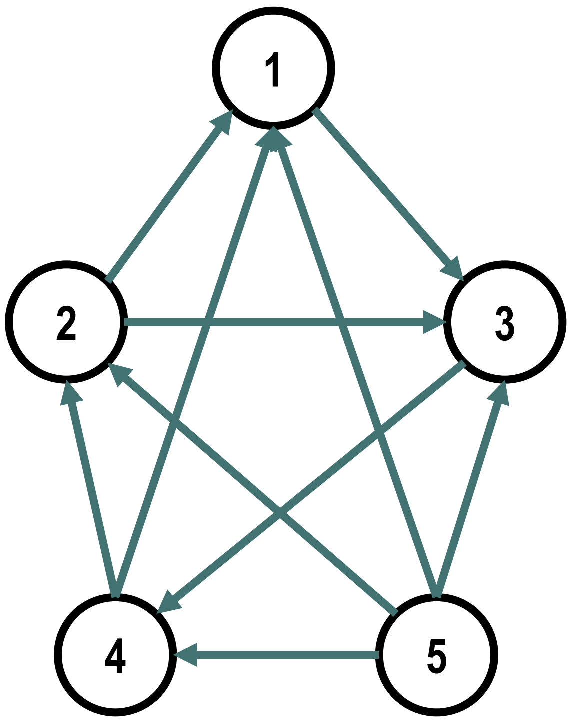
Dual Graph


A - Example of an urban street network
B - Axial map
2
6
7
12
3
11
10
9
1
8
13
4
5
C - Dual graph
6
2
11
7
3
1
8
12
4
9
13
5
10

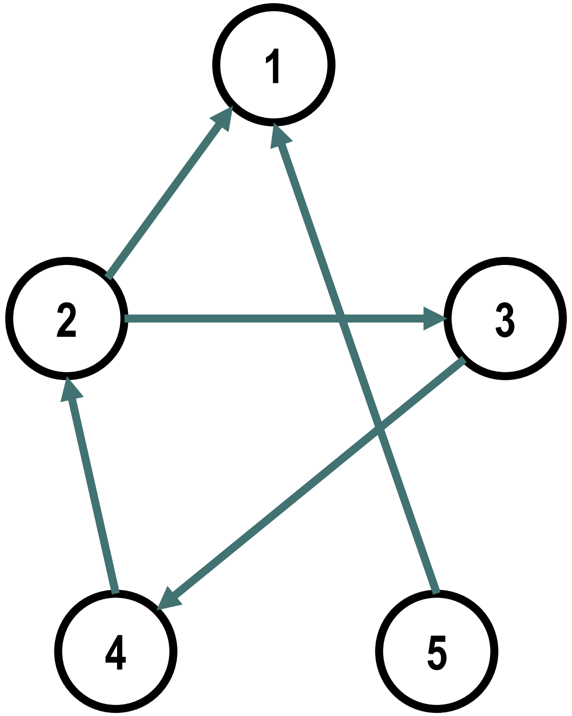
Connectivity in a Graph



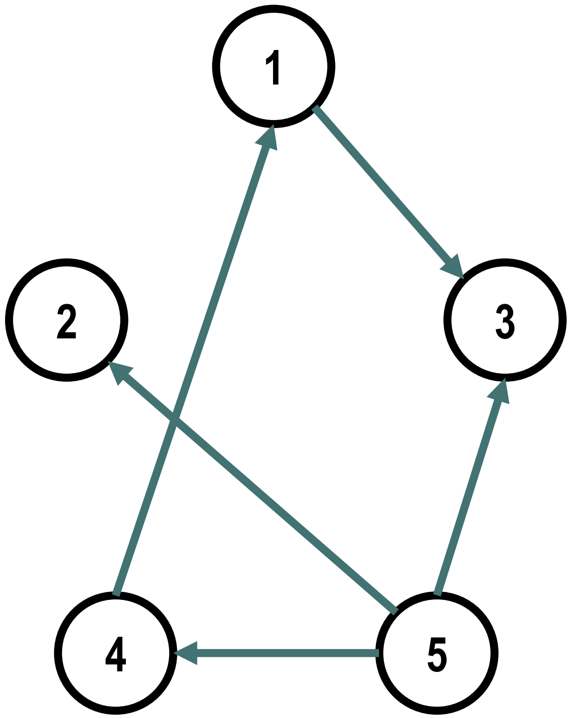
Complementary Graph



G

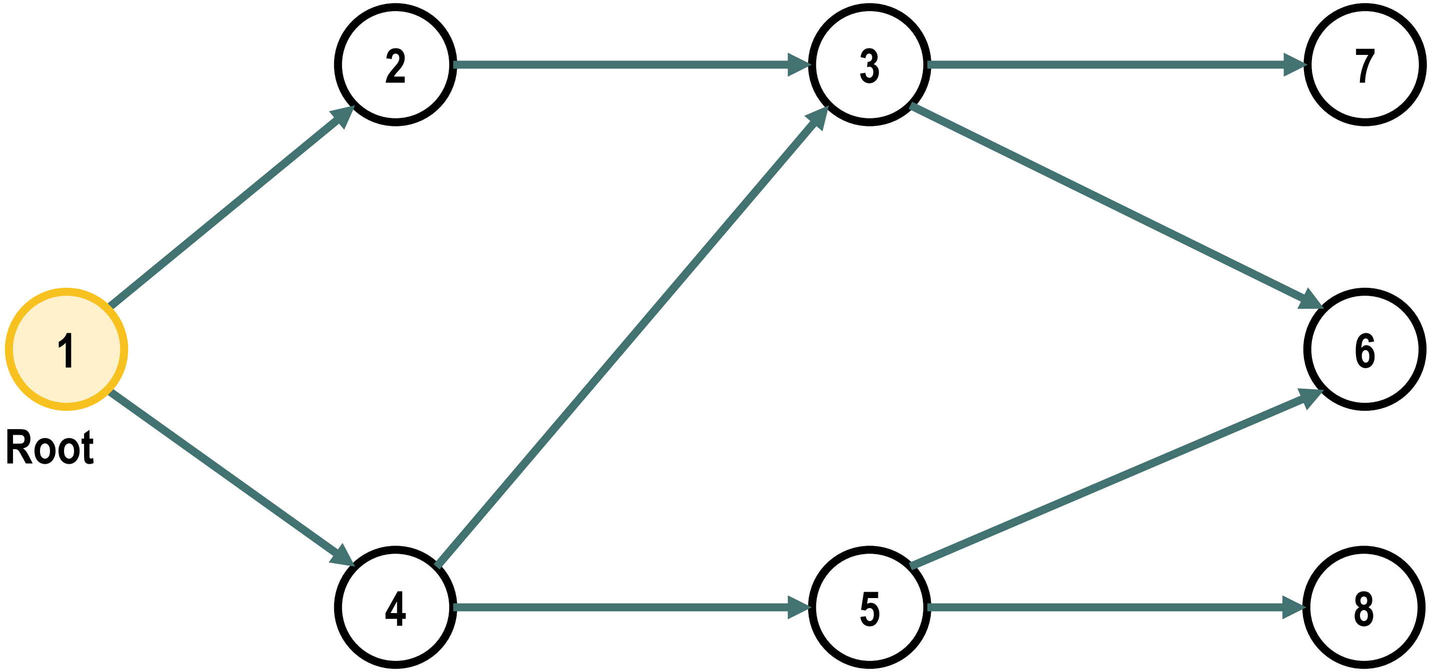


X

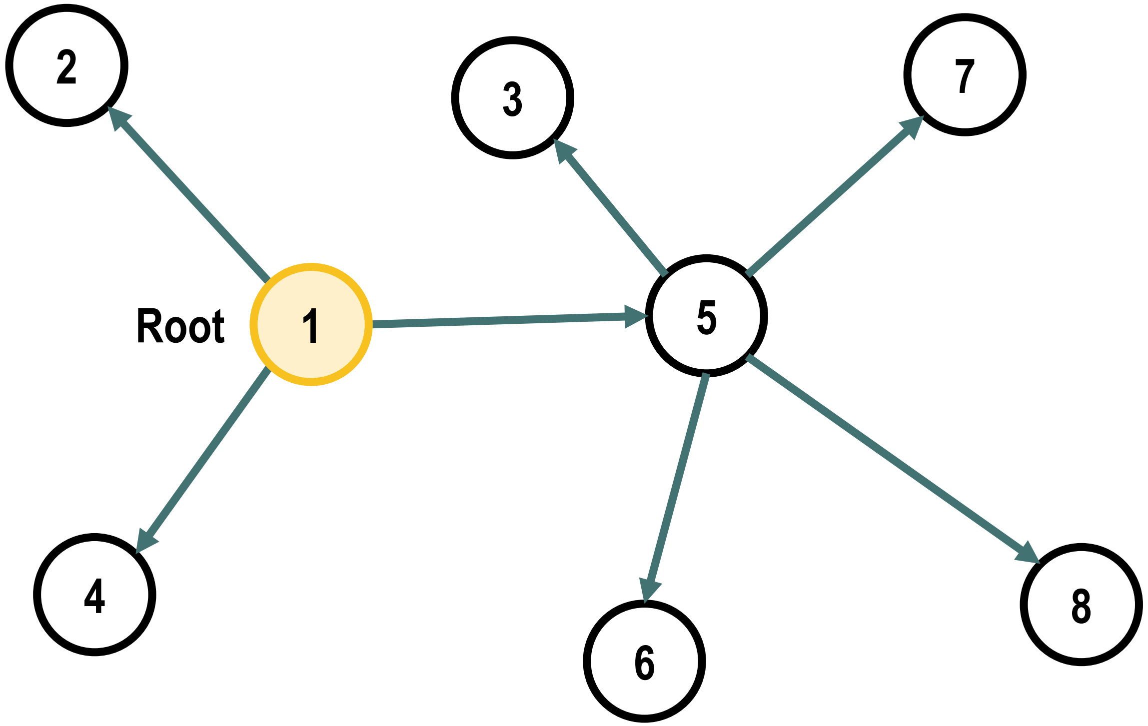


Y

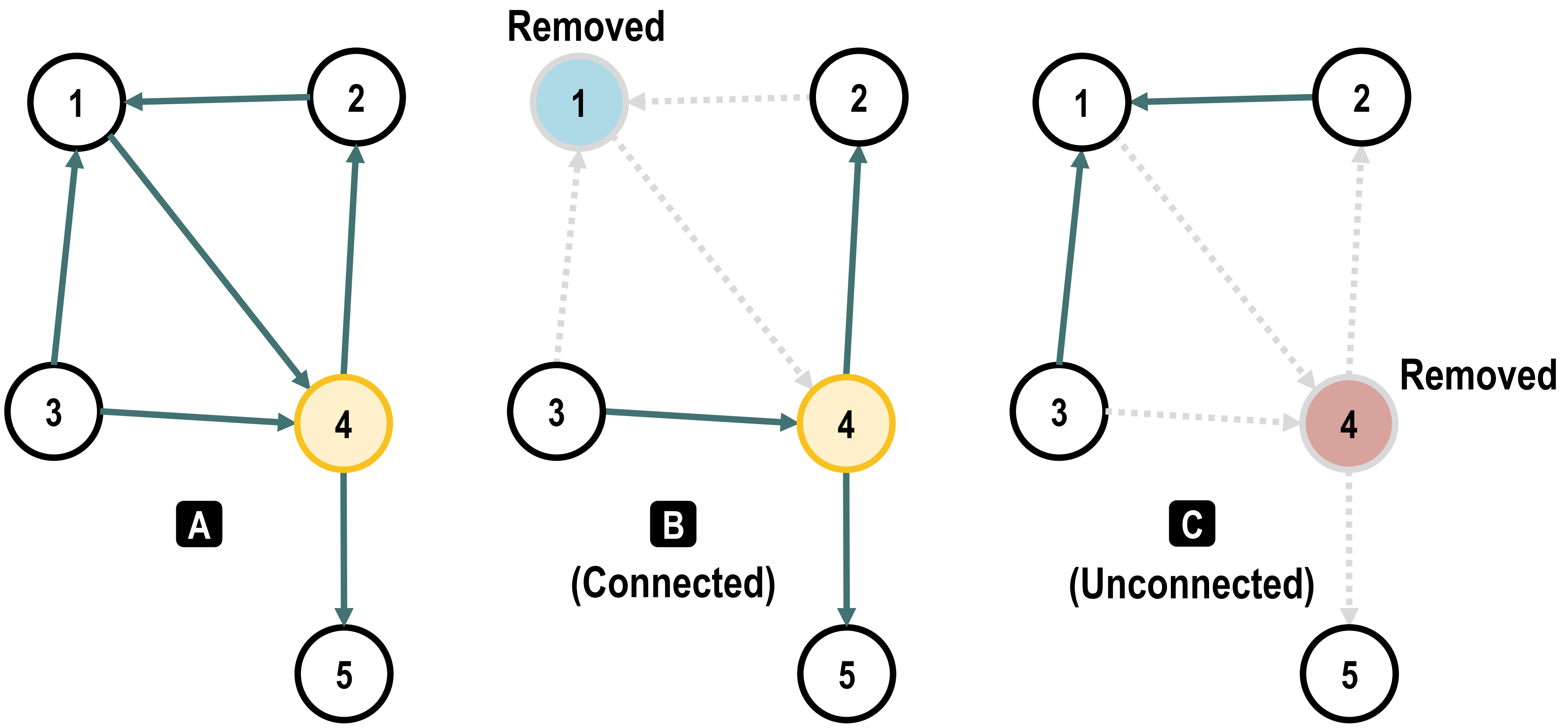
Root Node



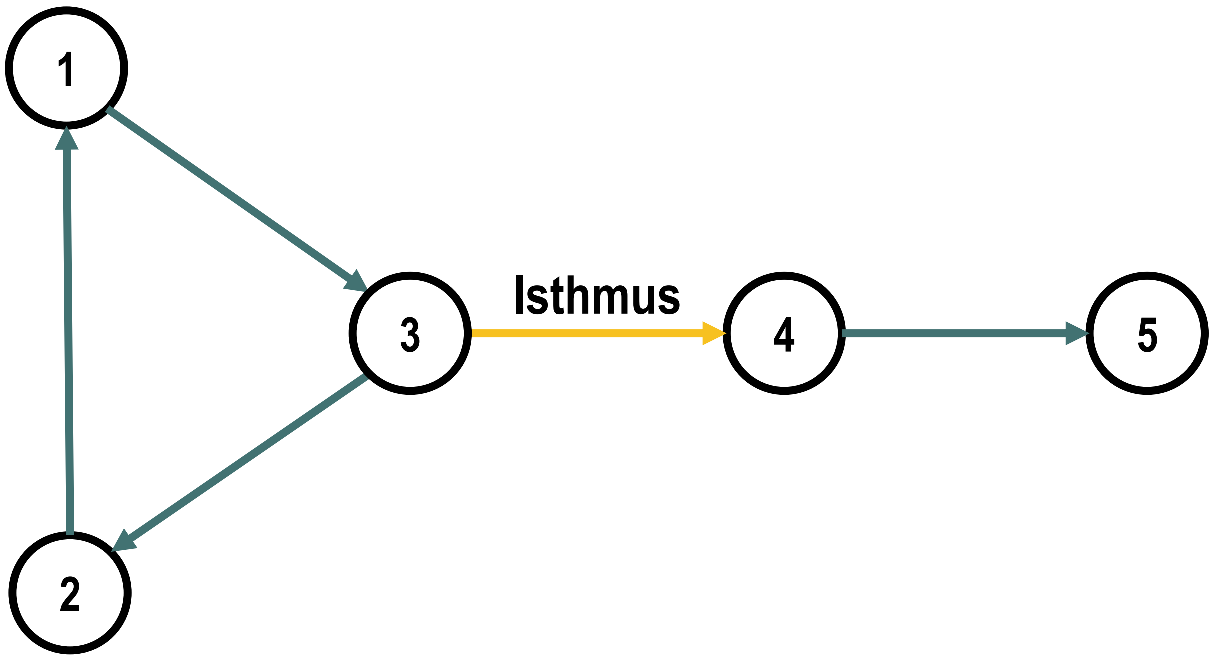
Tree Graph

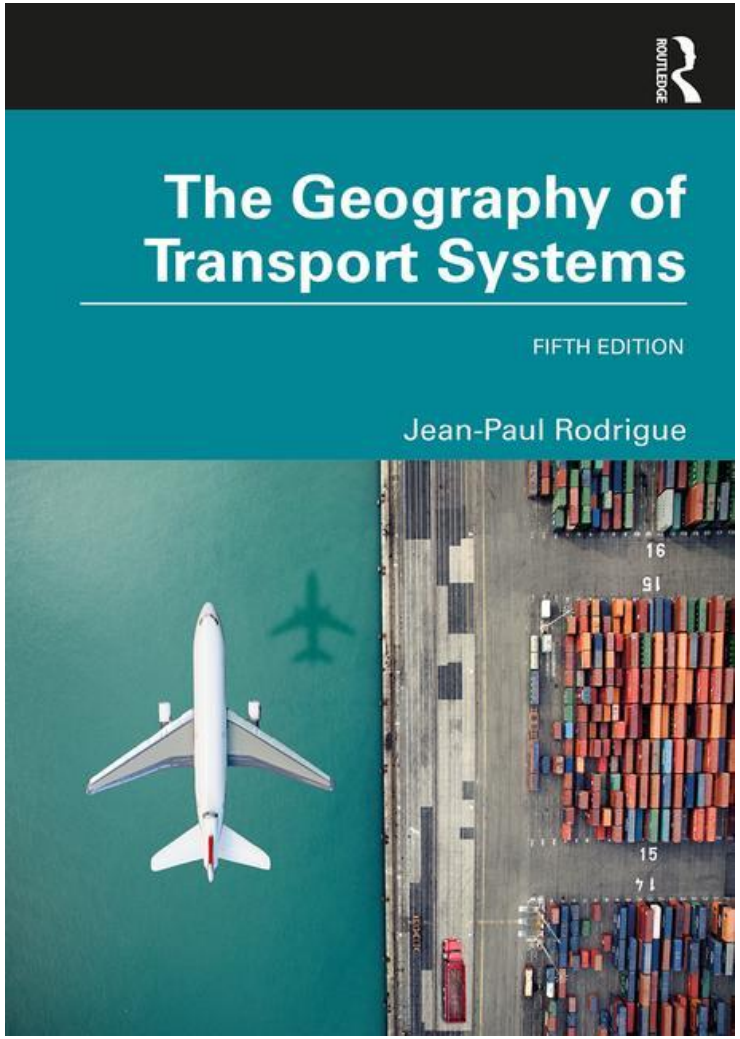


Articulation Node



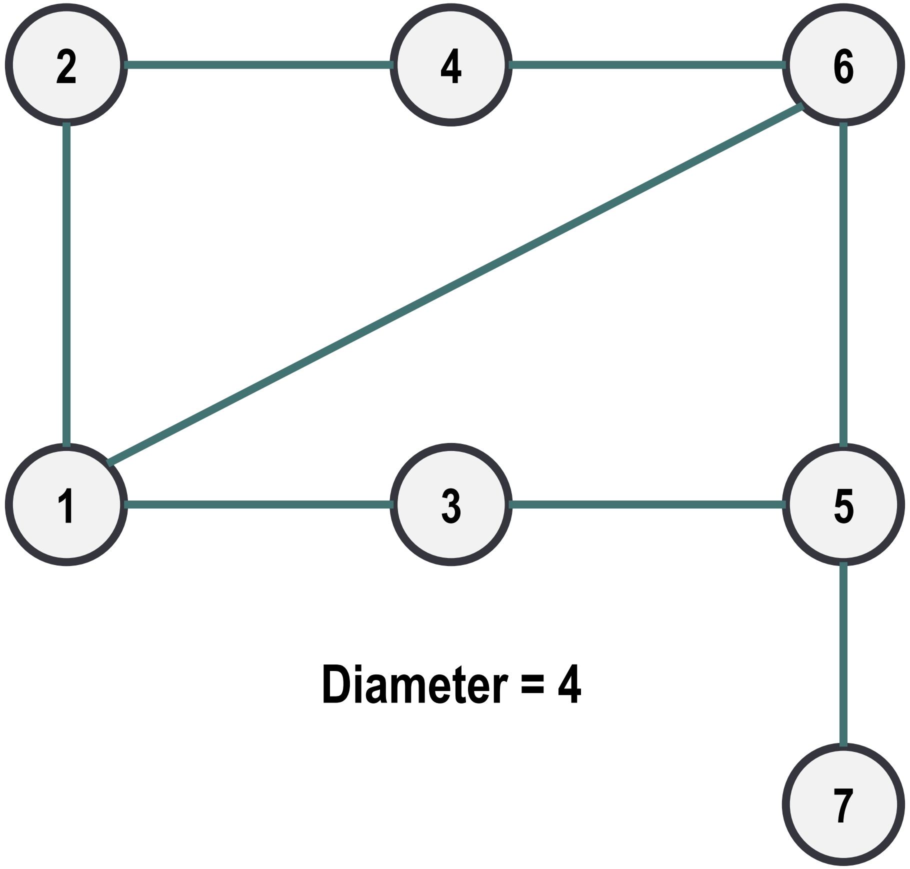
Isthmus Connection





Graph Theory: Indexes and Measures

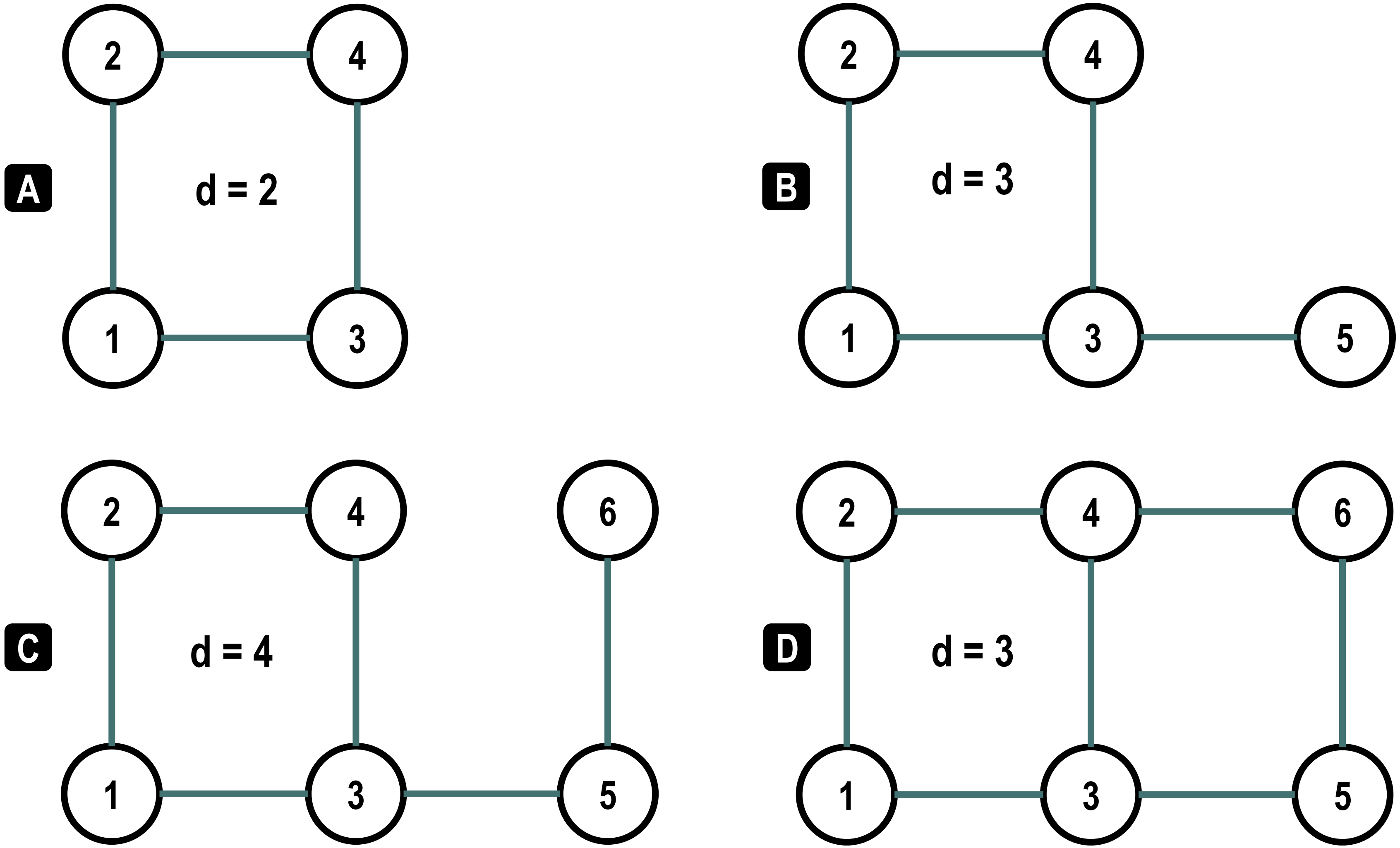
Diameter of a Graph



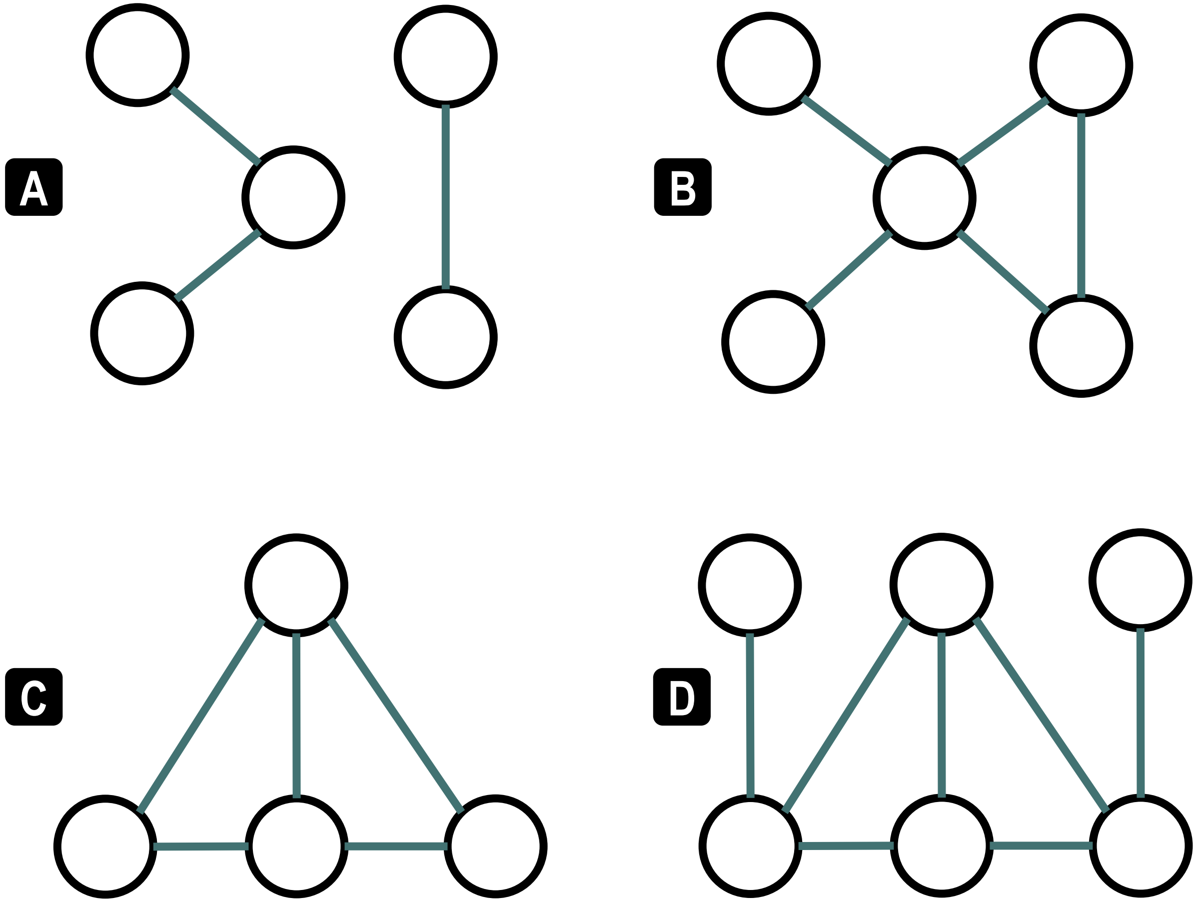
Shimbel Distance

v	1	2	3	4	5	6	7
1	0	1	1	2	2	1	3
2	1	0	2	1	3	2	4
3	1	2	0	3	1	2	2
4	2	1	3	0	2	1	3
5	2	3	1	2	0	1	1
6	1	2	2	1	1	0	2
7	3	4	2	3	1	2	0

Changes in the Diameter of a Graph



Number of Cycles in a Graph

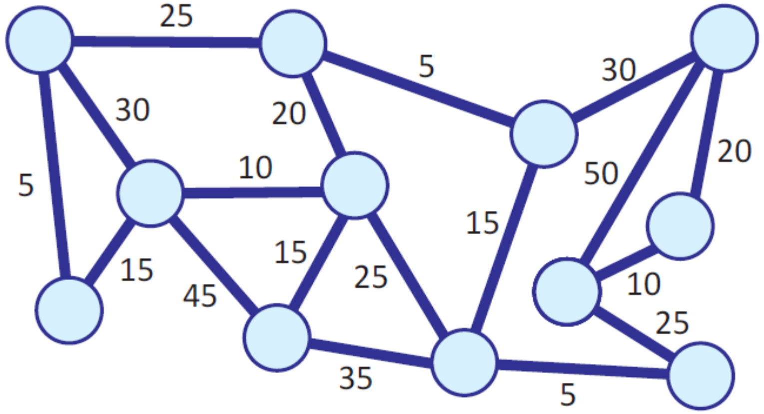


$$u = e - v + p$$

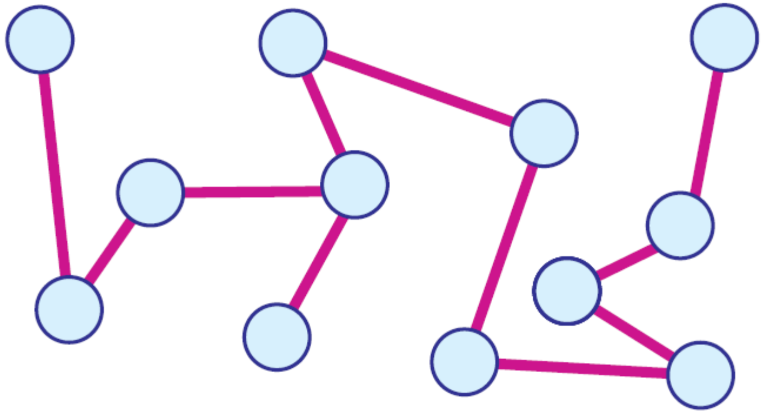
	e	v	p	u
A	3	5	2	0
B	5	5	1	1
C	5	4	1	2
D	7	6	1	2

Cost

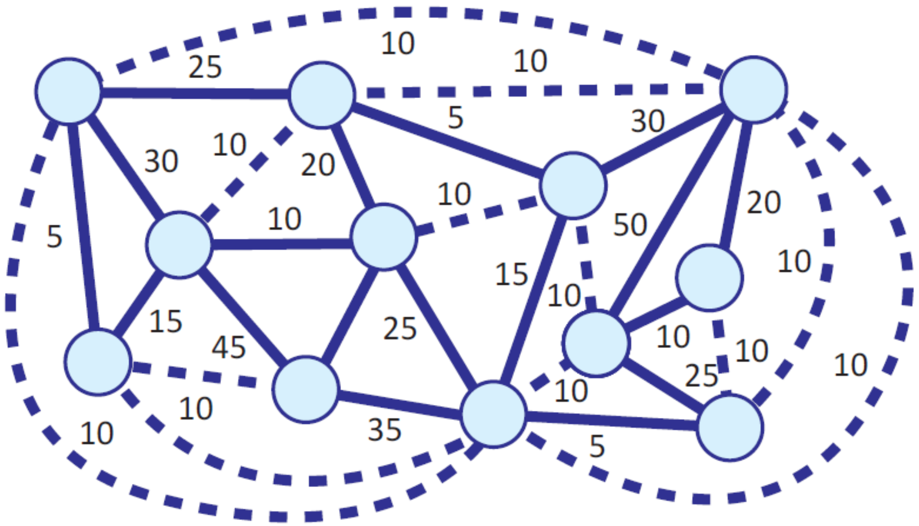
A - Original network and weighted links



B - Minimum Spanning Tree (MST)

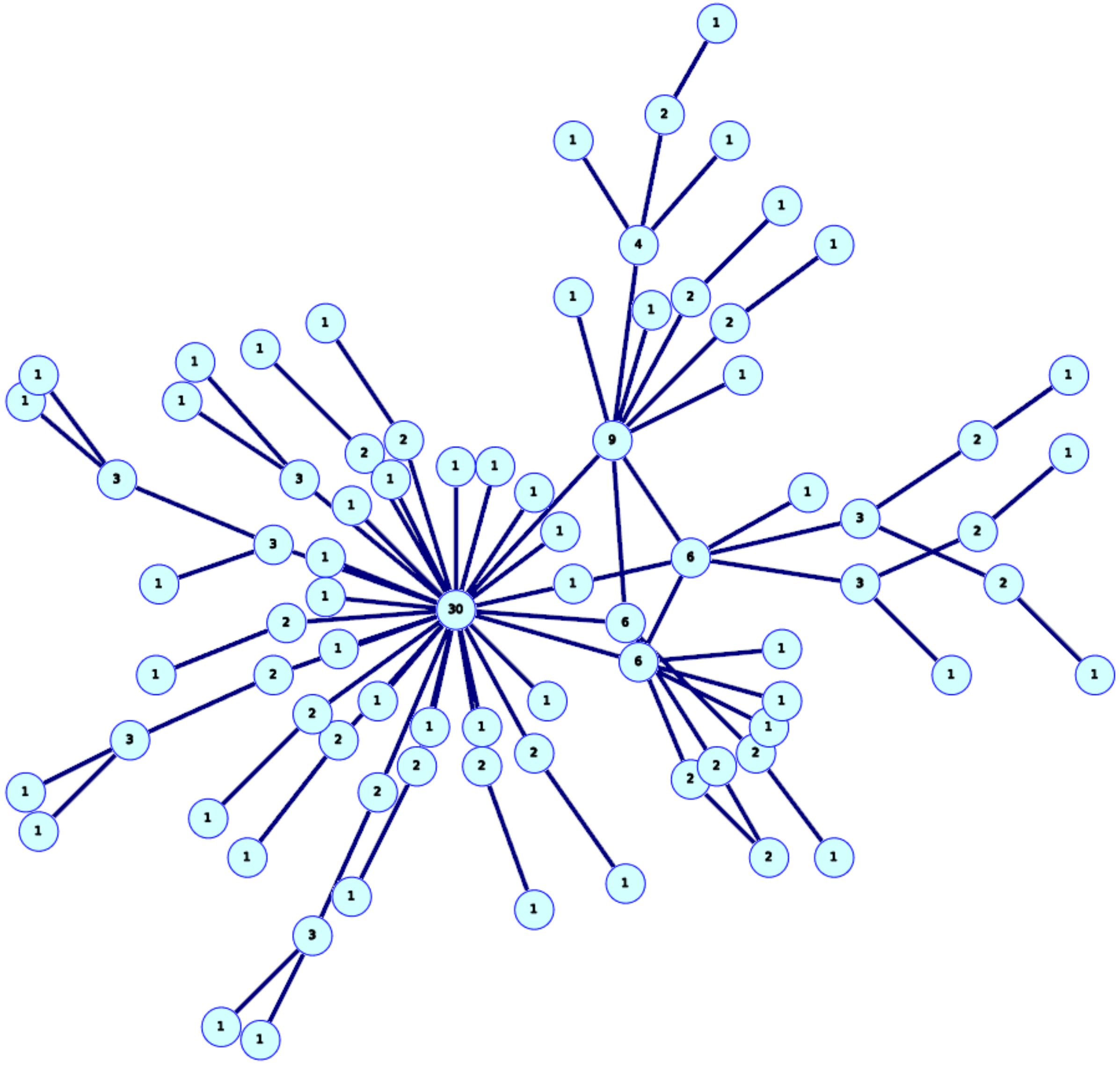


C - Greedy triangulation (GT)

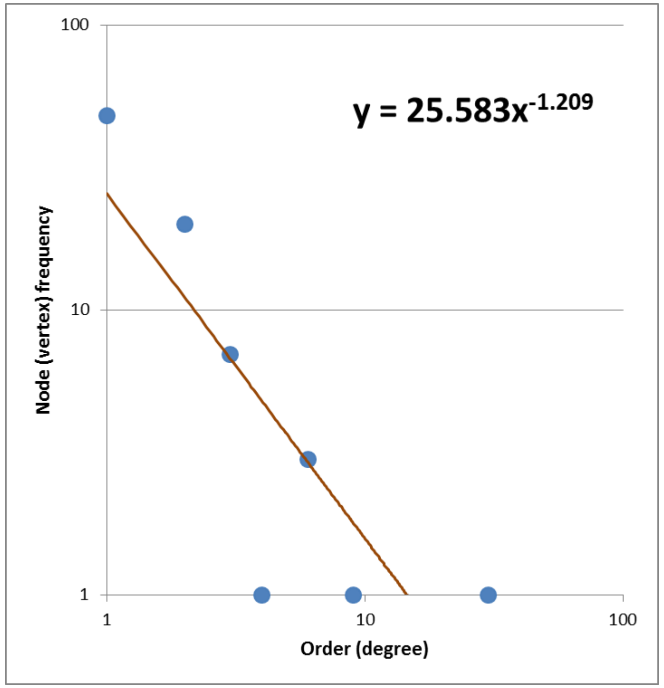


	Cost (weight)	Cost (links)
A	360	18
B	145	11
C	480	29
CostRel	0.642	0.389

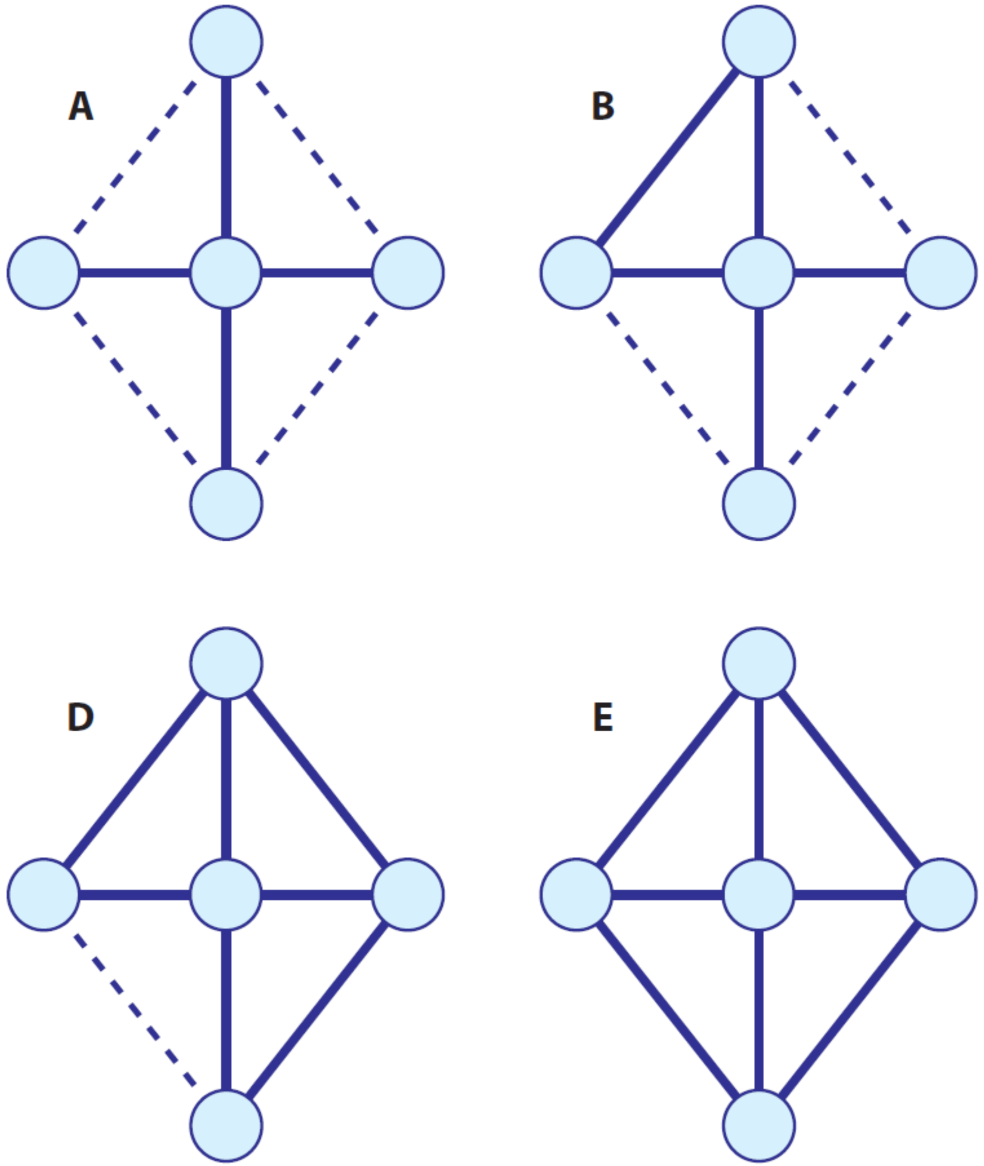
Hierarchy



Order (degree)	Node (vertex) frequency
1	48
2	20
3	7
4	1
6	3
9	1
30	1

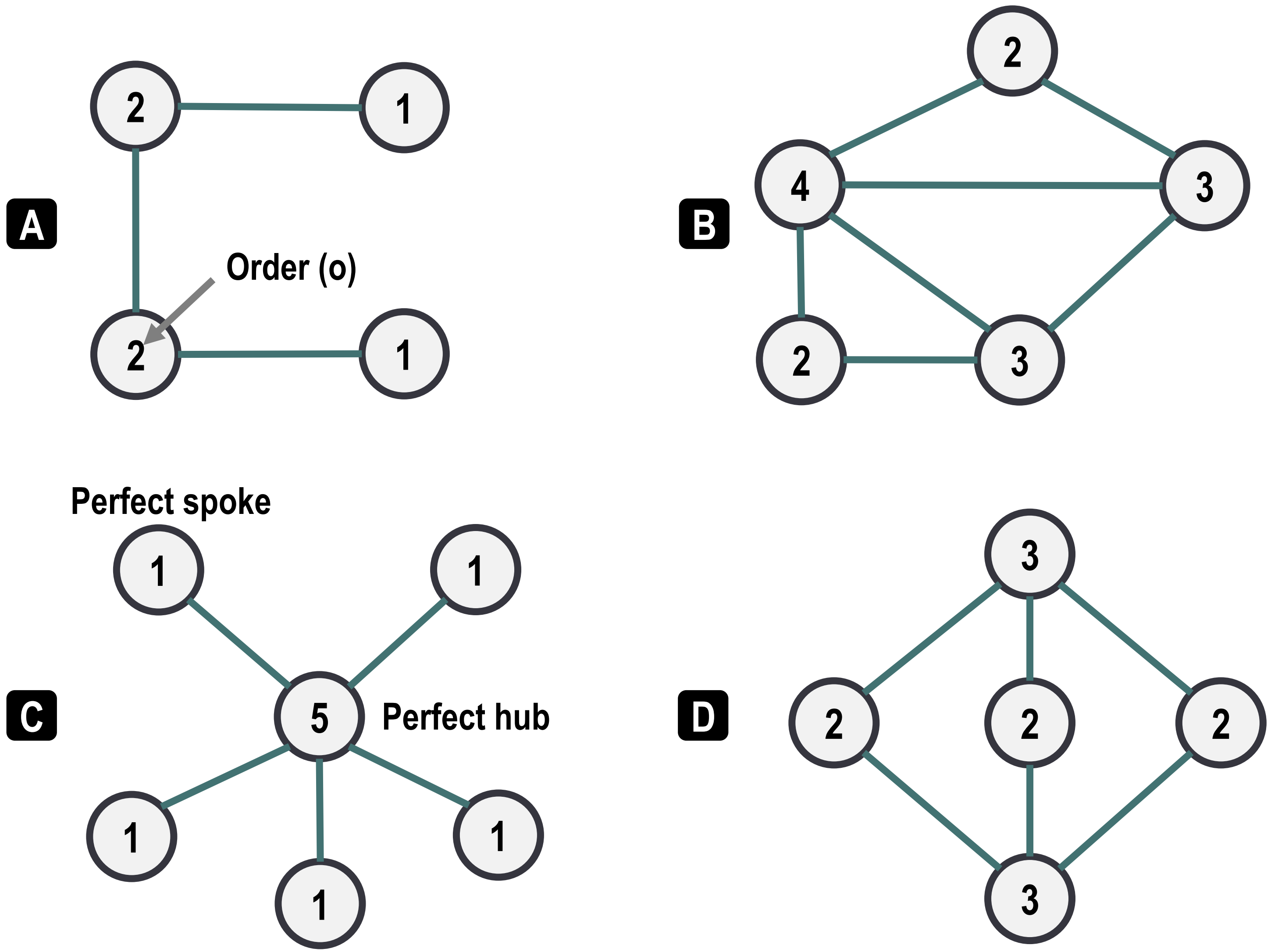


Transitivity

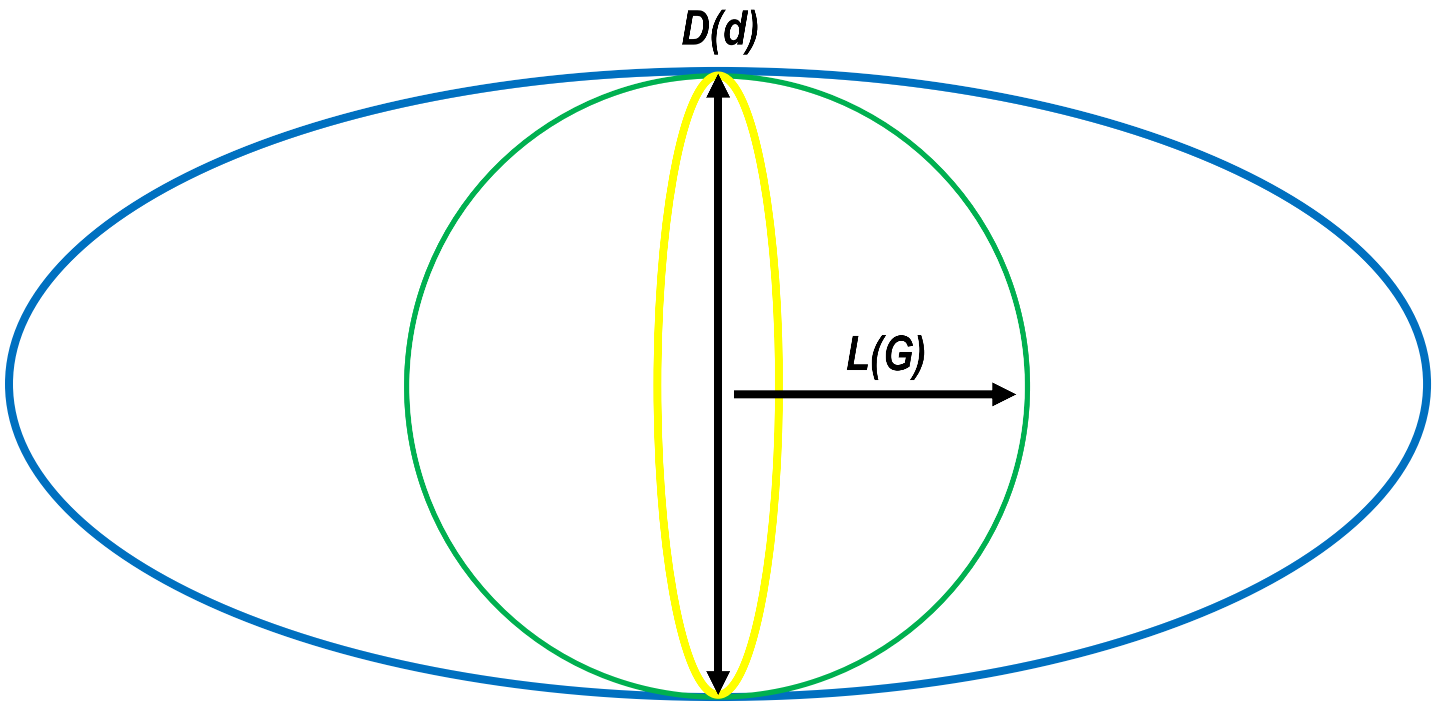


	Number of existing triplets (t0)	Number of possible triplets (t1)	Transitivity (t0 / t1)
A	0	4	0
B	1	4	0.25
C	2	4	0.5
D	3	4	0.75
E	4	4	1

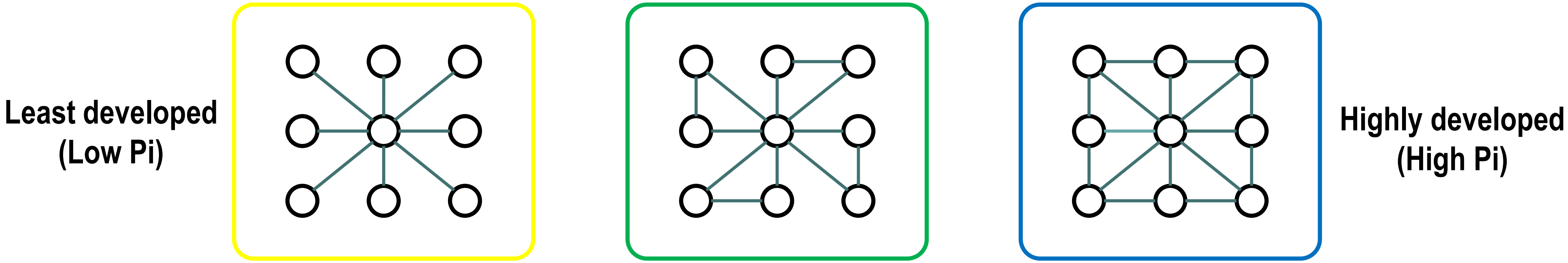
Order of a Node



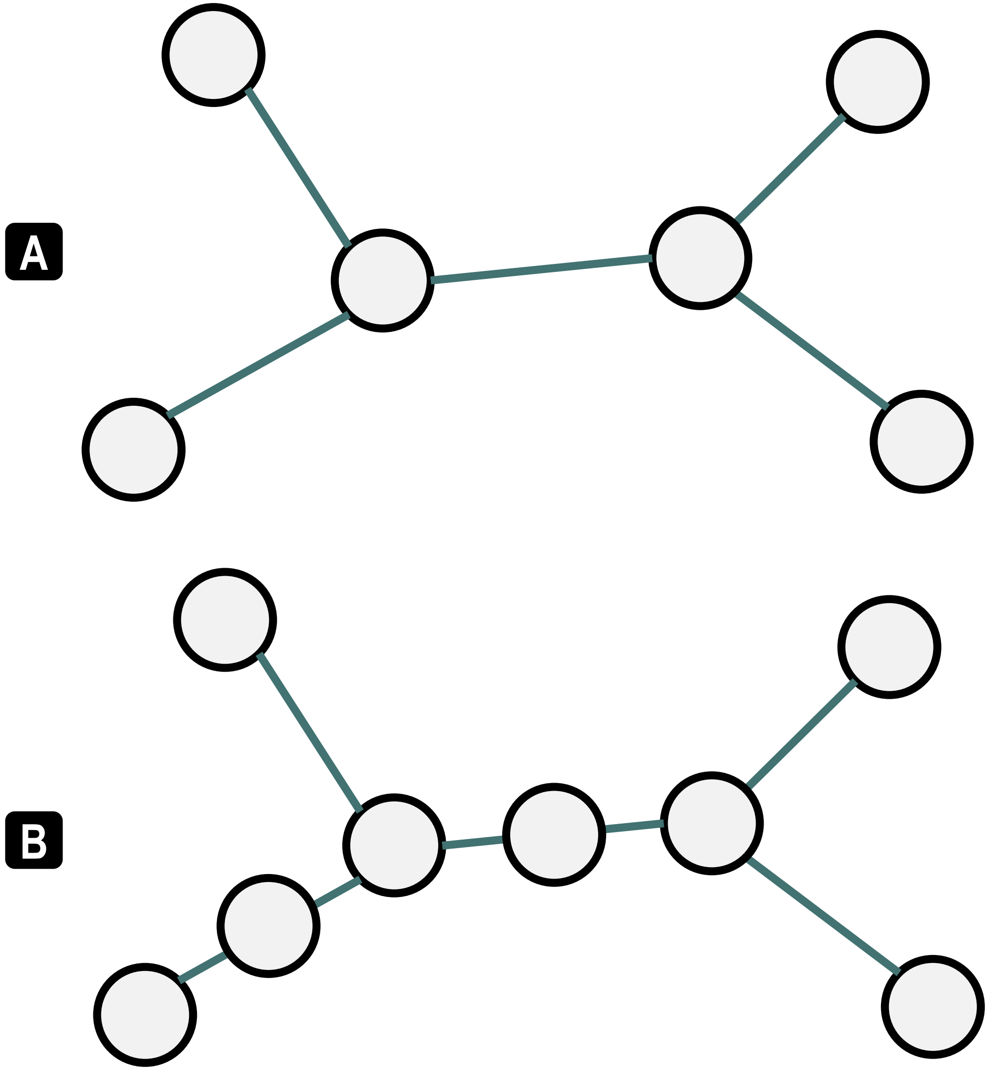
Pi Index and the Shape of Transportation Networks



$$\Pi = \frac{L(G)}{D(d)}$$



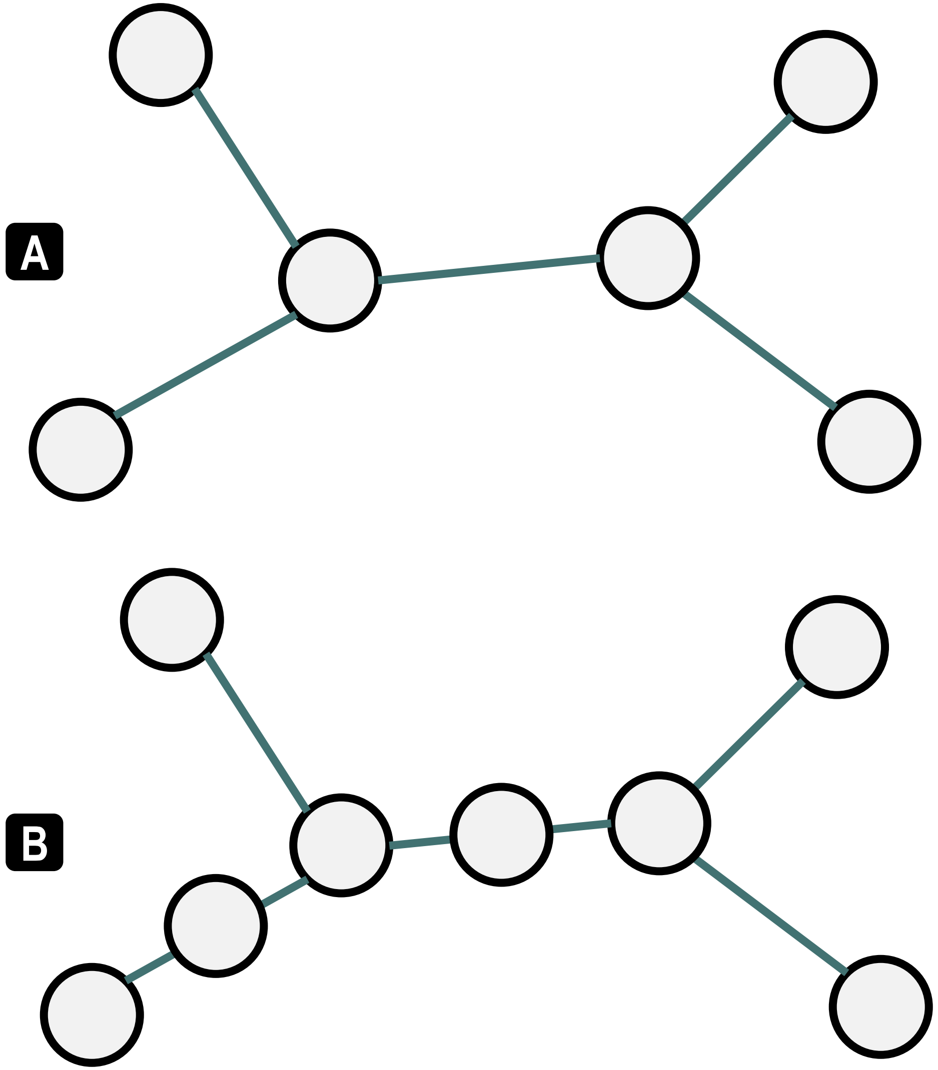
Eta Index



$$\eta = \frac{L(G)}{e}$$

	L(G)	e	Eta
A	80 km	5	16.0
B	80 km	7	11.4

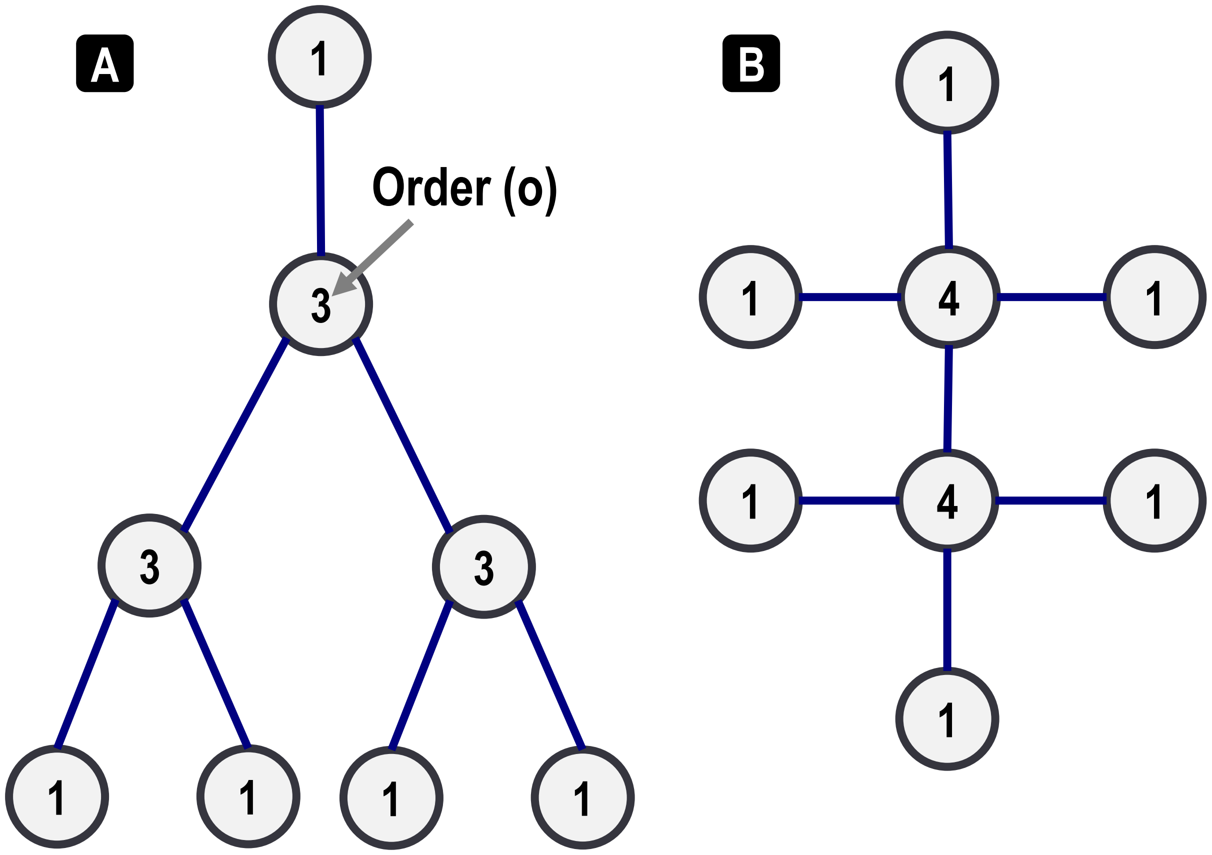
Theta Index



$$\theta = \frac{Q(G)}{v}$$

	Q(G)	v	Theta
A	3,500 t	6	583.3
B	3,500 t	8	437.5

Iota Index



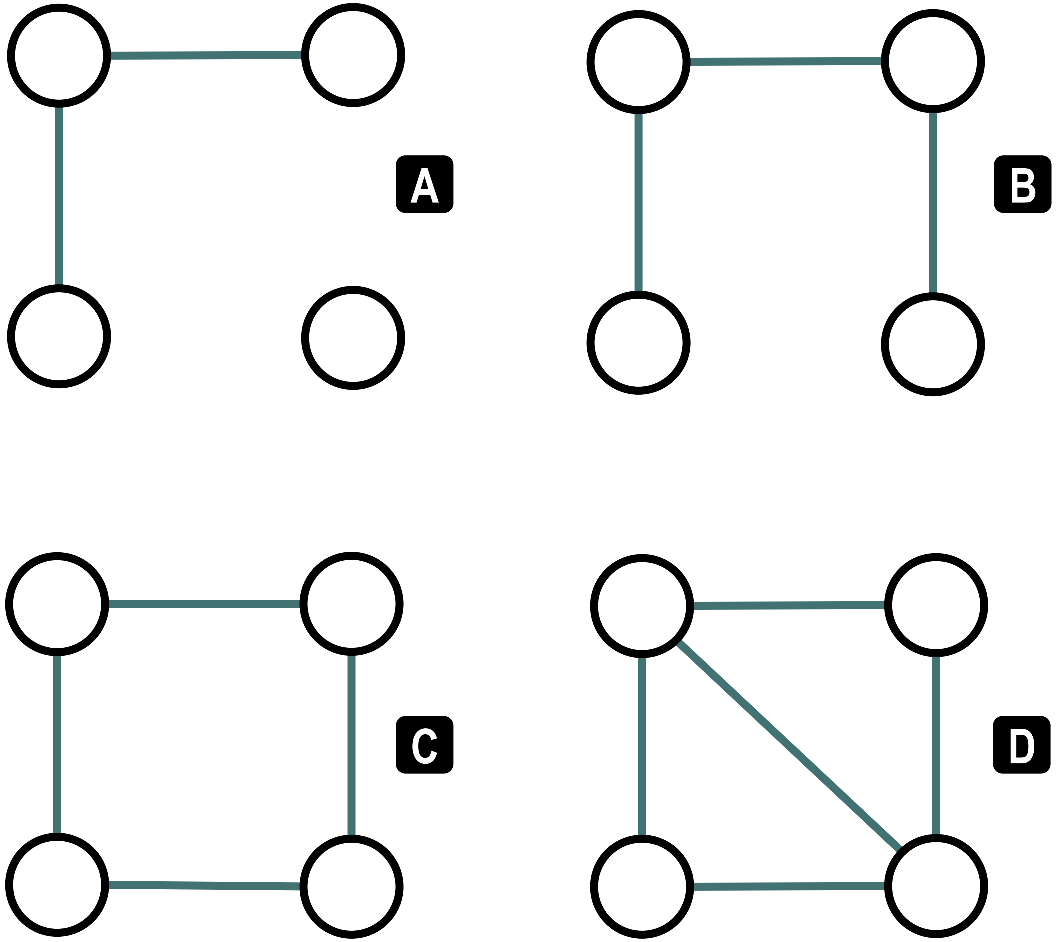
$$\iota = \frac{L(G)}{W(G)}$$

$$W(G) = 1, \forall o = 1$$

$$W(G) = \sum_{e} 2 * o \,, \forall o > 1$$

	L(G)	W(G)	Iota
A	80	23	3.47
B	80	22	3.63

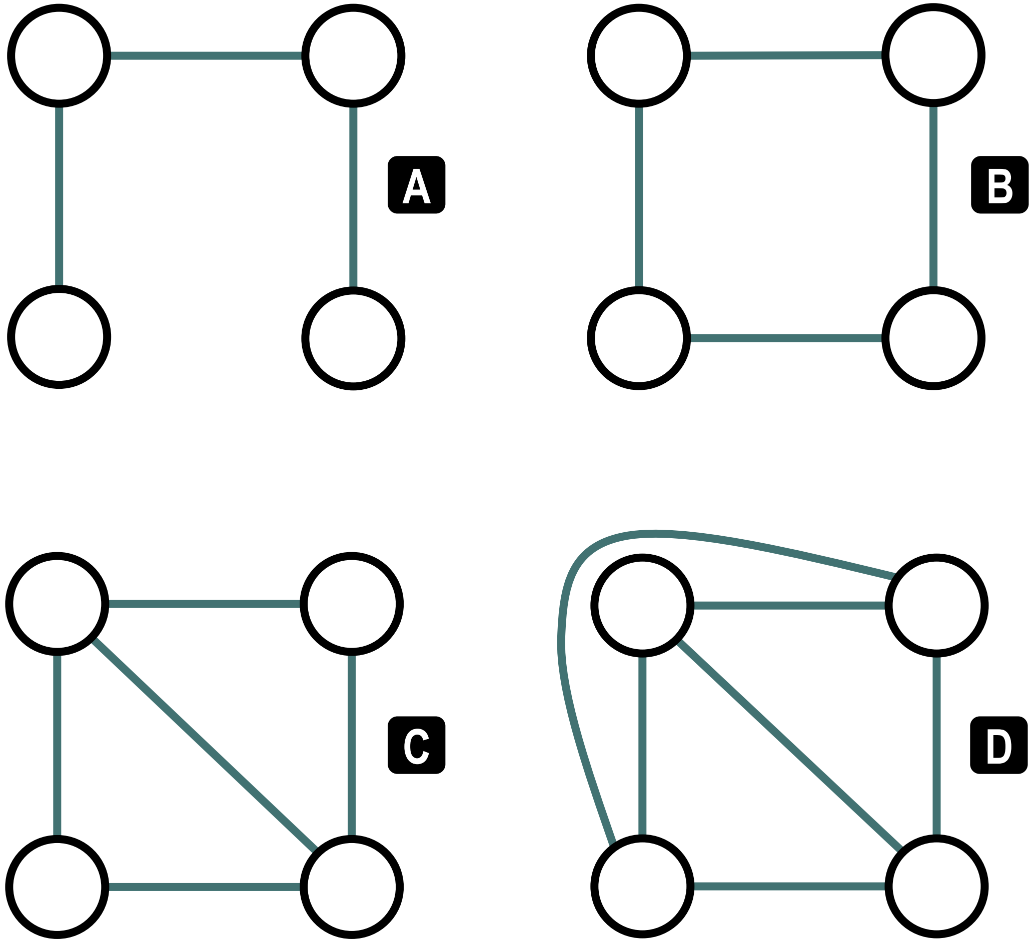
Beta Index



$$\beta = \frac{e}{v}$$

	e	v	Beta
A	2	4	0.5
B	3	4	0.75
C	4	4	1.0
D	5	4	1.25

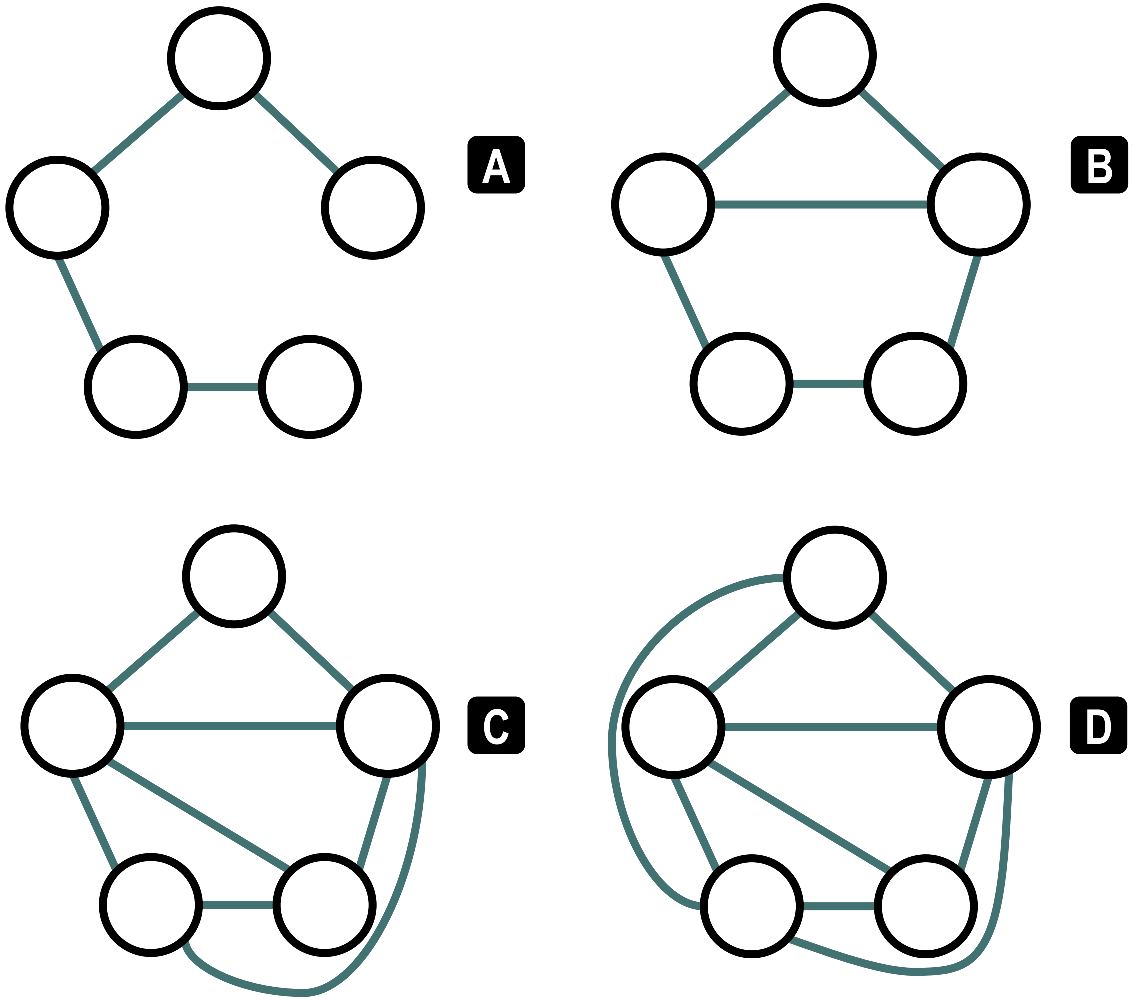
Alpha Index



$$\alpha = \frac{u}{2v - 5}$$

	u (*e-v+p*)	*2v-5*	Alpha
A	0	3	0.0
B	1	3	0.33
C	2	3	0.66
D	3	3	1.0

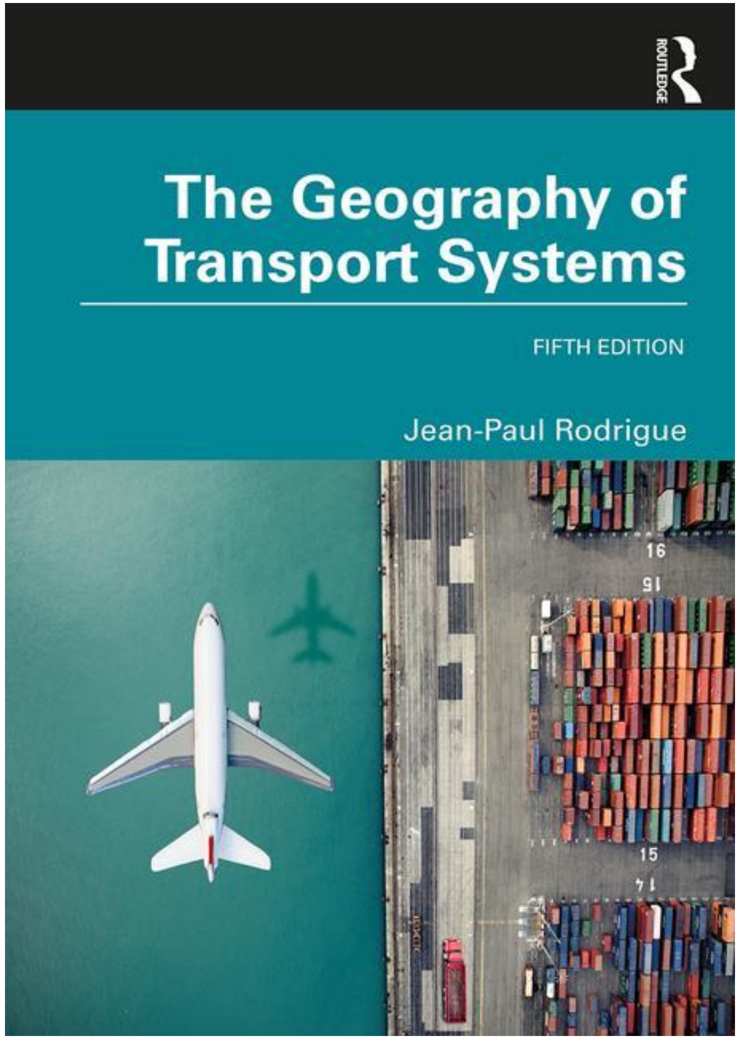
Gamma Index



$$\gamma = \frac{e}{3(v-2)}$$

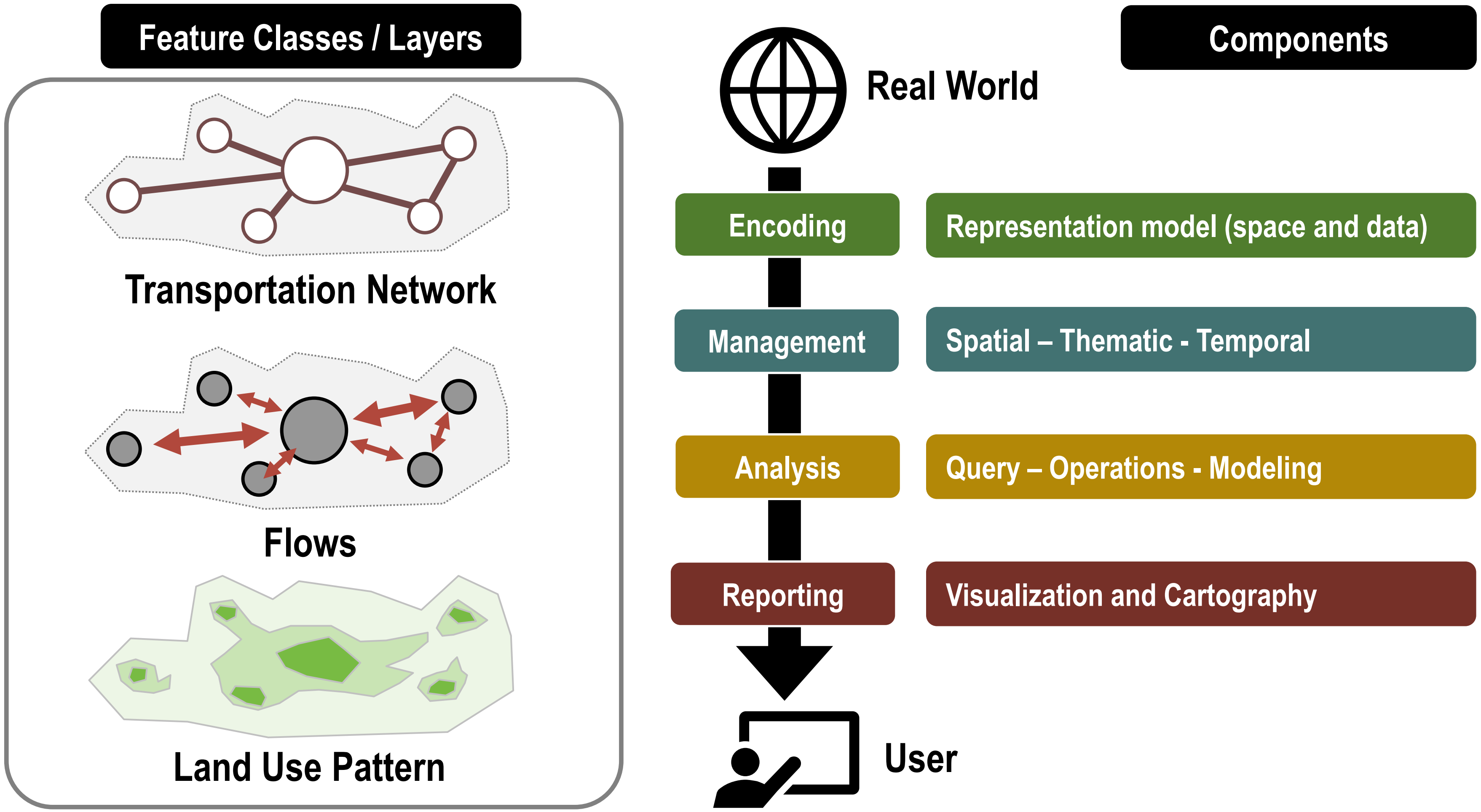
	e	3(v-2)	Gamma
A	4	9	0.44
B	6	9	0.66
C	8	9	0.88
D	9	9	1.0

Under construction

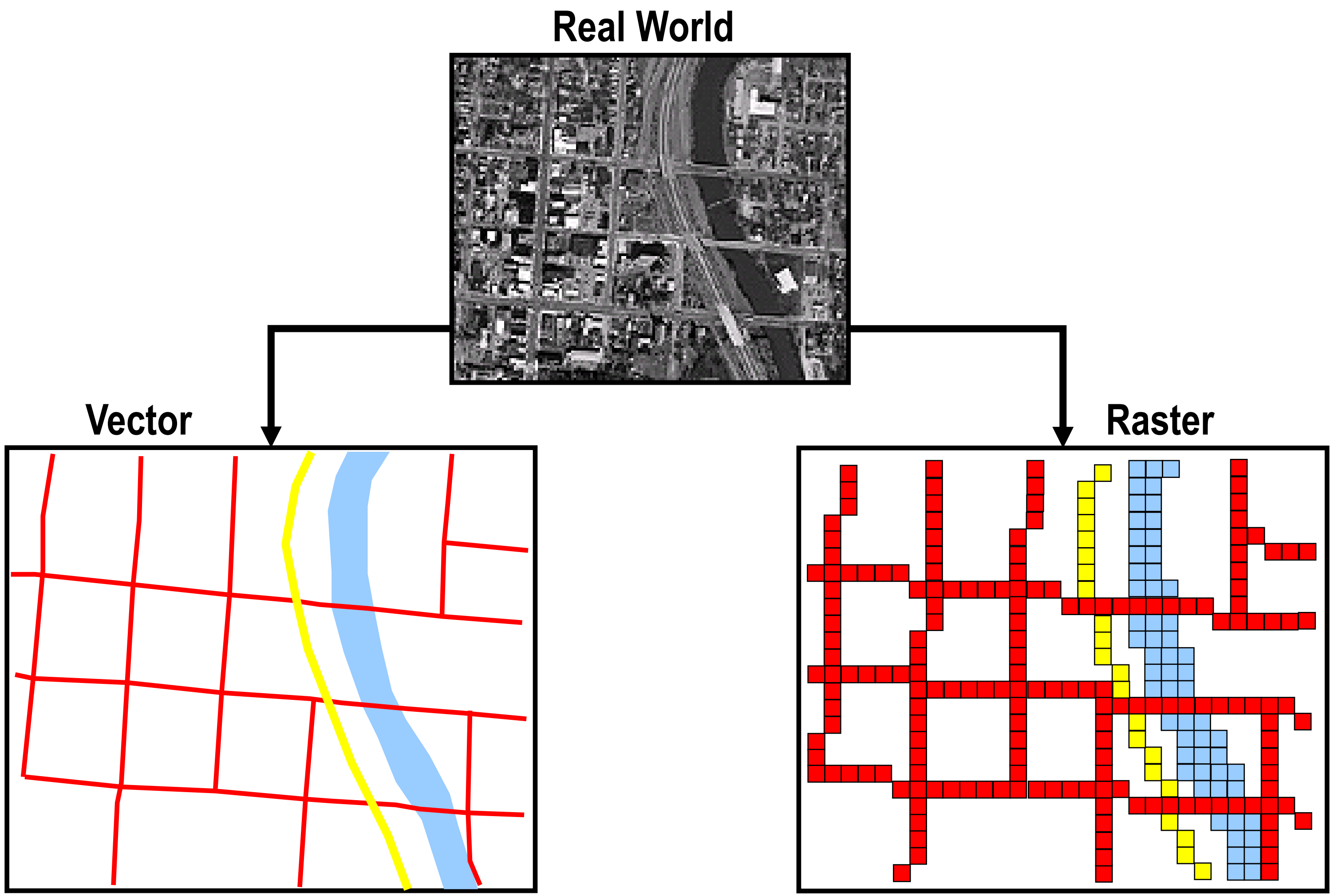


Geographic Information Systems for Transportation (GIS-T)

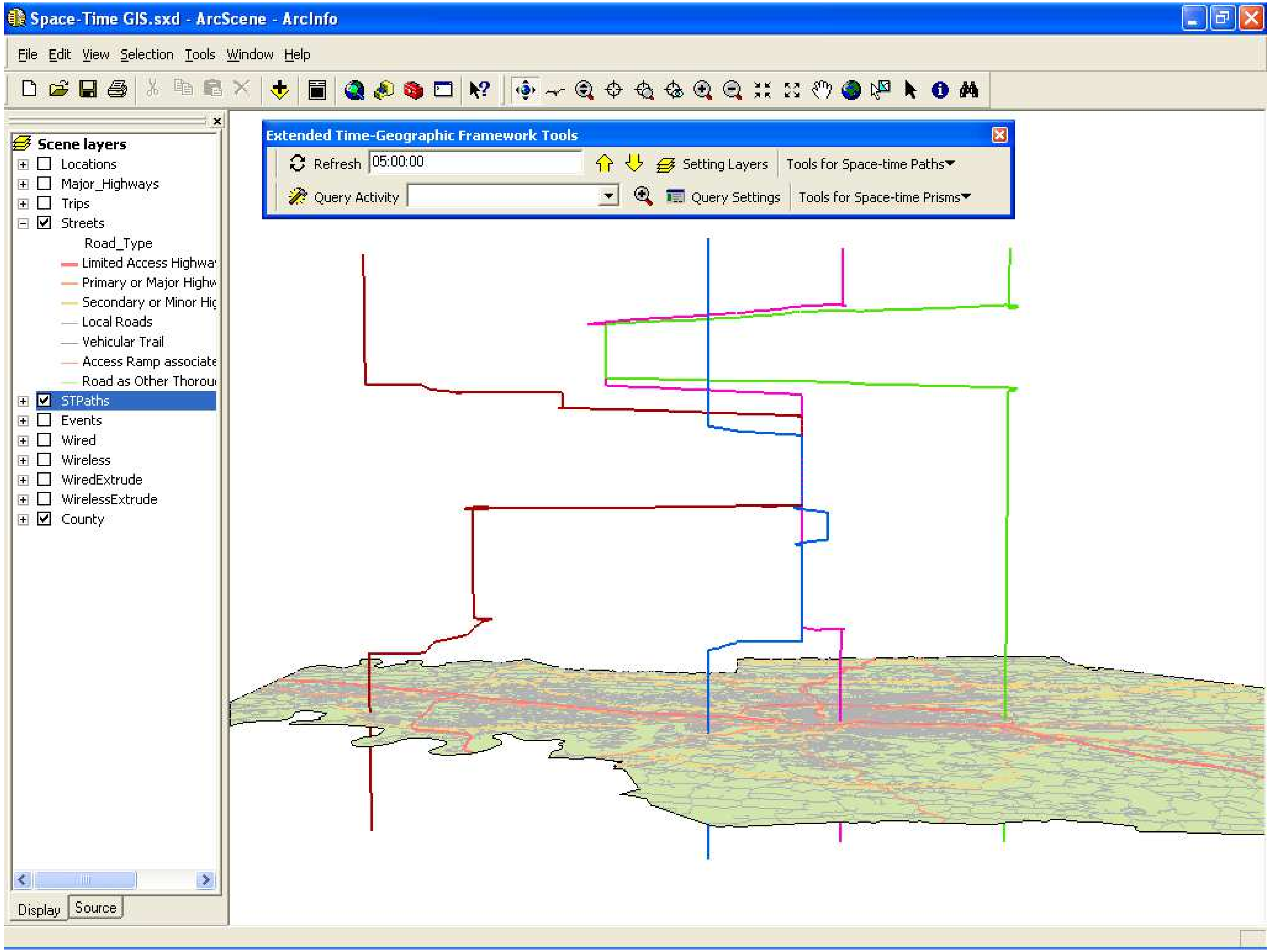
Geographic Information Systems and Transportation



GIS Data Models

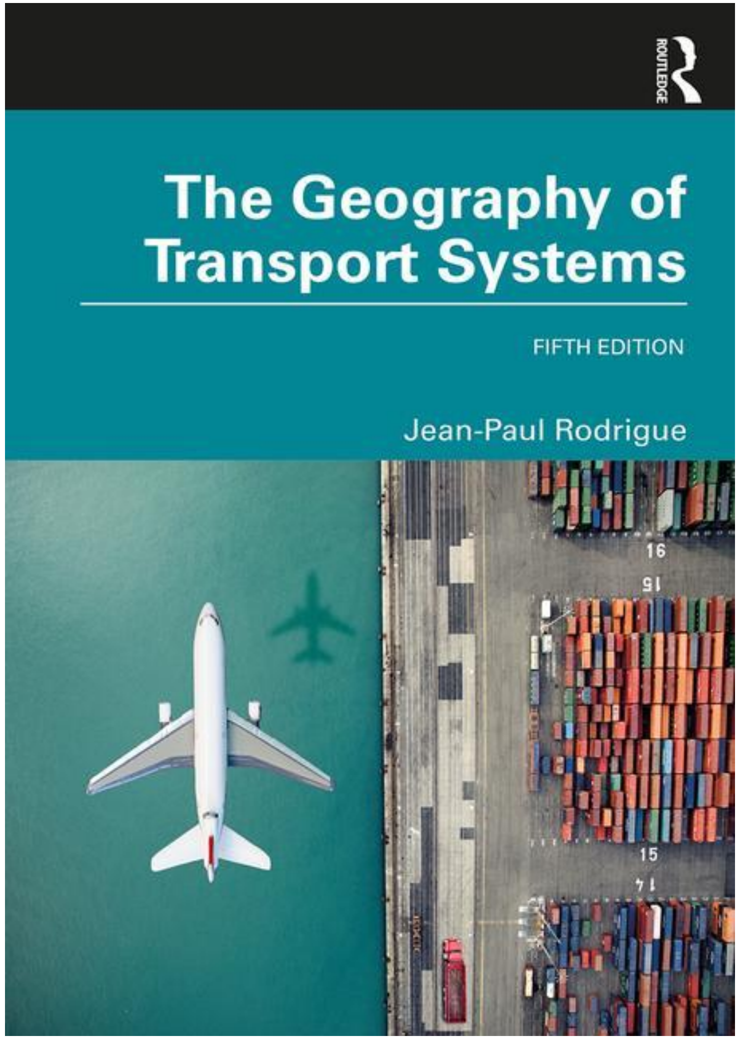


Space / Time GIS



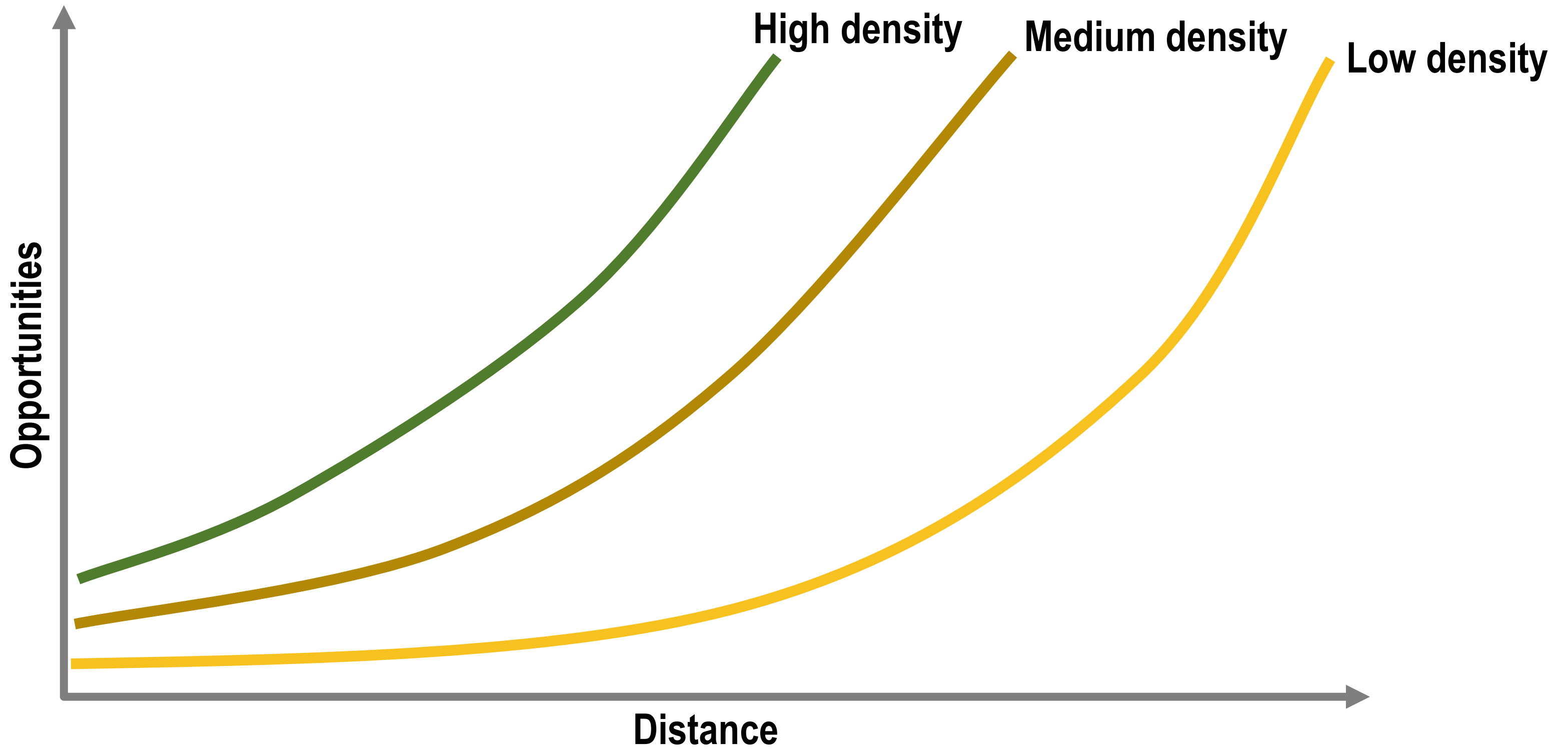
GIS in the Value Chain

Inbound Logistics	**Optimization of warehouse usage; logistics modeling**
Sales and Marketing	GIS as a market analysis tool; simulation of dispersion of new products; target marketing and advertising
Services	Route planning; dealer network maintenance; customer complaints; dispatch; maintenance forecasting
Operations	Enhancing the spatial content of process or product
Outbound Logistics	Route planning; fleet management; delivery assessment

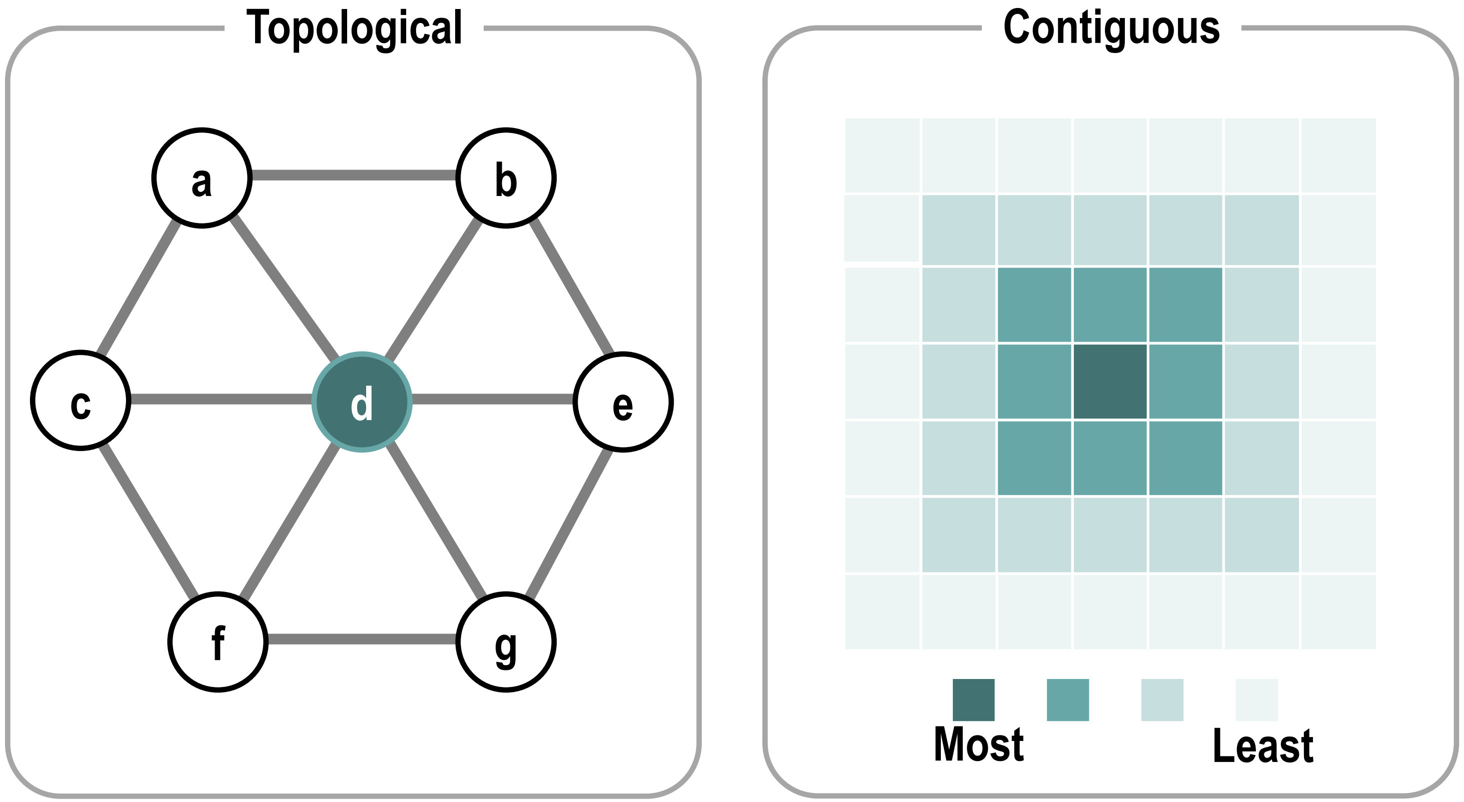


Transportation and Accessibility

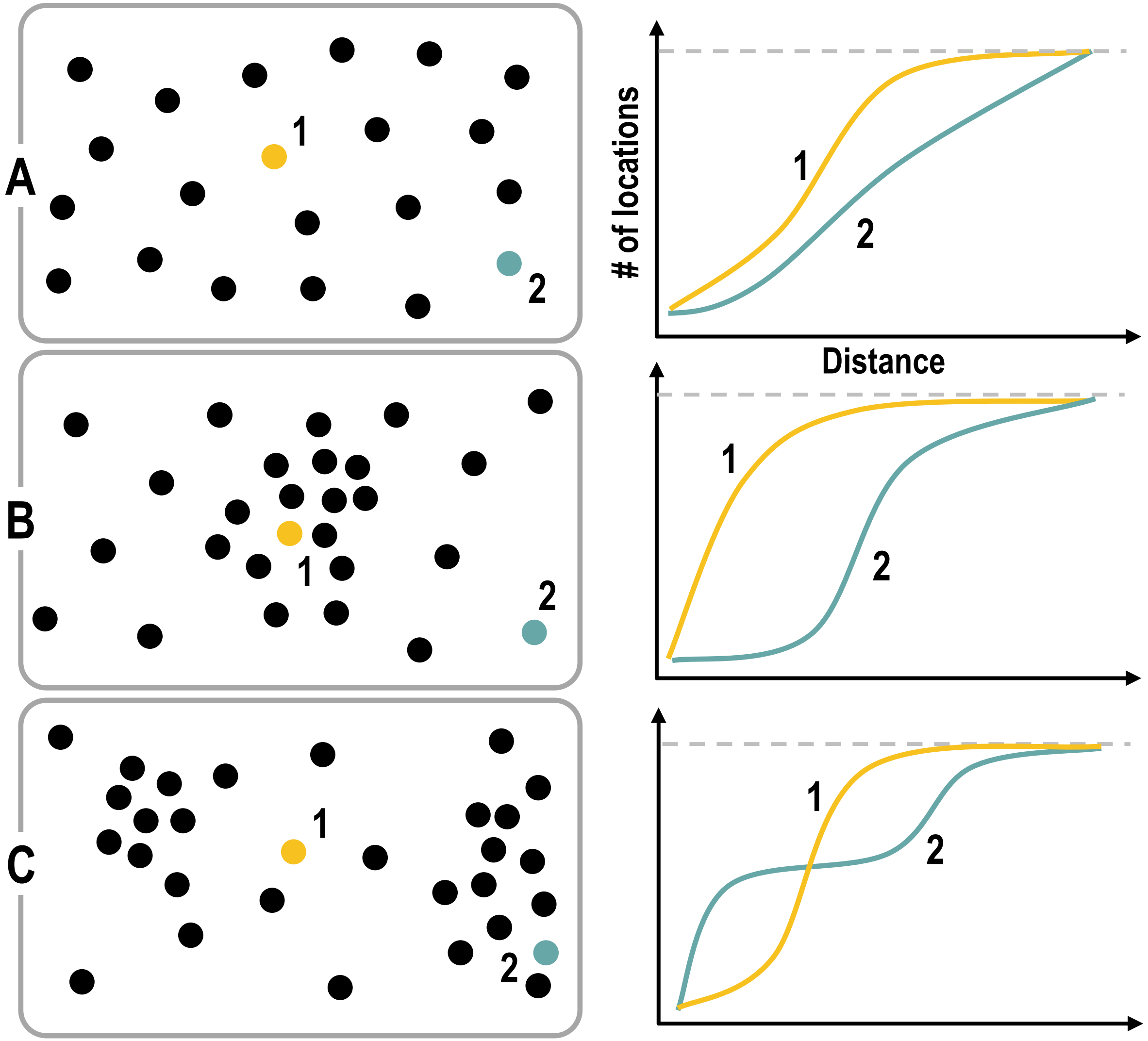
Relationship between Distance and Opportunities



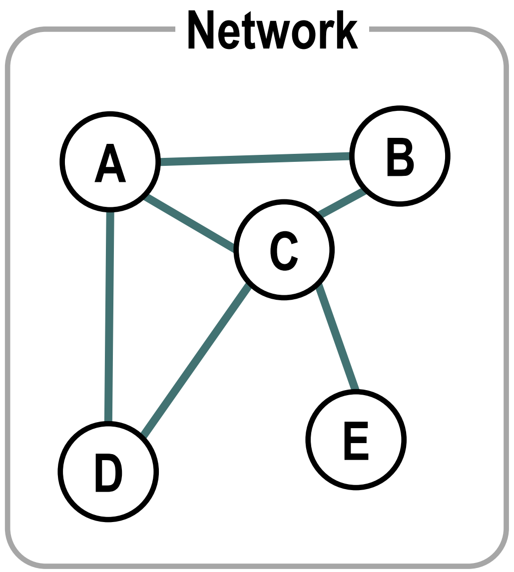
Topological and Contiguous Accessibility



Accessibility and Spatial Structure



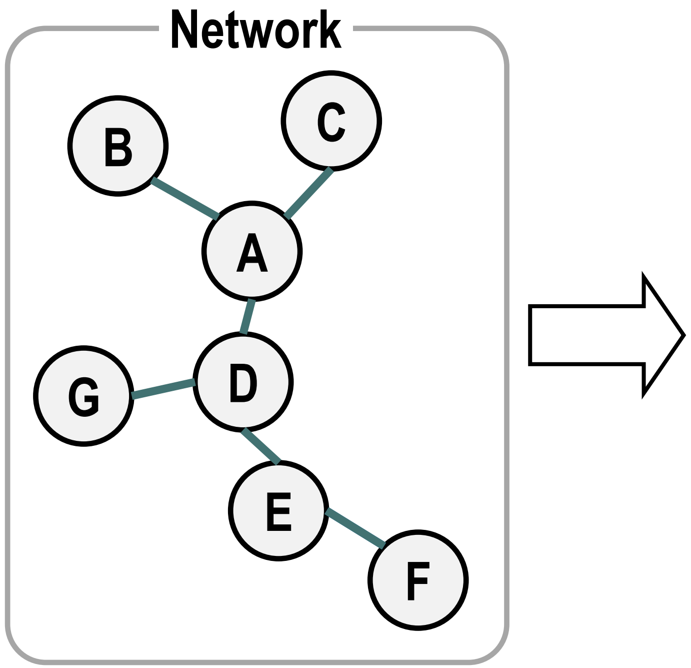
Simple Connectivity Matrix



Connectivity Matrix

	A	B	C	D	E
A	0	1	1	1	0
B	1	0	1	0	0
C	1	1	0	1	1
D	1	0	1	0	0
E	0	0	1	0	0

More Complex Connectivity Matrix



Connectivity Matrix

	A	B	C	D	E	F	G
A	0	1	1	1	0	0	0
B	1	0	0	0	0	0	0
C	1	0	0	0	0	0	0
D	1	0	0	0	1	0	1
E	0	0	0	1	0	1	0
F	0	0	0	0	1	0	0
G	0	0	0	1	0	0	0

Total Accessibility Matrix (T-Matrix)

C2

	A	B	C	D	E
A	3	1	2	1	1
B	1	2	1	2	1
C	2	1	4	1	0
D	1	2	1	2	1
E	1	1	0	1	1

=

C1

	A	B	C	D	E
A	0	1	1	1	0
B	1	0	1	0	0
C	1	1	0	1	1
D	1	0	1	0	0
E	0	0	1	0	0

X

C1

	A	B	C	D	E
A	0	1	1	1	0
B	1	0	1	0	0
C	1	1	0	1	1
D	1	0	1	0	0
E	0	0	1	0	0

T

	A	B	C	D	E	Σ
A	3	2	3	2	1	11
B	2	2	2	2	1	9
C	3	2	4	2	1	12
D	2	2	2	2	1	9
E	1	1	1	1	1	5
Σ	11	9	12	9	5	46

=

C2

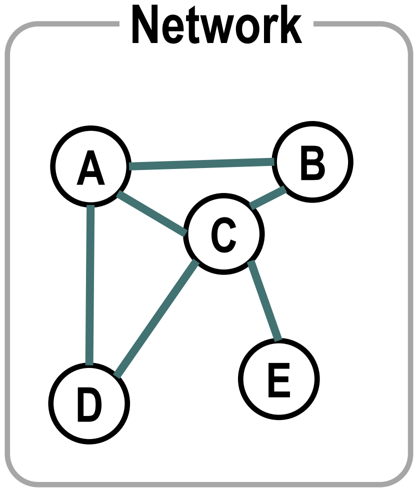
	A	B	C	D	E
A	3	1	2	1	1
B	1	2	1	2	1
C	2	1	4	1	0
D	1	2	1	2	1
E	1	1	0	1	1

\+

C1

	A	B	C	D	E
A	0	1	1	1	0
B	1	0	1	0	0
C	1	1	0	1	1
D	1	0	1	0	0
E	0	0	1	0	0

Shimbel Distance (D-Matrix)



C1

	A	B	C	D	E
A	0	1	1	1	0
B	1	0	1	0	0
C	1	1	0	1	1
D	1	0	1	0	0
E	0	0	1	0	0

=1

D1

	A	B	C	D	E
A	0	1	1	1	
B	1	0	1		
C	1	1	0	1	1
D	1		1	0	
E			1		0

C2

	A	B	C	D	E
A	3	1	2	1	1
B	1	2	1	2	1
C	2	1	4	1	0
D	1	2	1	2	1
E	1	1	0	1	1

=2

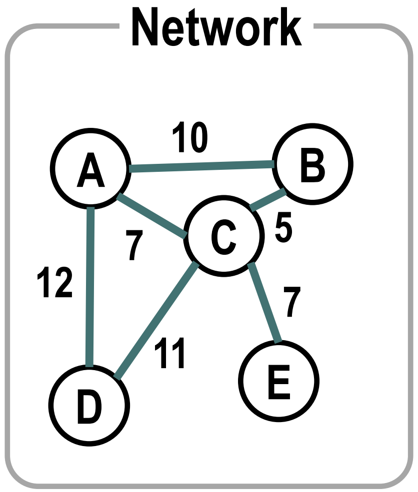
D2

	A	B	C	D	E
A	0	1	1	1	2
B	1	0	1	2	2
C	1	1	0	1	1
D	1	2	1	0	2
E	2	2	1	2	0

D

	A	B	C	D	E	Σ
A	0	1	1	1	2	5
B	1	0	1	2	2	6
C	1	1	0	1	1	4
D	1	2	1	0	2	6
E	2	2	1	2	0	7
Σ	5	6	4	6	7	28

Valued Graph (L-Matrix)



L1

	A	B	C	D	E
A	0	10	7	12	∞
B	10	0	5	∞	∞
C	7	5	0	11	7
D	12	∞	11	0	∞
E	∞	∞	7	∞	0

L2

	A	B	C	D	E	Σ
A	0	10	7	12	14	43
B	10	0	5	16	12	43
C	7	5	0	11	7	30
D	12	16	11	0	18	57
E	14	12	7	18	0	51
Σ	43	43	30	57	51	194

=

L1

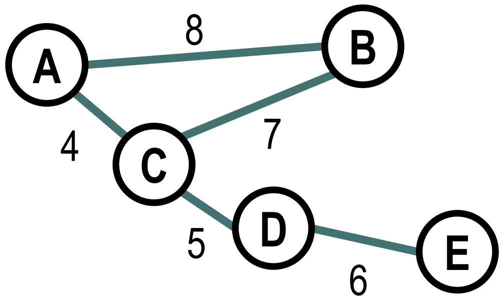
	A	B	C	D	E
A	0	10	7	12	∞
B	10	0	5	∞	∞
C	7	5	0	11	7
D	12	∞	11	0	∞
E	∞	∞	7	∞	0

\+

L1

	A	B	C	D	E
A	0	10	7	12	∞
B	10	0	5	∞	∞
C	7	5	0	11	7
D	12	∞	11	0	∞
E	∞	∞	7	∞	0

Geographic Accessibility



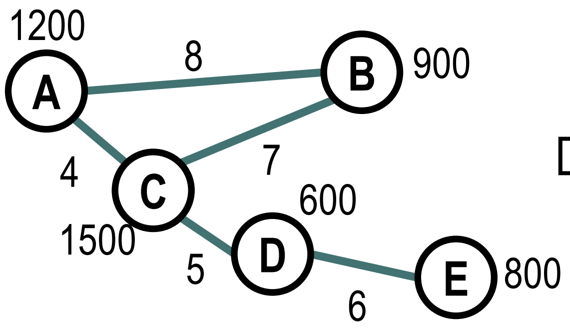
L

	A	B	C	D	E
A	0	8	4	9	15
B	8	0	7	12	18
C	4	7	0	5	11
D	9	12	5	0	6
E	15	18	11	6	0

A(G)

	A	B	C	D	E	∑/n
A	0	8	4	9	15	7.2
B	8	0	7	12	18	9.0
C	4	7	0	5	11	5.4
D	9	12	5	0	6	6.4
E	15	18	11	6	0	10.0
∑/n	7.2	9.0	5.4	6.4	10.0	38.0

Potential Accessibility



L

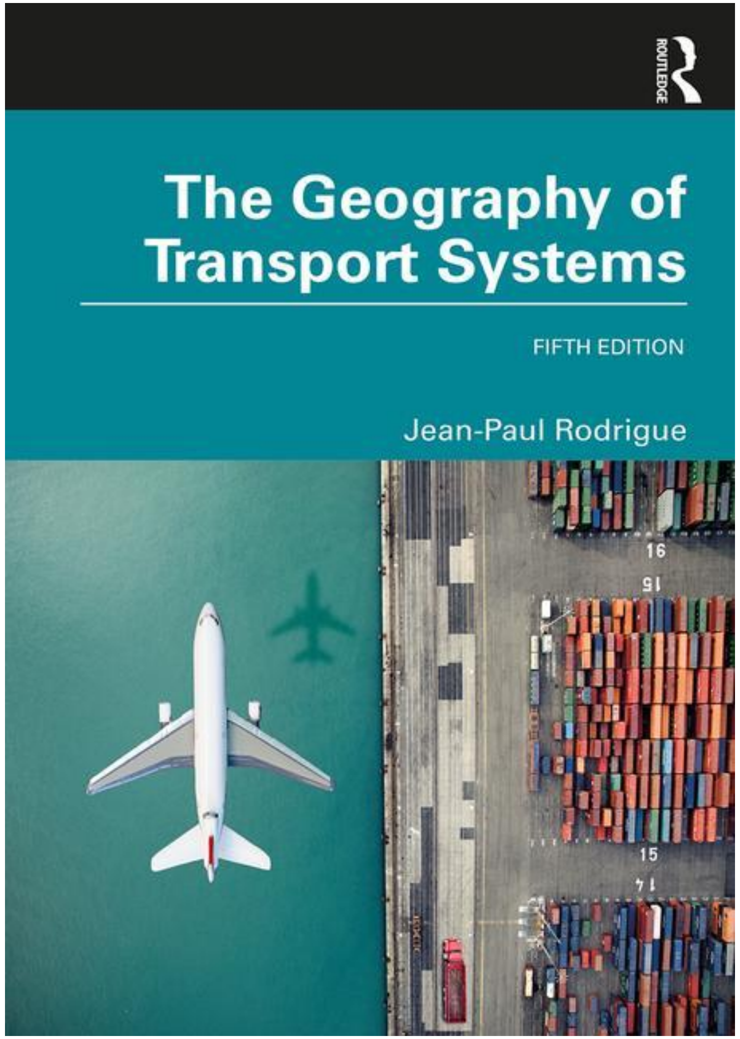
	A	B	C	D	E
A	0	8	4	9	15
B	8	0	7	12	18
C	4	7	0	5	11
D	9	12	5	0	6
E	15	18	11	6	0

P

A	1200
B	900
C	1500
D	600
E	800

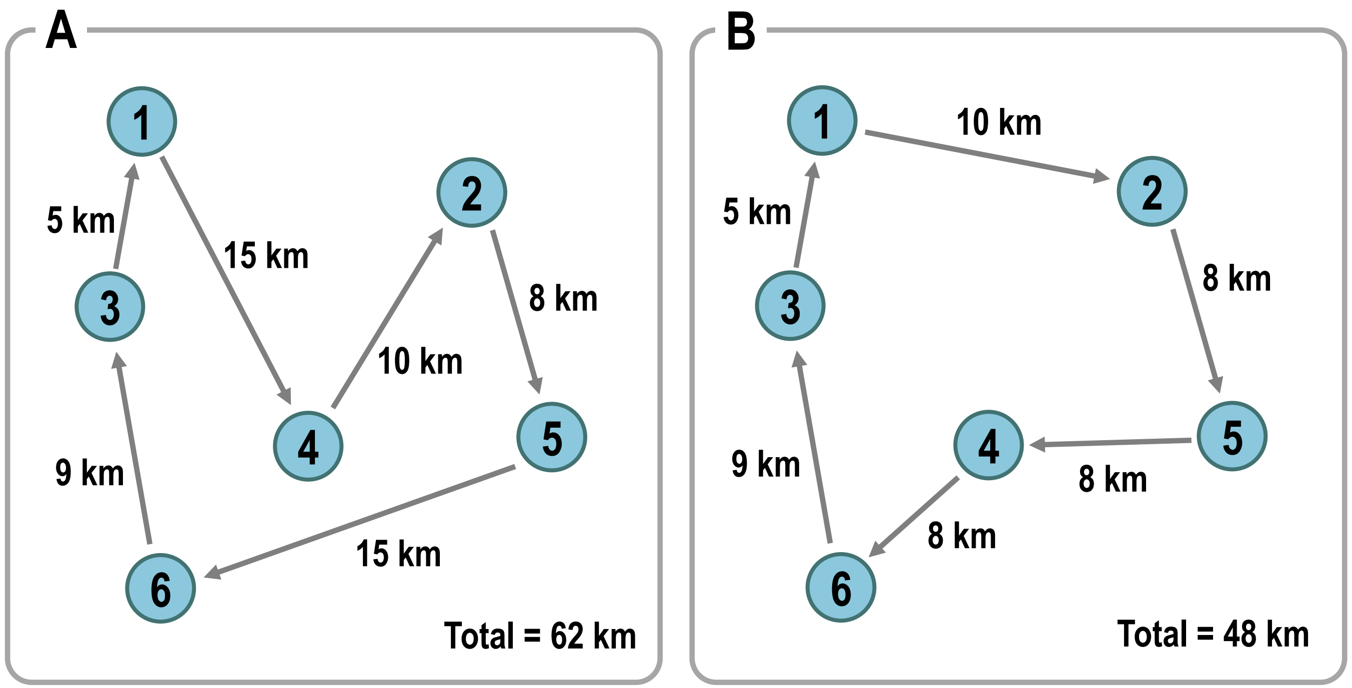
P(G)

i\j	A	B	C	D	E	∑i
A	1200.0	150.0	300.0	133.3	80.0	1863.3
B	112.5	900.0	128.6	75.0	50.0	1266.1
C	375.0	214.3	1500.0	300.0	136.4	2525.7
D	66.6	50.0	120.0	600.0	100.0	936.6
E	53.3	44.4	72.7	133.3	800.0	1103.7
∑j	1807.4	1358.7	2121.3	1241.6	1166.4	7695.4

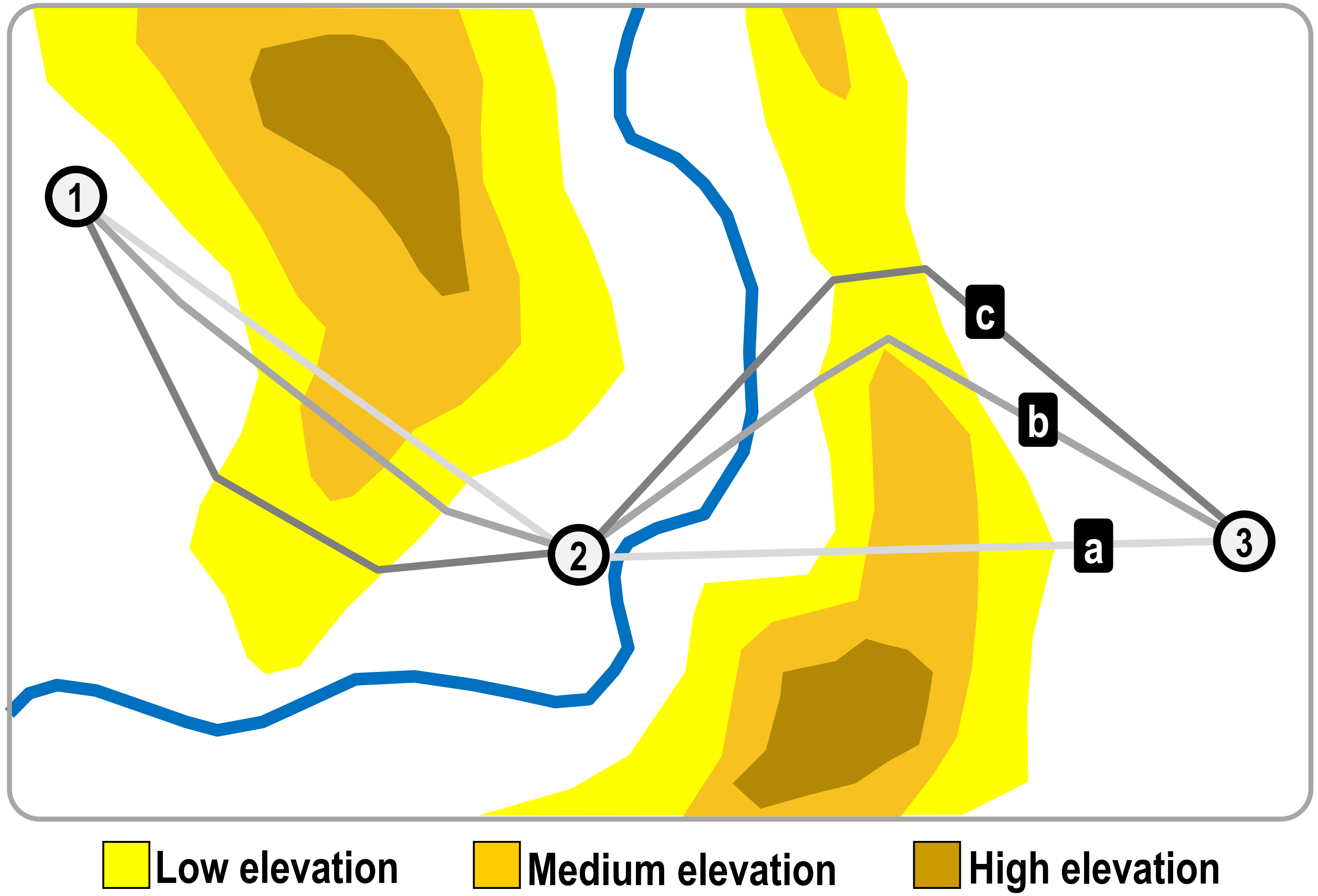


The Route Selection Process

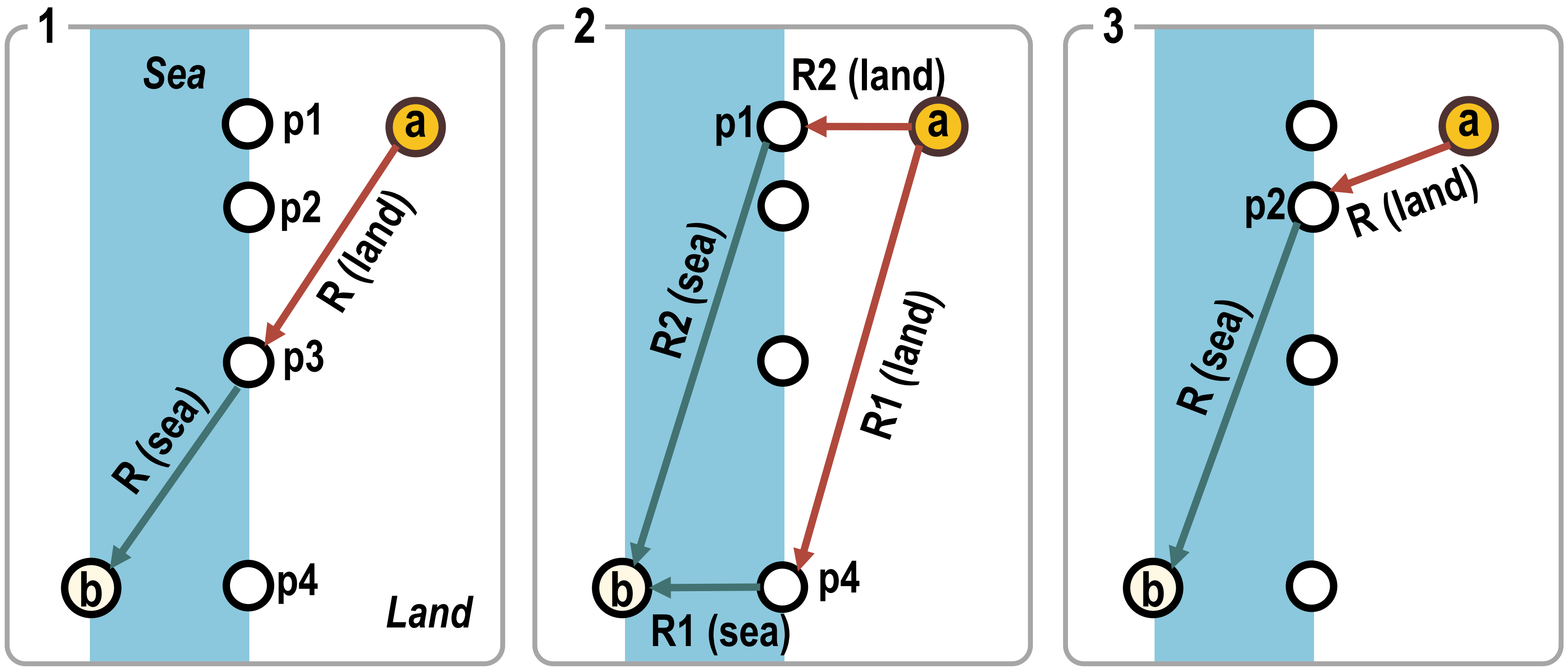
The Traveling Salesperson Problem



Effect of Topography on Route Selection



Effect of Transport Costs on Route Selection

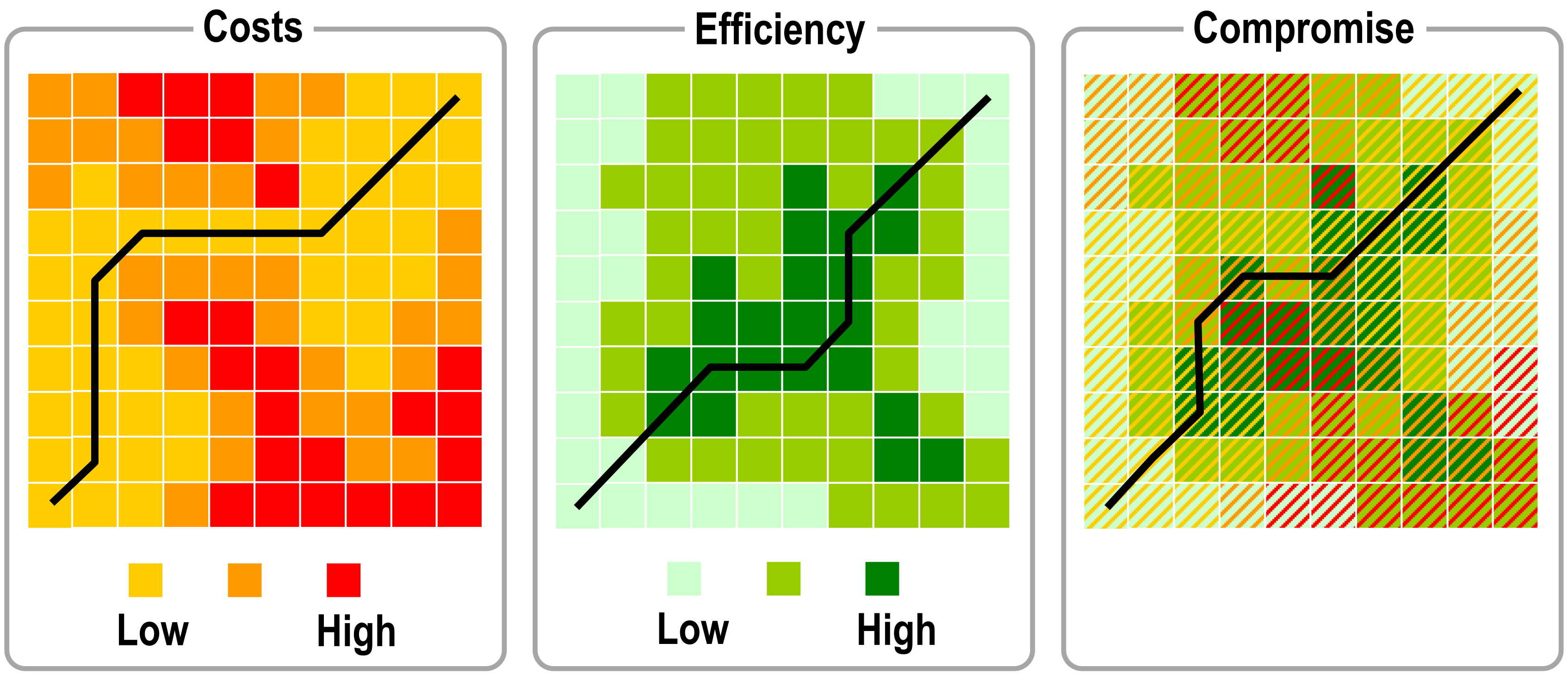


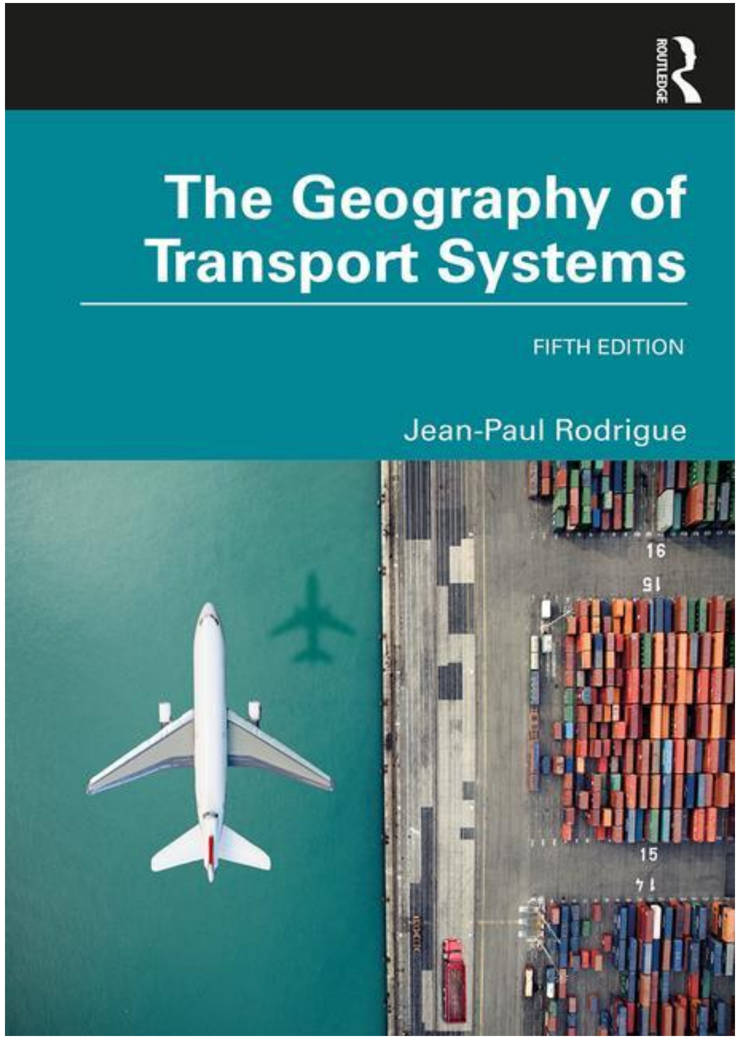
R {C(sea) = C(land)}

R1 {C(sea) > C(land)}
R2 {C(sea) < C(land)}

R {ΔC(land) > ΔC(sea)}

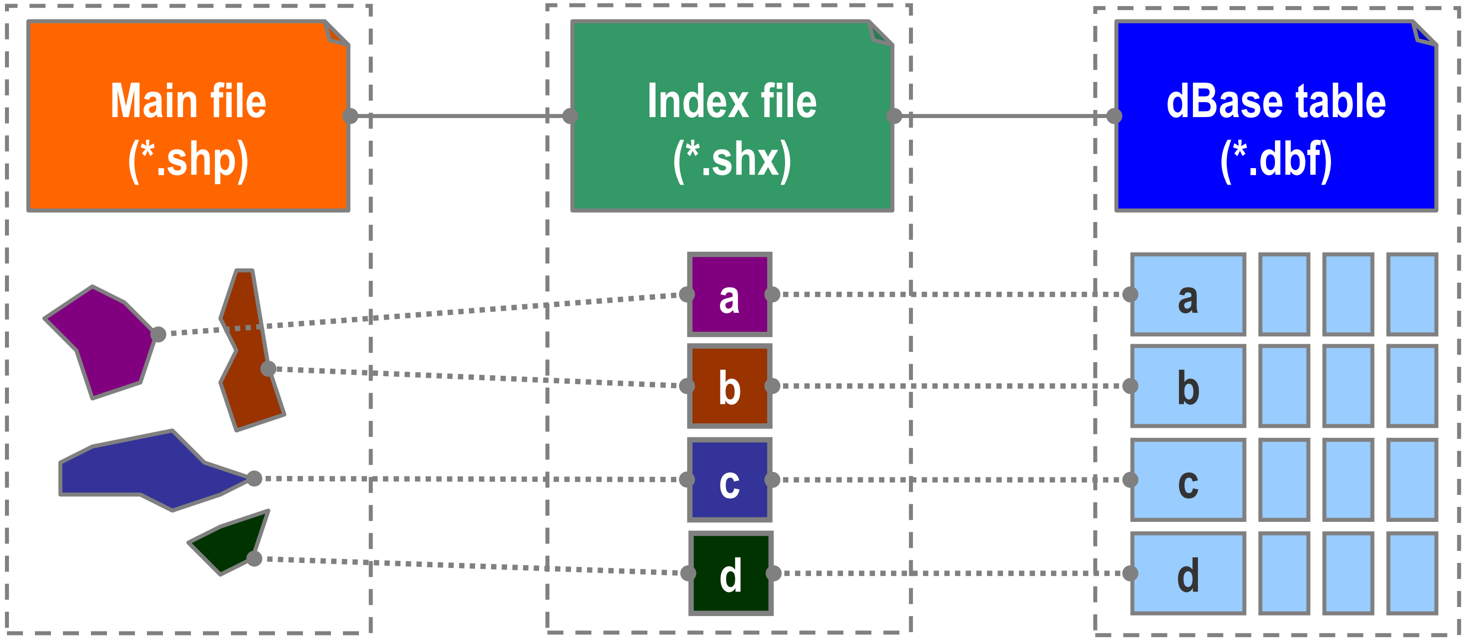
Cost Minimization and Efficiency Maximization in Route Selection





Network Data Models

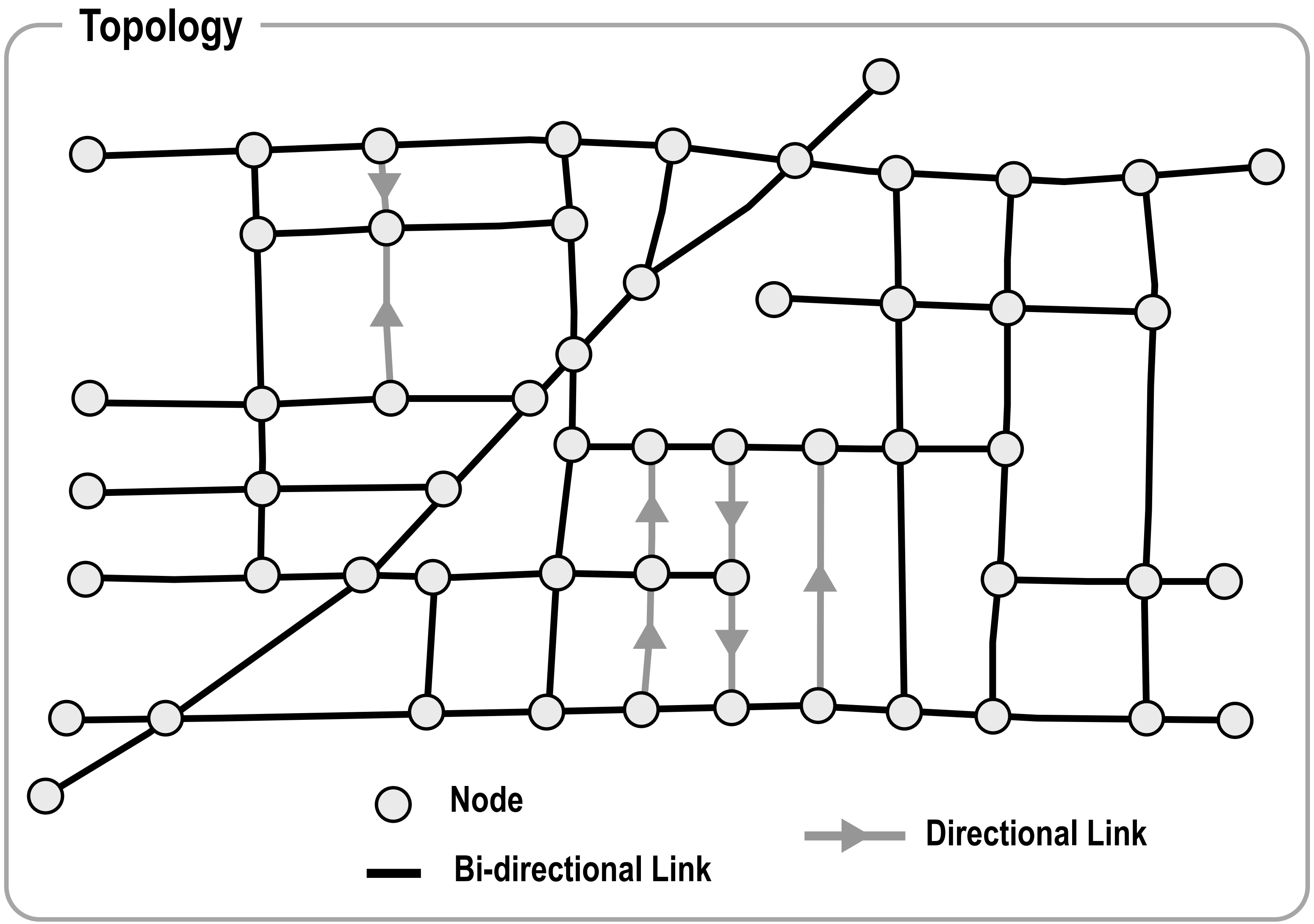
The ESRI Shapefile Model



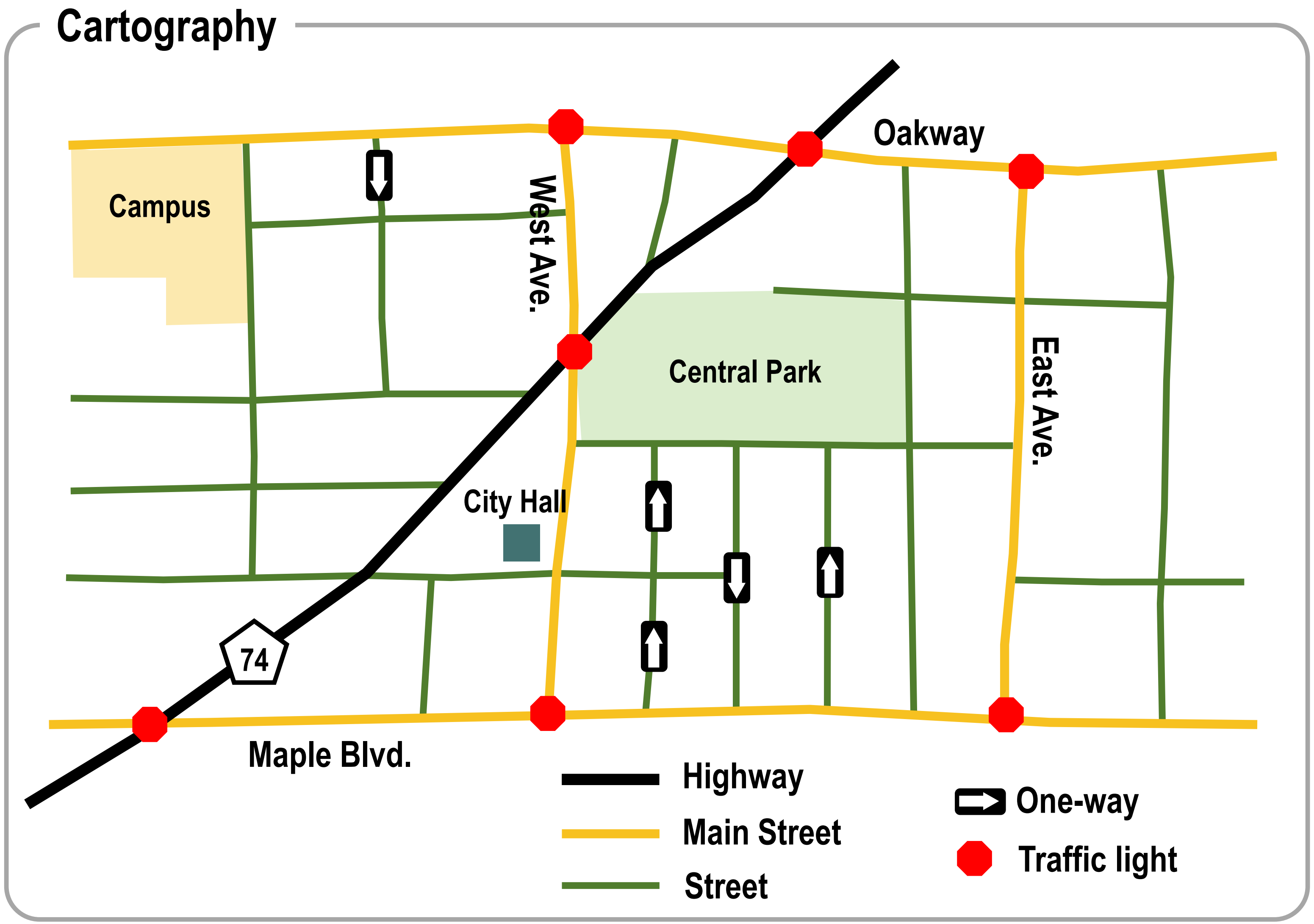
geom	id	shp_len	type	surface	width	lanes	name
	101	4507.4	2	asphalt	85.3	4	I95
	102	3491.1	1	concrete	45.1	2	Route 4
	103	2321.8	3	asphalt	75.9	4	Pinewood
	104	682.9	5	gravel	35.2	2	Ridge
	105	1279.1	4	asphalt	60.3	4	Main
	…	…	…	…	…	…	…

Predefined fields | **custom fields**

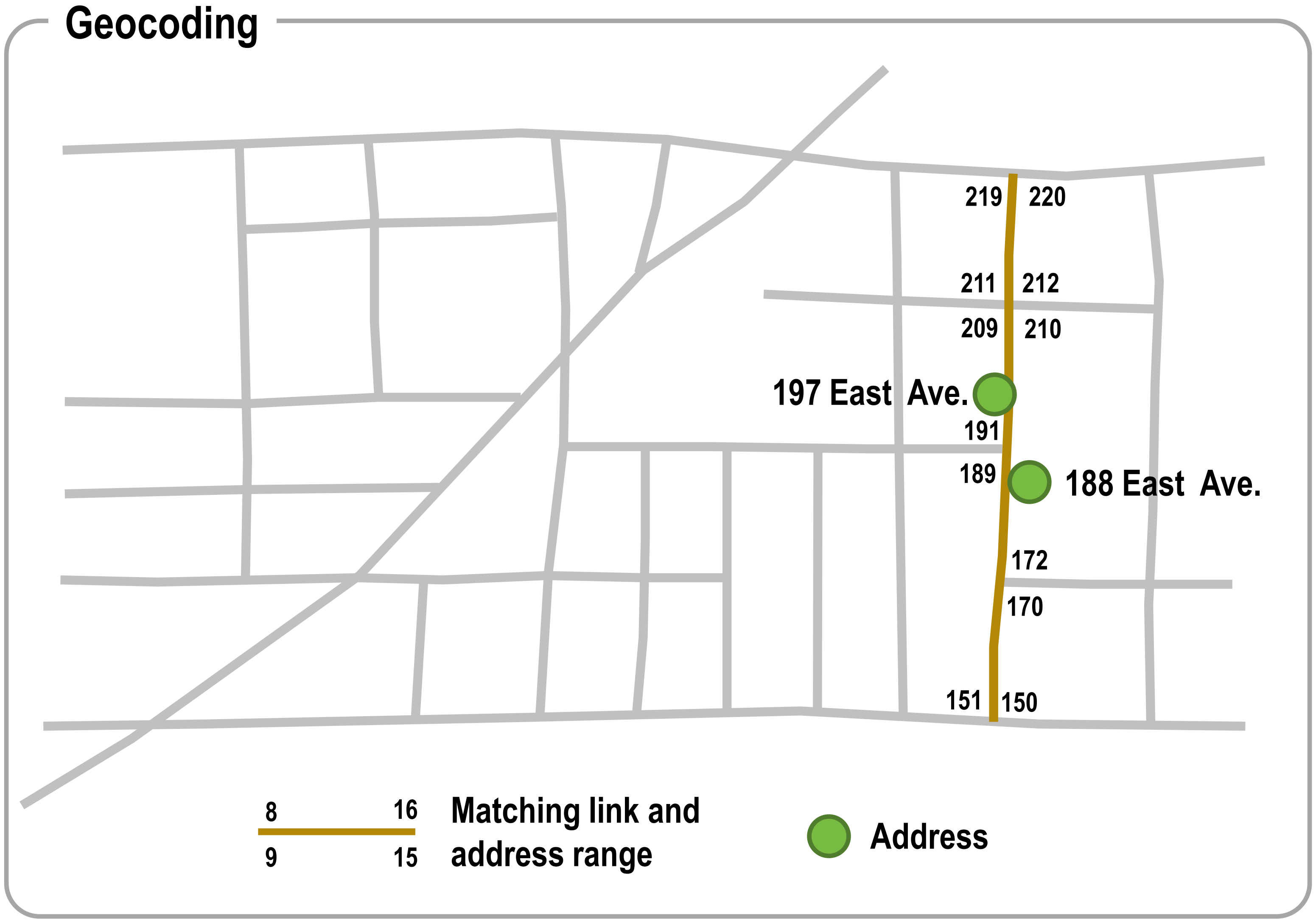
Topology of a Network Data Model



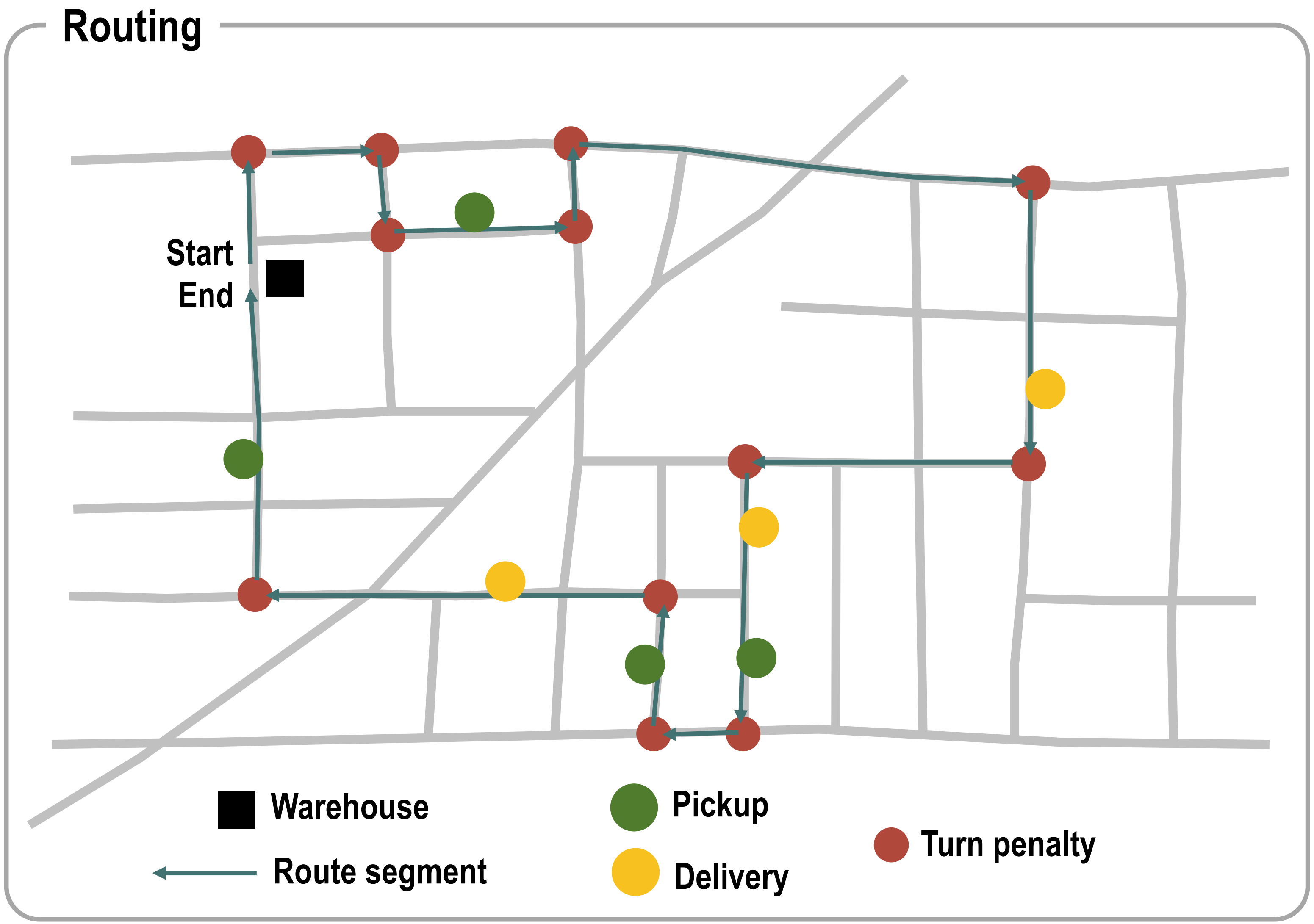
Cartography of a Network Data Model



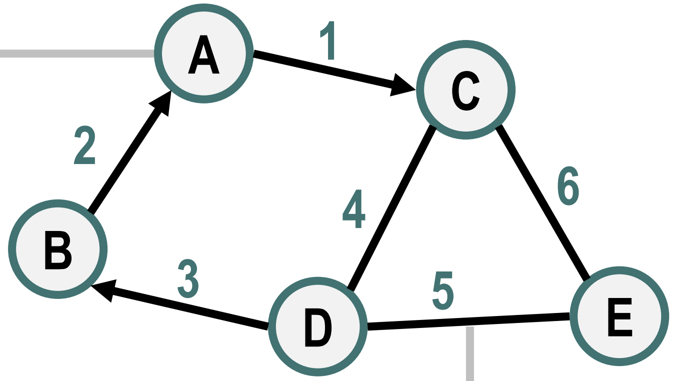
Geocoding in a Network Data Model



Routing in a Network Data Model



Relational Database Representation of a Simple Network



Nodes		
ID	Lat	Long
A	40.42345	-75.1245
B	40.31021	-75.2510
C	40.41882	-74.9124
D	40.25908	-75.0031
E	40.28990	-74.7893

Links			
ID	From	To	One_Way
1	A	C	Yes
2	B	A	Yes
3	D	B	Yes
4	D	C	No
5	D	E	No
6	C	E	No

Creation of a Connectivity Matrix with a Link Table

Links			
ID	From	To	One_Way
1	C	A	Yes
2	B	A	Yes
3	D	B	Yes
4	D	C	No
5	D	E	No
6	C	E	No

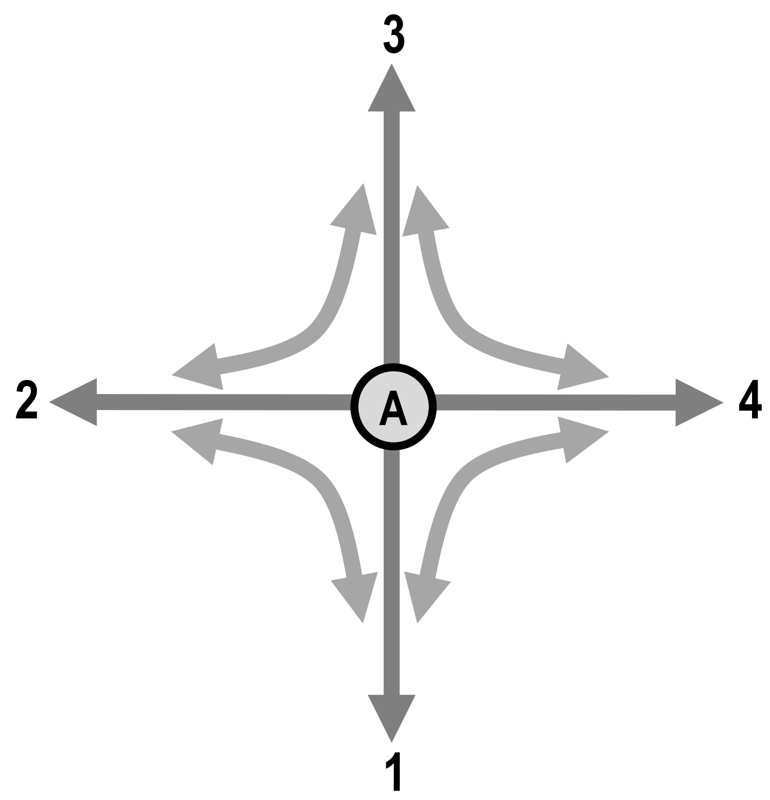
$$C_{ij} = 0 \; \forall i, j$$

$$\forall ID[i], C_{From[i],To[i]} = 1$$

$$\forall One\_Way[i] = "No", C_{To[i],From[i]} = 1$$

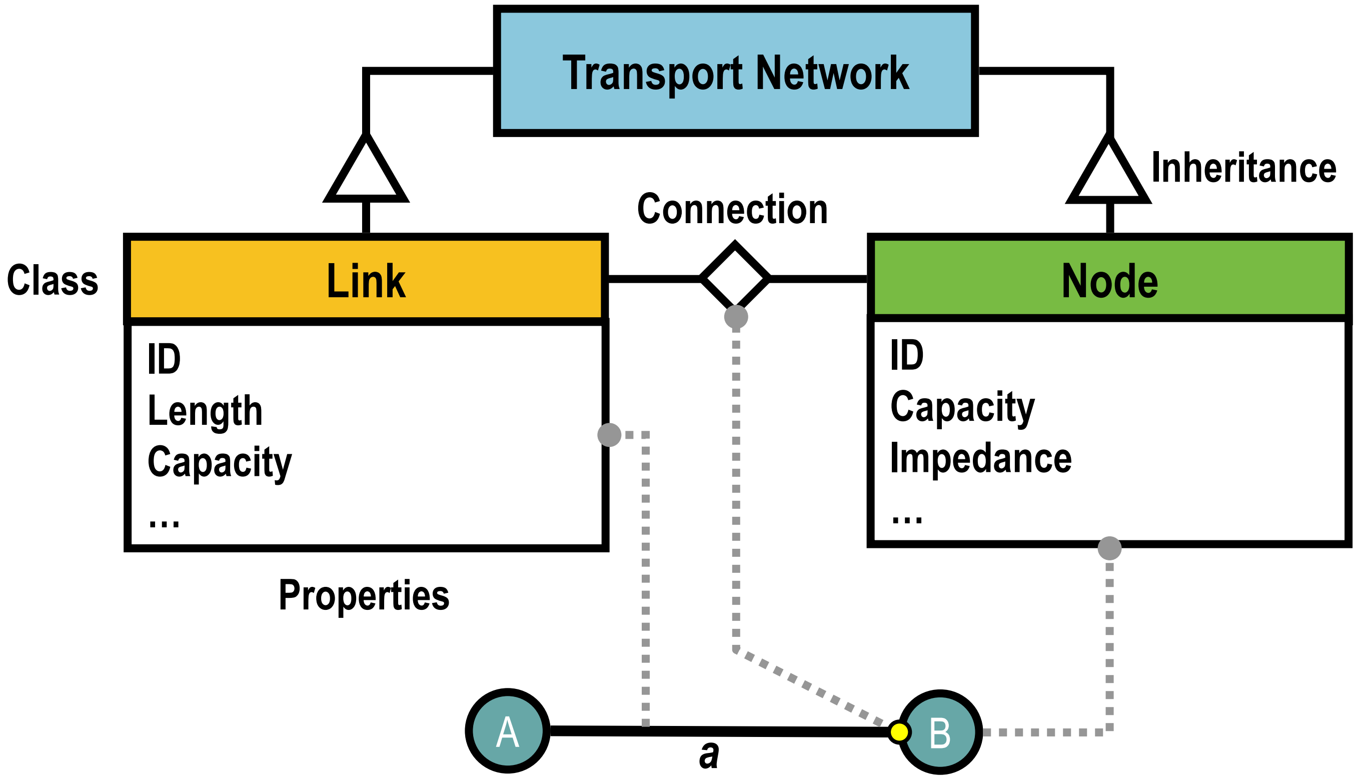
Connectivity Matrix (C)					
	A	B	C	D	E
A	0	0	0	0	0
B	1	0	0	0	0
C	1	0	0	1	1
D	0	1	1	0	1
E	0	0	1	1	0

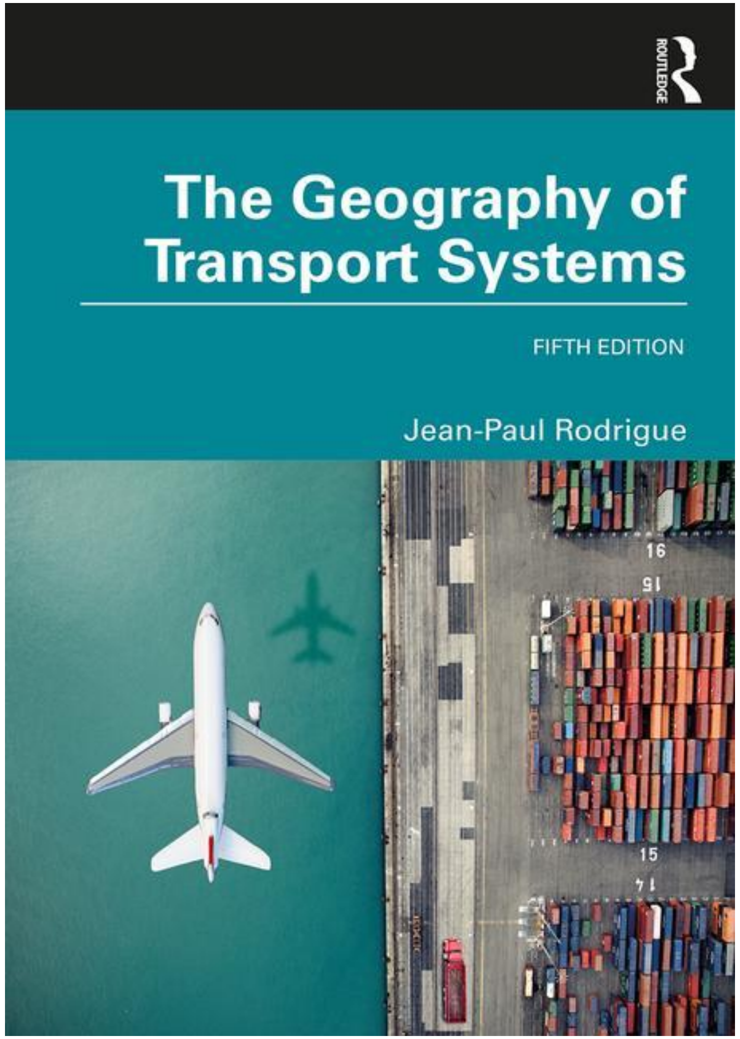
Turn Penalties at an Intersection



Turn Penalty Table – Node A		
From	**To**	**Penalty**
1	2	2
2	1	1
1	3	0
3	1	0
1	4	1
4	1	2
2	3	2
3	2	1
2	4	0
4	2	0
3	4	-1
4	3	1

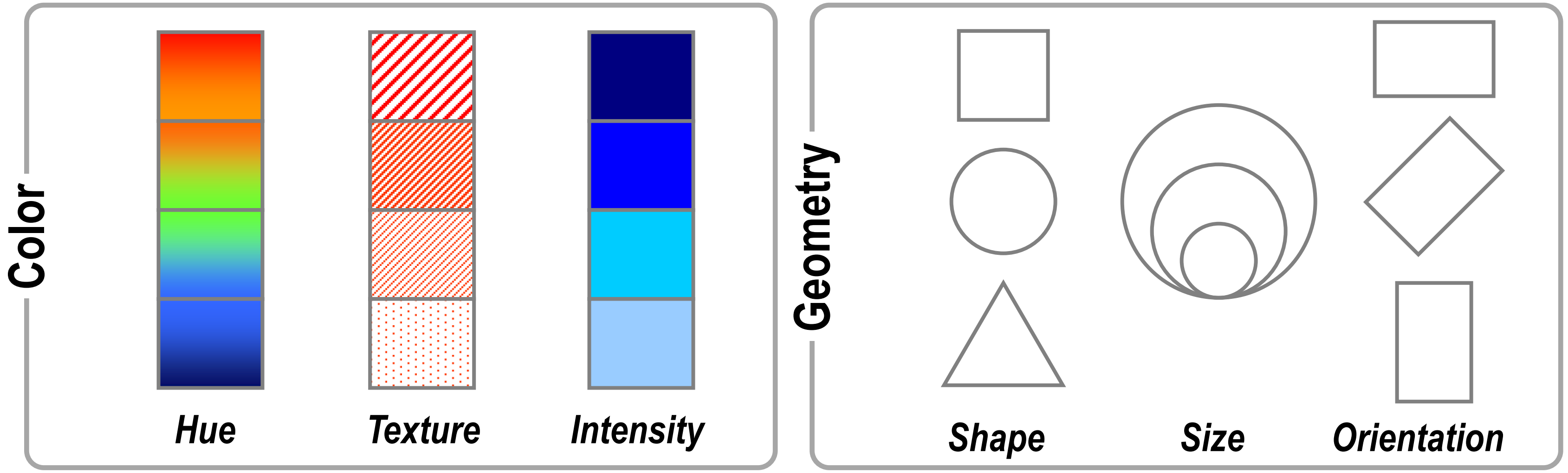
Object-Oriented Network Model



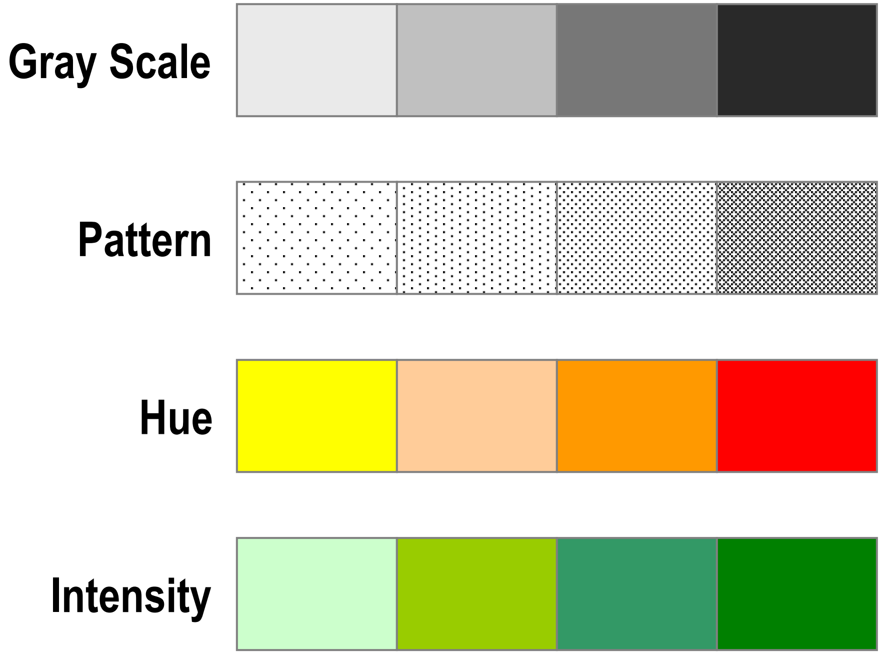


Symbolization of Transport Features in a GIS

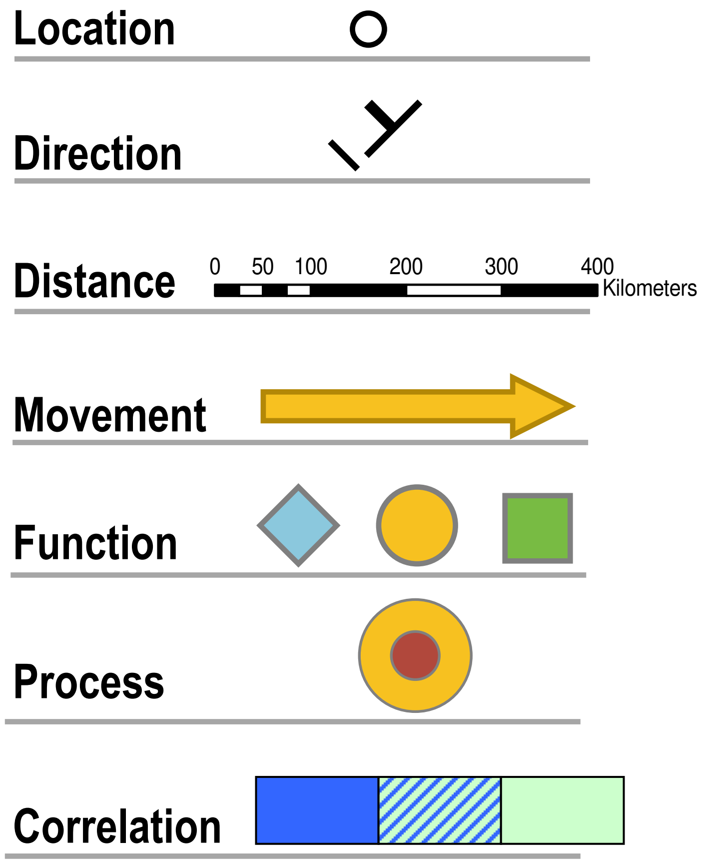
Visual Resources



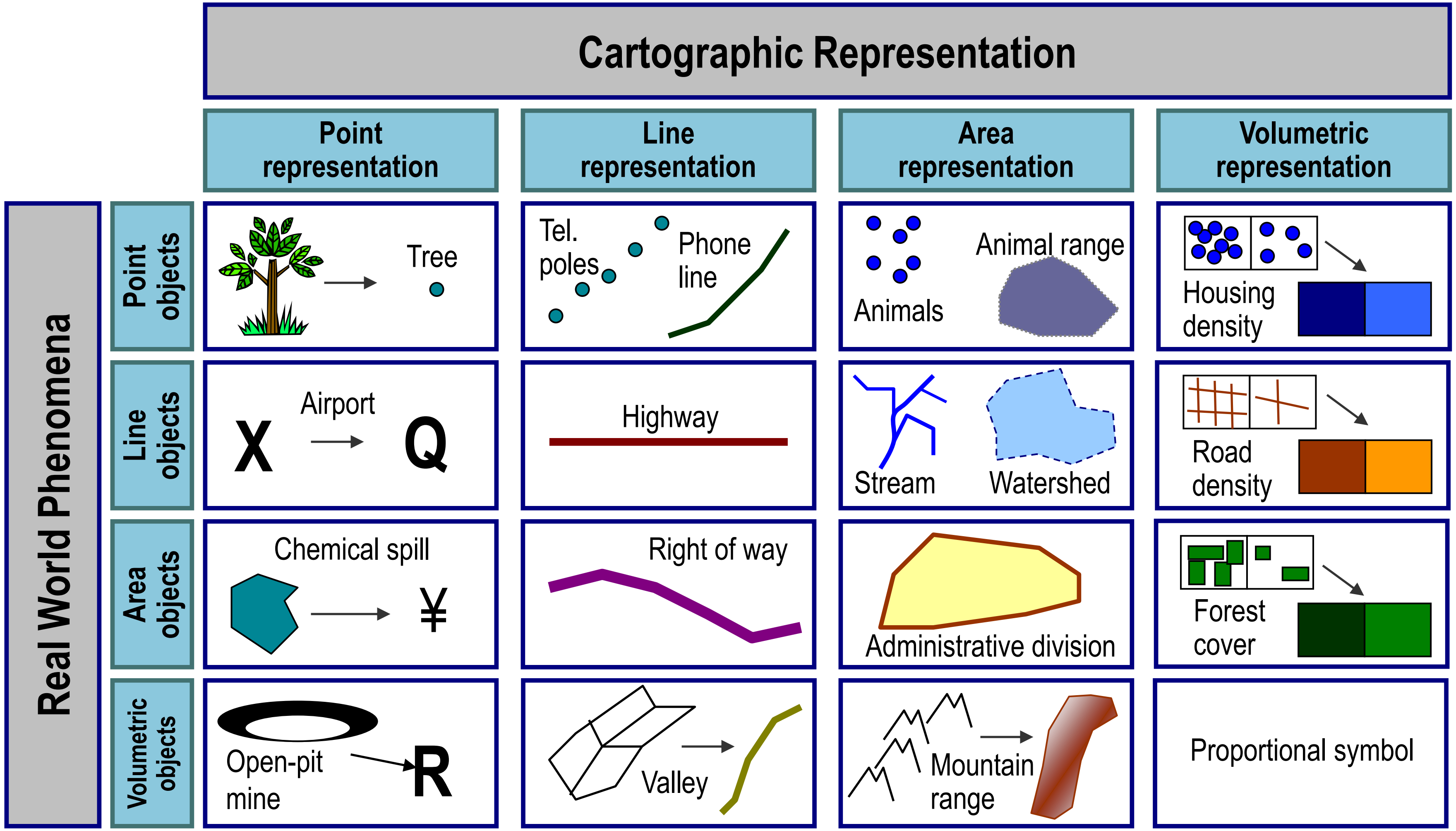
Category Ranges



Visual Resources and Geographical Features

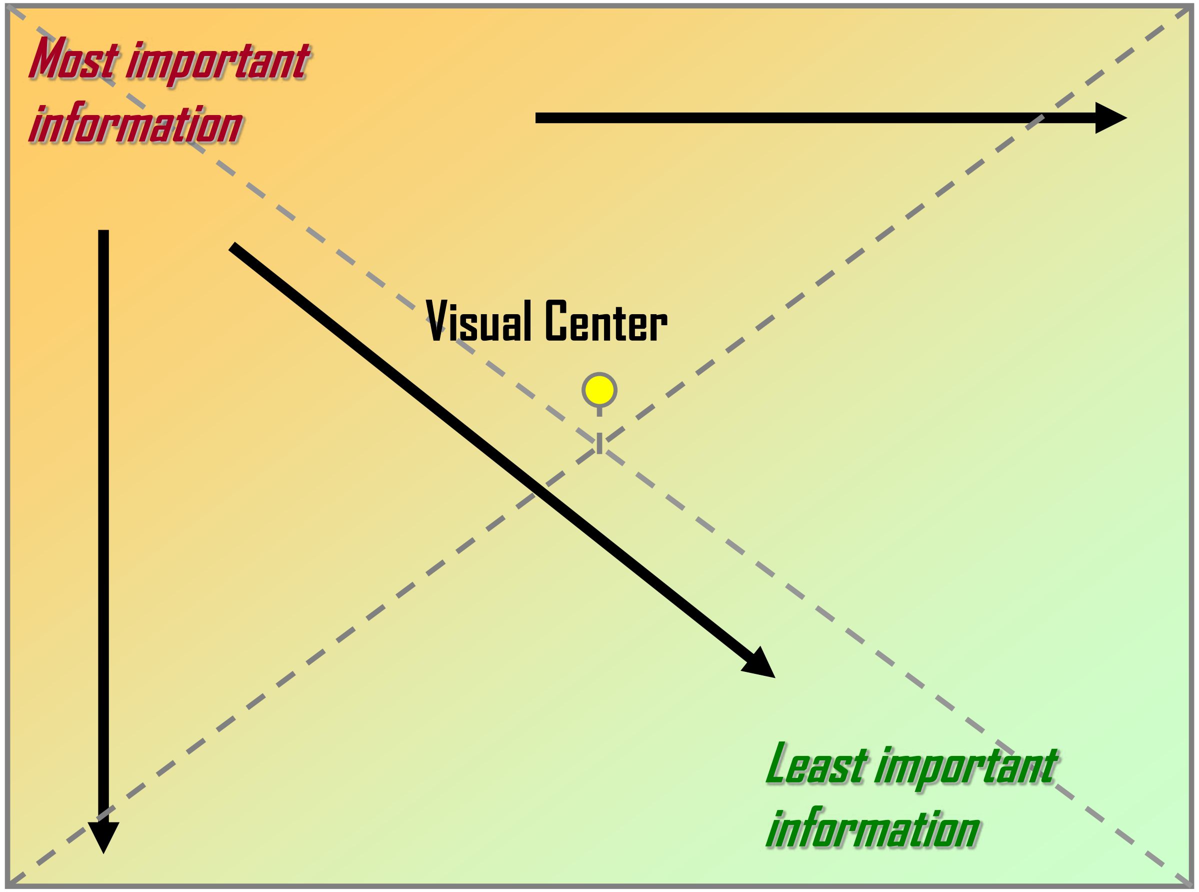


Visual Resources

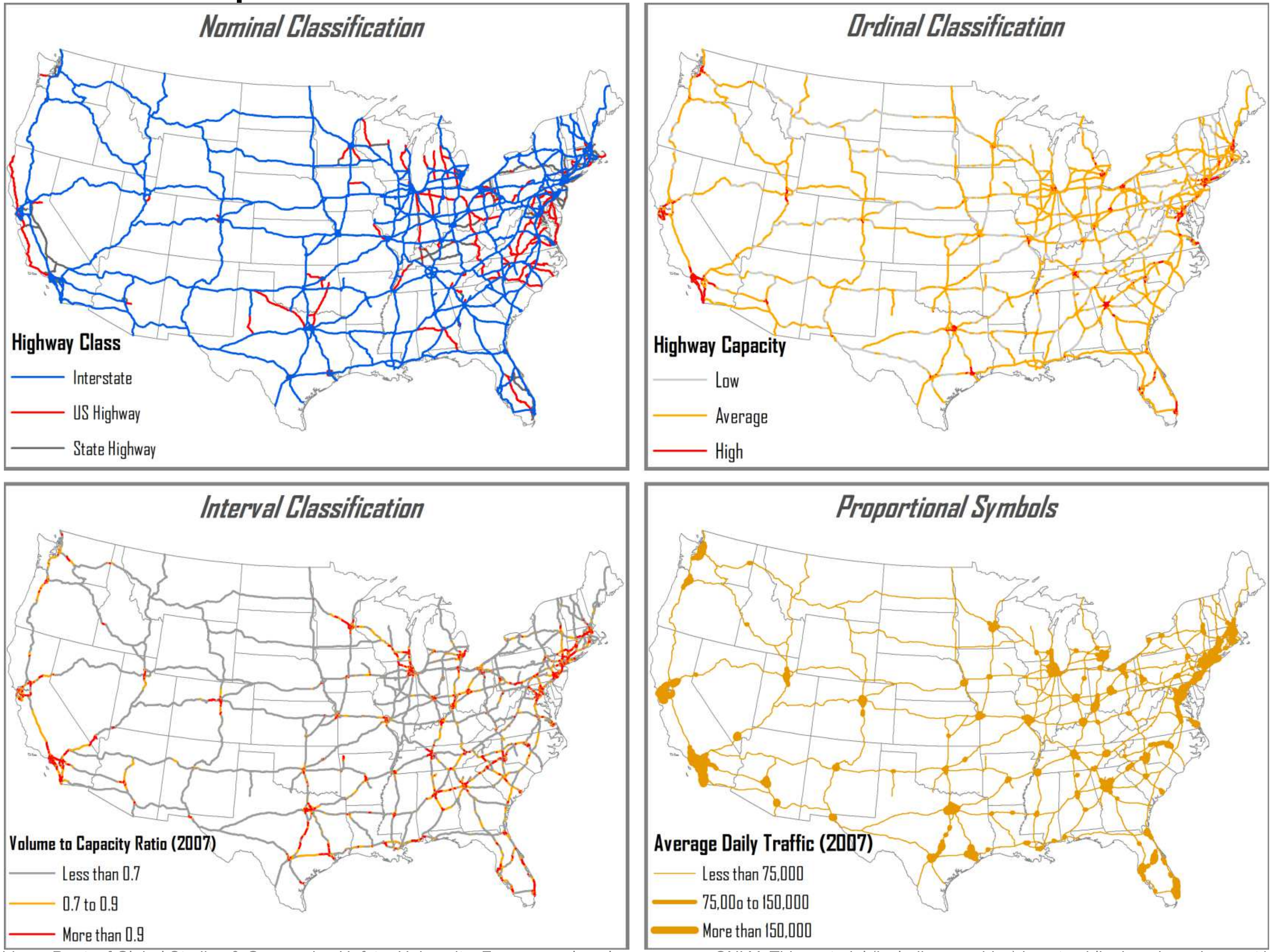


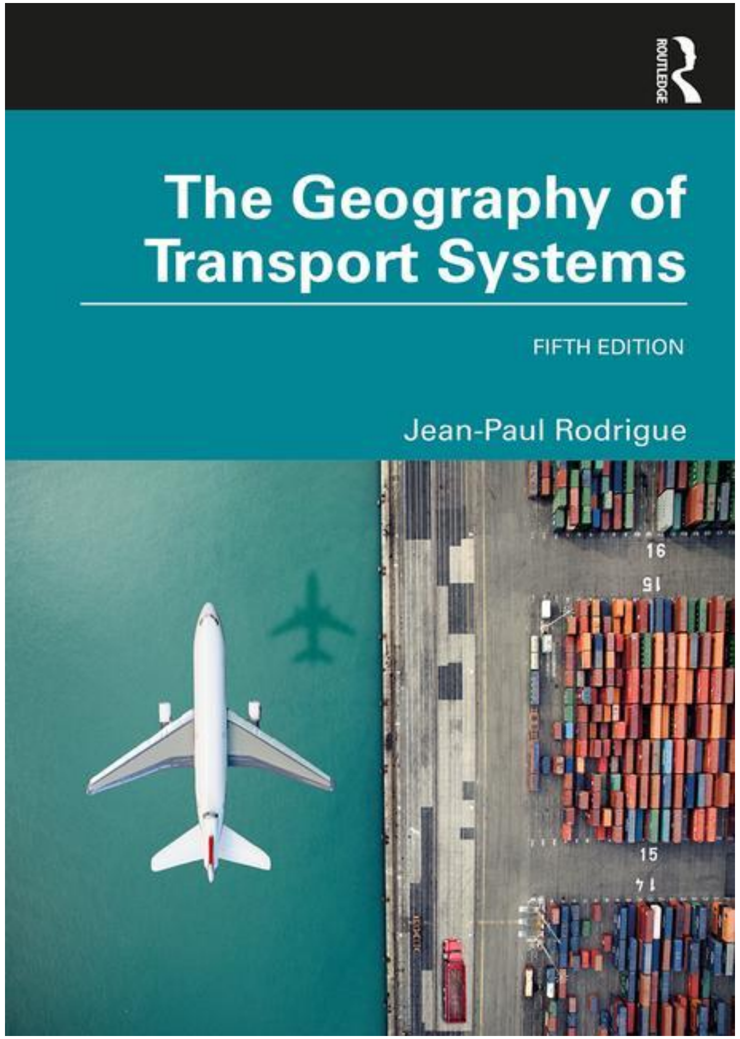
Major Map Elements

Balancing the Importance of Graphic Elements



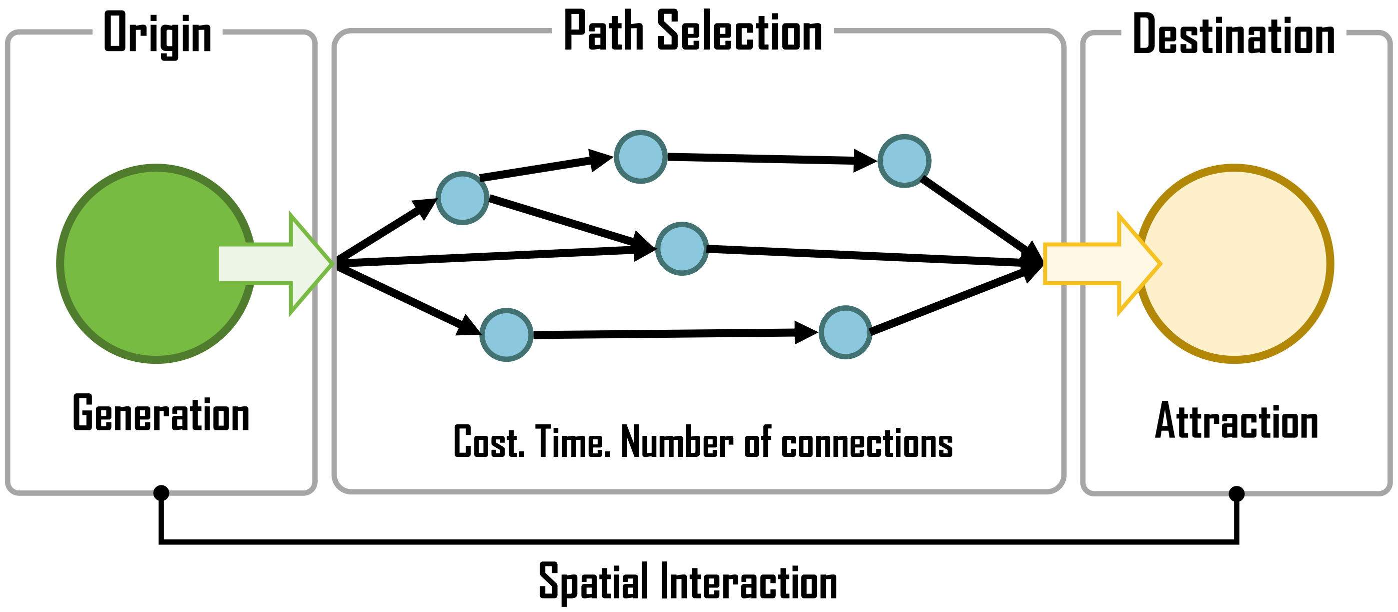
Symbolization of Transport Features



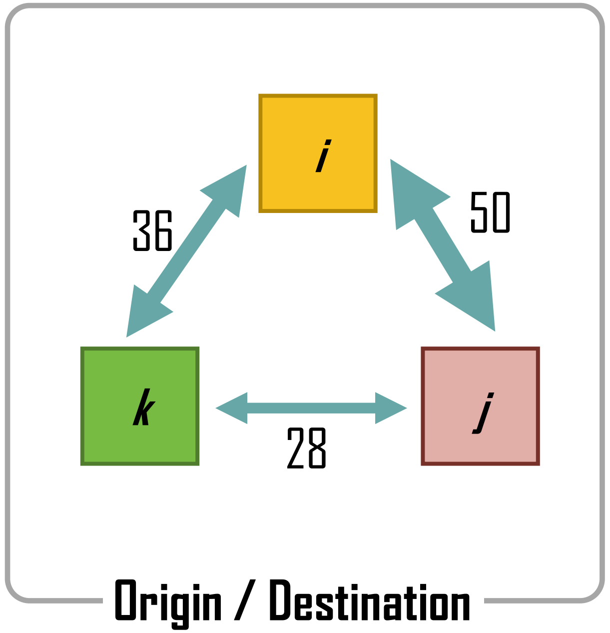


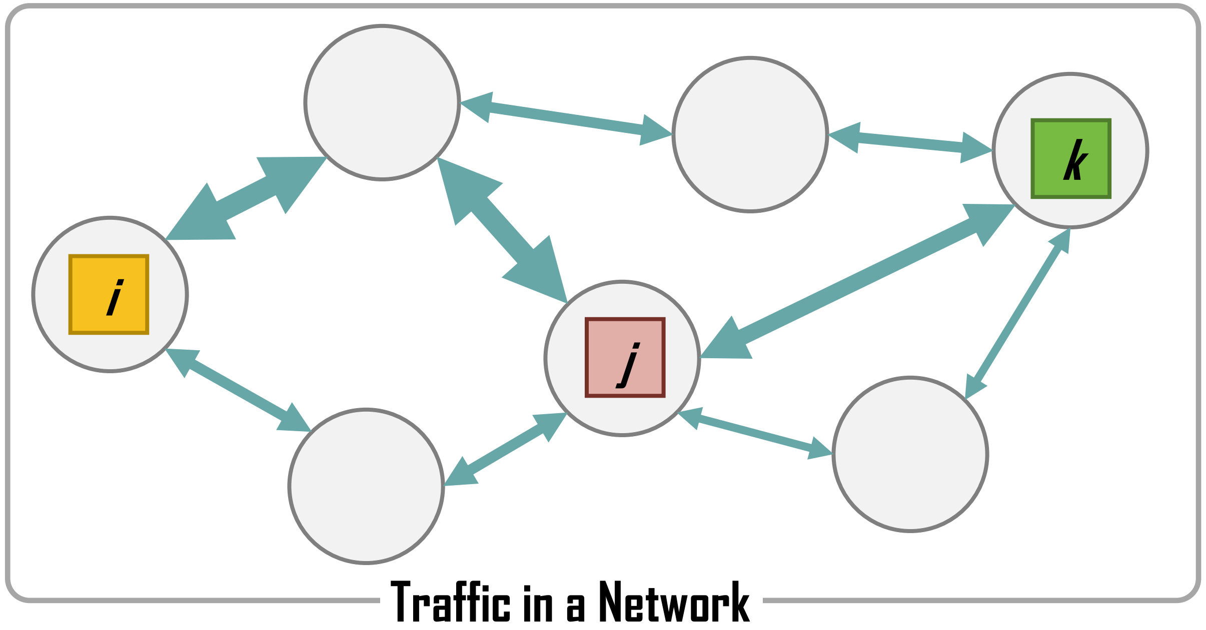
Traffic Assignment

Traffic Assignment Problem

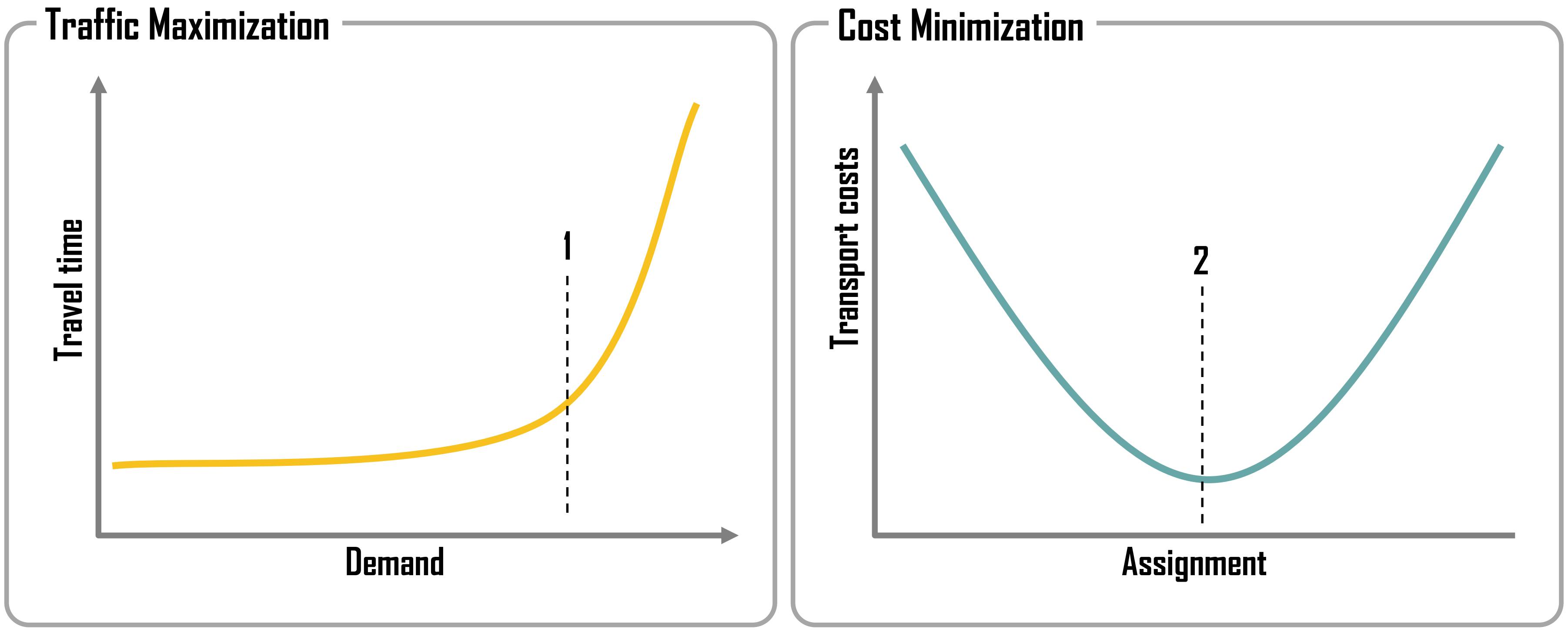


Spatial Interactions and Traffic Assignment

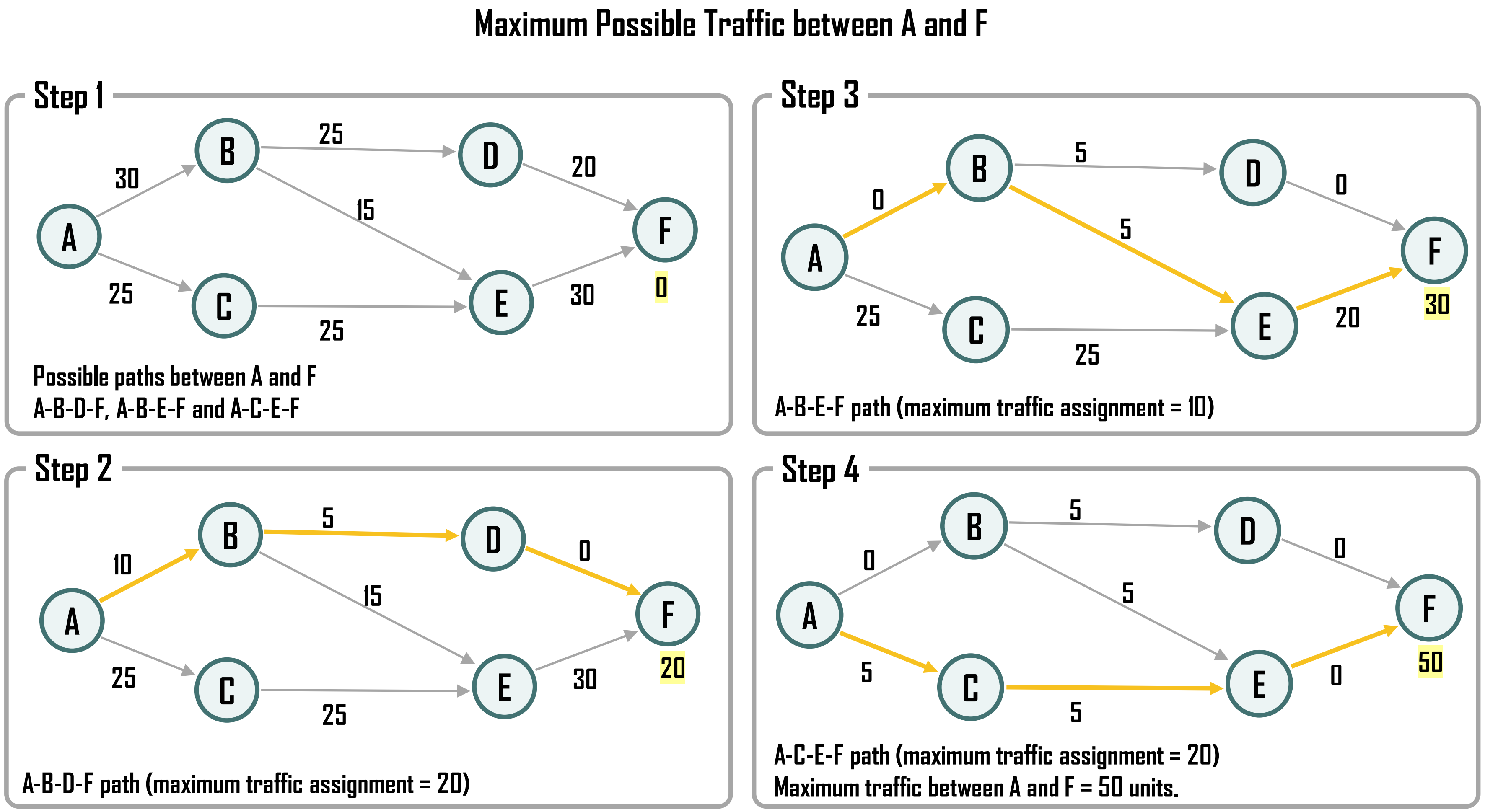




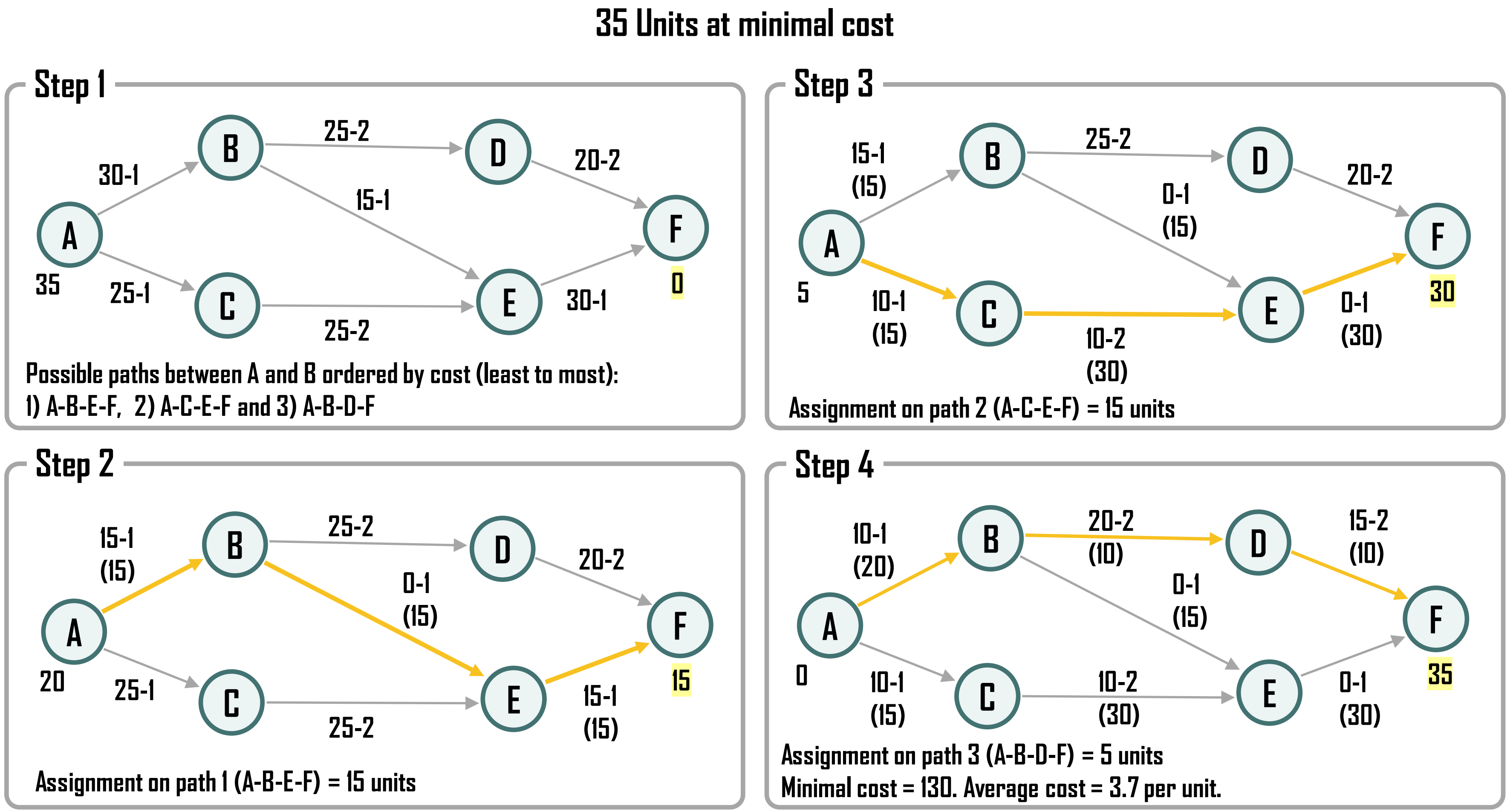
Two Perspectives for Considering Traffic



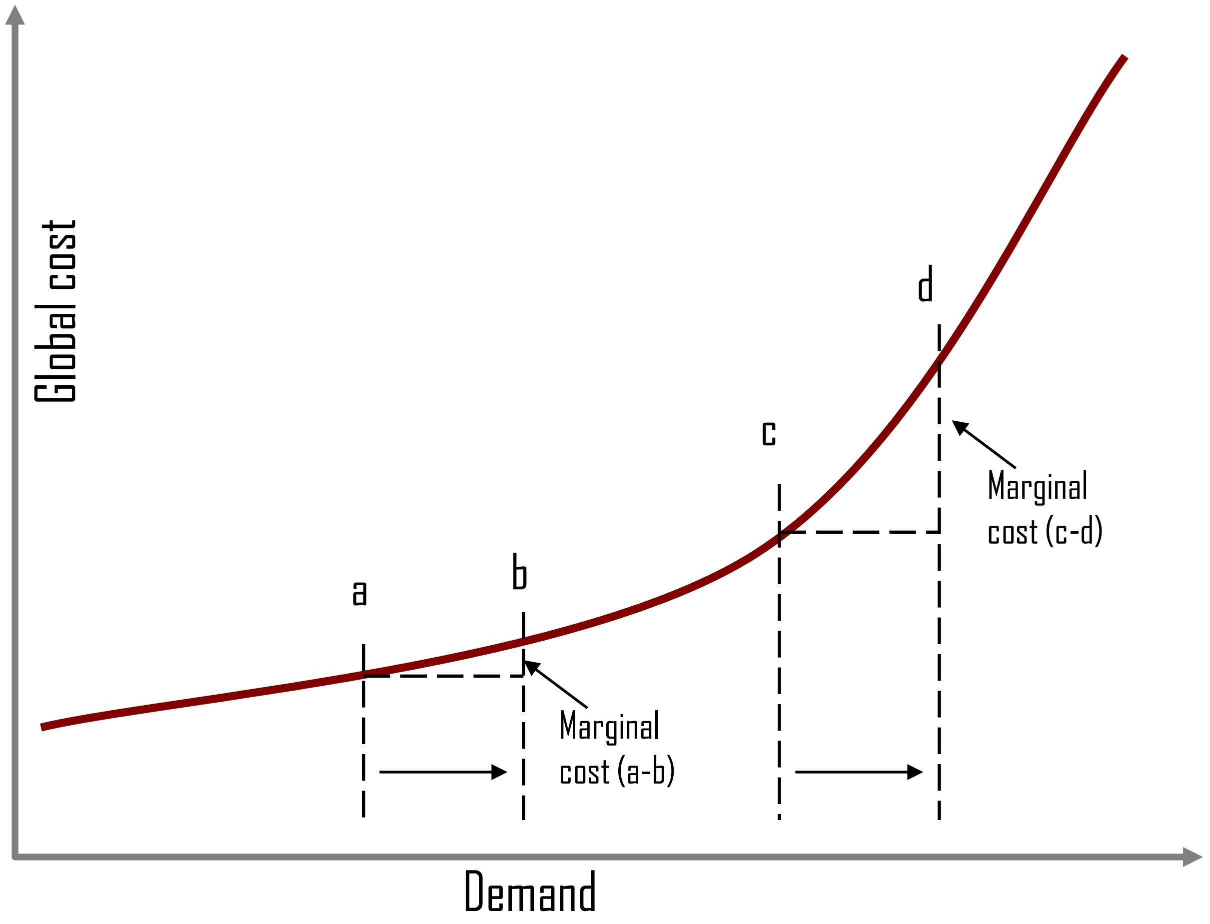
Heuristic Method for Traffic Maximization



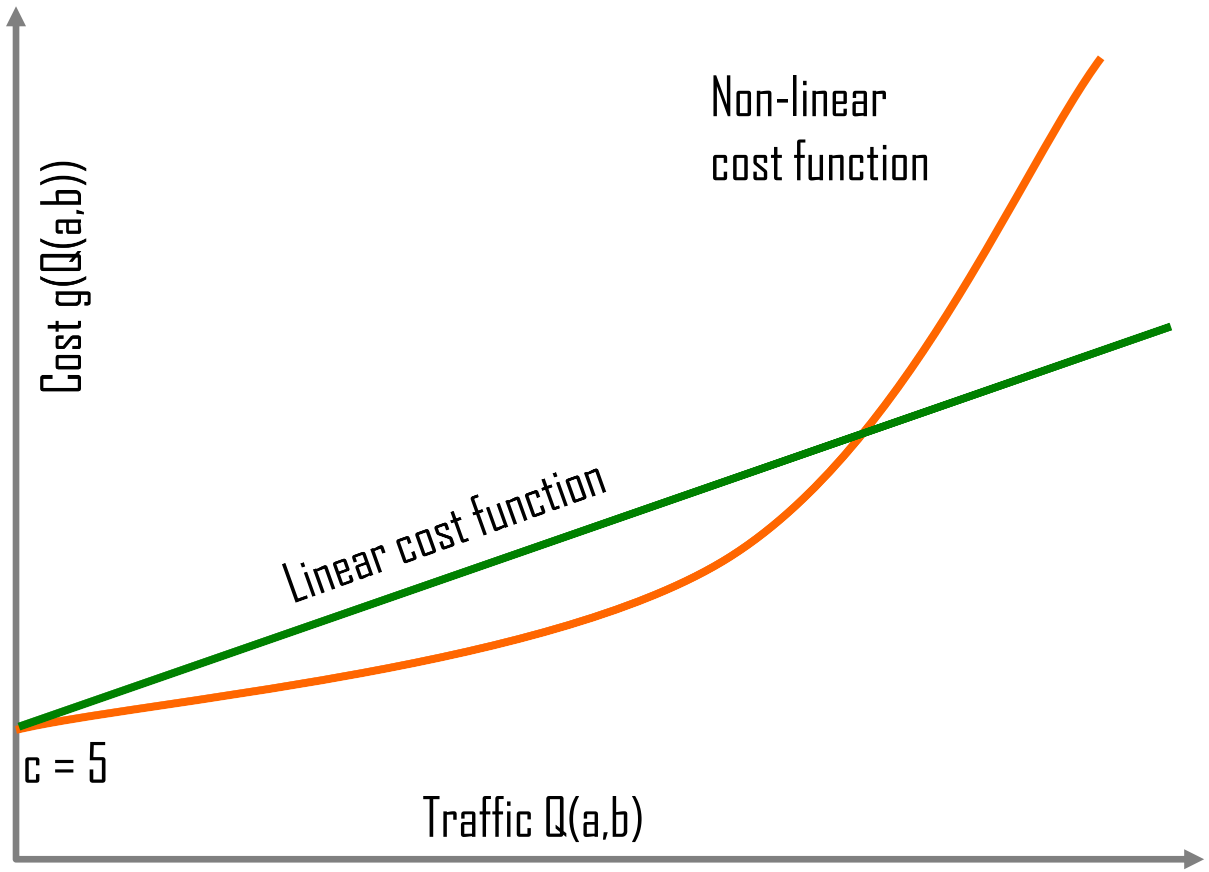
Heuristic Method for Costs Minimization



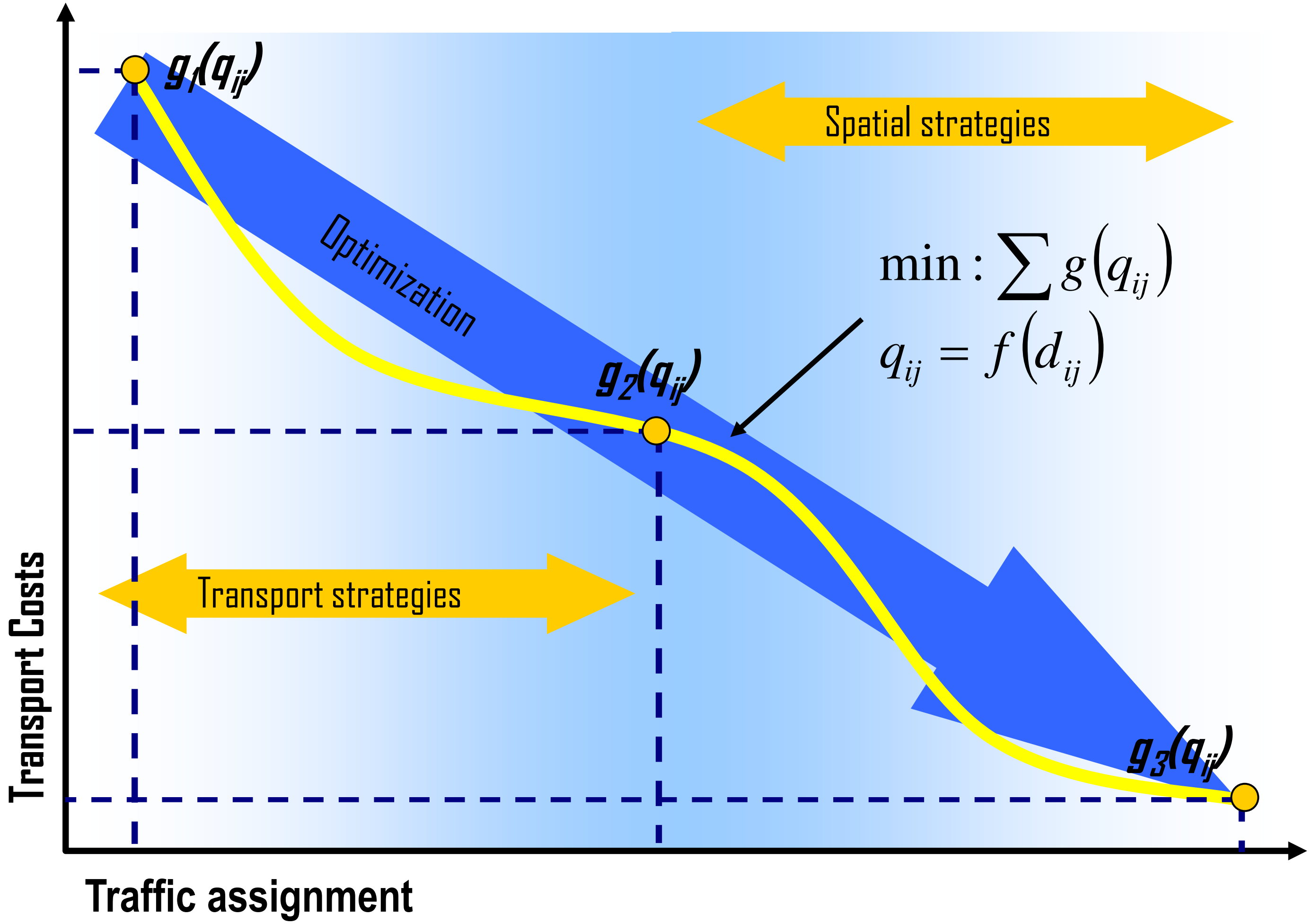
Types of Traffic Costs

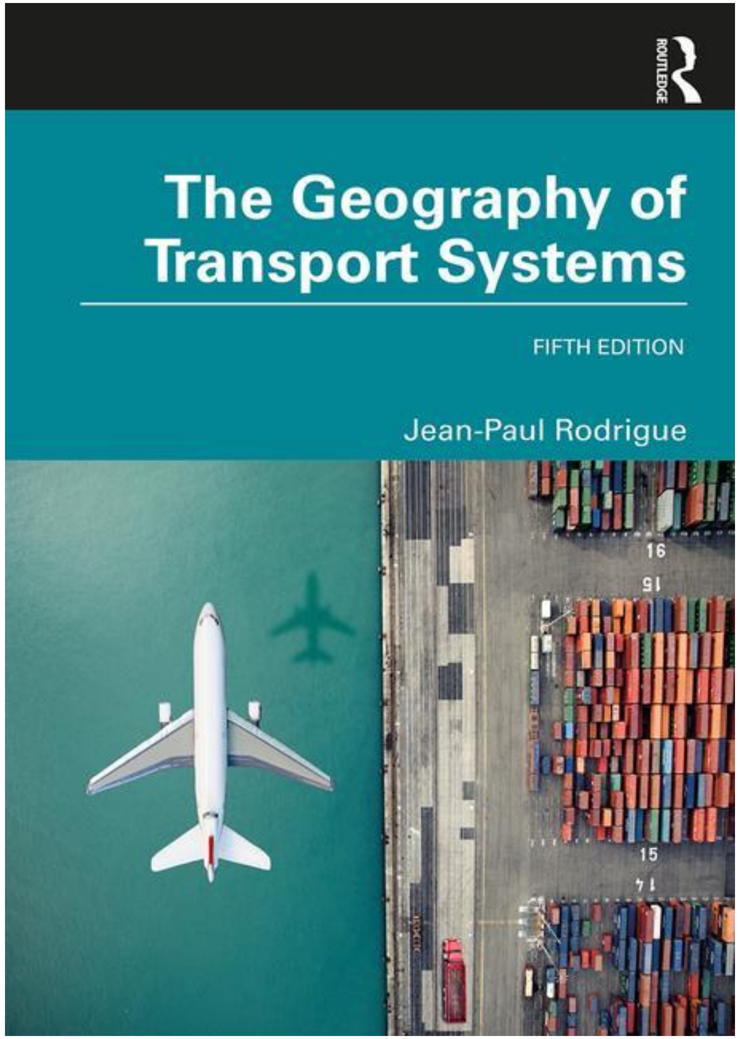


Traffic Cost Functions



Morphology, Urban Transportation and OR





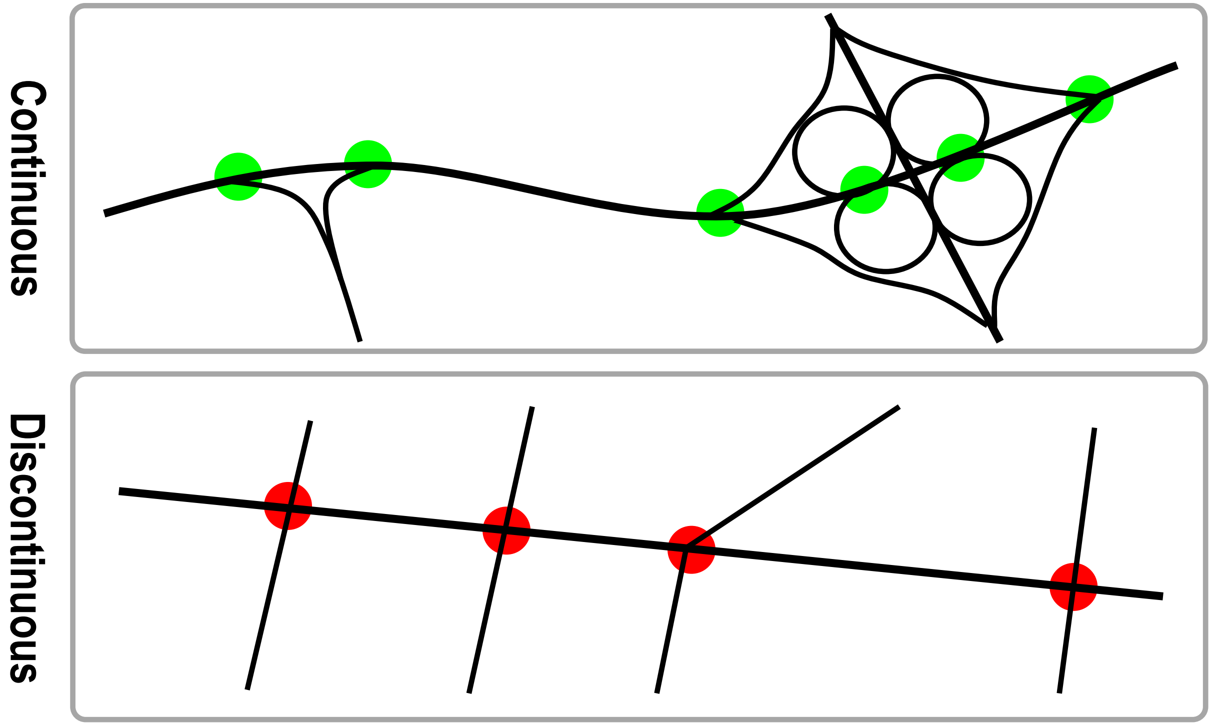
Technical Performance Indicators

Technical Performance Indicators

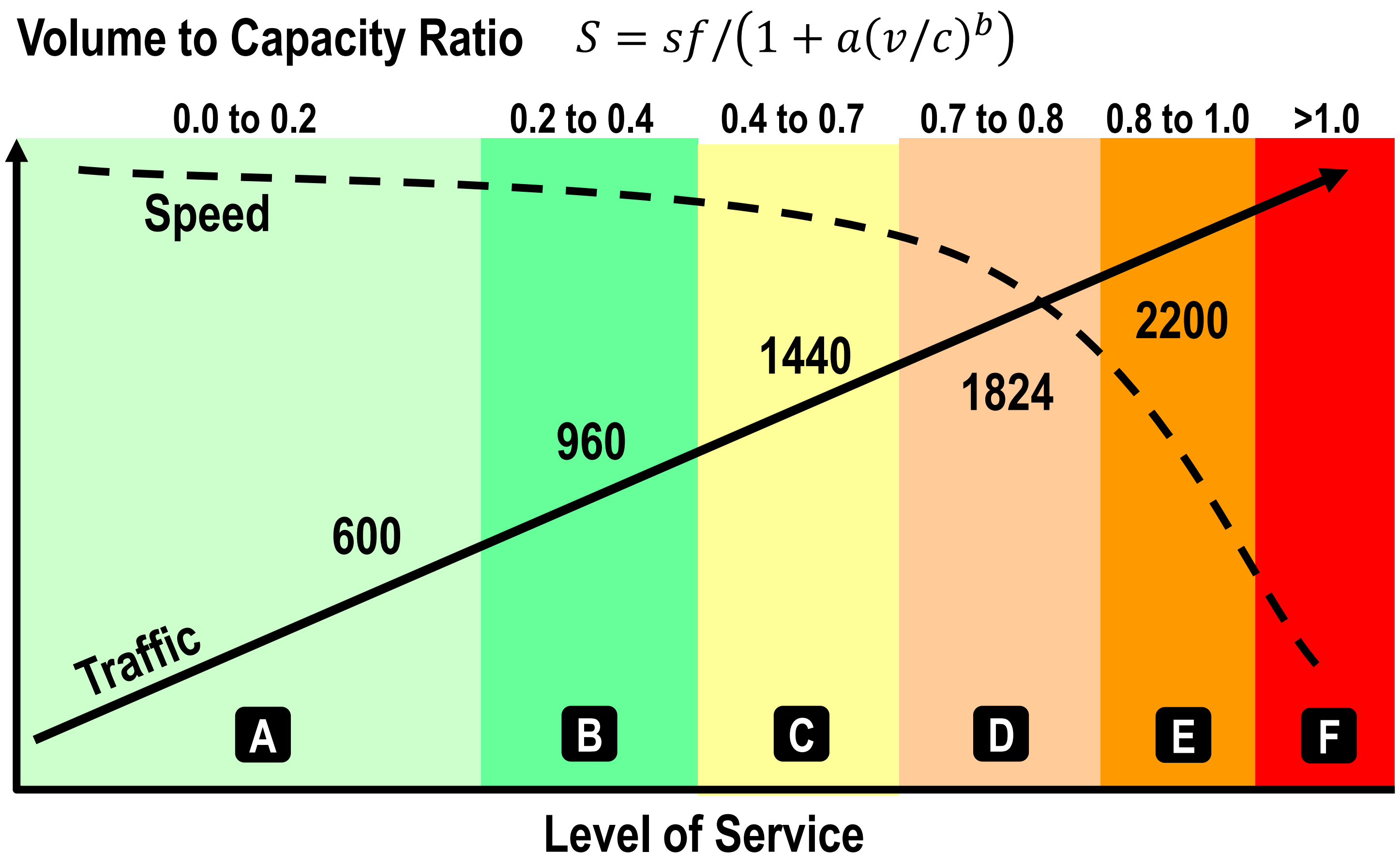
Indicator	Passenger	Freight	Description
Passenger / freight density	passenger-km / km	ton-km / km	A standard measure of transport efficiency.
Mean distance traveled	passenger-km / passenger	ton-km / ton	A measure of the ground covering capacity of networks and different transport modes.
Mean per capita ton output (freight) Mean number of trips per capita (passenger)	passengers / population	tons / population	Used to measure the relative performance of transport modes.
Mean load factor	number of passengers aboard / total carrying capacity (%)	actual load (ton) / overall load capacity (ton) (%)	Particularly useful with increasing complexity of logistics associated with containerization of freight (i.e. of empty returns). Can also be used to measure transit ridership.

Common Economic Impact Indicators		
Factors of production	Scale-specific indicators	
	Micro	Macro
Output / Capital	Transport sector income / Local income	Output / GDP
Output / Labor	Output / Local income	
Capital / Labor		

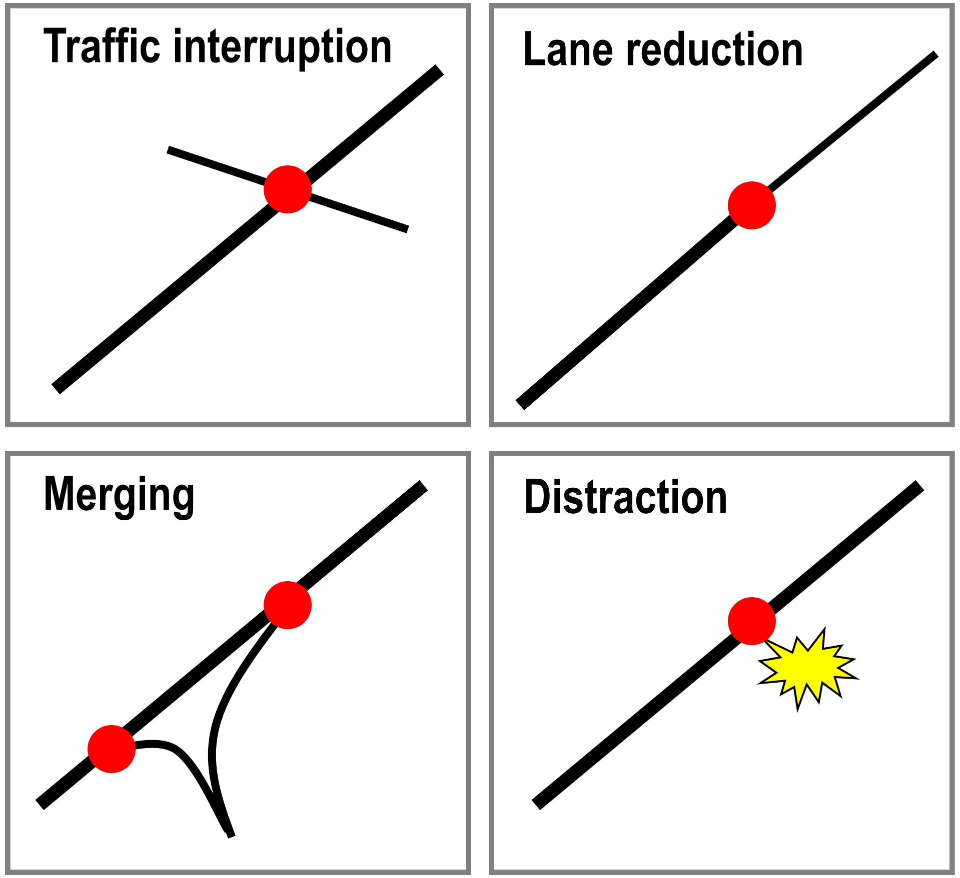
Continuous and Discontinuous Traffic



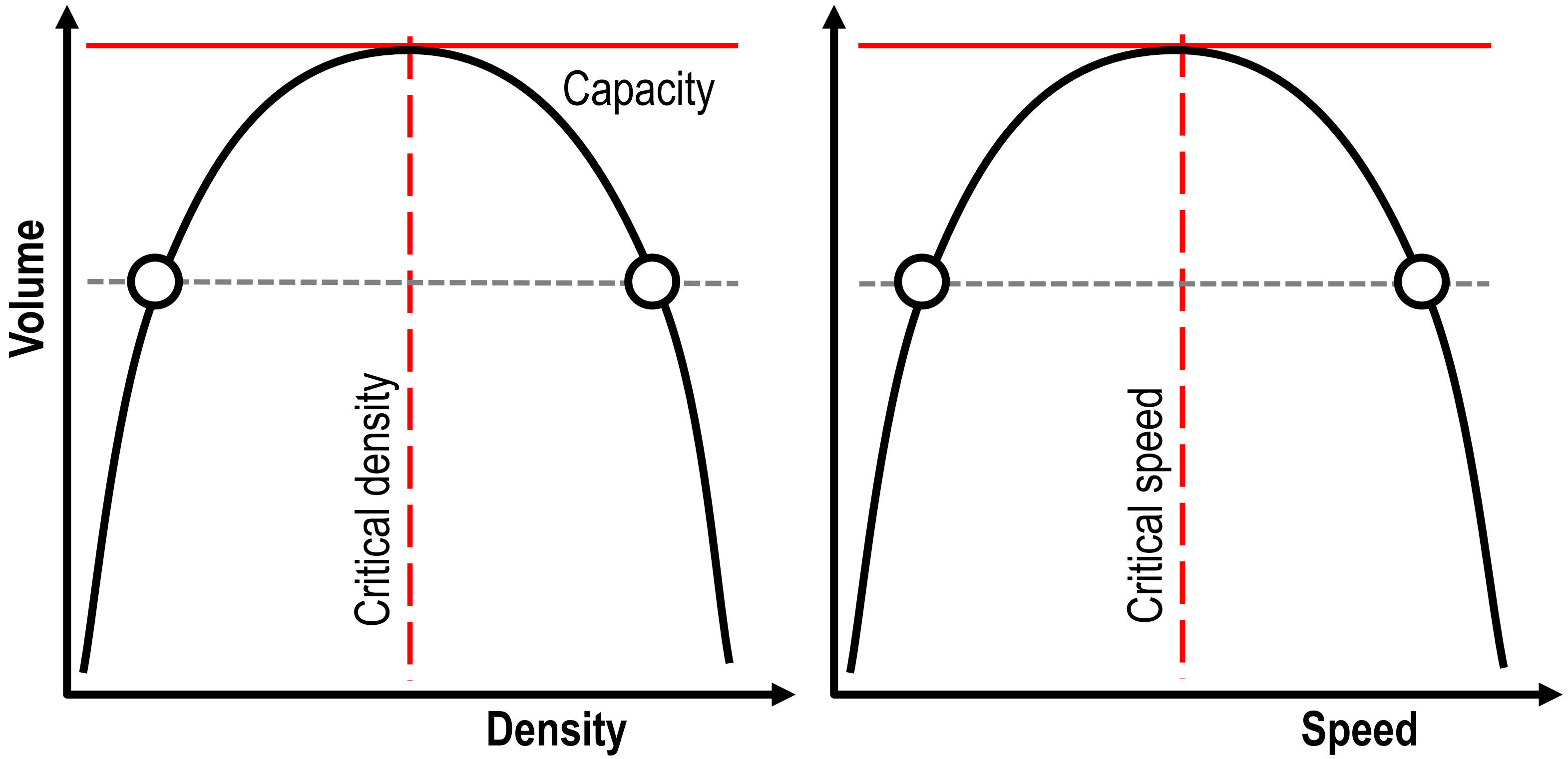
Levels of Service for Road Transportation (Vehicle per Lane per Hour)



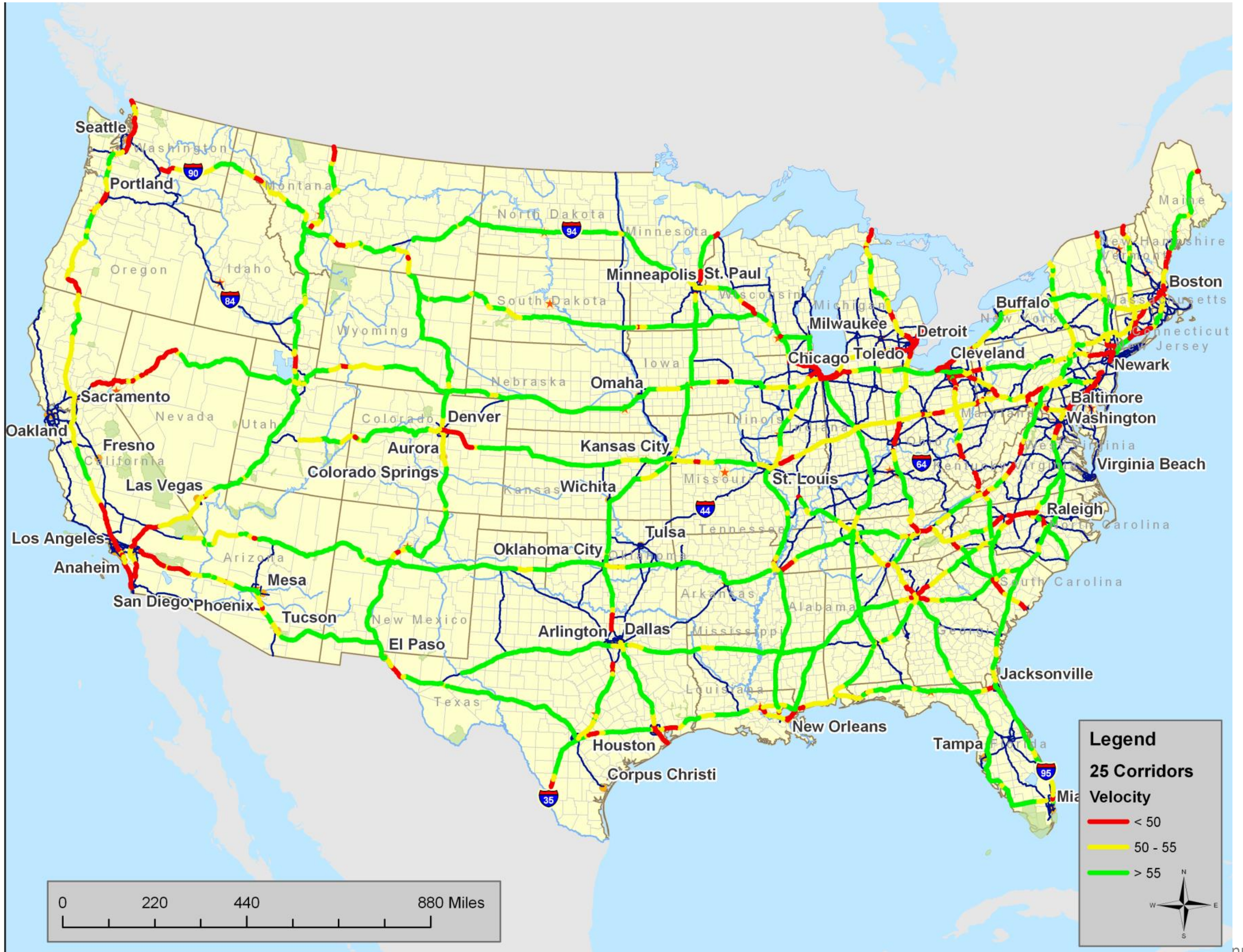
Causes of Road Transportation Bottlenecks

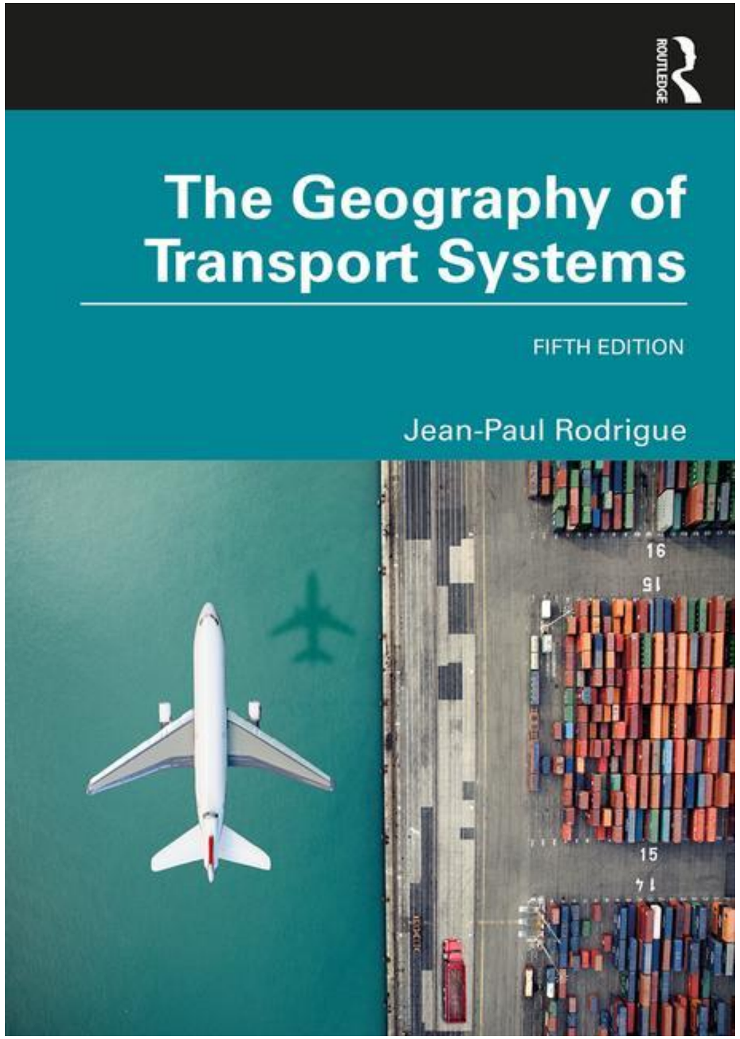


Critical Density and Critical Speed



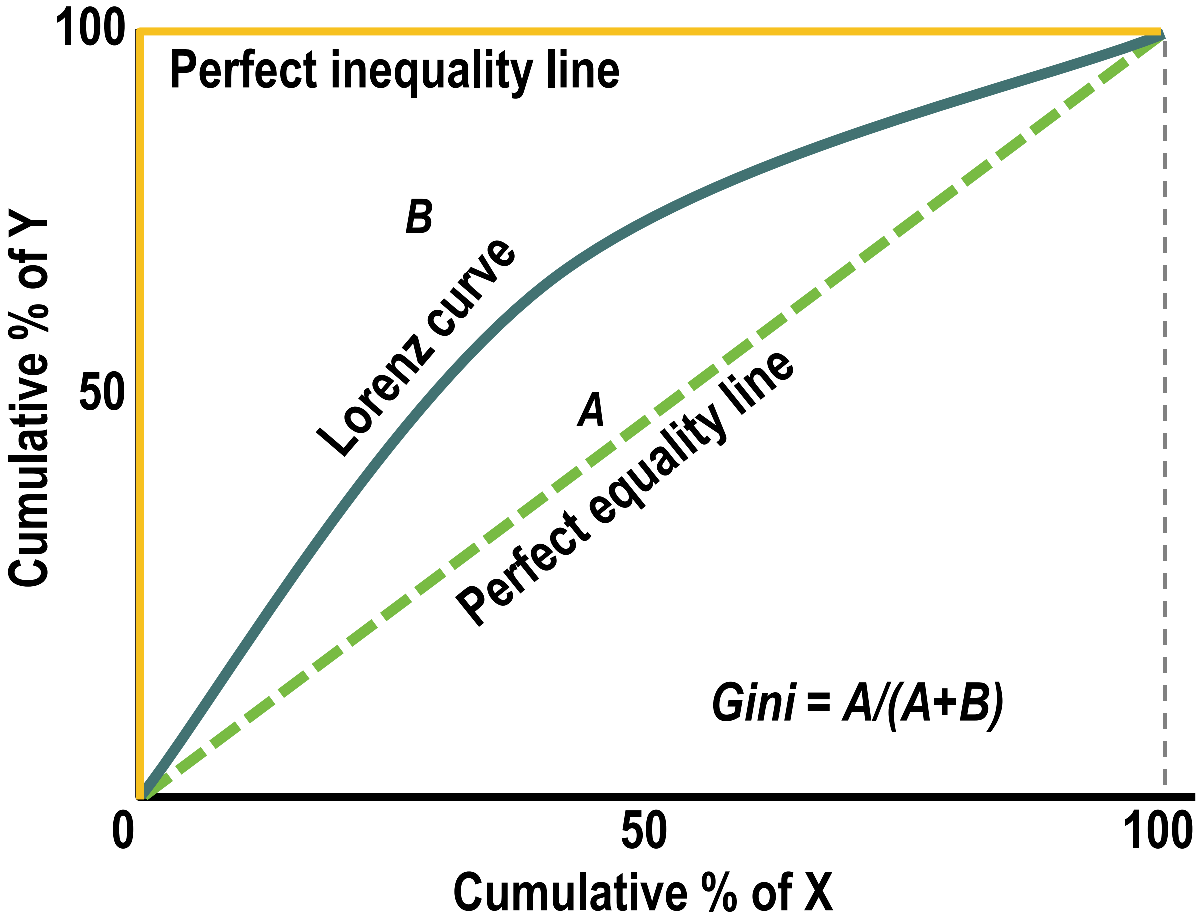
Under Construction



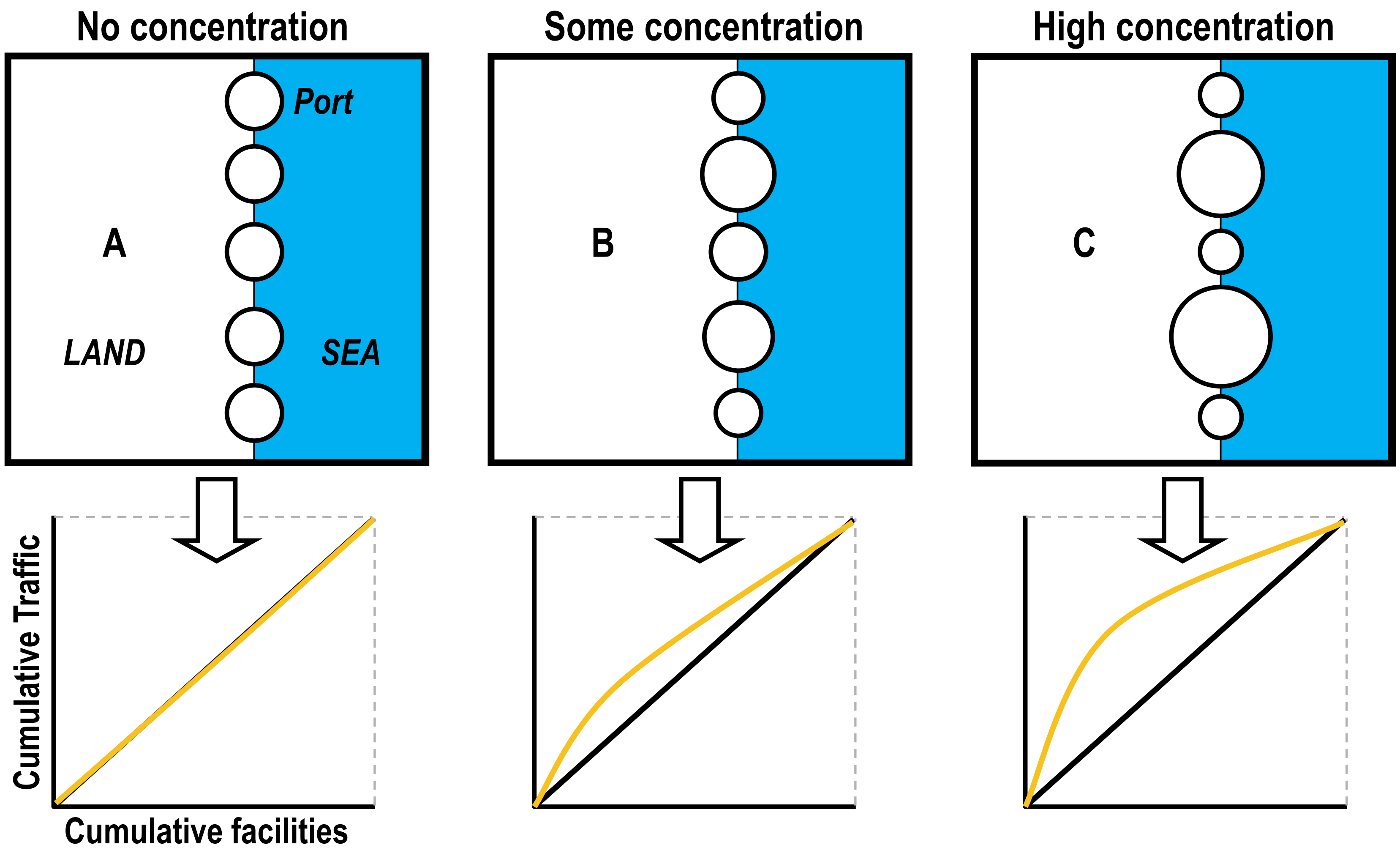


The Gini Coefficient

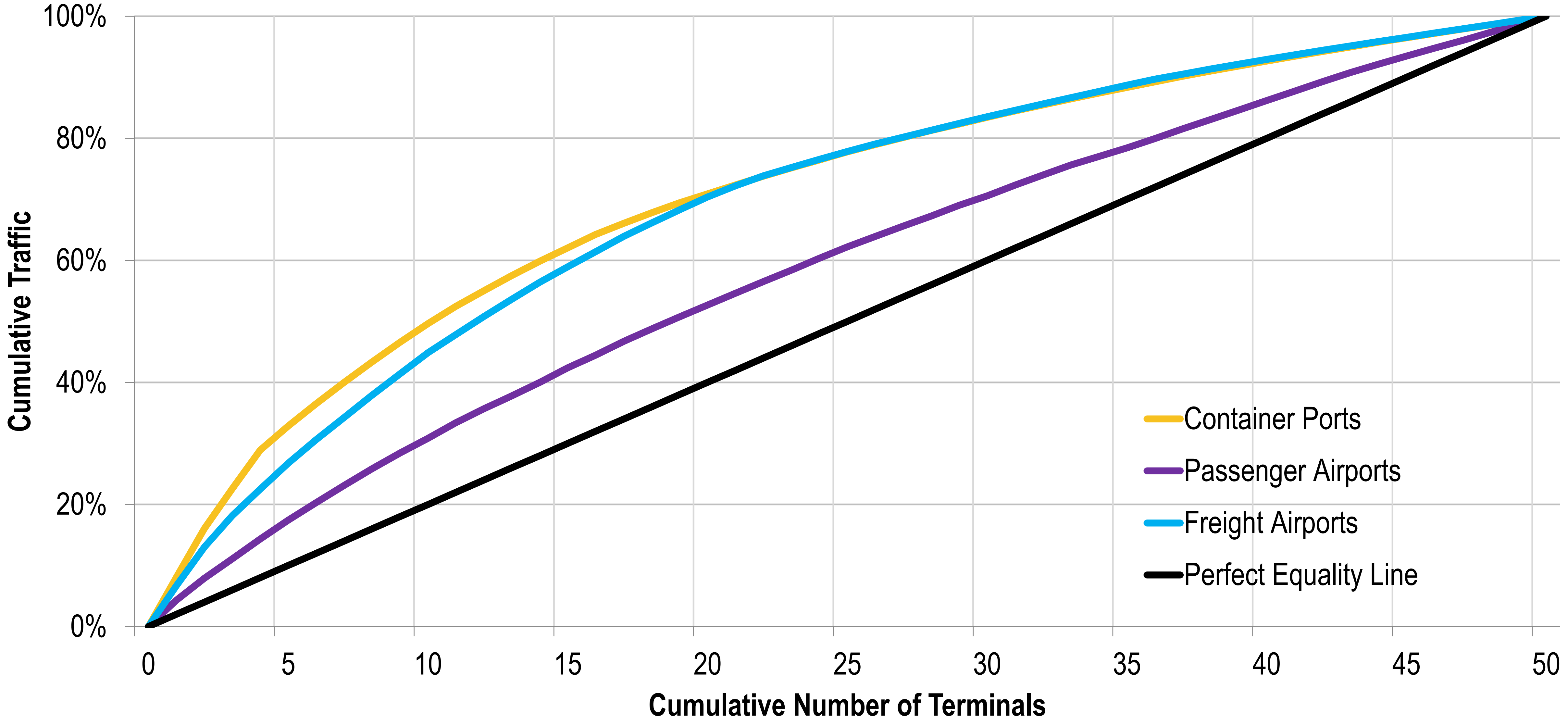
The Lorenz Curve



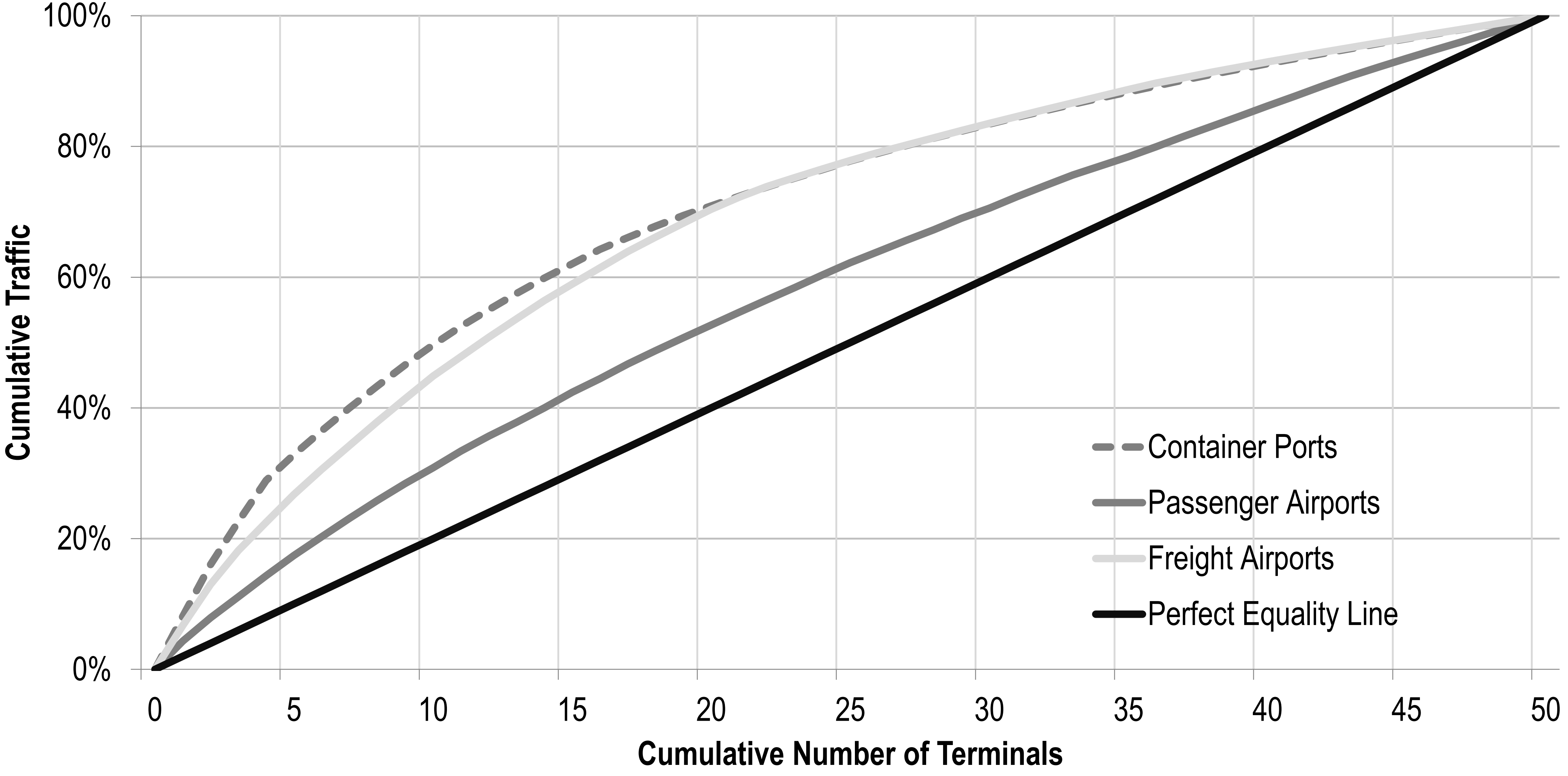
Traffic Concentration and Lorenz Curves



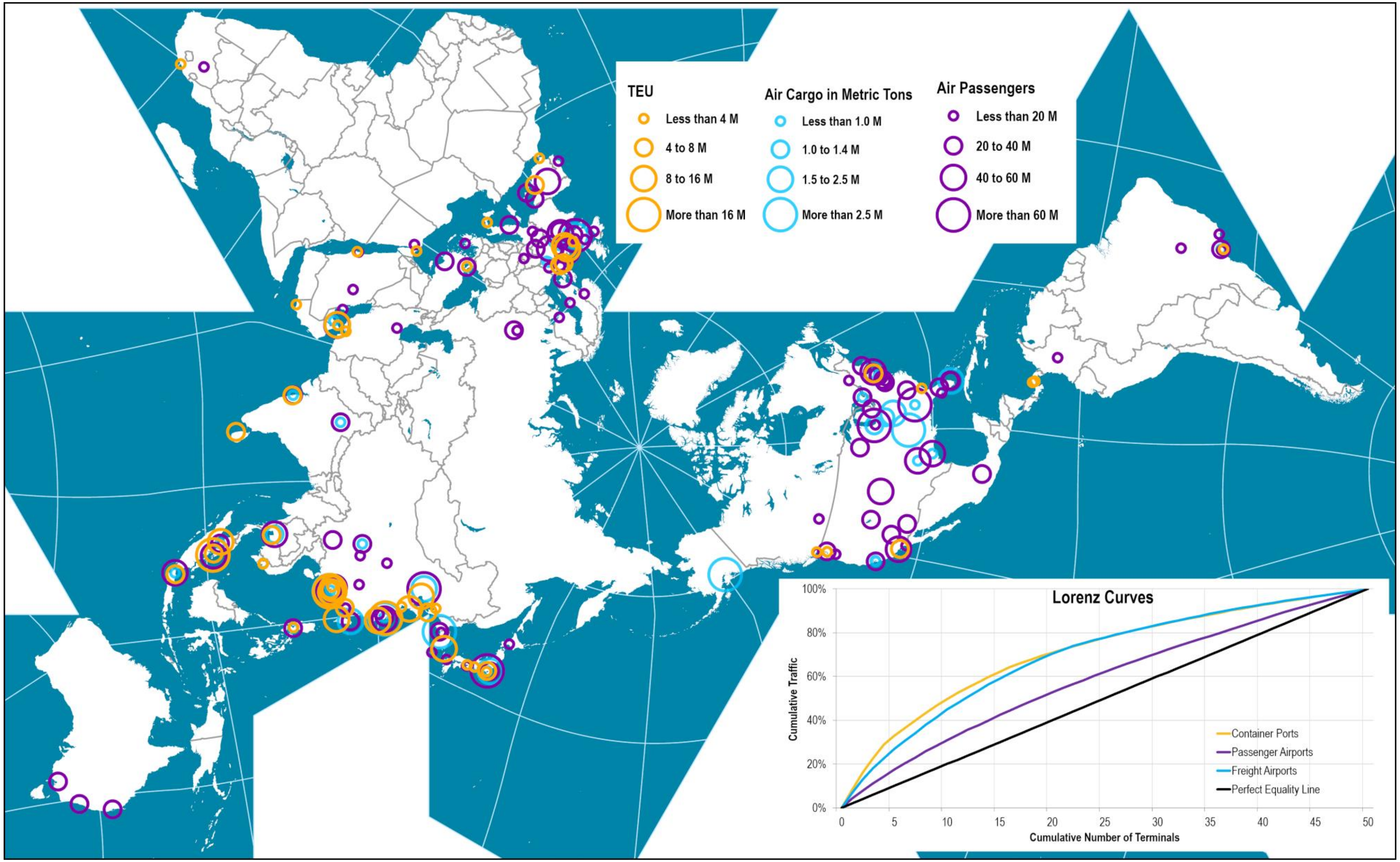
Lorenz Curves of the World's 50 Largest Container Ports, Passenger Airports and Freight Airports, 2010



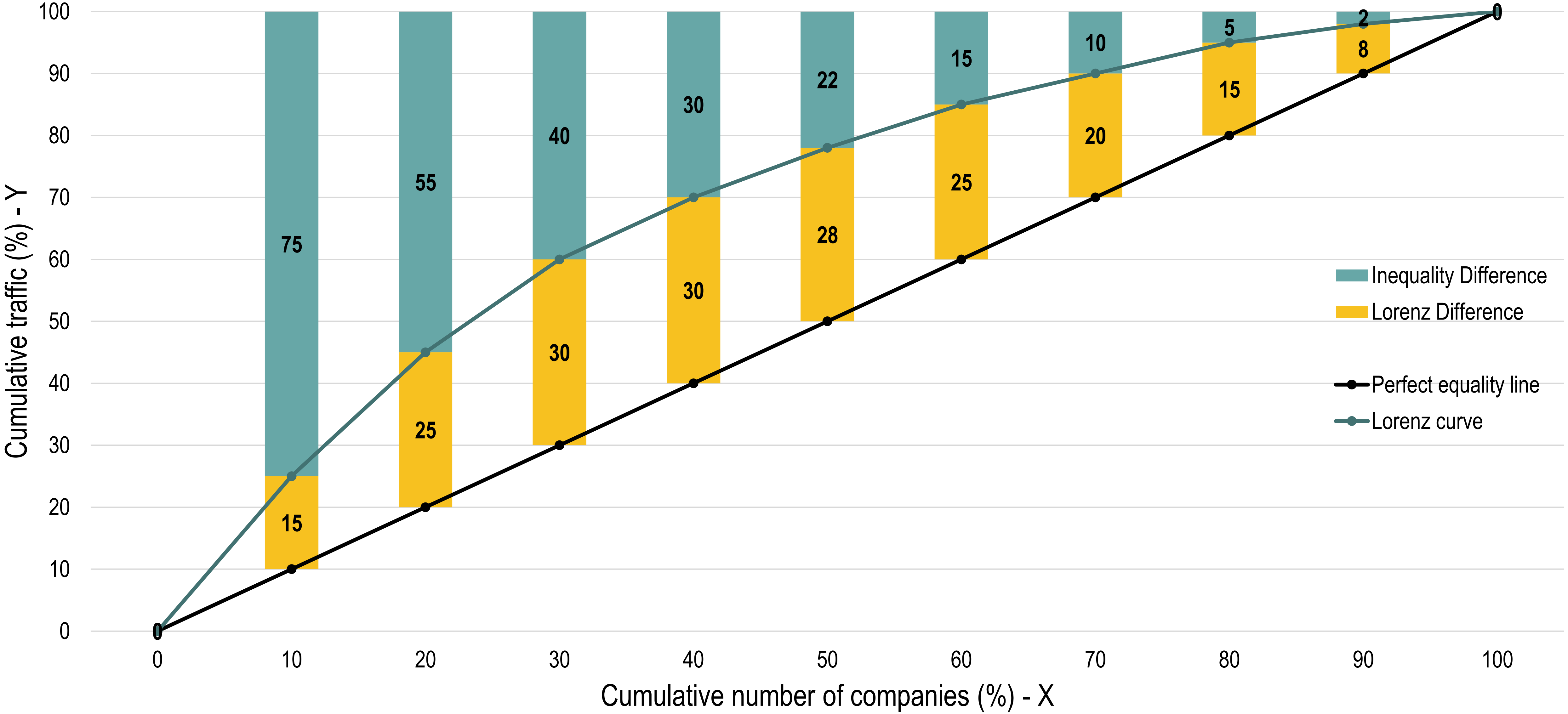
Lorenz Curves of the World's 50 Largest Container Ports, Passenger Airports and Freight Airports, 2010 (Greyscale)



World’s 50 Largest Container Ports, Passenger Airports and Freight Airports, 2010



Lorenz and Perfect Inequality Differences



Calculation of the Index of Dissimilarity

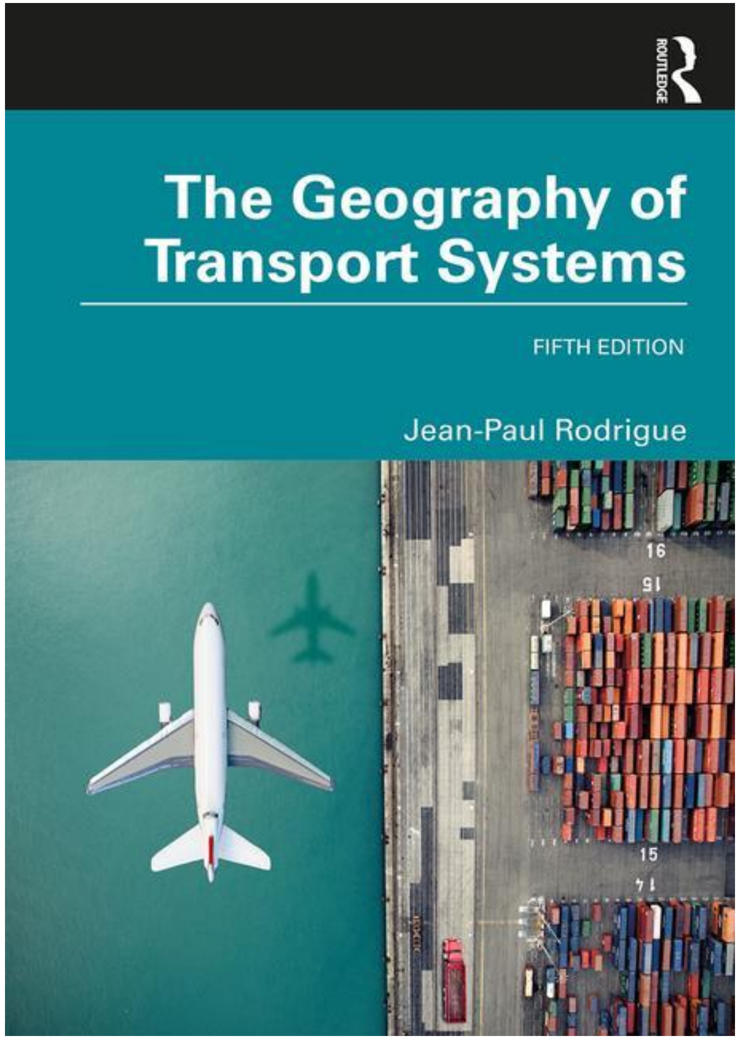
$$ID = 0.5 \sum_{i=1}^{N} |X_i - Y_i| = 0.325$$

X (% of terminals)	Y (% of traffic)	|X – Y|
0.10	0.25	0.15
0.10	0.20	0.15
0.10	0.15	0.05
0.10	0.10	0.00
0.10	0.08	0.02
0.10	0.07	0.03
0.10	0.05	0.05
0.10	0.05	0.05
0.10	0.03	0.07
0.10	0.02	0.08
1.0	1.0	0.65

Calculation of the Gini Coefficient

$$G = 1 - \sum_{i=1}^{N} (\sigma Y_{y-1})(\sigma X_{i-1} - \sigma X_i) = 0.392$$

Y	σX (Cumulative)	σY (Cumulative)	$\sigma Y_{i-1} + \sigma Y_i$ (A)	$\sigma X_{i-1} – \sigma X_i$ (B)	A*B
0.25	0.10	0.25	0.25	0.10	0.025
0.20	0.20	0.45	0.70	0.10	0.070
0.15	0.30	0.60	1.05	0.10	0.105
0.10	0.40	0.70	1.30	0.10	0.130
0.08	0.50	0.78	1.48	0.10	0.148
0.07	0.60	0.85	1.63	0.10	0.163
0.05	0.70	0.90	1.75	0.10	0.175
0.05	0.80	0.95	1.85	0.10	0.185
0.03	0.90	0.98	1.93	0.10	0.193
0.02	1.00	1.00	1.98	0.10	0.198
1.00					1.392



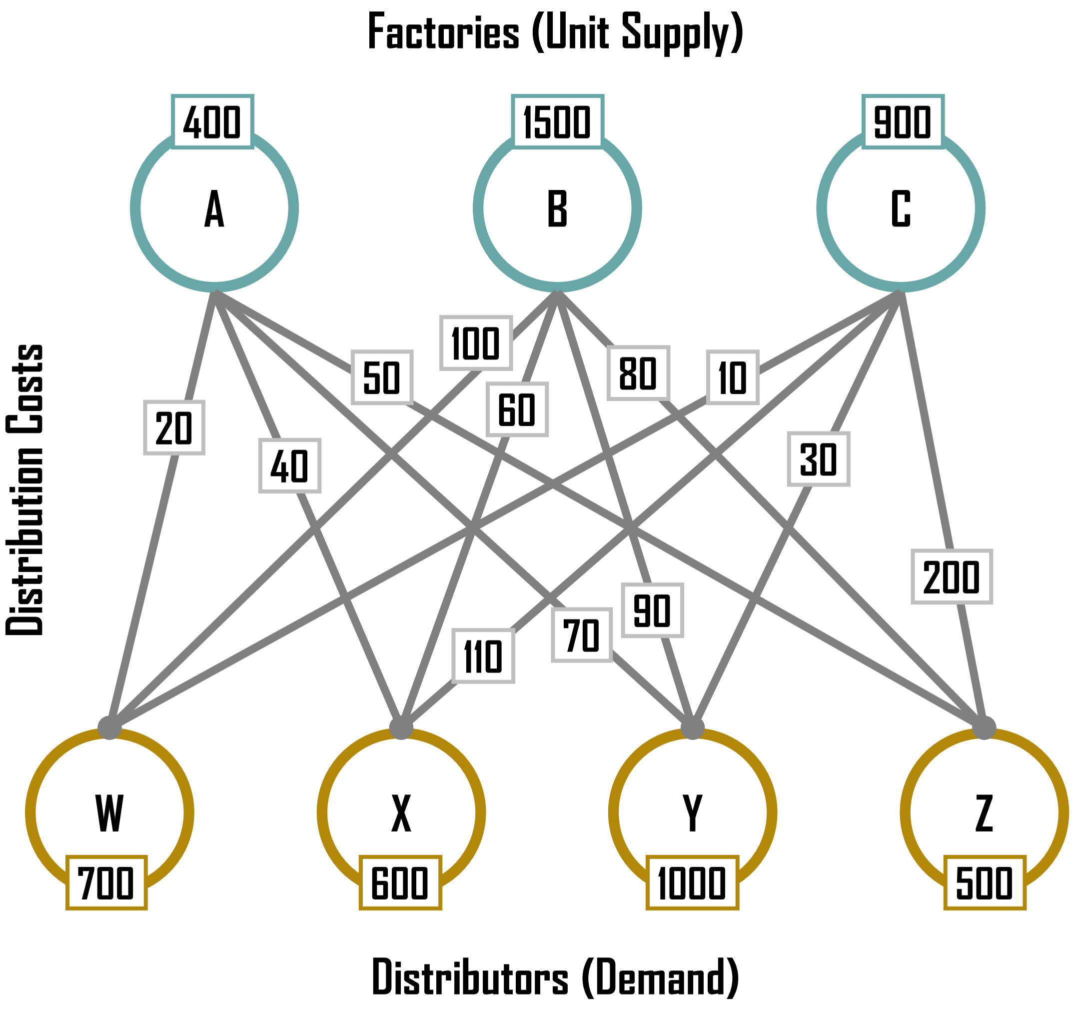
Linear Programming

Basic Linear Programing Objective Function

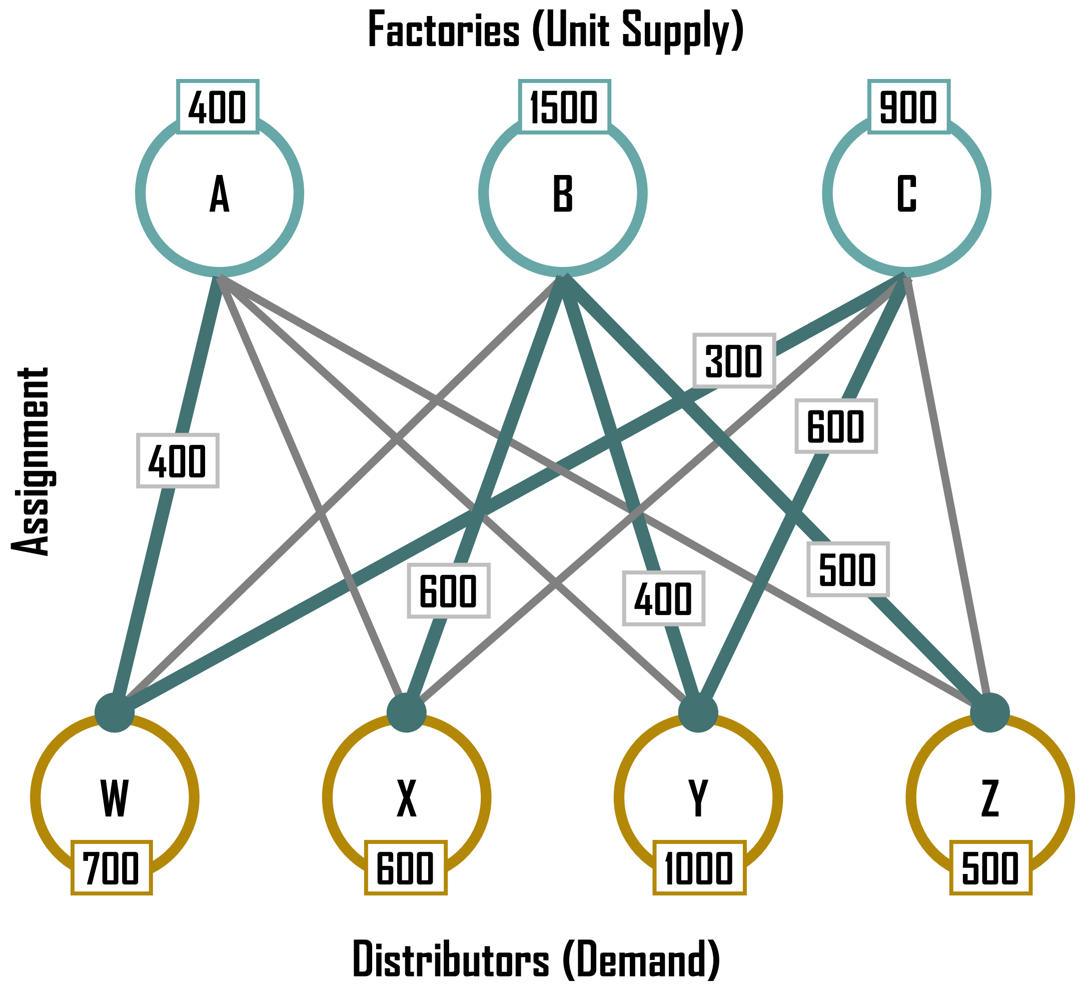
$$Min: \sum_a \sum_b g\big(Q(a,b)\big)\ subject\ to$$

$$Q(a,b) \geq 0$$

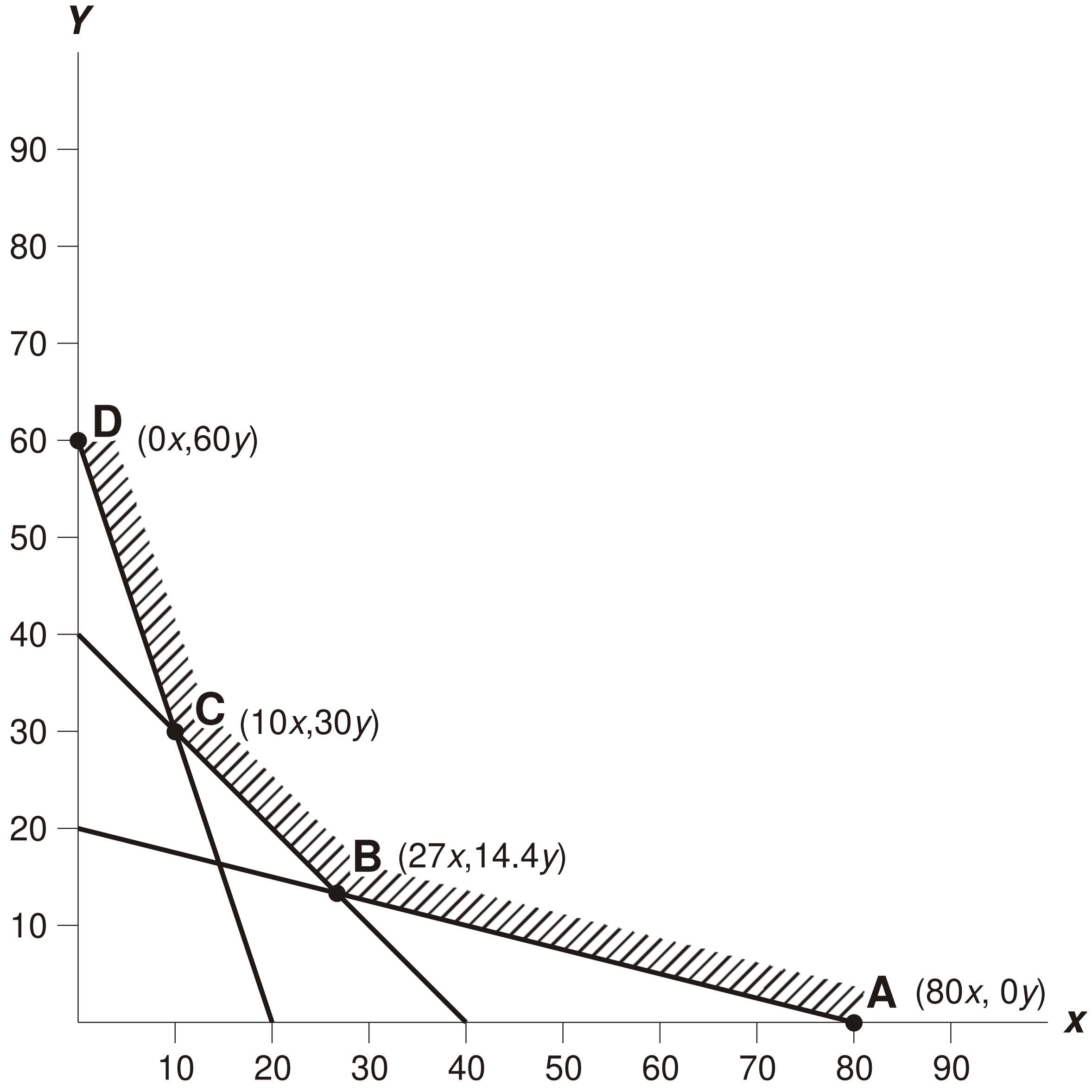
Graphic Formulation of the Distribution Problem



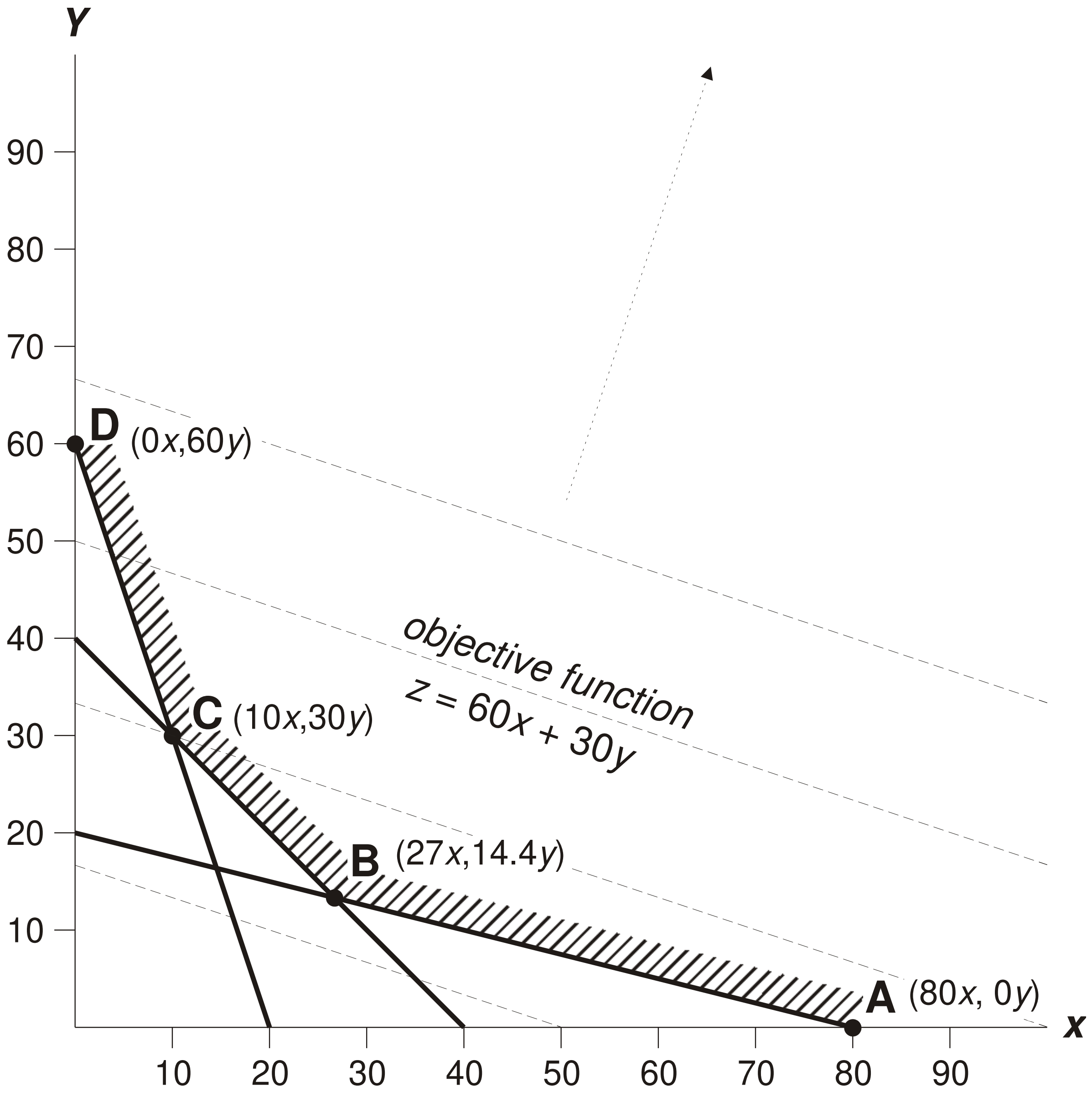
Graphic Solution of the Distribution Problem

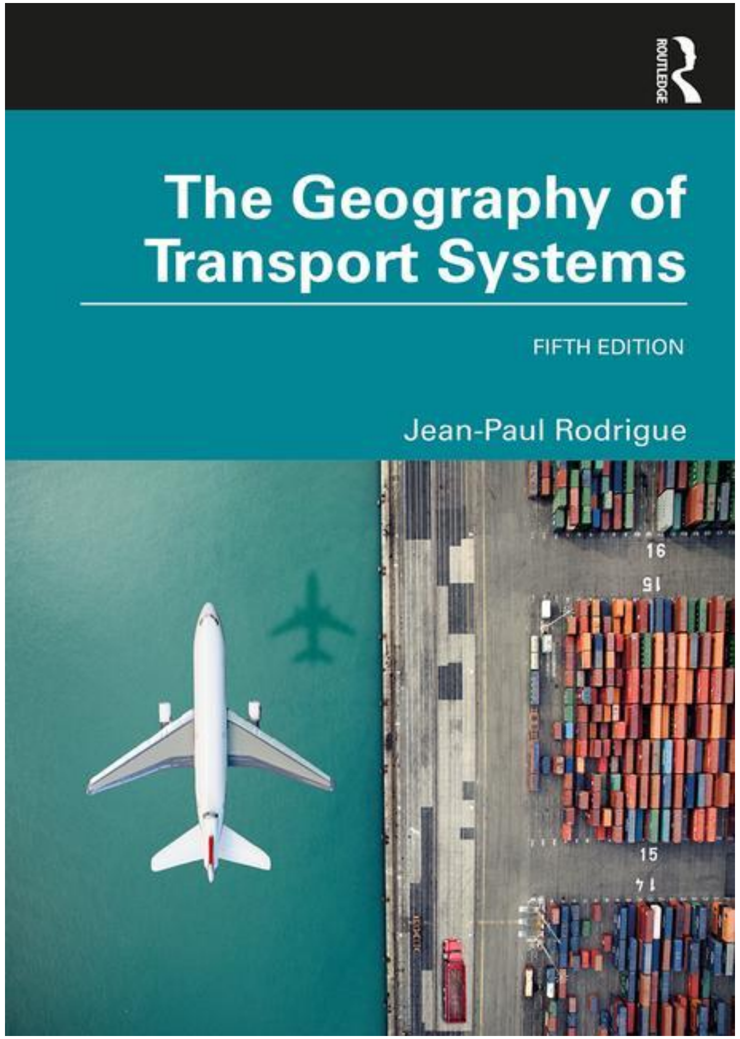


Linear Inequalities



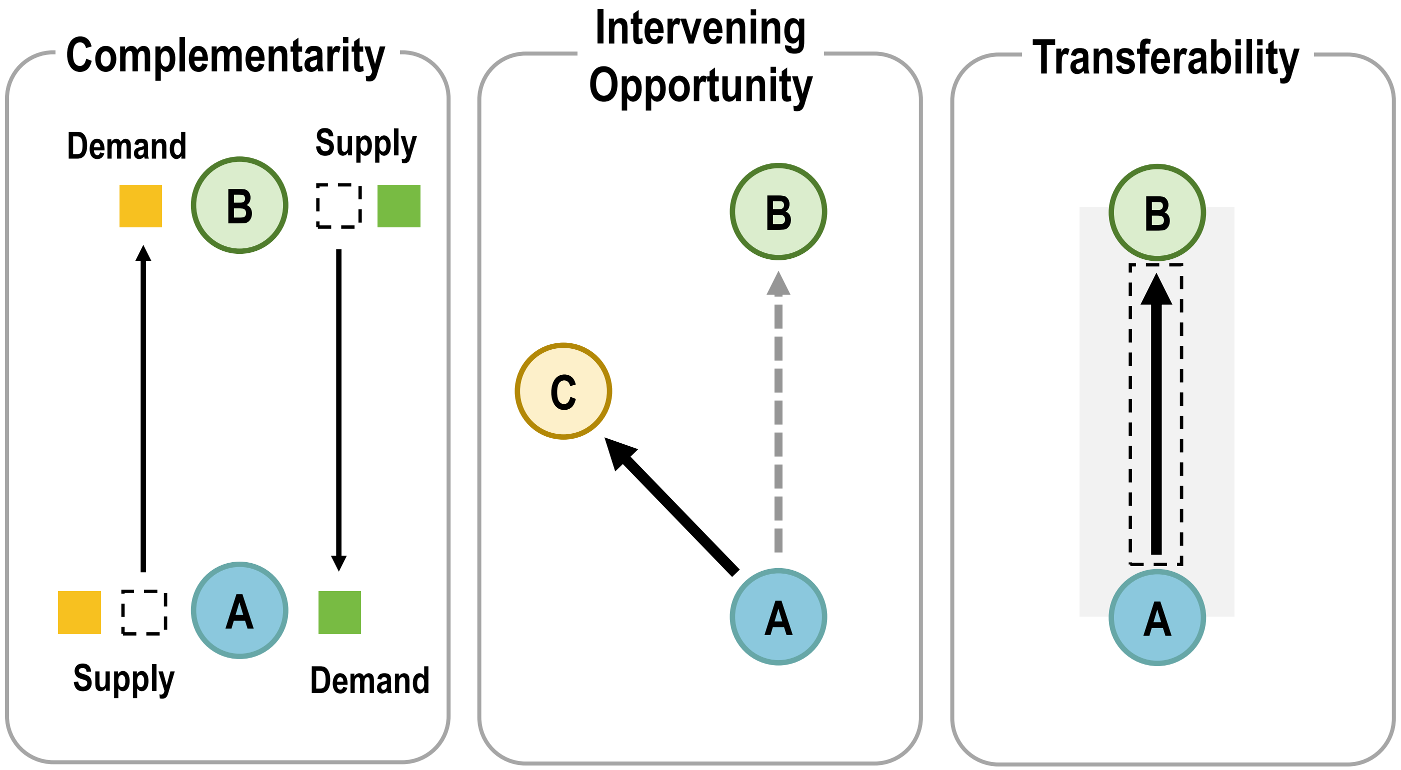
Optimal Solution



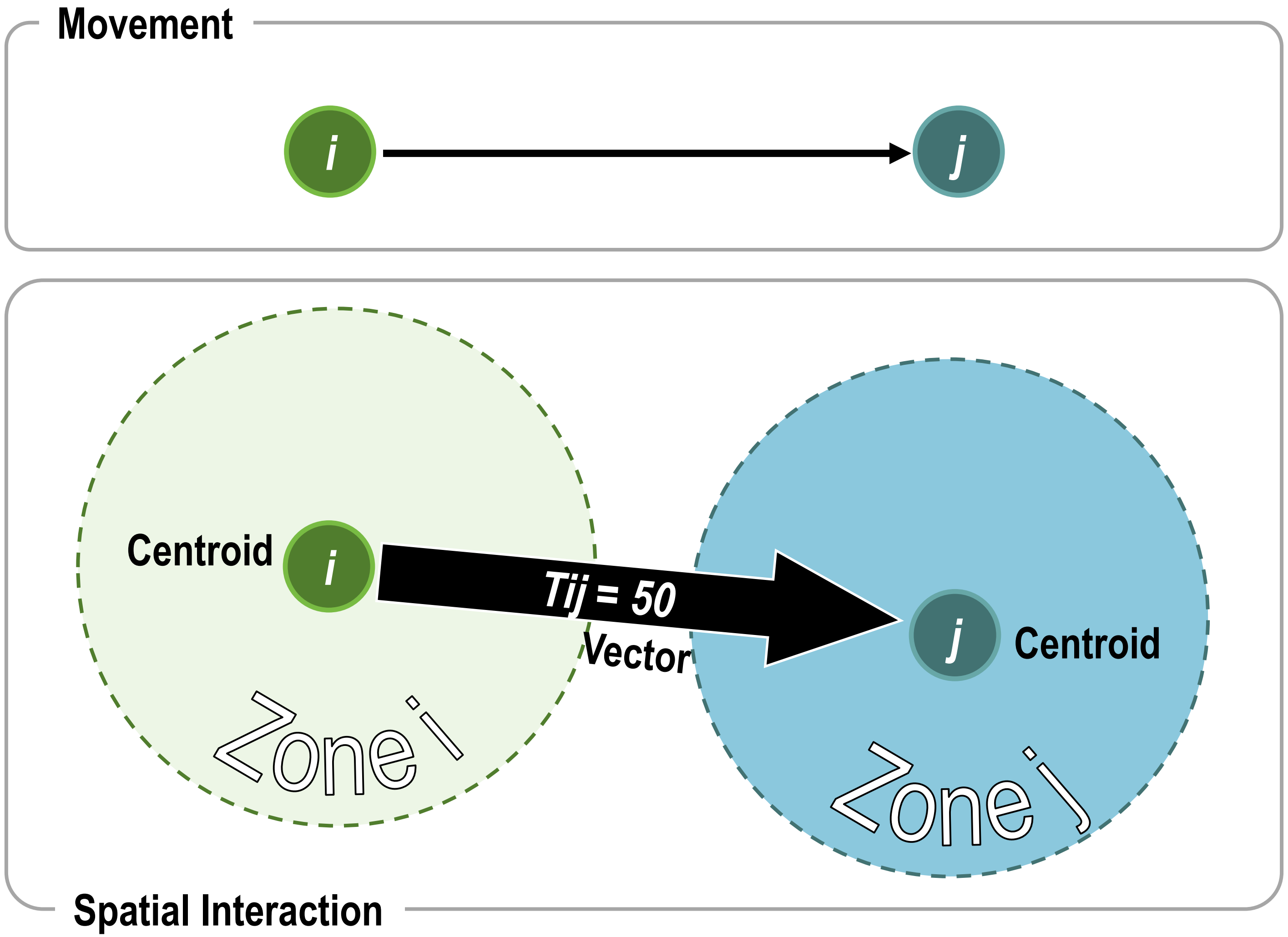


Spatial Interactions and the Gravity Model

Conditions for the Realization of a Spatial Interaction

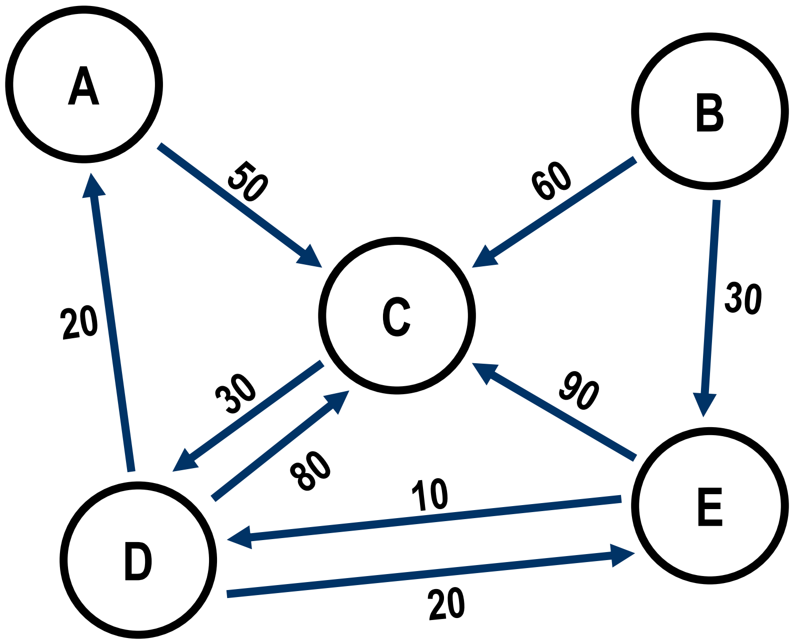


Representation of a Movement as a Spatial Interaction



Constructing an O/D Matrix

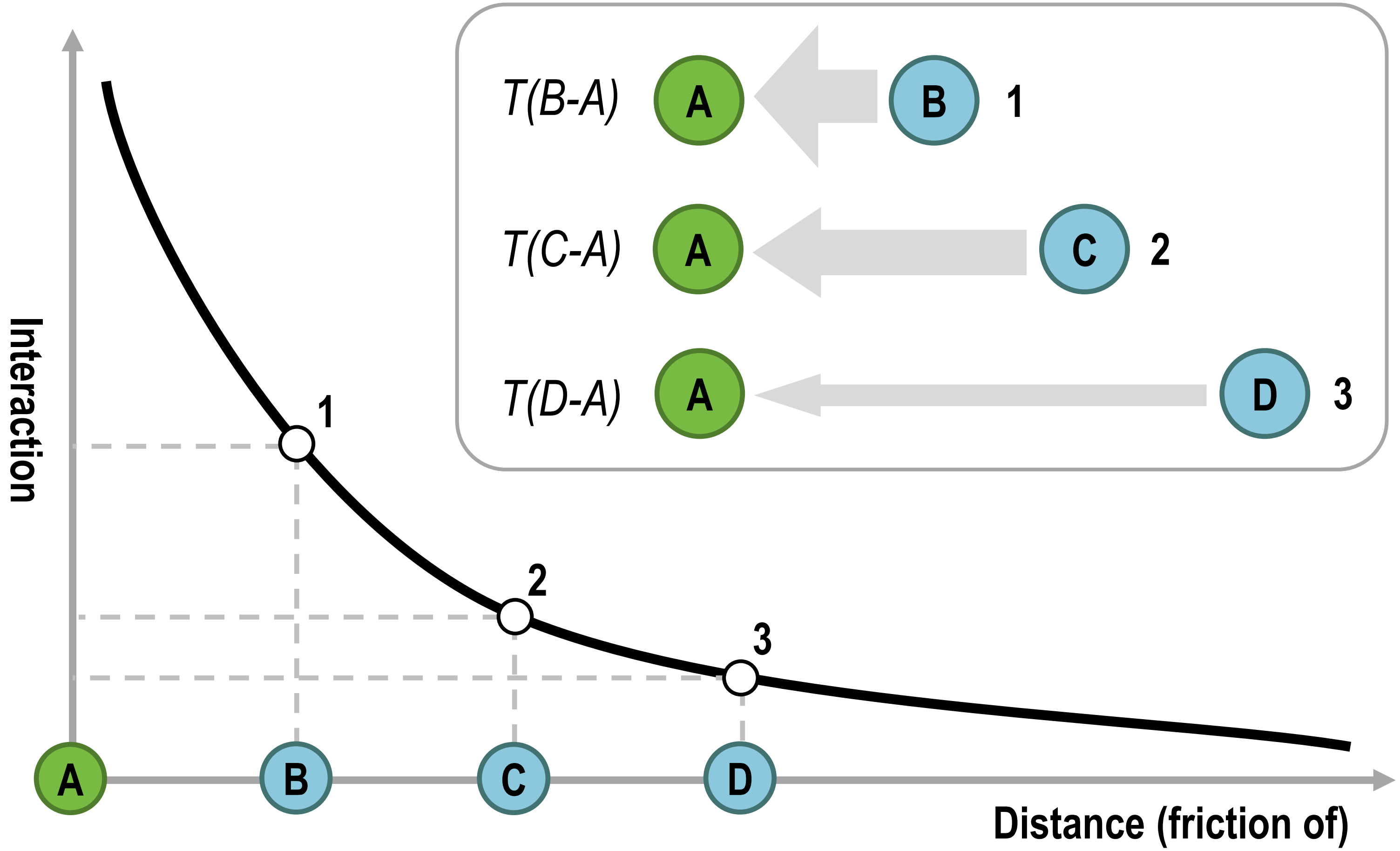
Spatial Interactions



O/D Matrix

	A	B	C	D	E	Ti
A	0	0	50	0	0	50
B	0	0	60	0	30	90
C	0	0	0	30	0	30
D	20	0	80	0	20	120
E	0	0	90	10	0	100
Tj	20	0	280	40	50	**390**

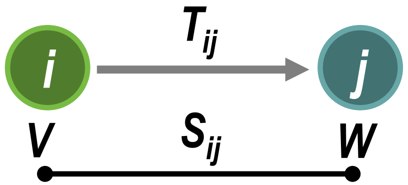
Relationship between Distance and Interactions



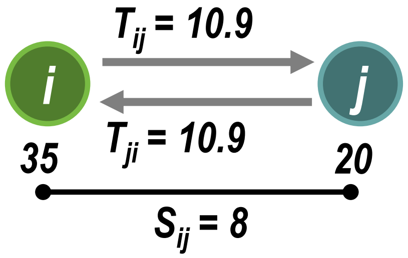
Three Basic Interaction Models

General Formulation

$$T_{ij} = f\left(V_i, W_j, S_{ij}\right)$$

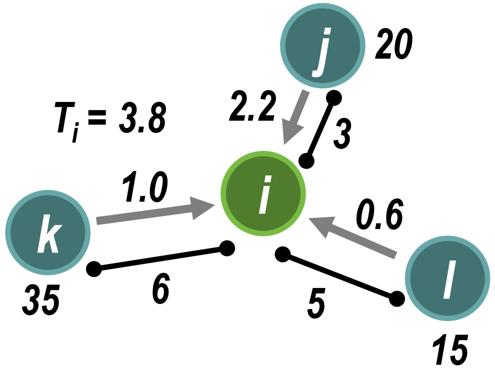


$$T_{ij} = \frac{V_i * W_j}{S_{ij}^2}$$



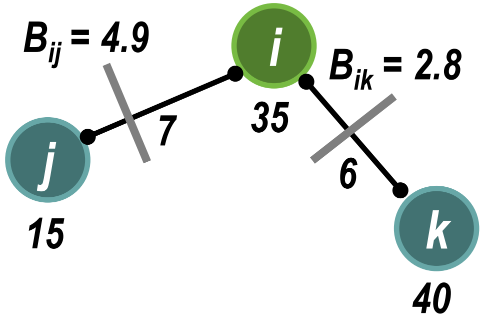
Gravity Model

$$T_i = \sum_j \frac{W_j}{S_{ij}^2}$$



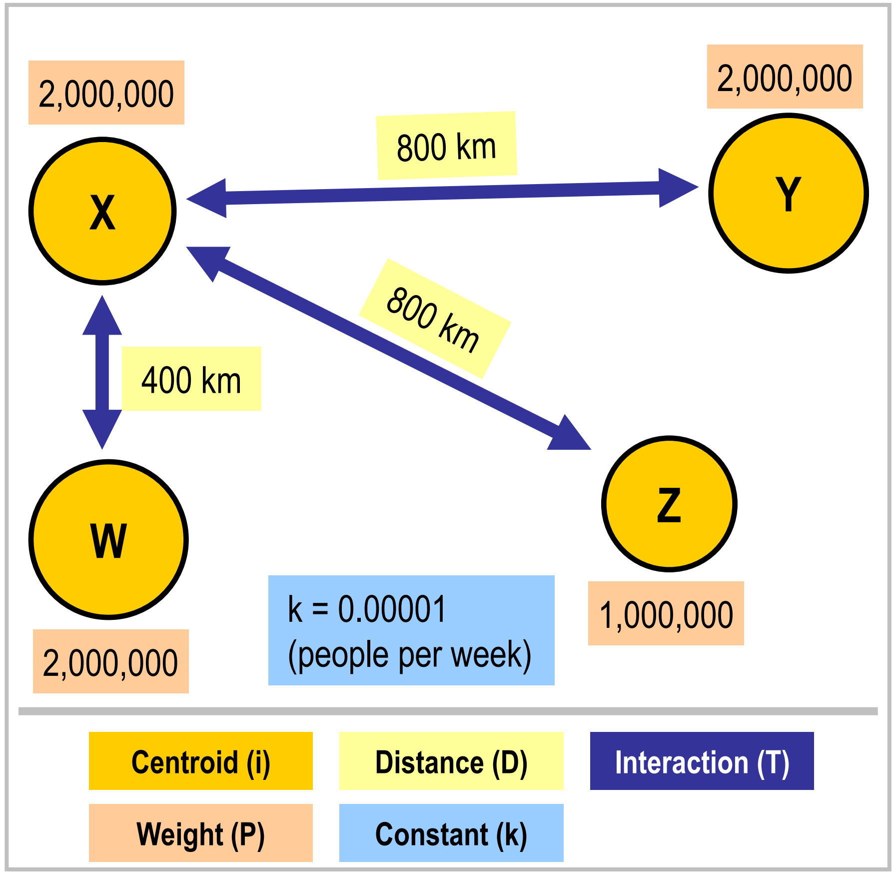
Potential Model

$$B_{ij} = \frac{S_{ij}}{1 + \frac{W_j}{V_i}}$$



Retail Model

Application of an Elementary Spatial Interaction Equation

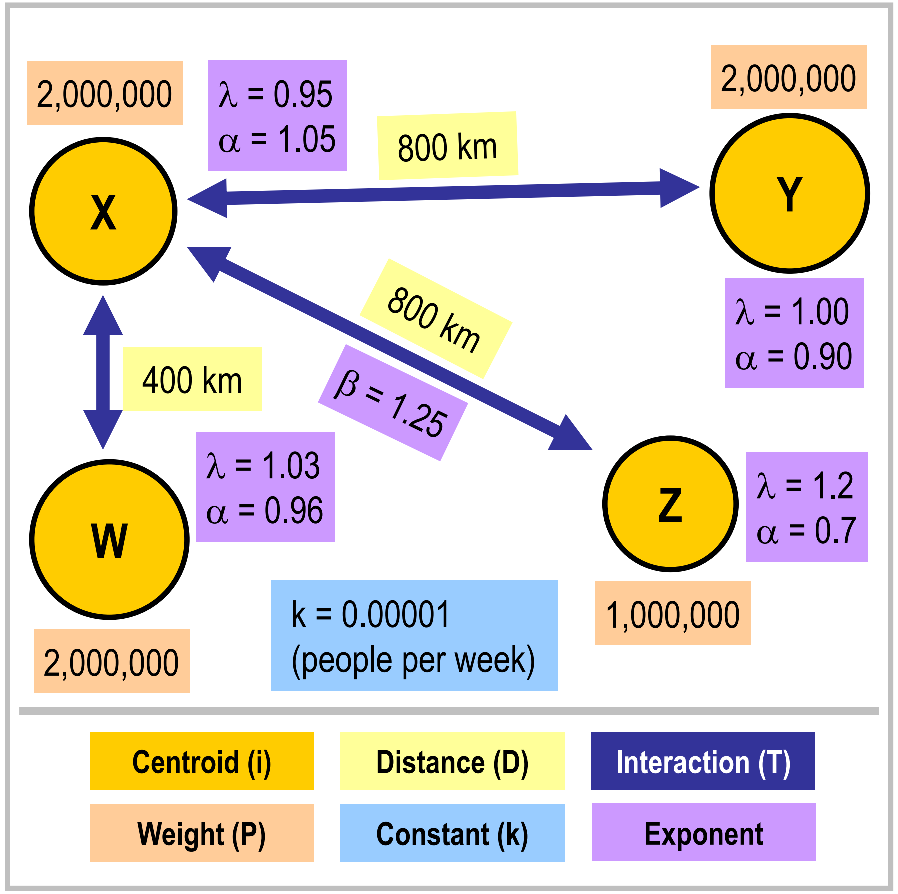


Elementary Formulation

$$T_{ij} = k\frac{P_i P_j}{D_{ij}}$$

	W	X	Y	Z	Ti
W		100,000			100,000
X	100,000		50,000	25,000	175,000
Y		50,000			50,000
Z		25,000			25,000
Tj	100,000	175,000	50,000	25,000	350,000

Application of a Simple Spatial Interaction Equation

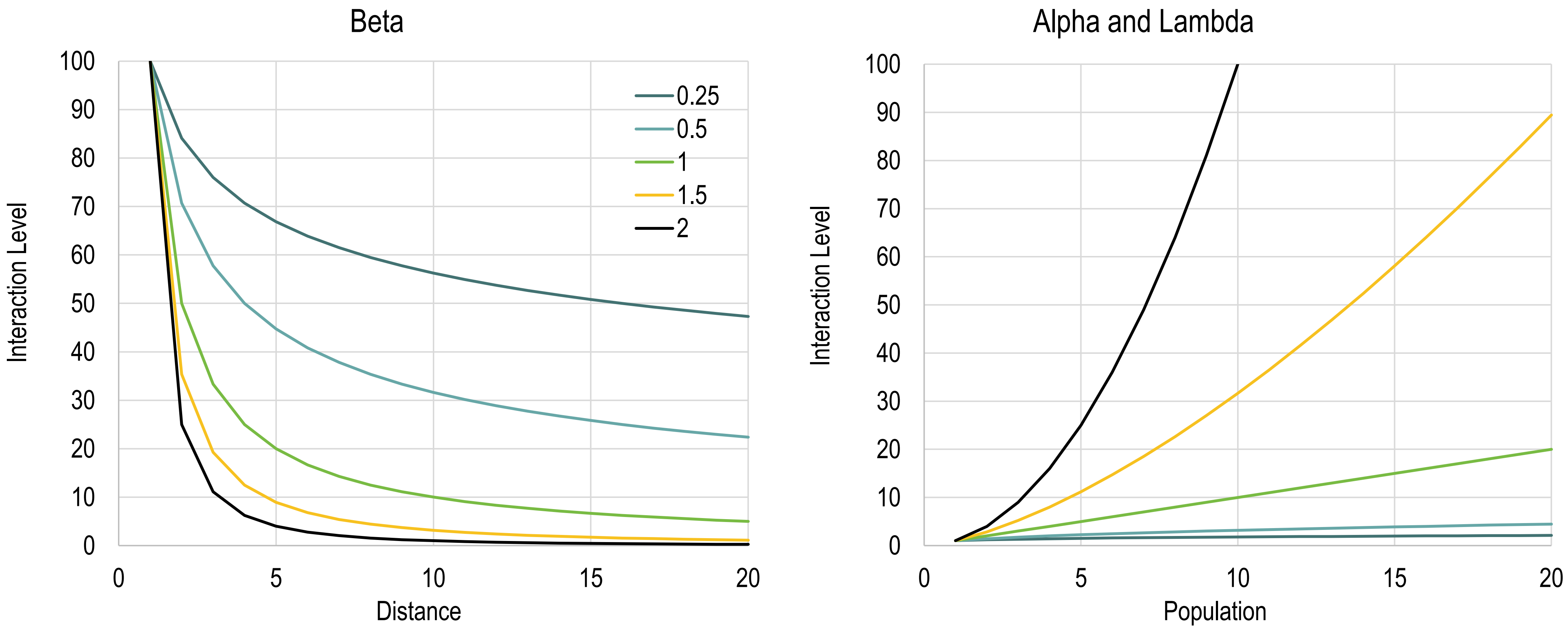


Simple Formulation

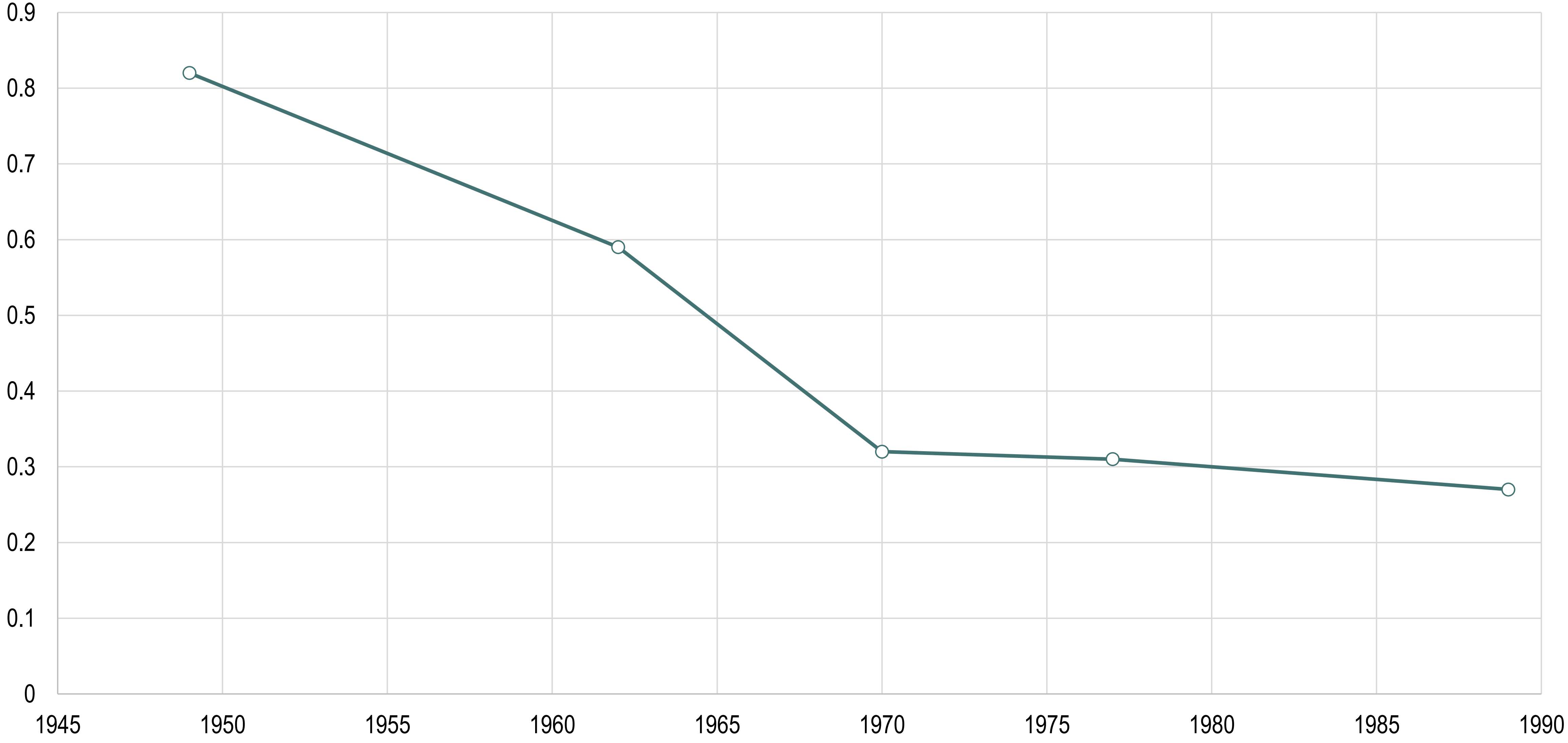
$$T_{ij} = k\frac{P_i^{\alpha} P_j^{\lambda}}{D_{ij}^{\beta}}$$

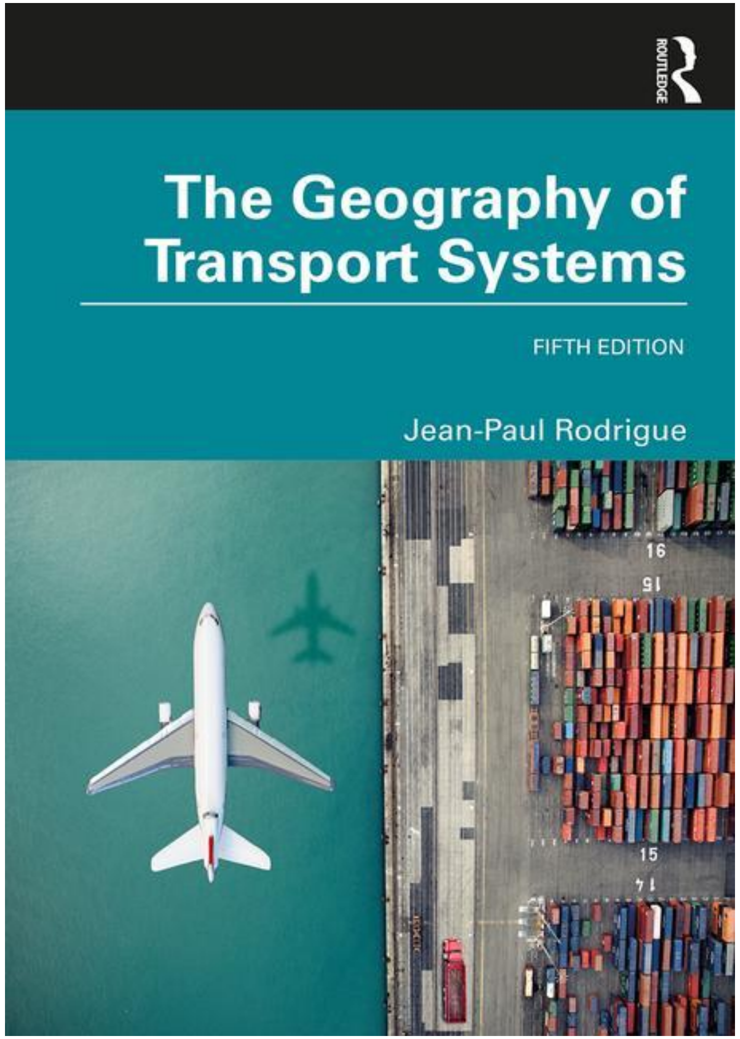
	W	X	Y	Z	Ti
W		71,378			71,378
X	6,059		2,203	36	8,298
Y		19,420			19,420
Z		153,893			153,893
Tj	6,059	244,692	2,203	36	252,990

Effects of beta, alpha and lambda on Spatial Interactions



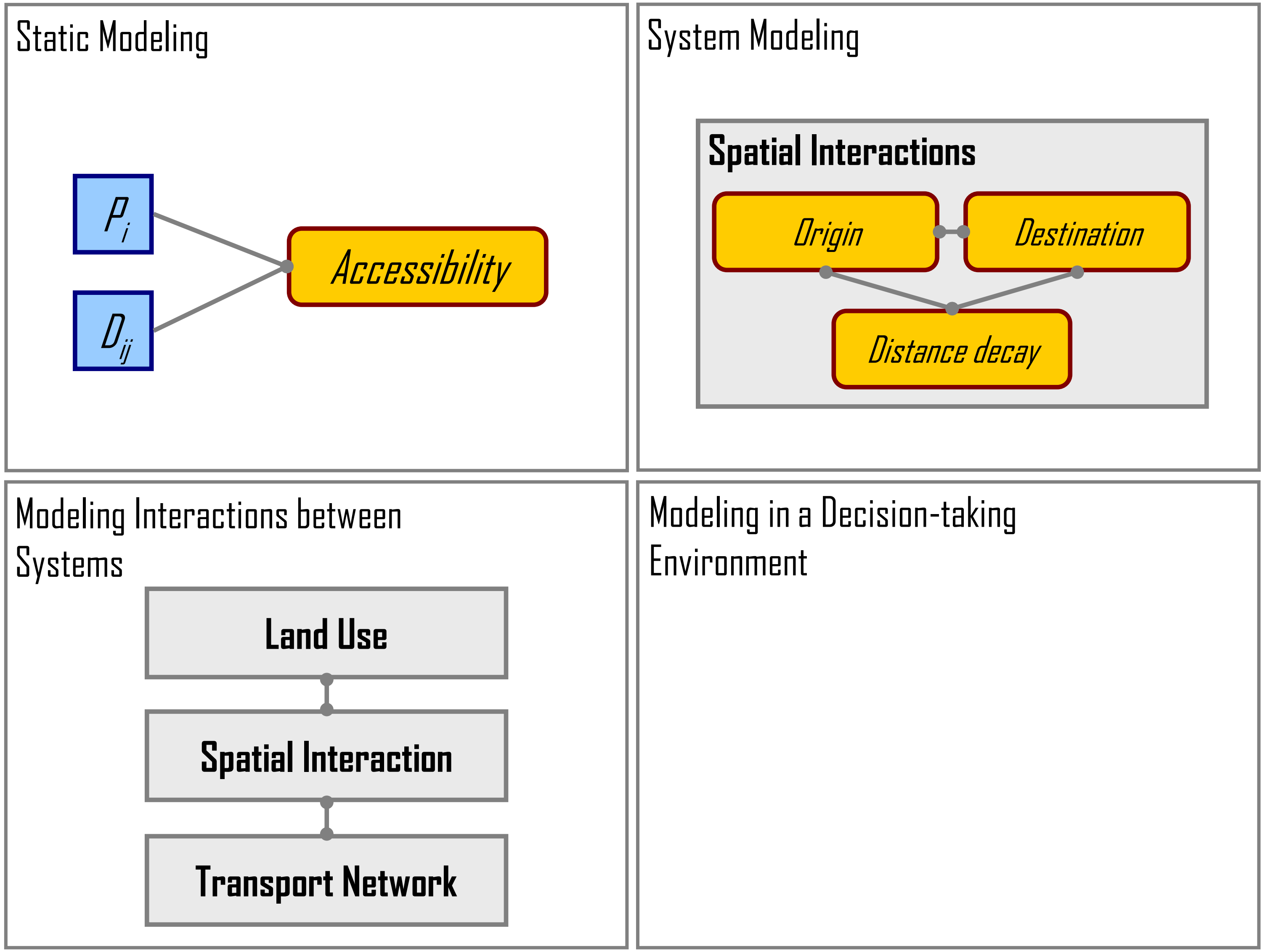
Chicago's Beta Values for Air Transportation, 1949-1989



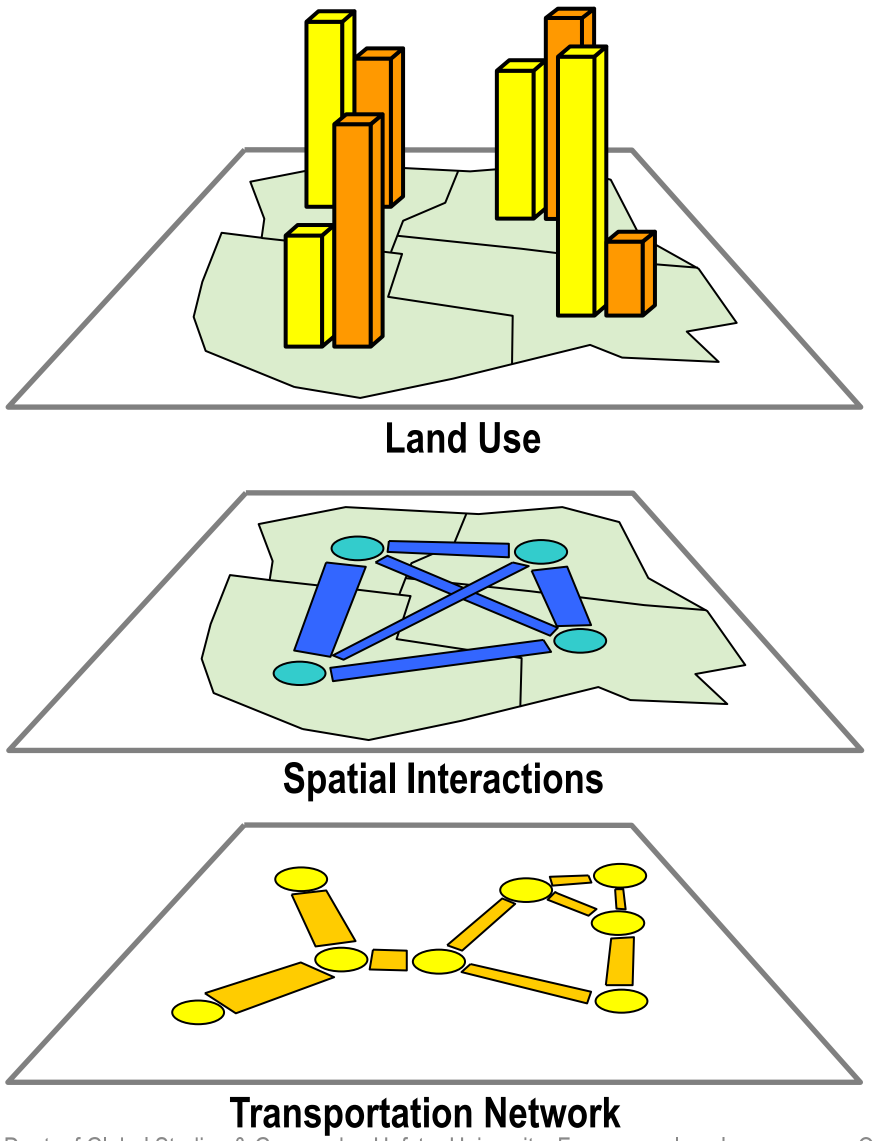


Transportation / Land Use Modeling

Modeling Transportation / Land Use Relationships (under construction)



Components of the Transportation / Land Use System

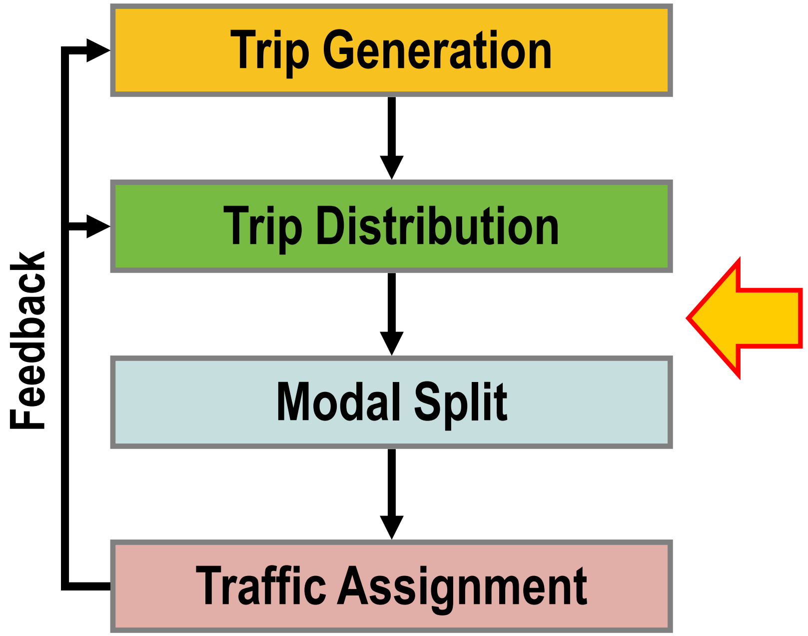


- Economic base theory
- Location theory
- Traffic generation and attraction models

- Spatial interaction models
- Distance decay parameters
- Modal split

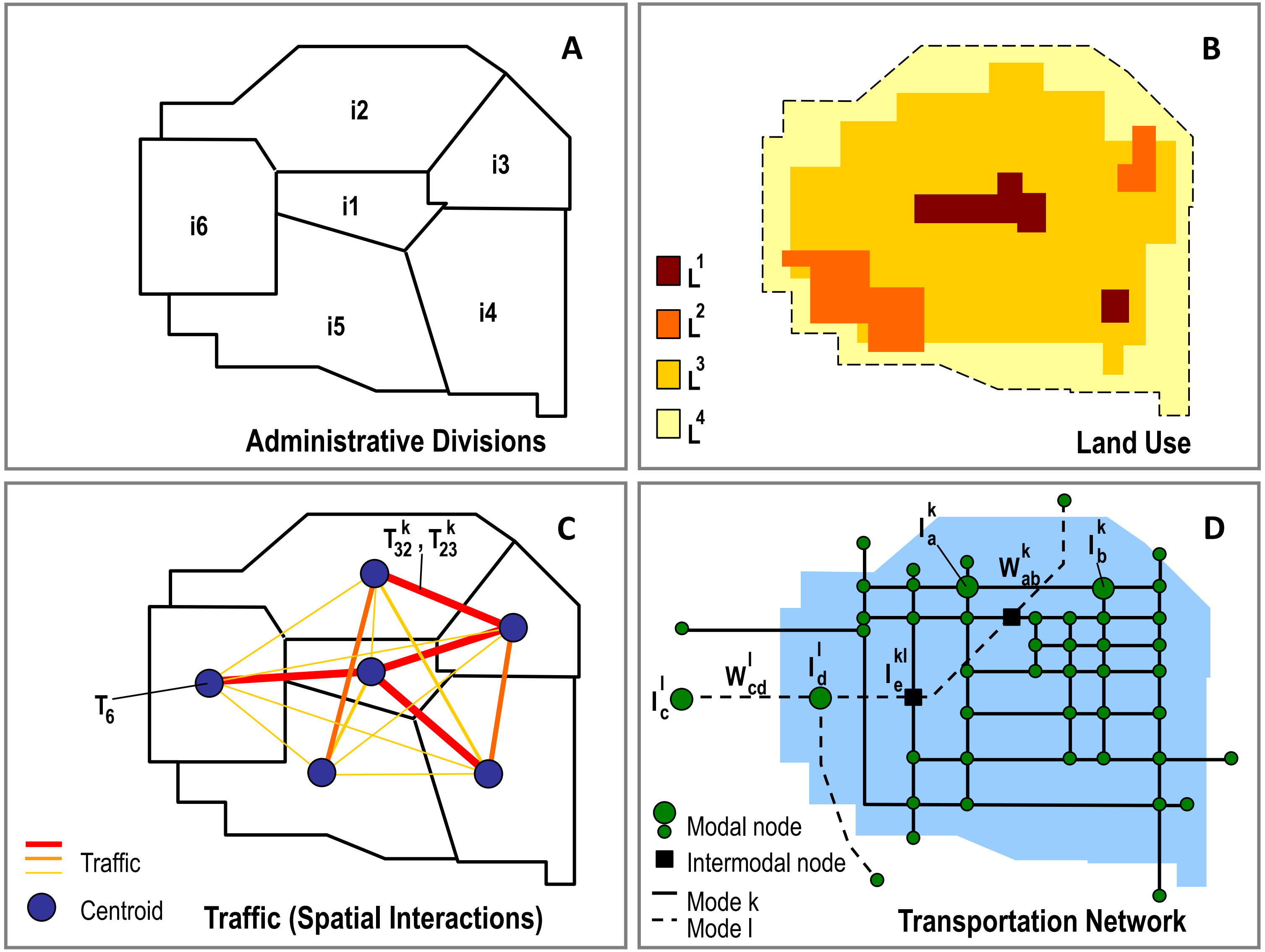
- Traffic assignment models
- Transport capacity

Four-Stages Transportation / Land Use Model

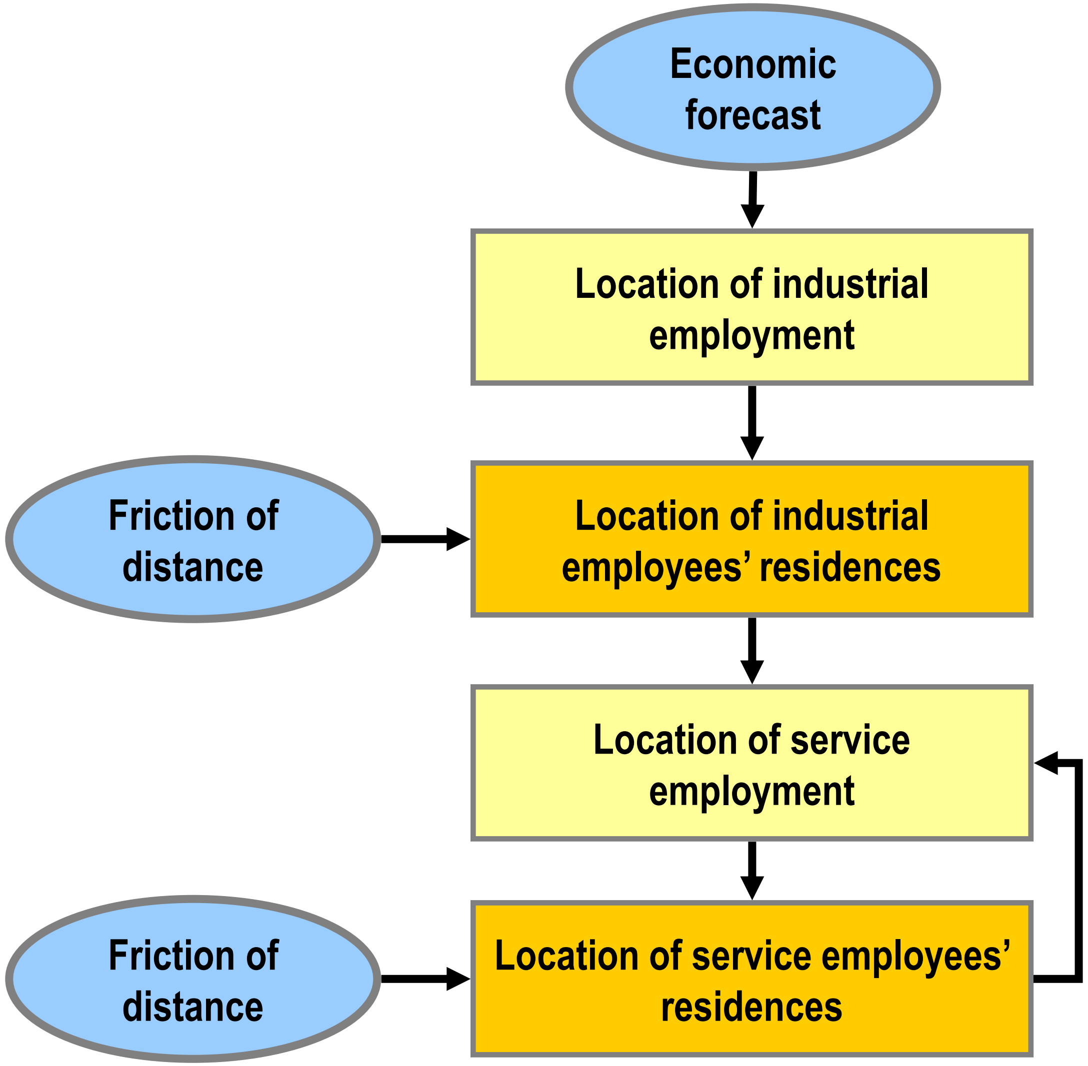


- Land Use Data
- Travel Generation Factors
- Friction of Distance Factors
- Calibration Factors
- Transportation Networks

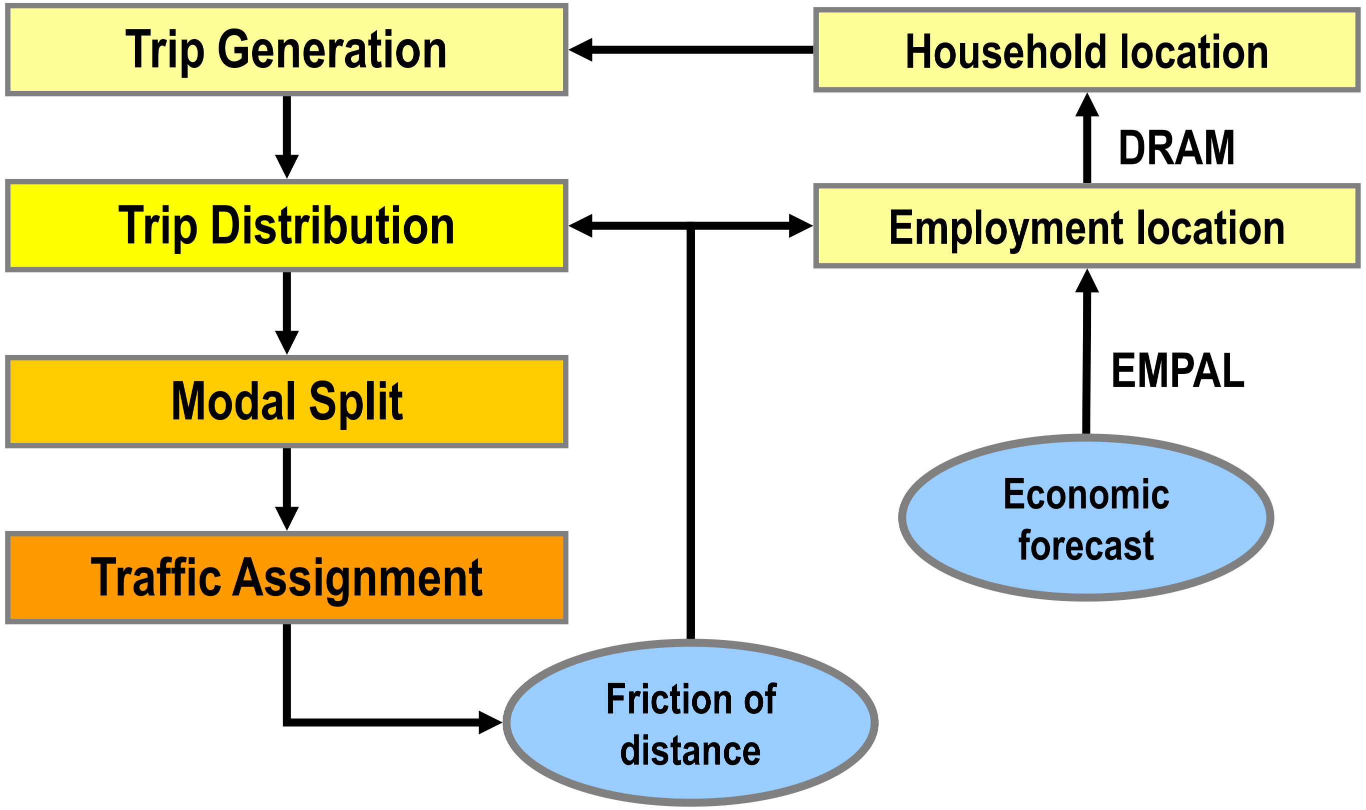
Measuring the Transportation / Land Use System



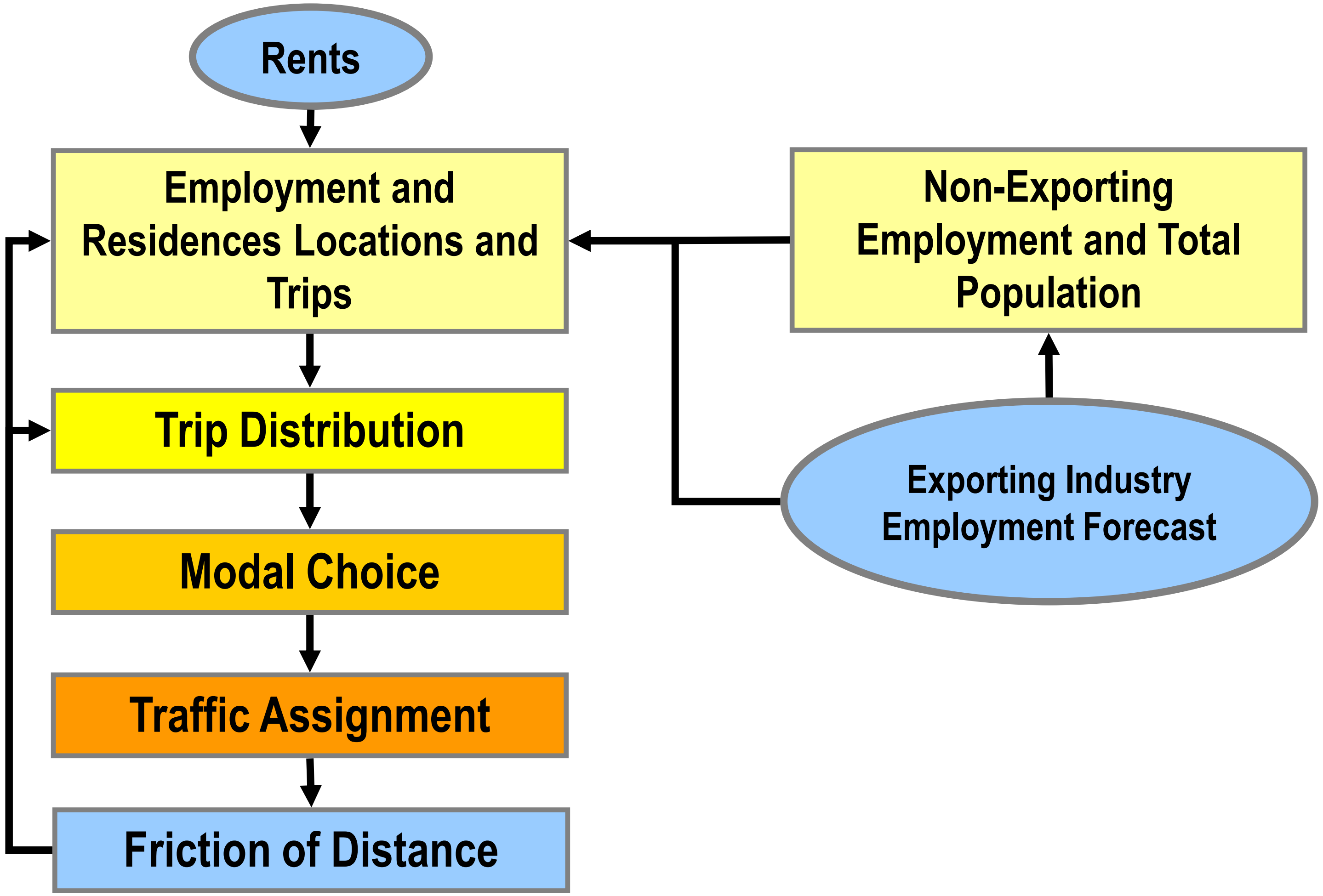
Lowry-Type Transportation / Land Use Model

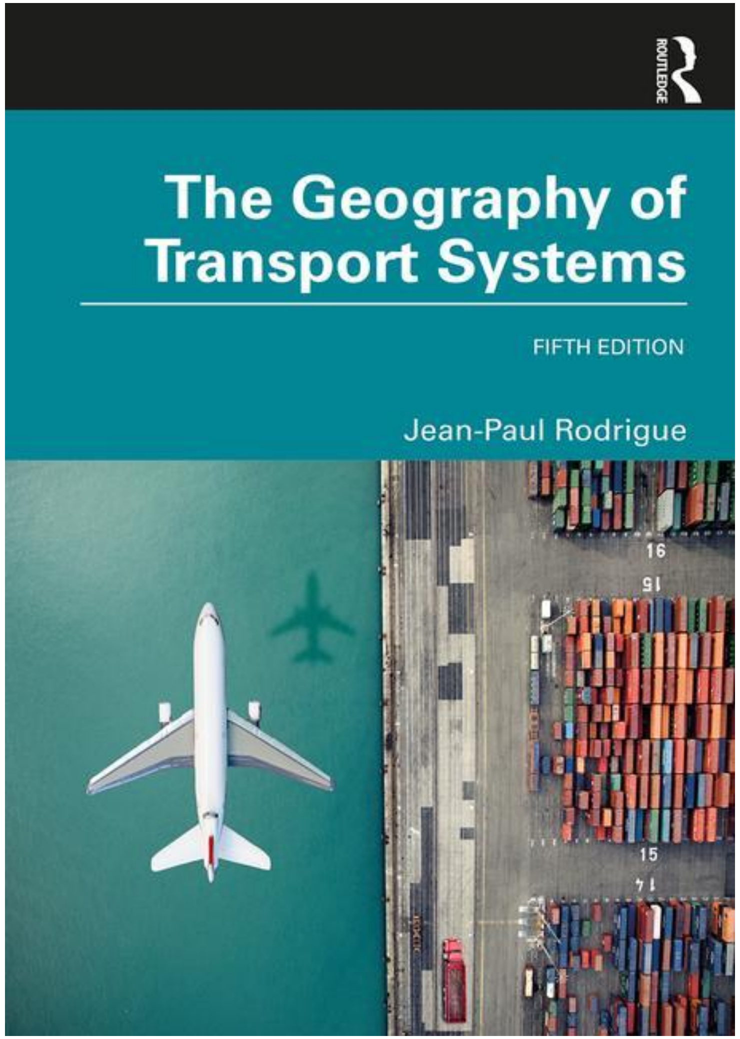


Integrated Land Use and Transportation Package



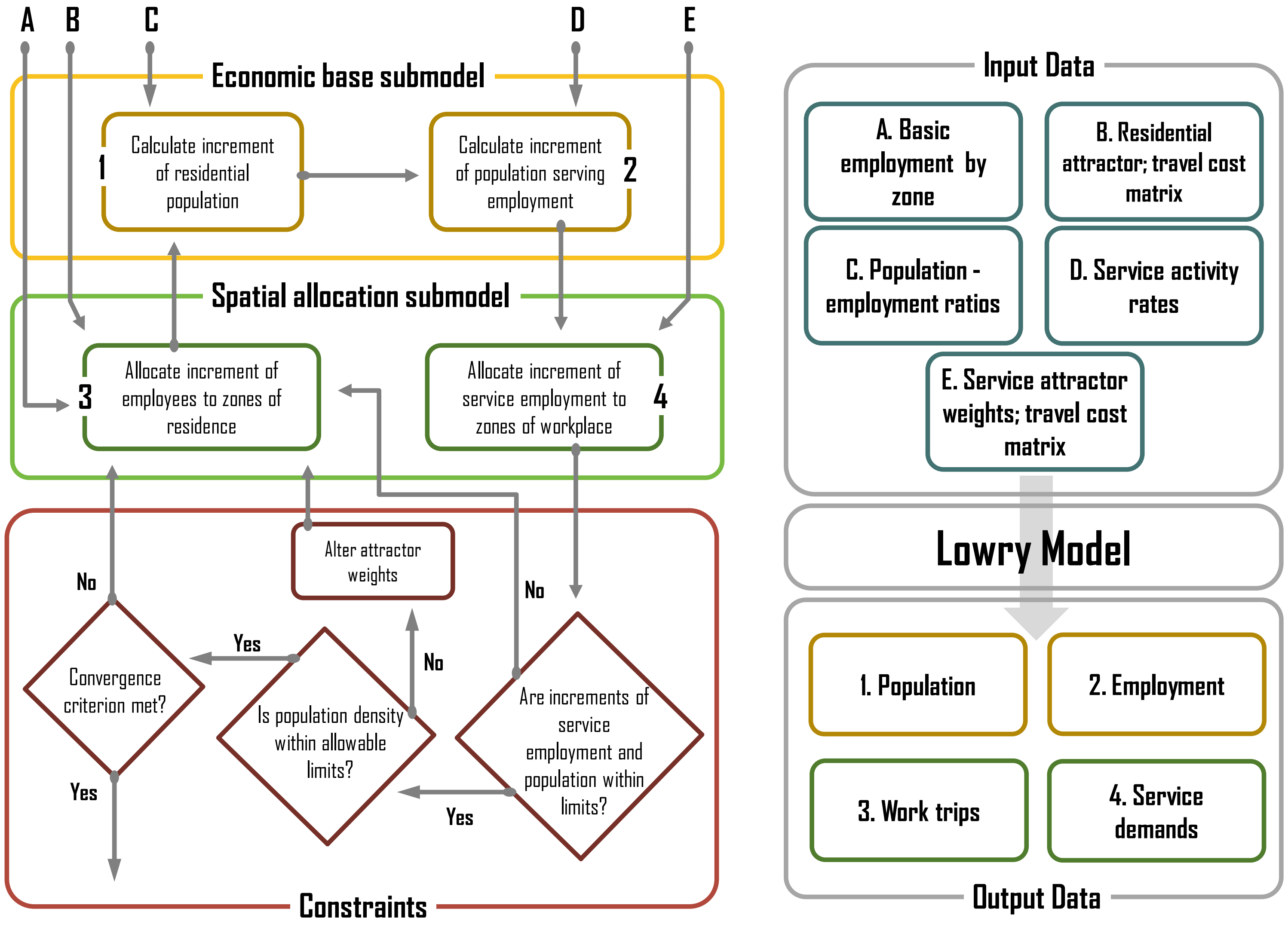
MEPLAN Transportation / Land Use Model

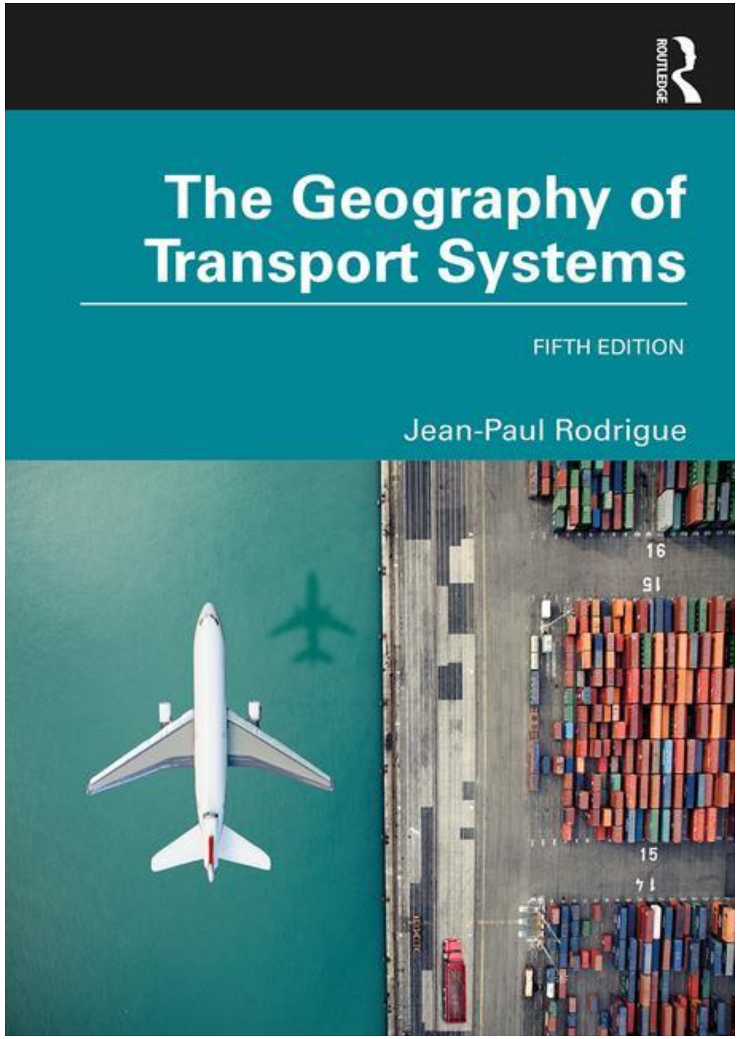




The Lowry Model

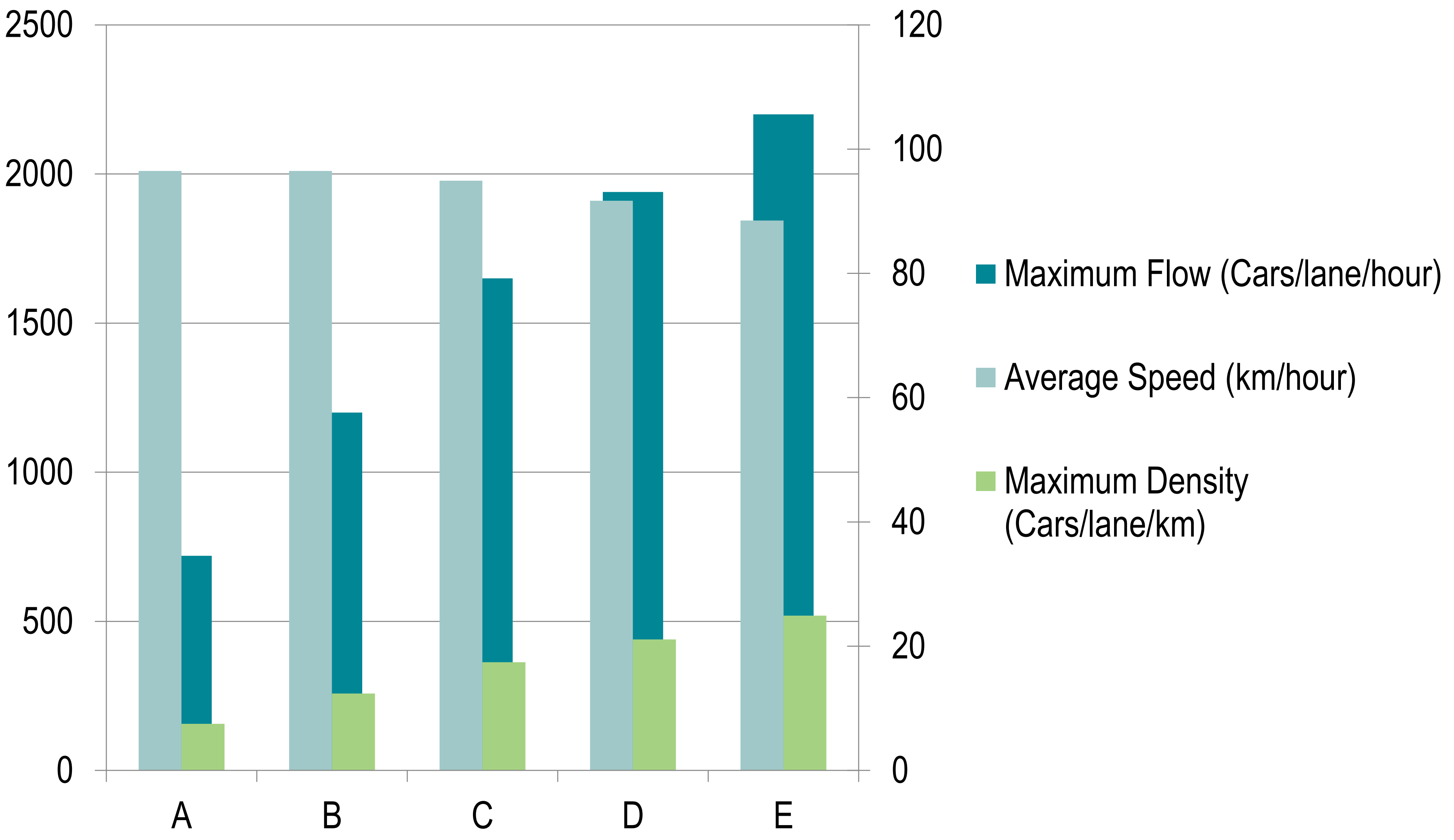
The Lowry Model



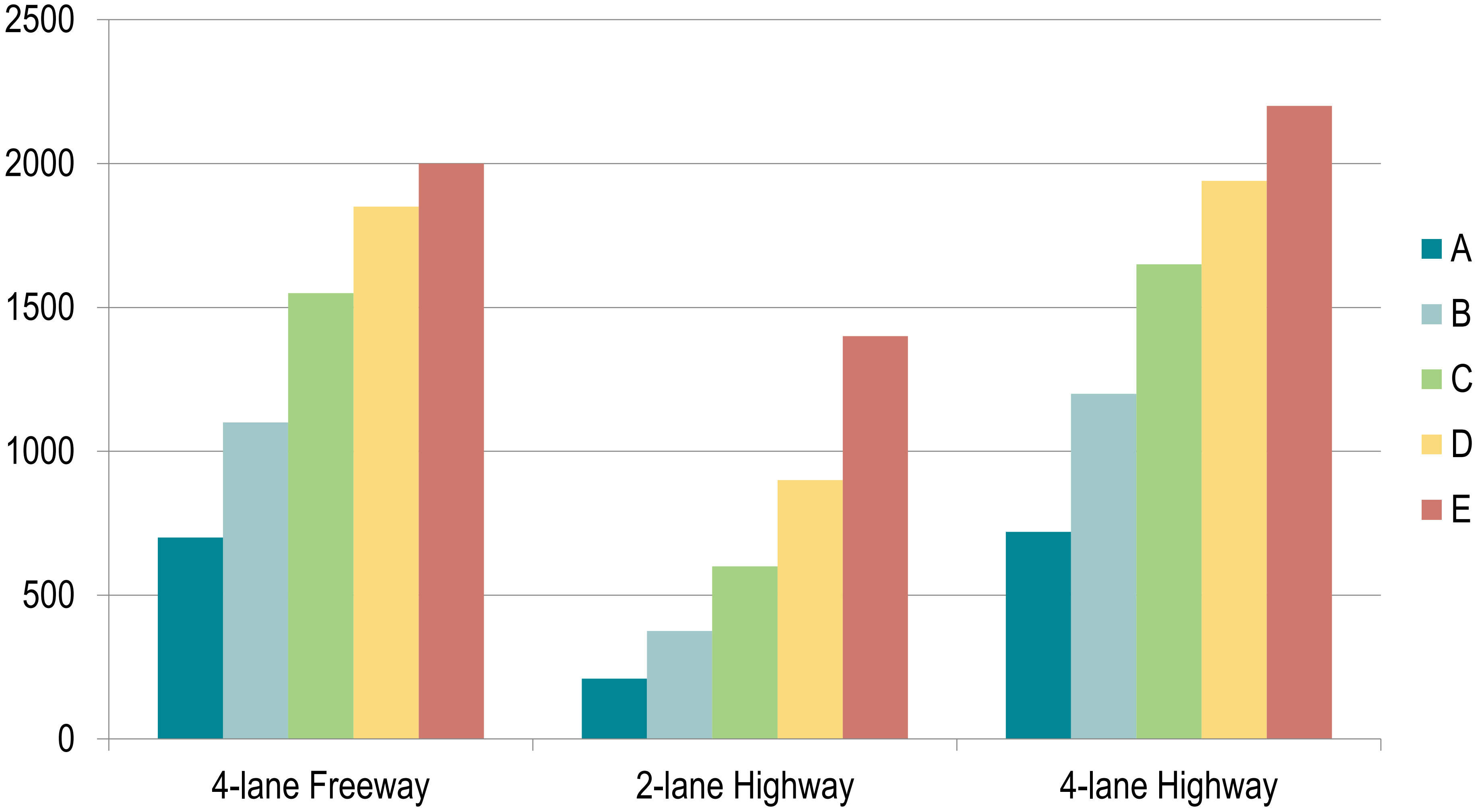


Evaluating Urban Transportation Quality

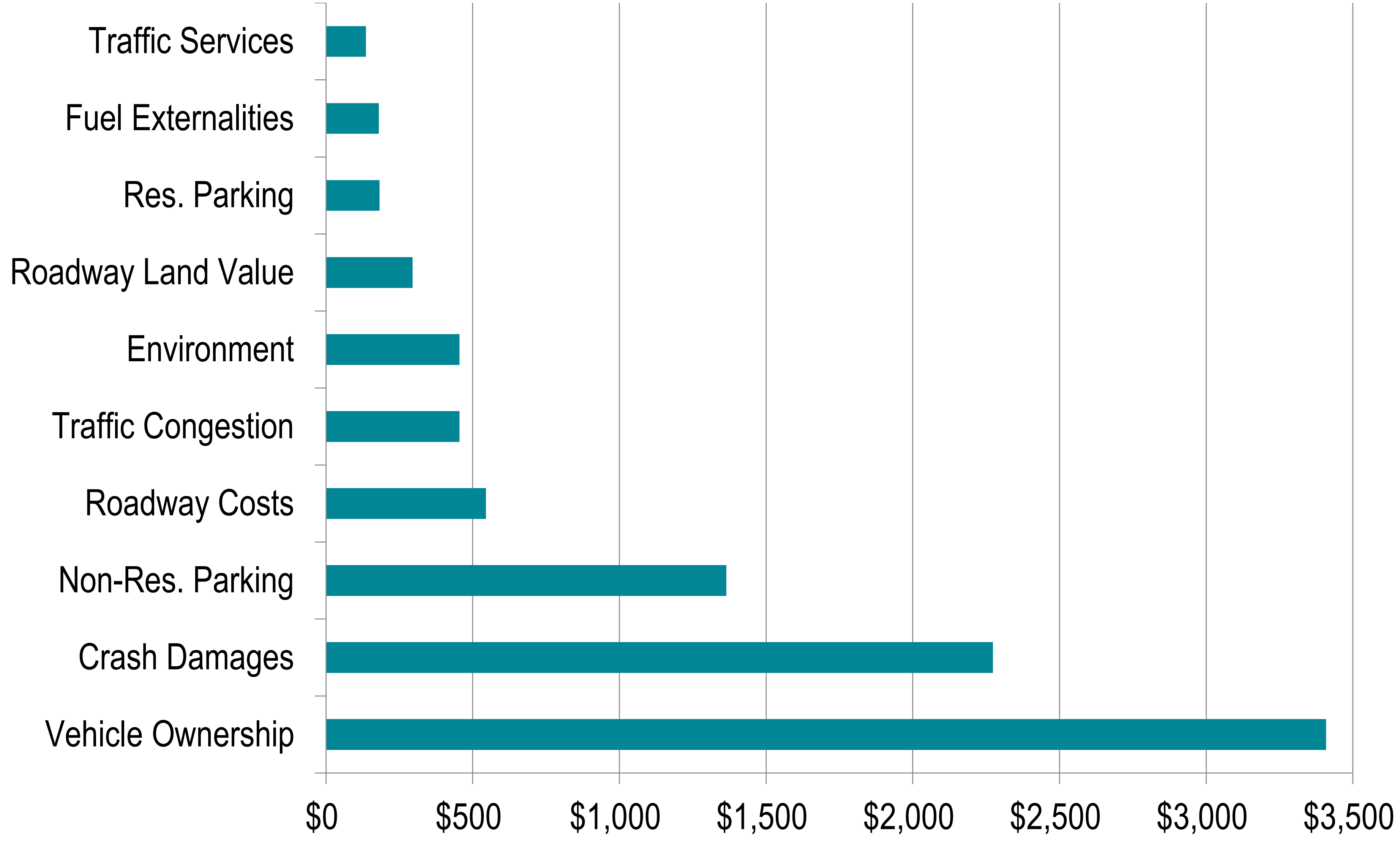
Roadway Levels of Service



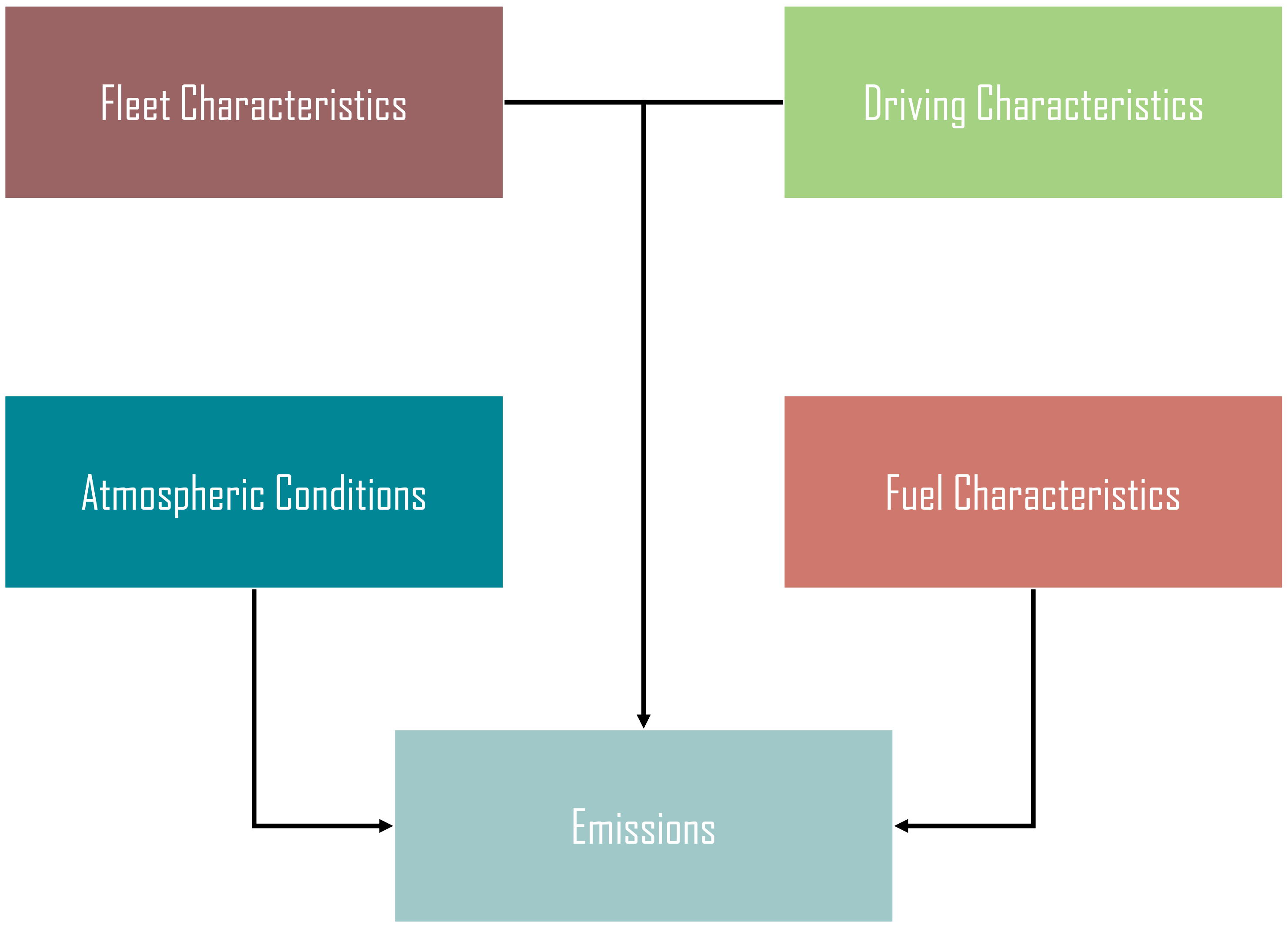
Maximum Traffic Volumes Per Level of Service (Passenger Cars Per Hour Per Lane)



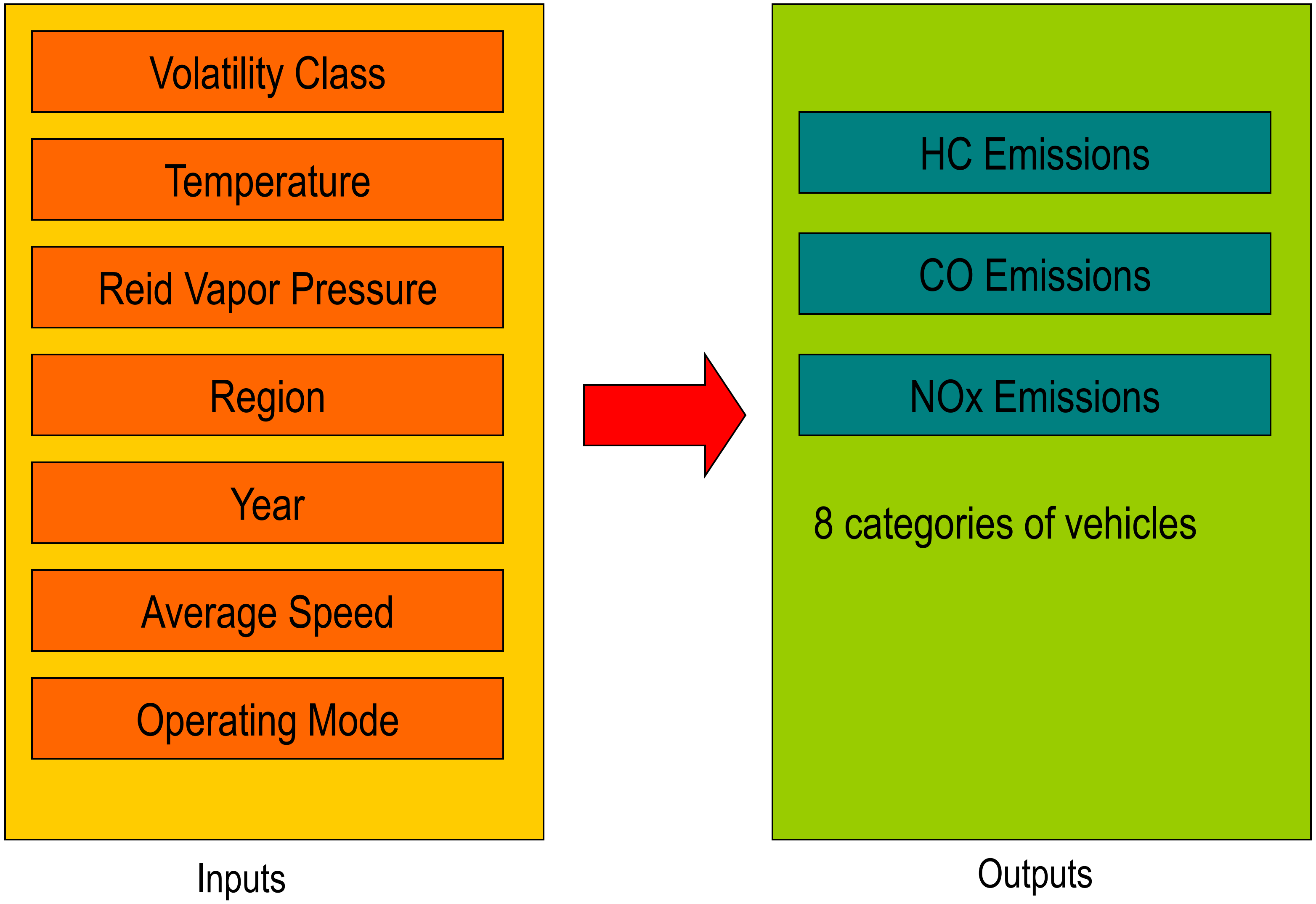
Costs of Motor Vehicle Use in the U.S., 2000

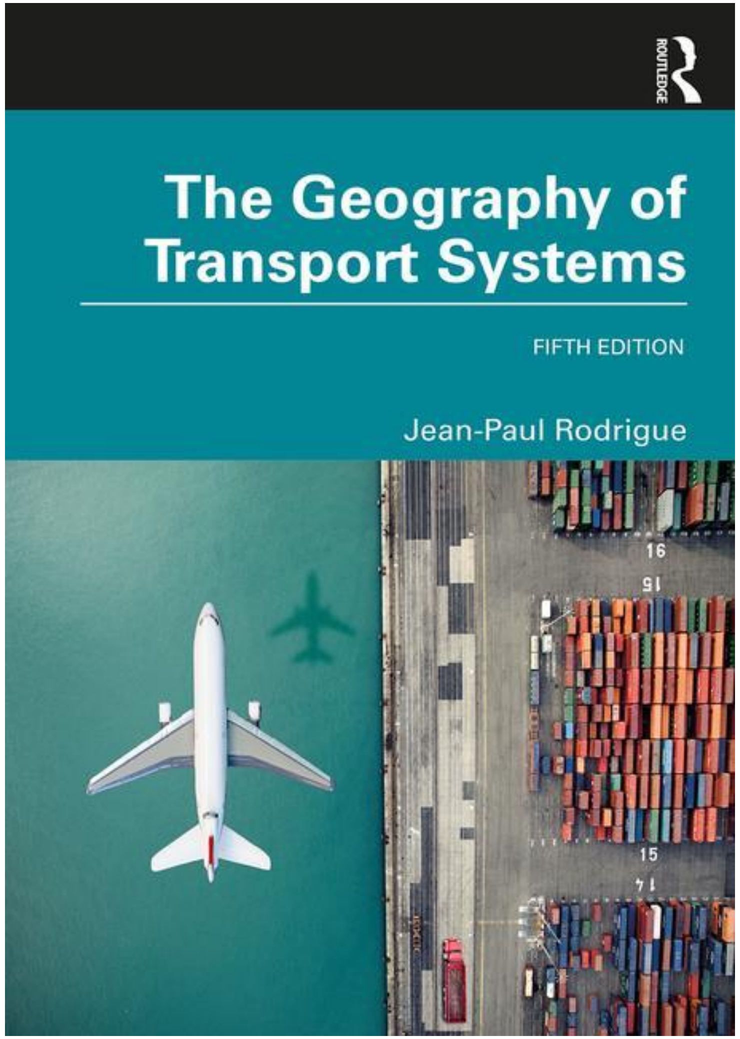


Components of the MOBILE Emission Model



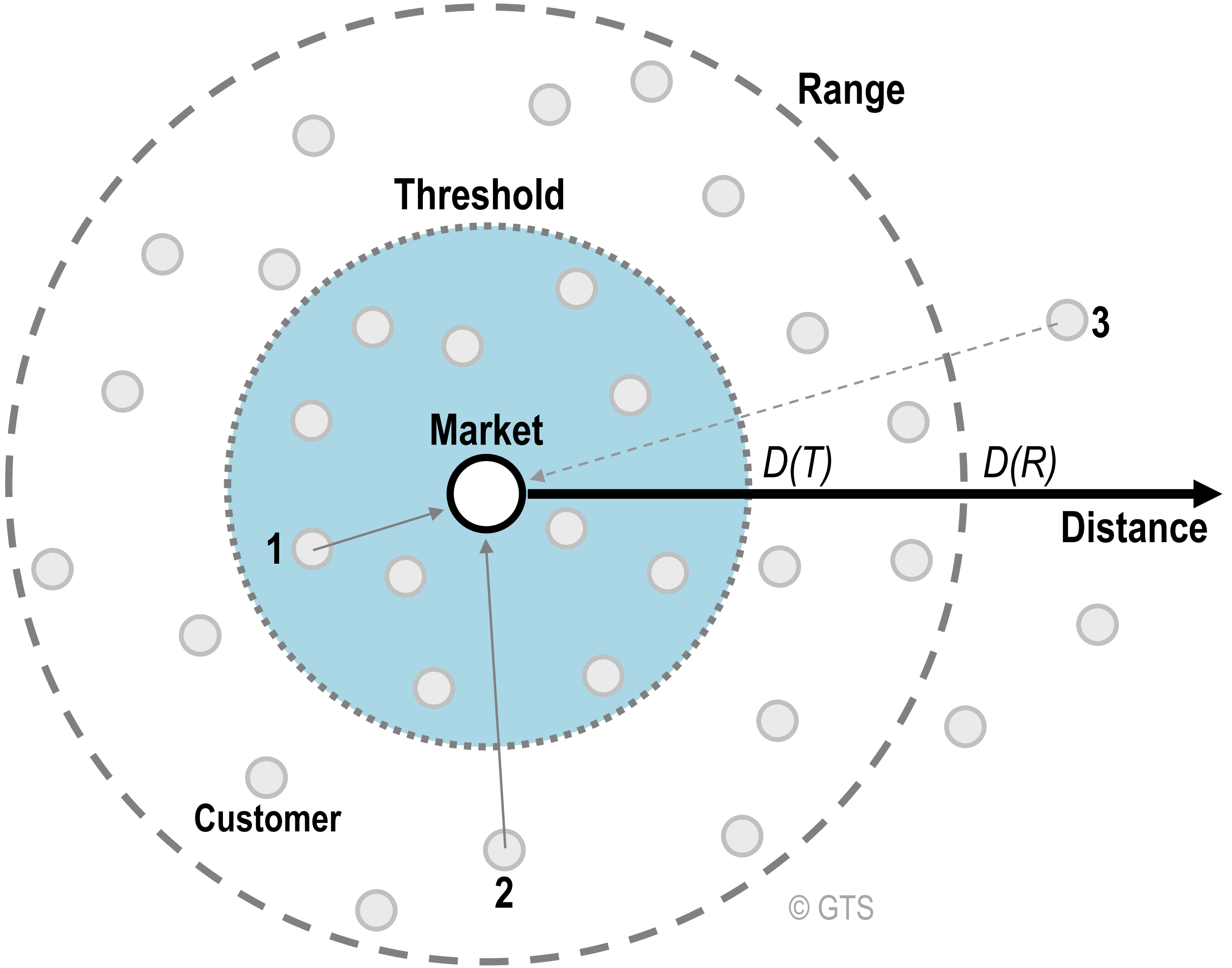
Inputs and Outputs of the MOBILE Emission Model



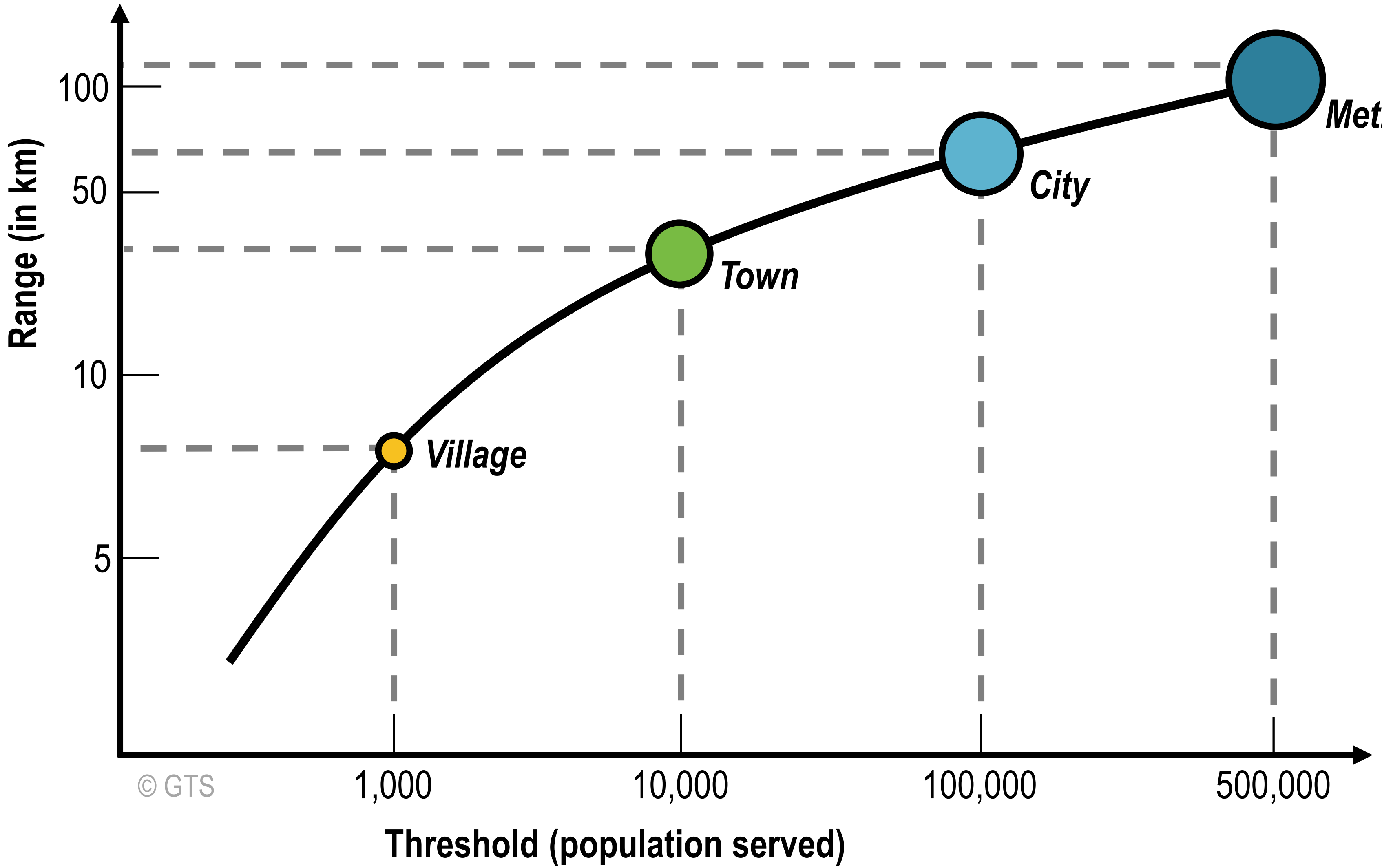


Market Areas Analysis

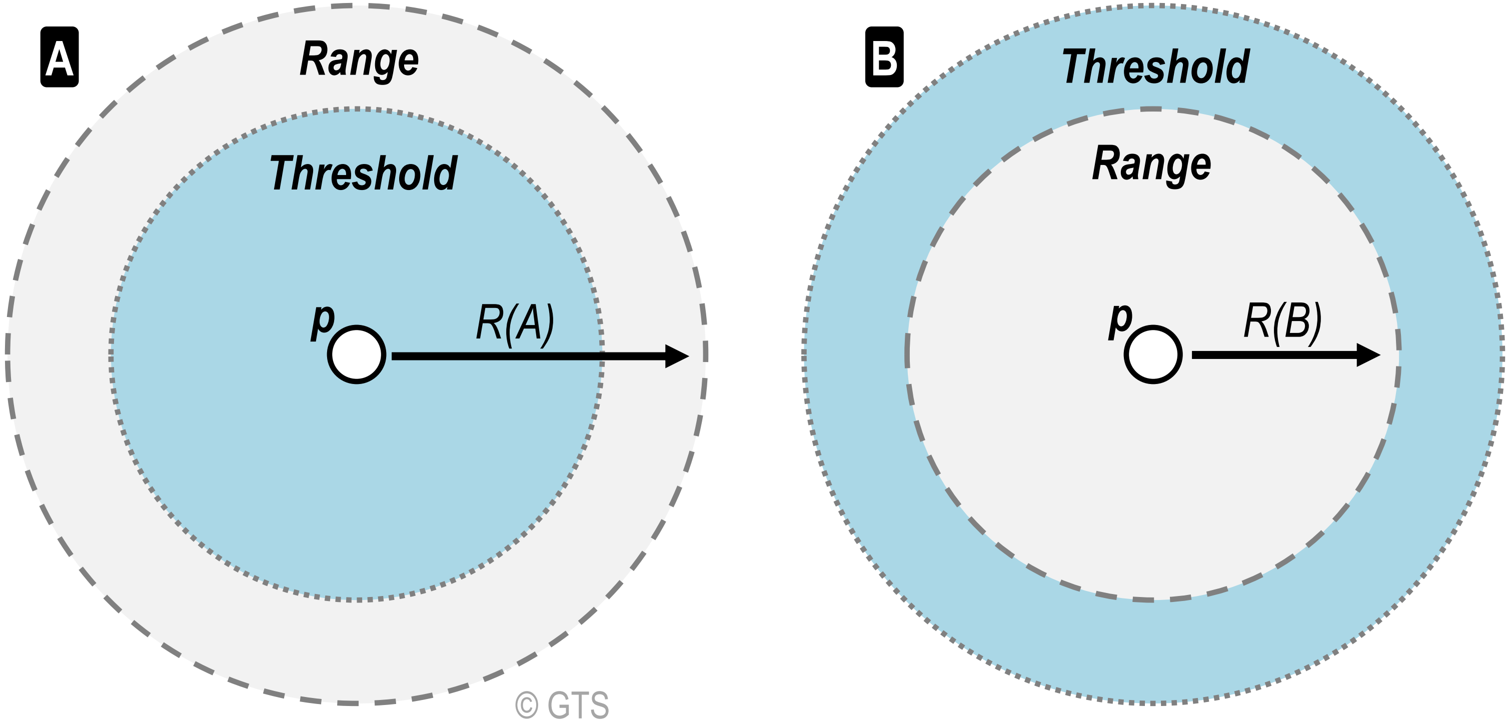
Market Threshold and Range



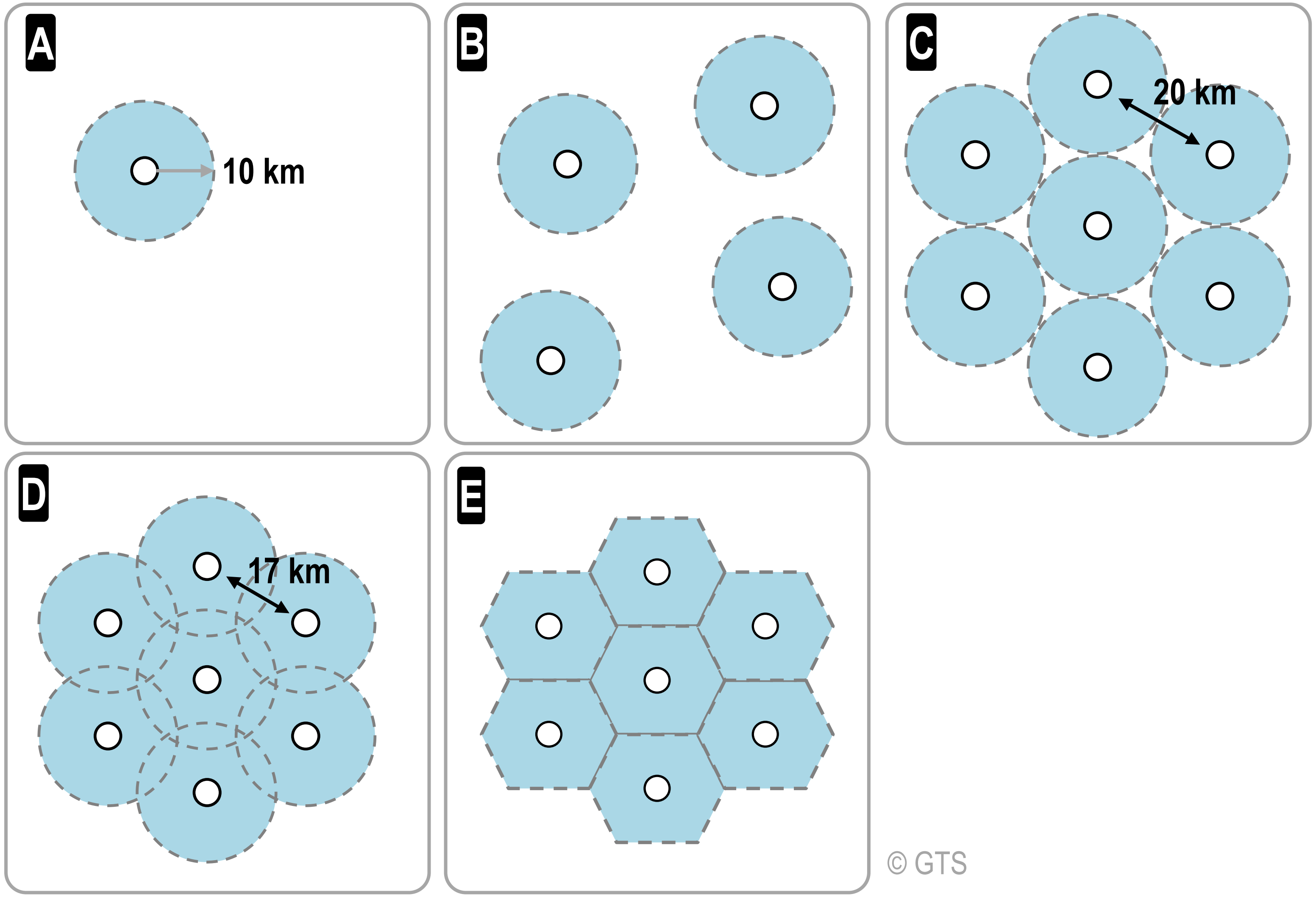
Market Size and Threshold



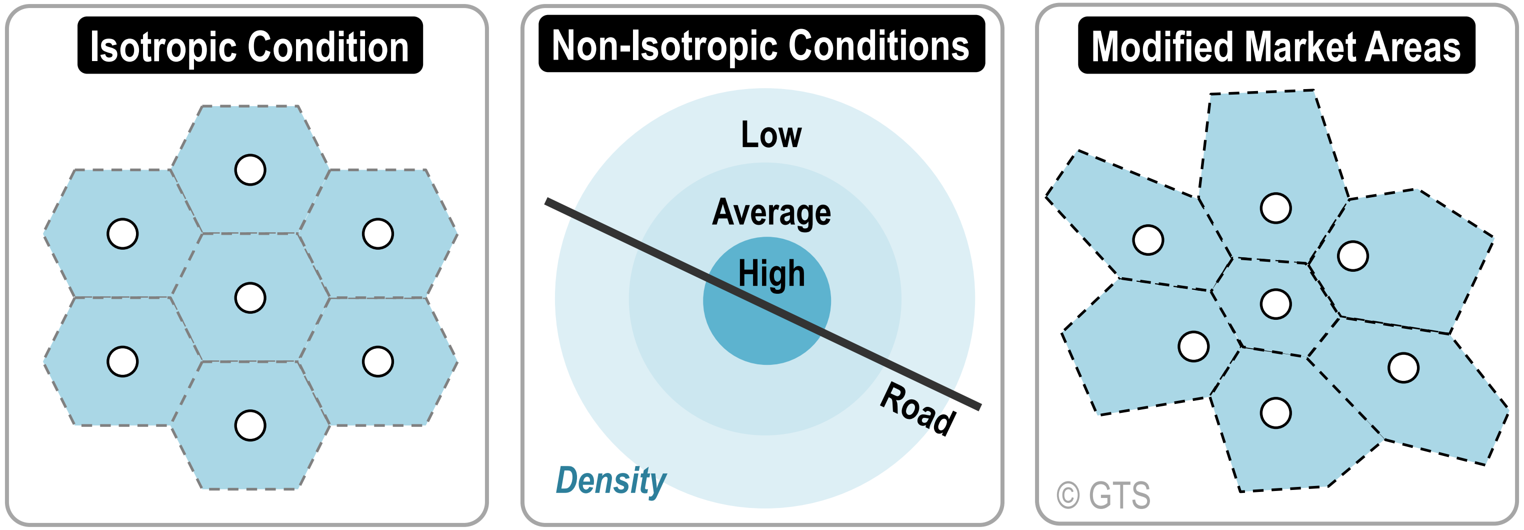
Market Profitability



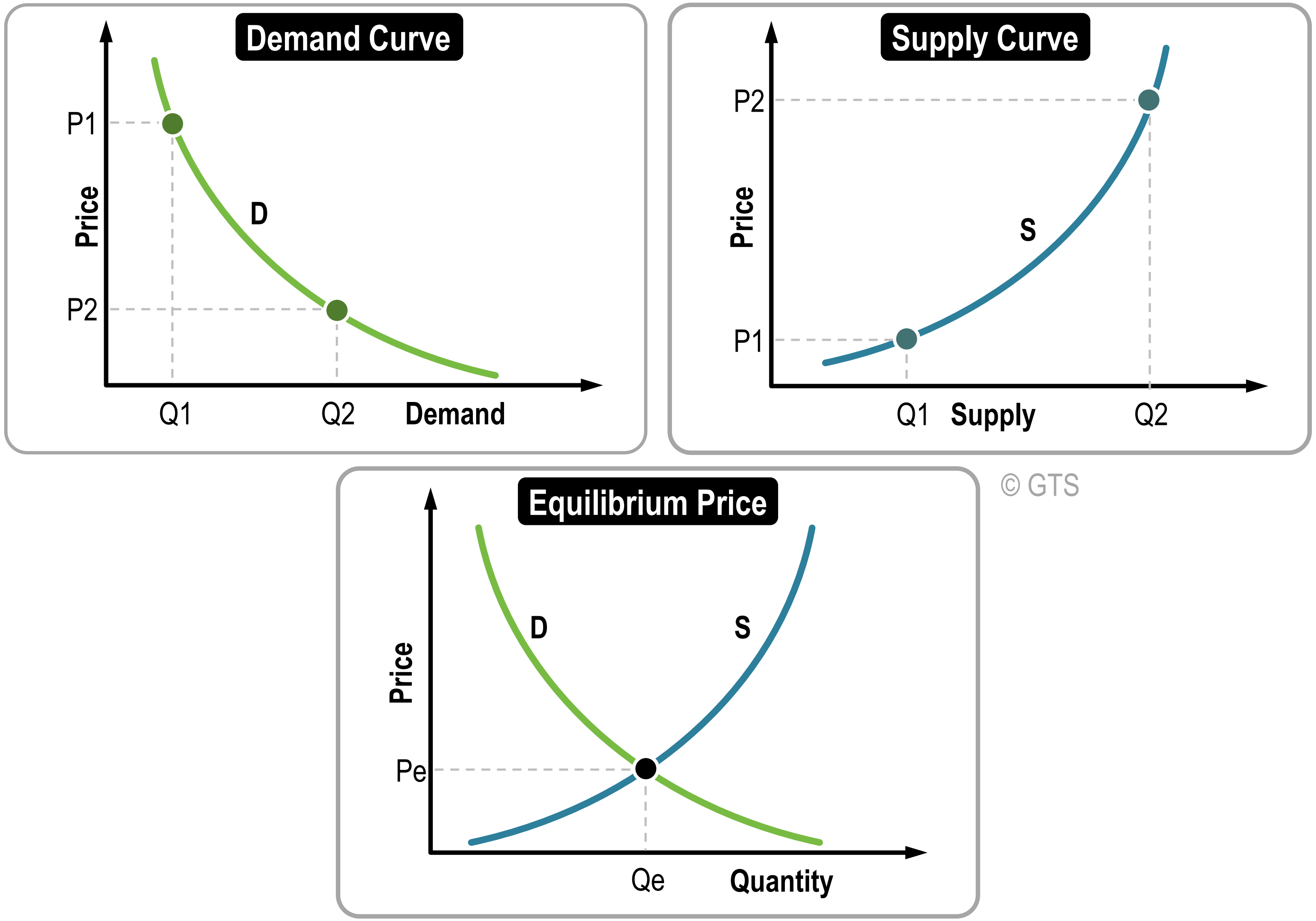
The Optimal Shape of a Market Area



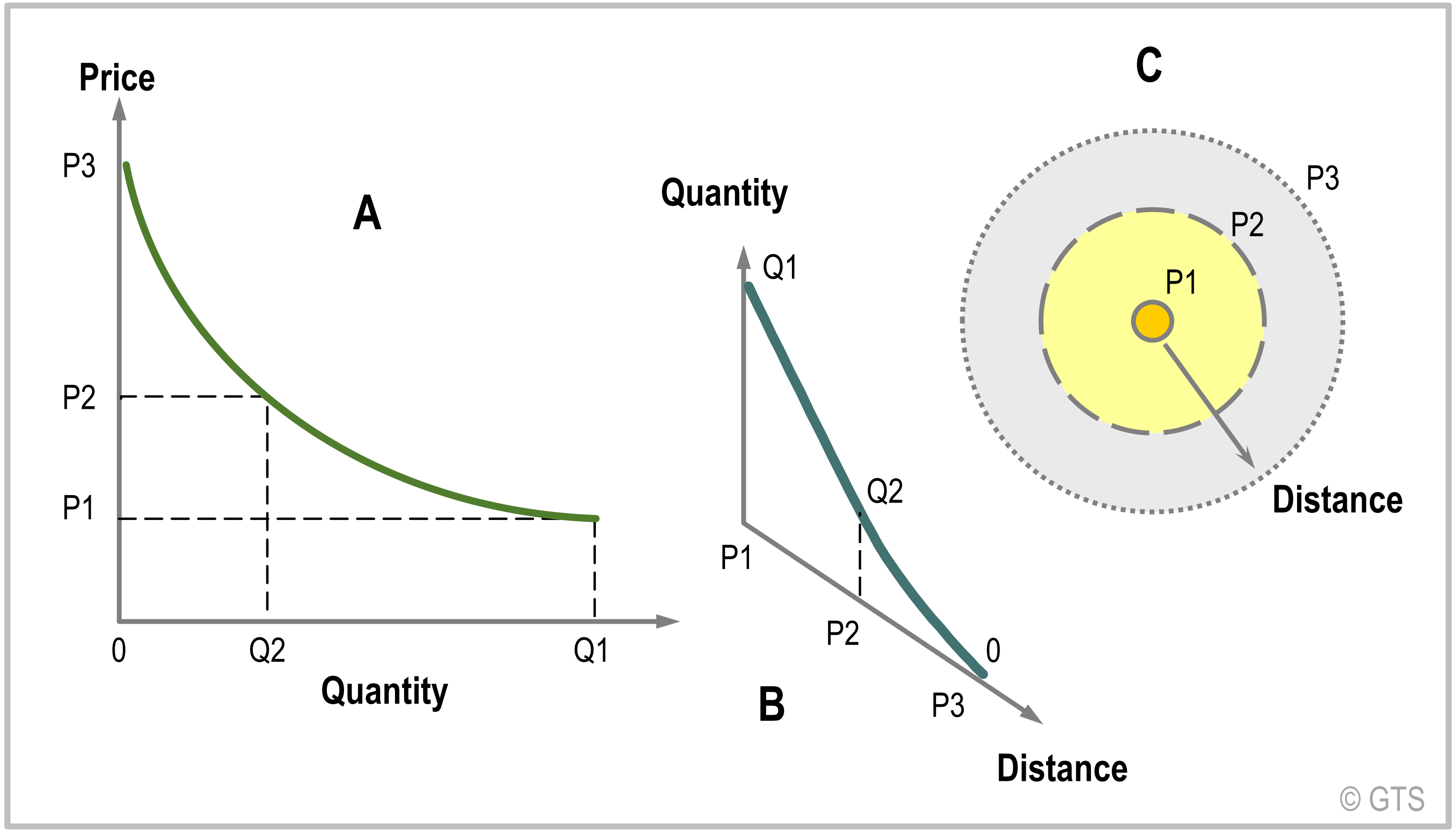
Non-Isotropic Conditions and the Shape of Market Areas



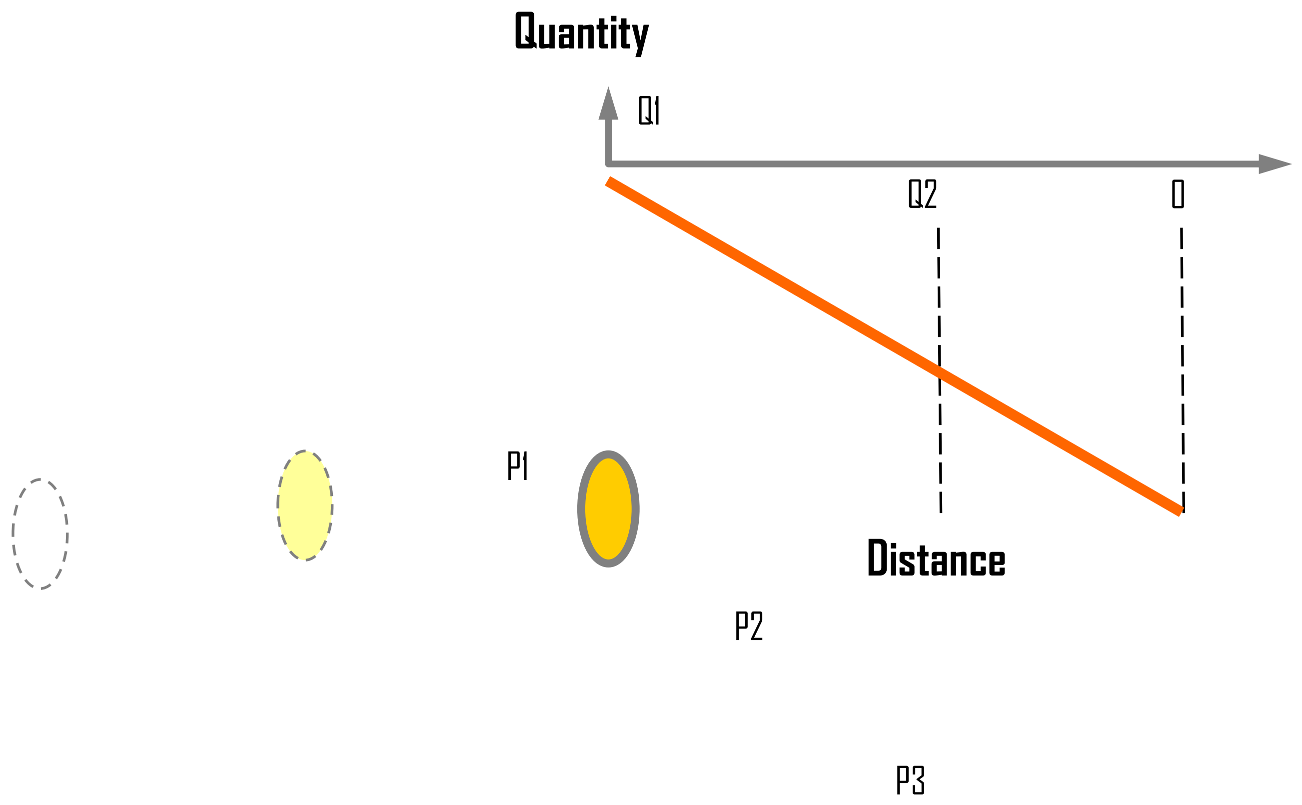
Supply, Demand and Equilibrium Price



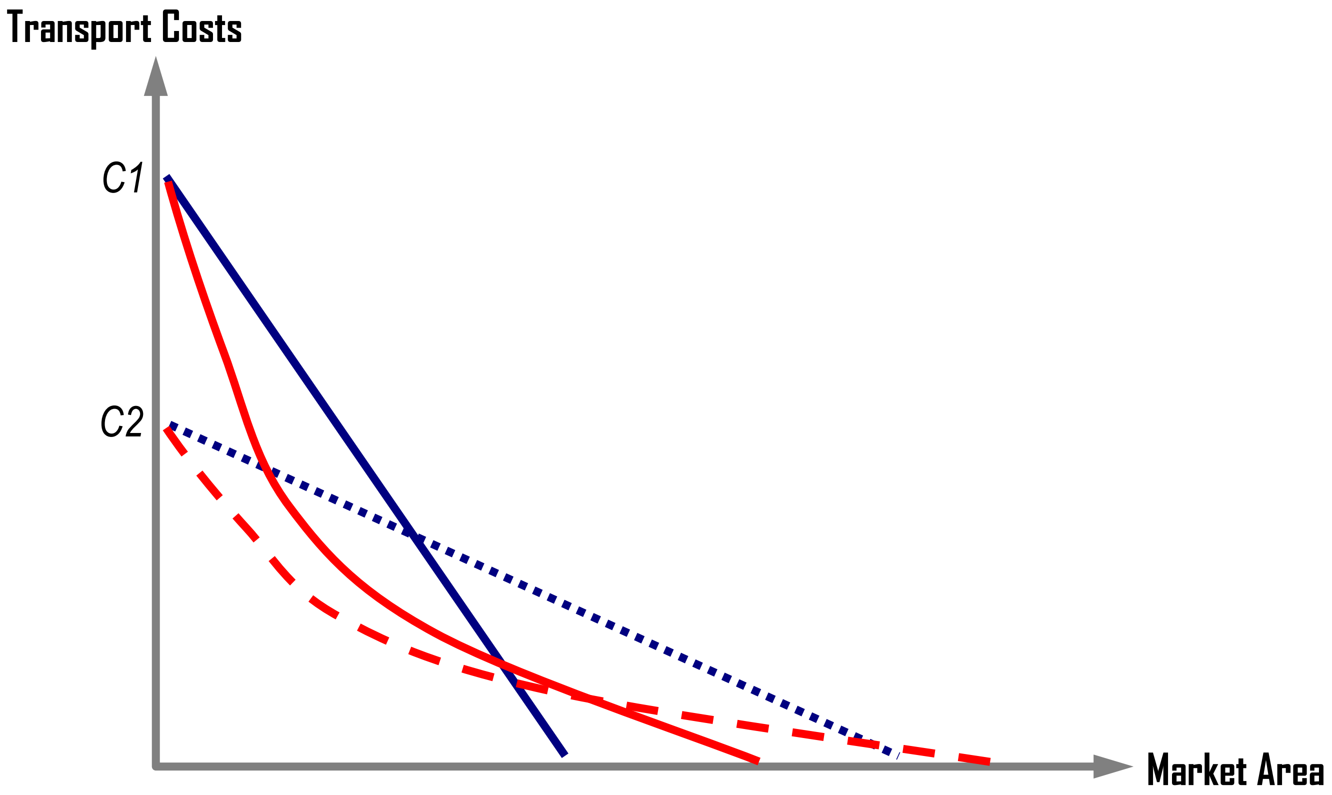
Derivation of a Market Area from a Supply / Demand Equilibrium



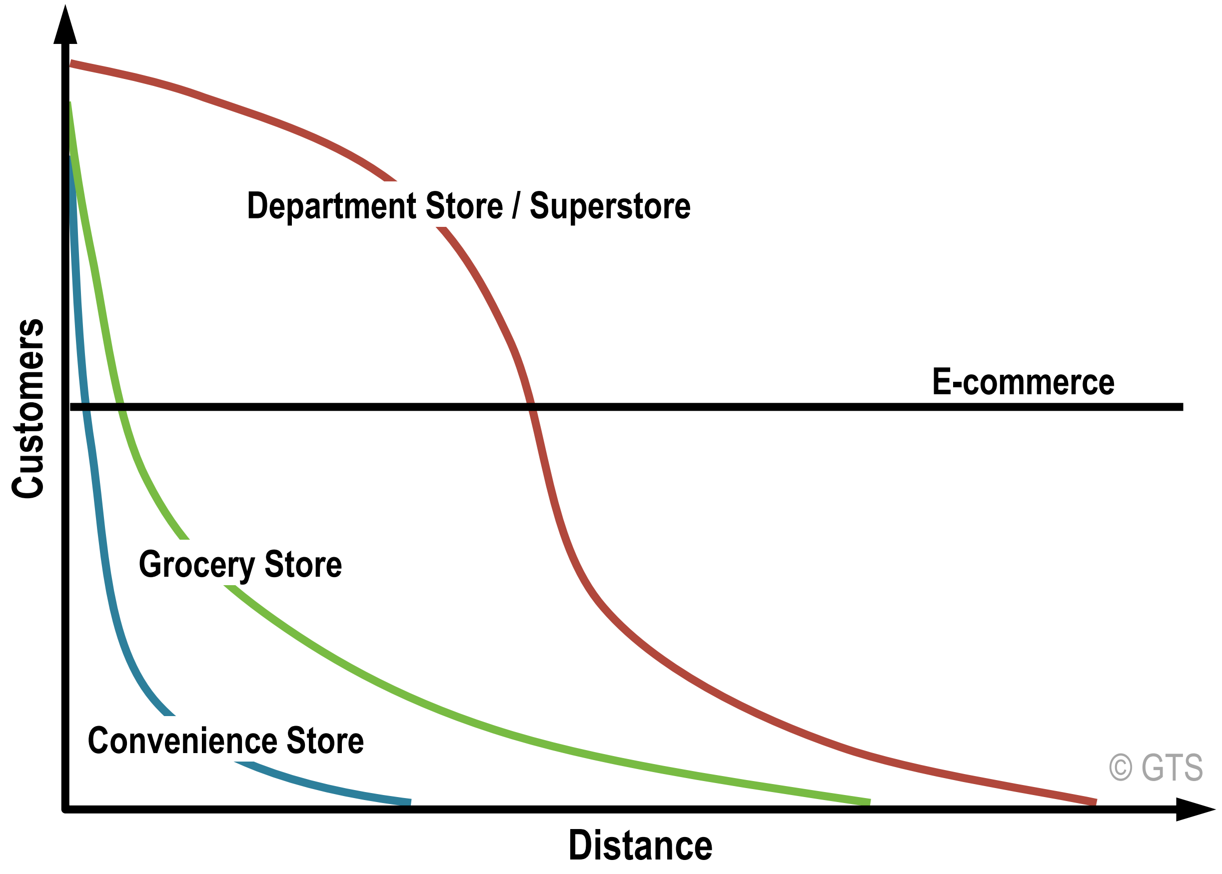
Demand Cone



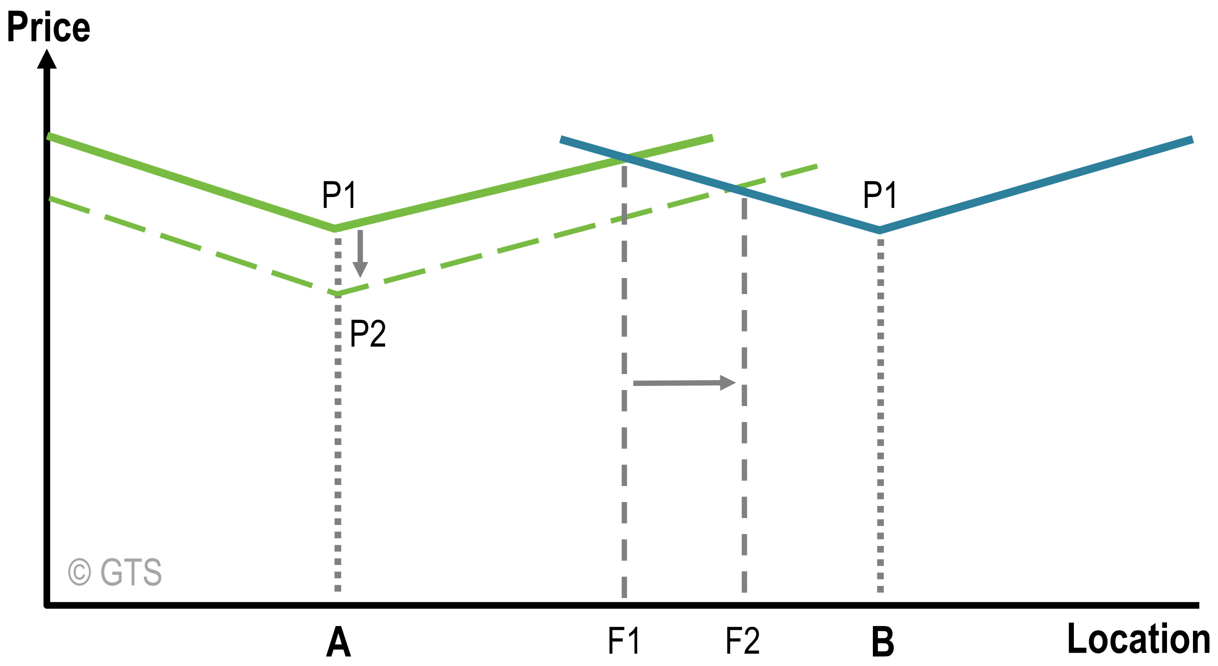
Transport Costs and Market Areas



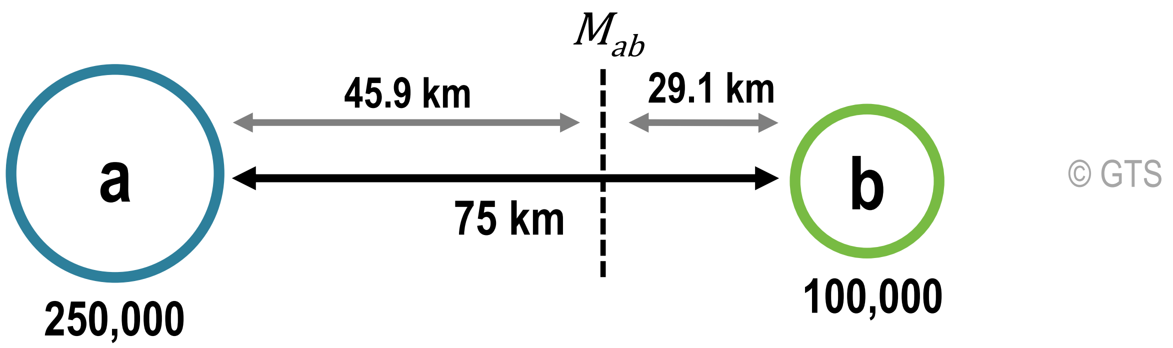
Conventional Distance Decay Curves for Retail Activities



Hotelling's Principle of Market Competition



Reilly's Law



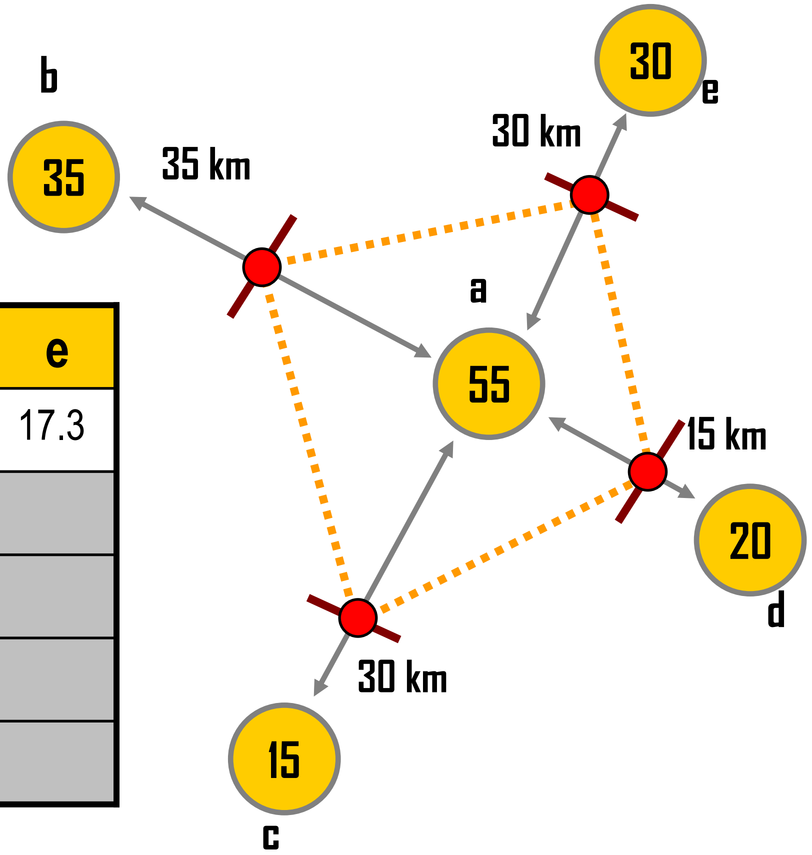
$$M_{ab} = \frac{D_{ab}}{1 + \sqrt{P_b / P_a}}$$

$$M_{ab} = \frac{75}{1 + \sqrt{100{,}000 / 250{,}000}}$$

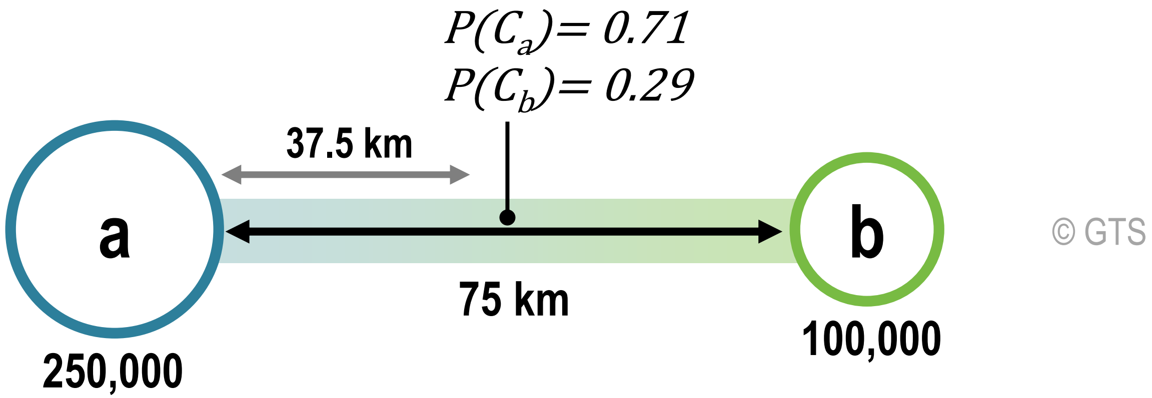
$$M_{ab} = 45.9$$

Reilly's Law and Market Areas

km	a	b	c	d	e
a		21.4	19.7	9.4	17.3
b	14.6				
c	10.3				
d	5.6				
e	12.7				



Huff's Law

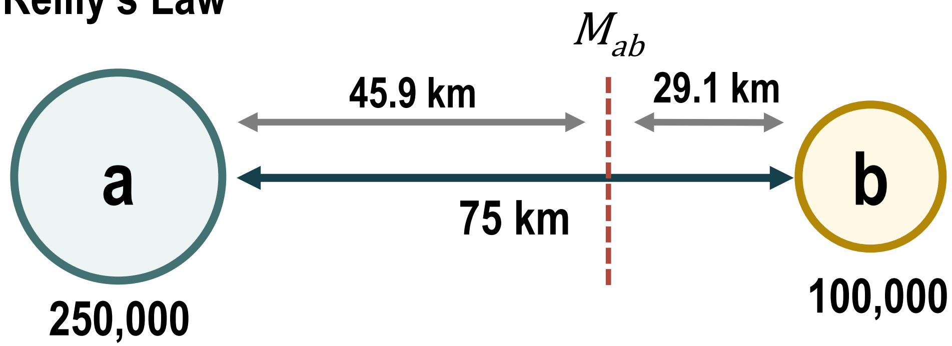


$$P(C_a) = \frac{P_a/D_a}{\sum_a^n P_a/D_a}$$

$$P(C_a) = \frac{250{,}000/37.5}{250{,}000/37.5 + 100{,}000/37.5}$$

$$P(C_a) = 0.71$$

Reilly's Law

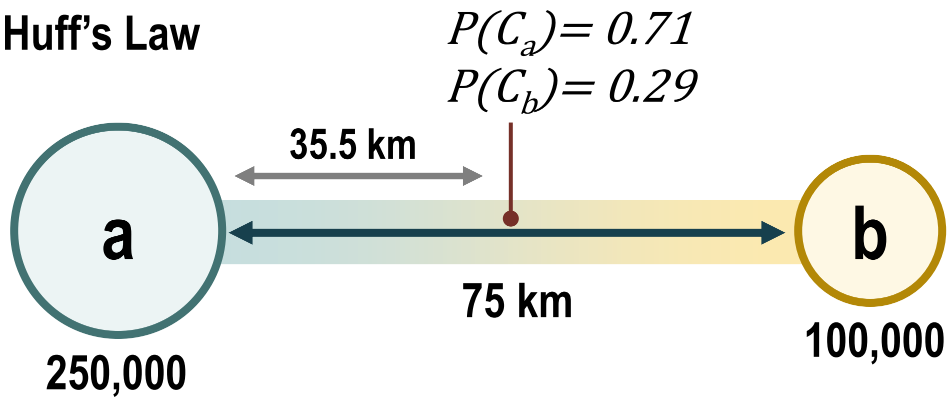


$$M_{ab} = \frac{D_{ab}}{1 + \sqrt{P_b/P_a}}$$

$$M_{ab} = \frac{75}{1 + \sqrt{100{,}000/250{,}000}}$$

$$M_{ab} = 45.9$$

Huff's Law

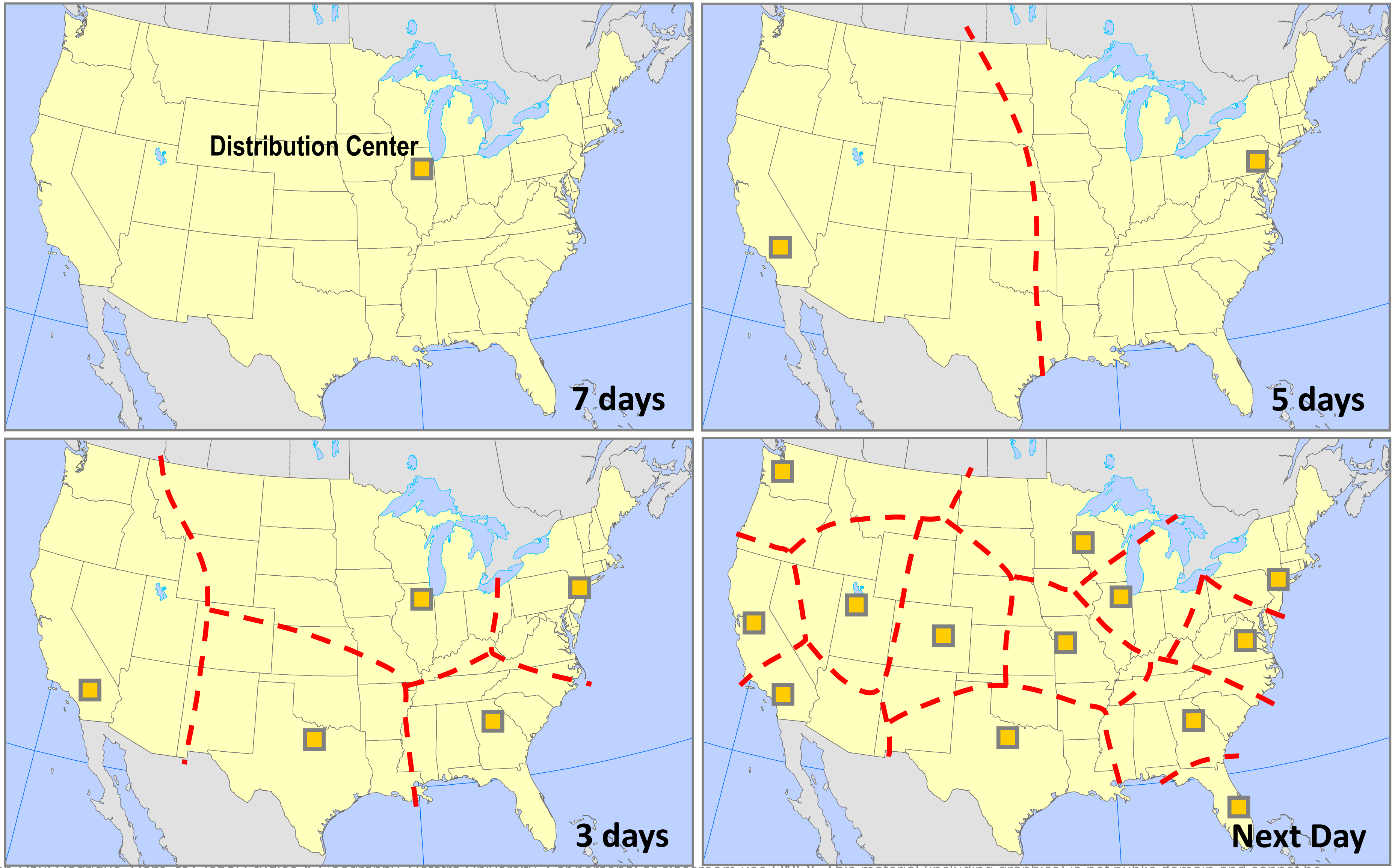


$$P(C_a) = \frac{P_b/D_a}{\sum_a^n P_a/D_{ab}}$$

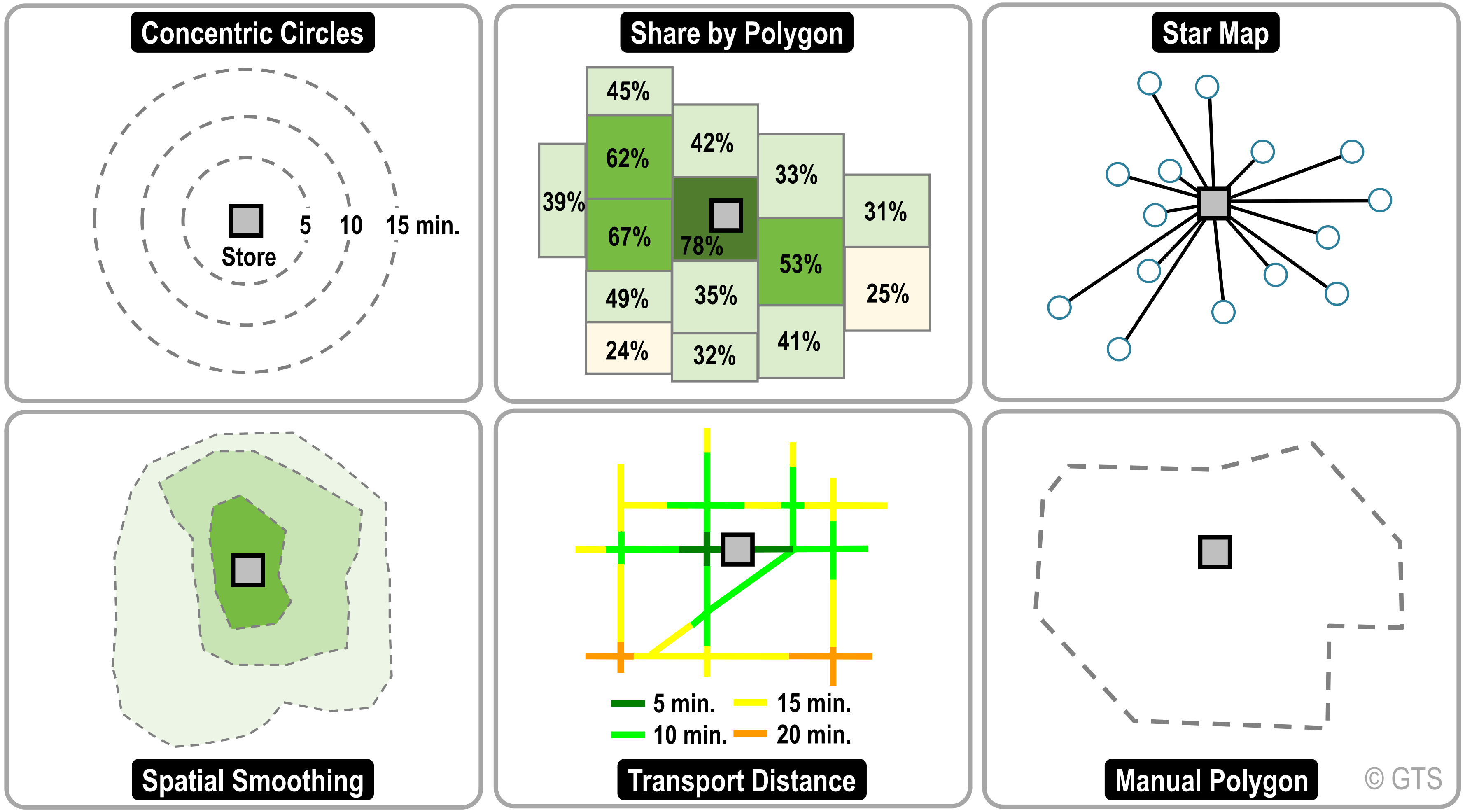
$$P(C_a) = \frac{250{,}000/37.5}{250{,}000/37.5 + 100{,}000/37.5}$$

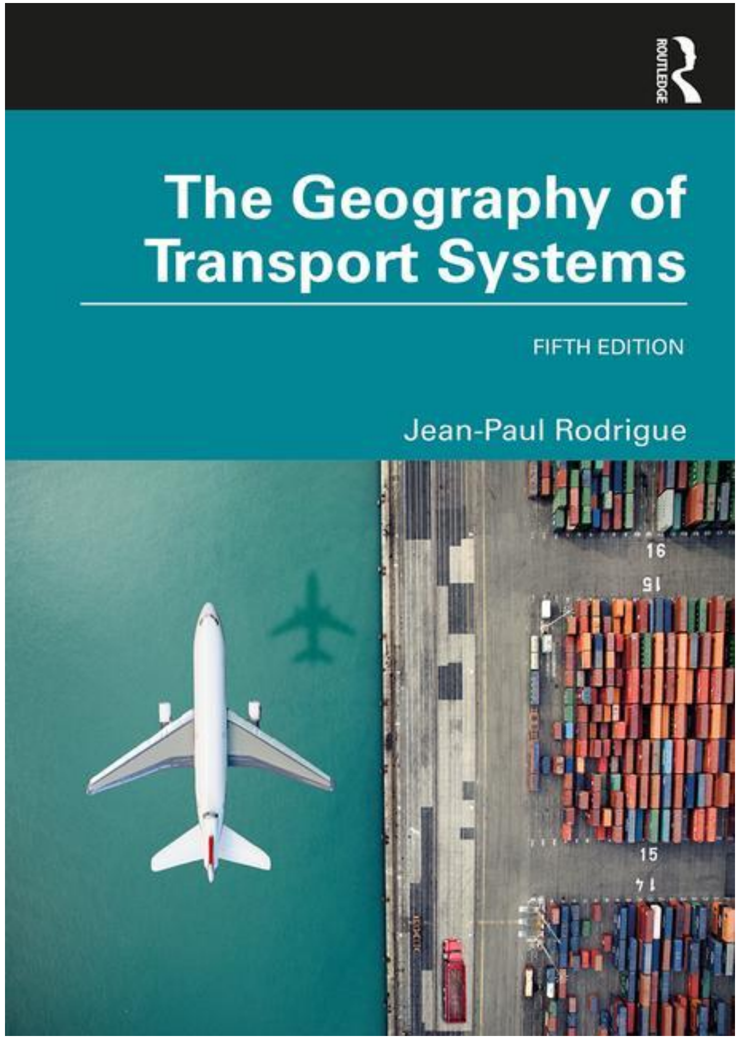
$$P(C_a) = 0.71$$

Location of Distribution Centers and Market Areas According to Response Time



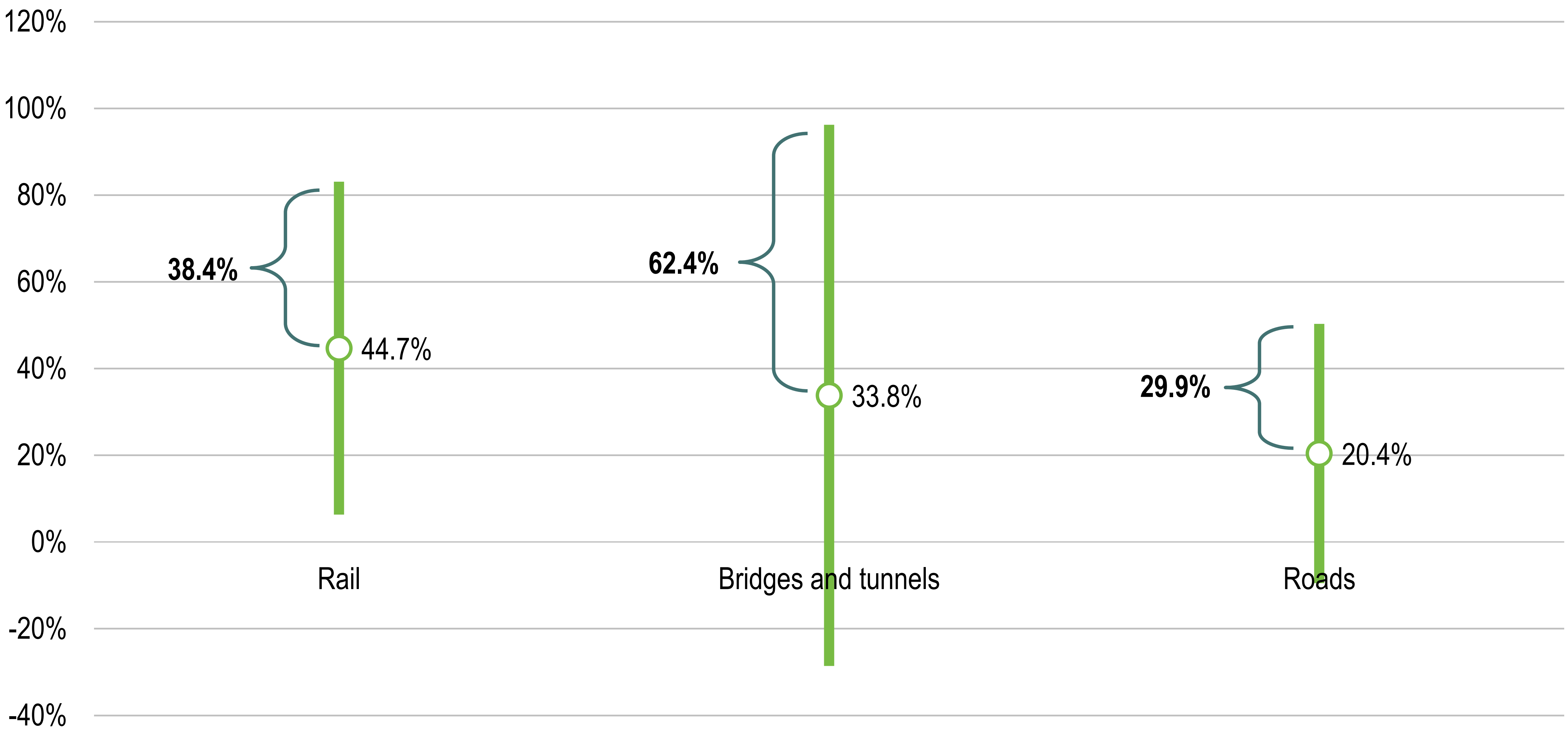
GIS Methods to Estimate Market Areas



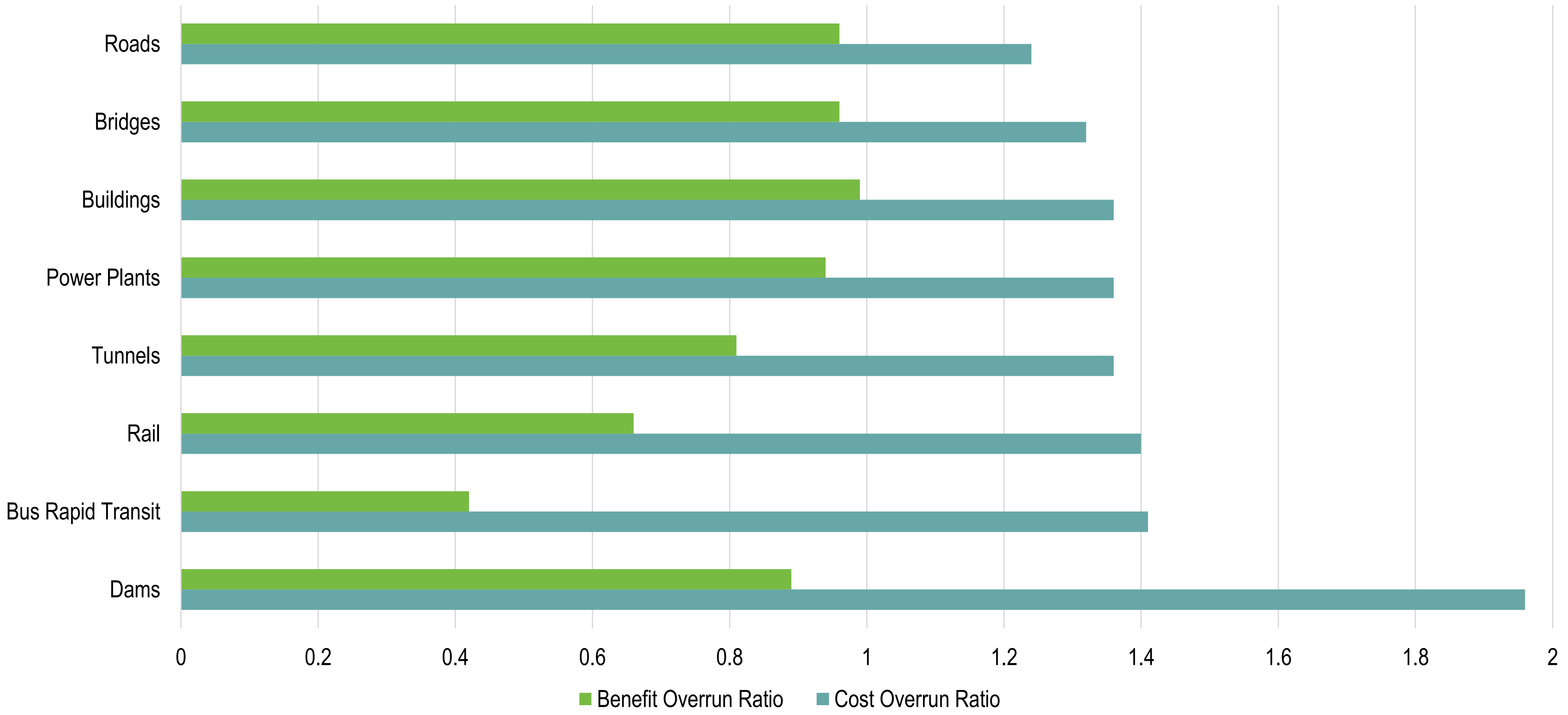


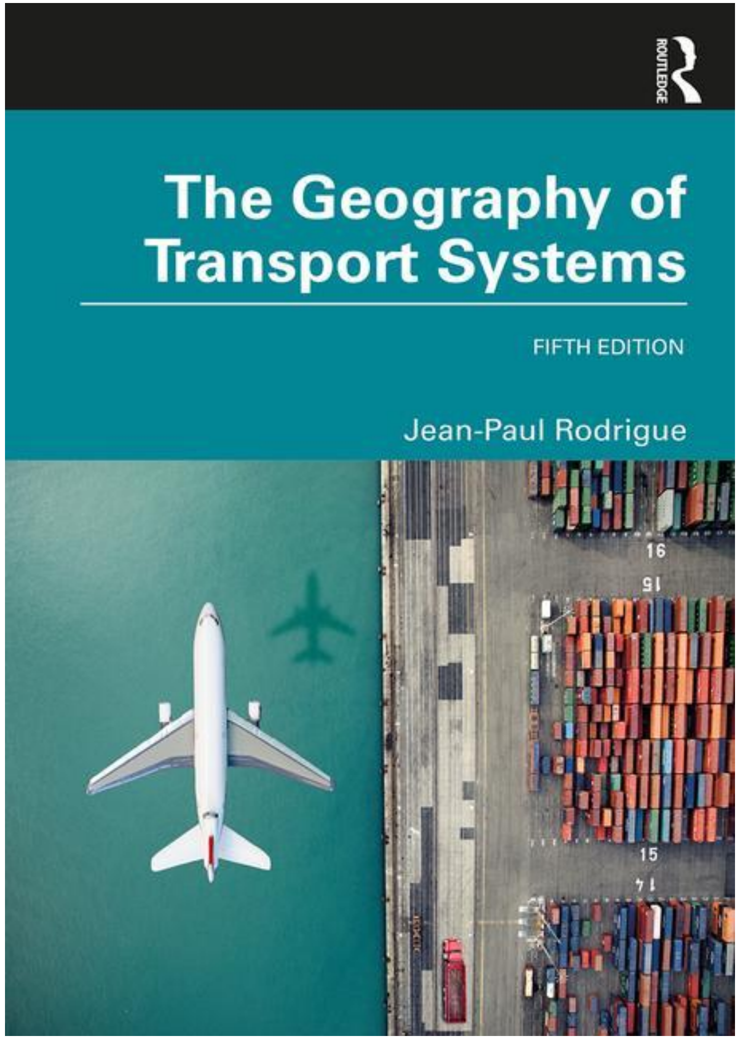
Cost / Benefit Analysis

Inaccuracy of Transportation Project Cost Estimates by Type of Project



Cost and Benefit Overruns Ratios by Type of Infrastructure Project





Transportation Environmental Management

Environmental Practices

Match activities with environmental components

What are the environmental components the logistics activities of the firm?

Link environmental components with regulations

What is the regulatory standing of each environmental component?

Assess risks, impacts and responsibilities

What are the risks of doing nothing? What are the rewards of improvements?

Identify environmental issues to be addressed

What are the most important issues to be addressed and their priority?

Develop commercial strategies

Which improvements can be implemented in management and operations?

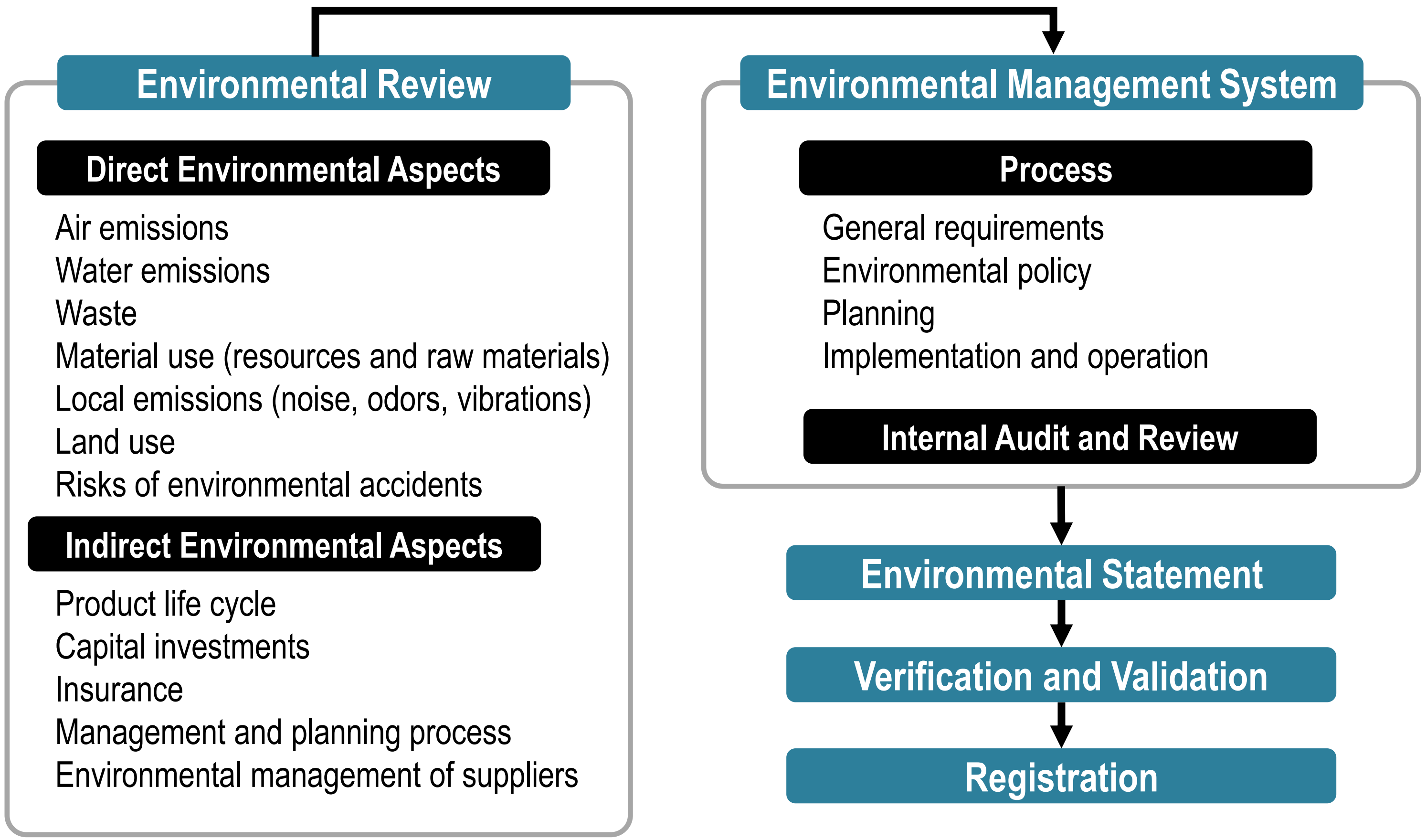
Introduce best practices

How improvements can be implemented?

Undertake monitoring and auditing

What is the effectiveness of the best practices and which adjustments are required?

The Implementation of an Environmental Management System



Environmental Management System for Ports and Maritime Shipping