1. TRANSPORT ECONOMICS

1.1. Organization

Course

- Transportation Economics explores the efficient use of society’s scarce resources for the movement of people and goods.
- This course carefully examines transportation markets and standard economic tools, how these resources are used, and how the allocation of society resources affects transportation activities.

Method

- This course is unique in that it uses a detailed analysis of econometric results from transportation literature to provide an integrated collection of theory and applications.
- Its numerous case studies illustrate the economic principles, discuss testable hypothesis, analyze econometric results, and examine each study's implications for public policy.
- These features make this a well-developed introduction to the foundations of transportation economics.

Lectures and seminars (2/0 + 0/2)

I. Transport economics
II. Transportation demand – the divisible goods case
III. Transportation demand – the discrete goods case
IV. Firm production and cost in transport – the long run
V. Firm production and cost in transport – the short run
VI. Competition, concentration and market power in transport

Empirical Project

- The major task will be to write an empirical project in transport economics.
- Deadlines:

  30th October …. Proposal

  30th December ….. Project

Structure of proposal (recommended)

1. A concise statement of the problem
2. Comments on the information that is available with one or two key references
3. A description of the research design that includes
   a) an economic model
   b) the econometric estimation and inference methods
   c) data sources
   d) estimation, hypothesis testing and prediction
4. The potential contribution of the research

Structure of project (recommended)

1. Statement of the problem
2. Review of literature
3. The economic model
4. The econometric model
5. The data
6. The estimation and inference procedures
7. The empirical results and conclusions
8. Possible extensions and limitations of the study
9. Acknowledgements
10. References

Exam

Evaluation:

- 20% - seminar's activity
- 40% - defense of empirical project
- 40 % - exam from transport economics

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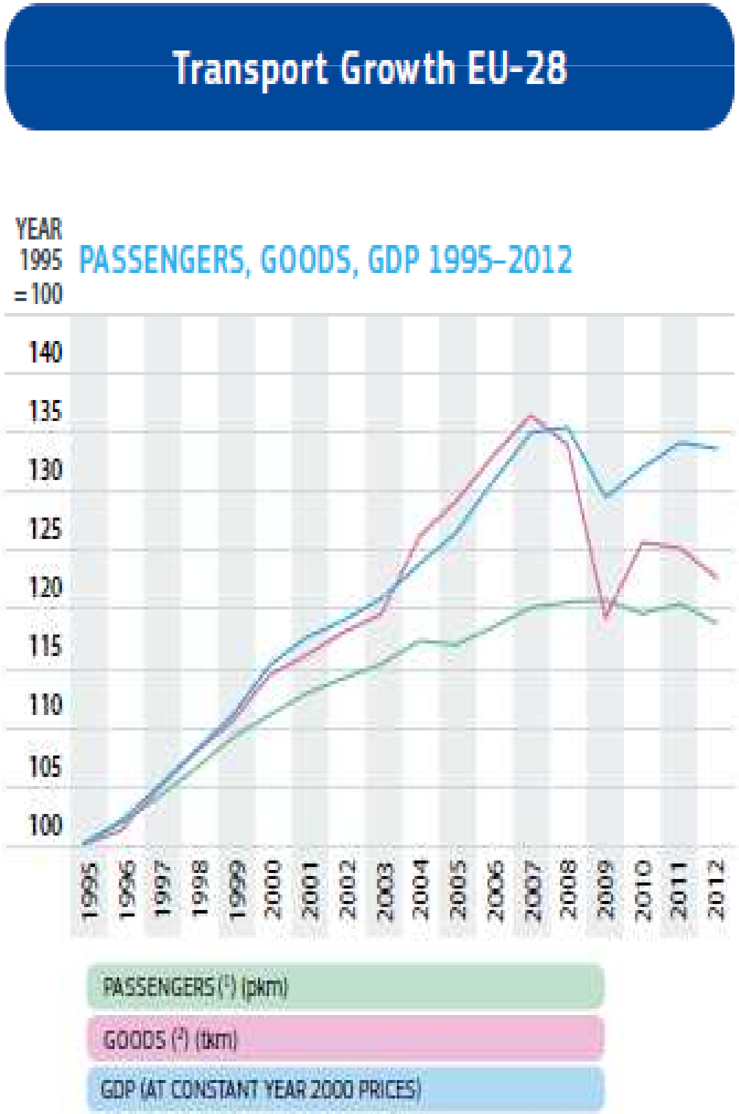
1.2. Transport and the Economy

What is transport economics?

- Transport economics is an applied area of economics that is concerned with the efficient use of society's scarce resources for the movement of people and goods from an origin to a destination.

Transport and GDP



- Decoupling of economic and transport growth
- Freight and passenger traffic growth
- The impact of world recession

Transport and Prices

- Do transport prices grow more quickly than other prices in the economy?
- Why?

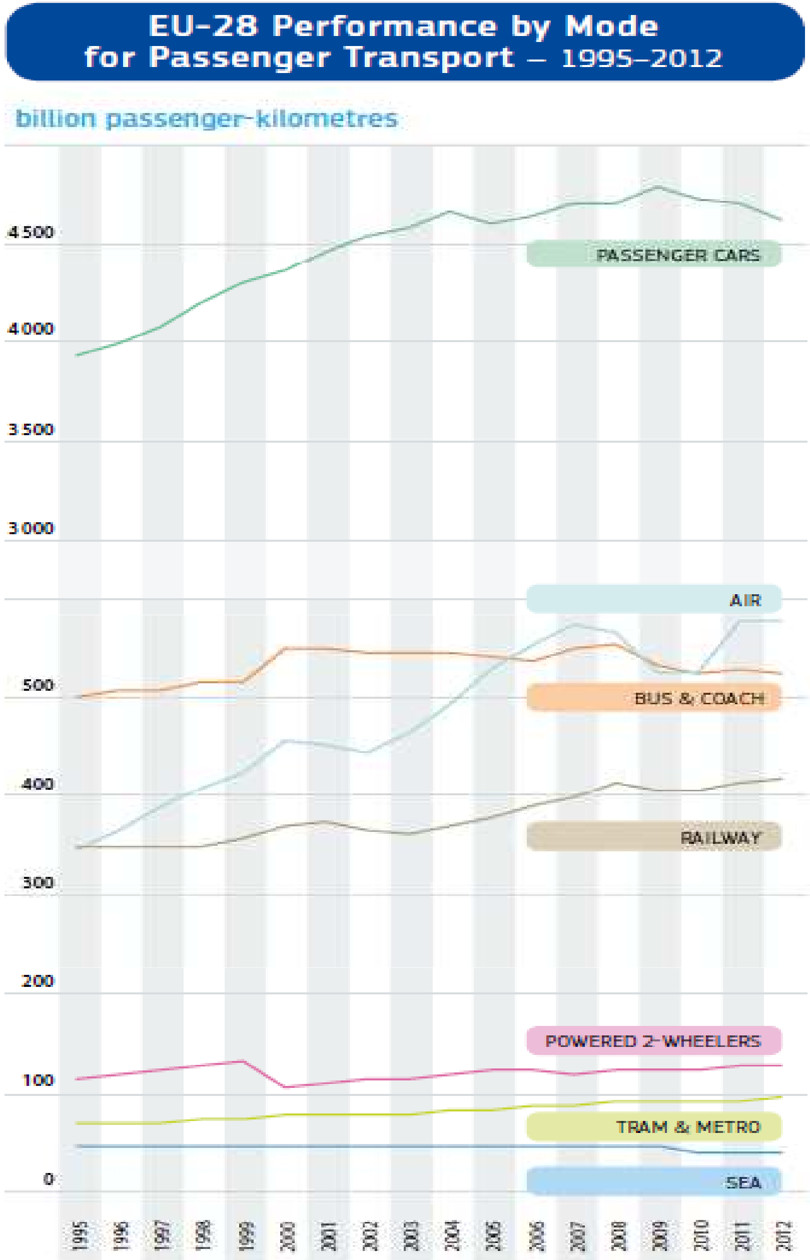
EU-28: Evolution of Consumer Prices for Passenger Transport

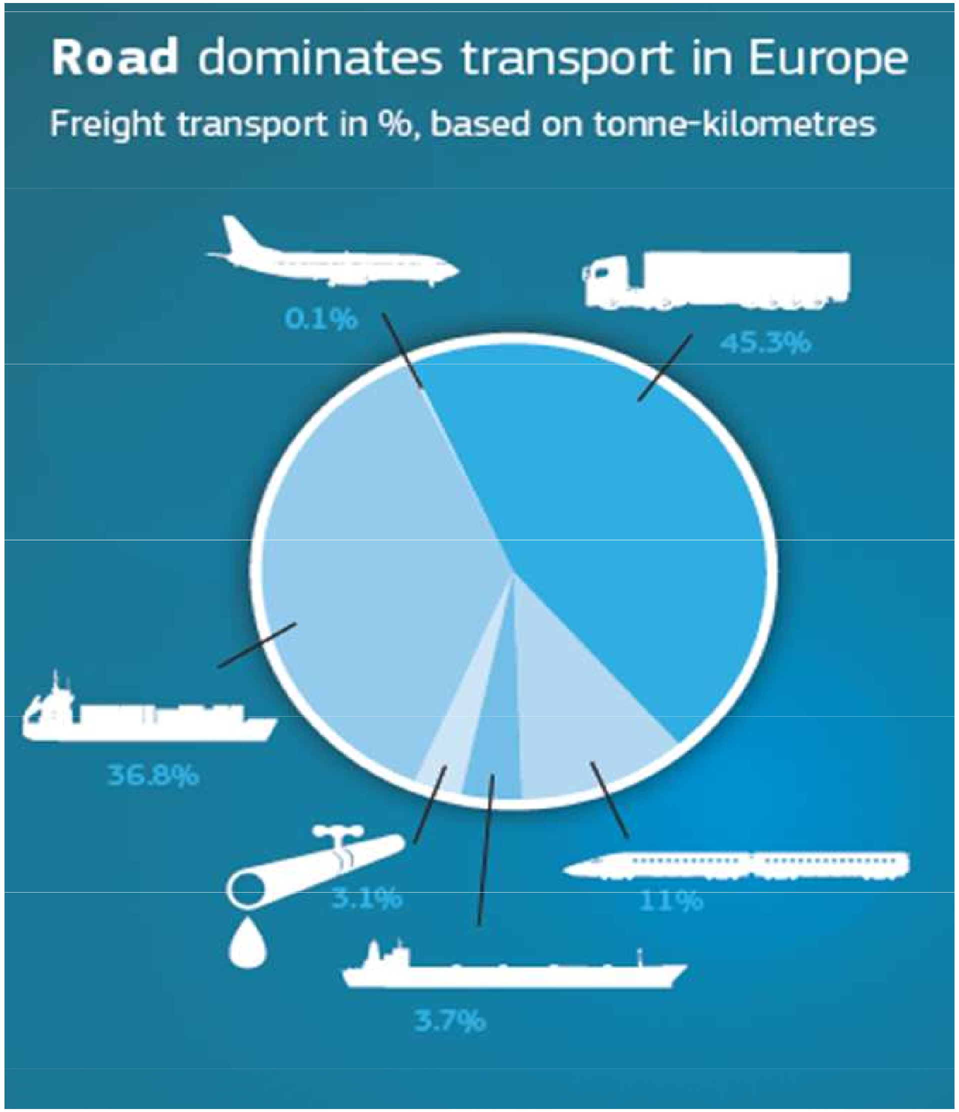
HARMONISED INDEX OF CONSUMER PRICES

YEAR 2005 = 100	ALL ITEMS	TRANSPORT	PURCHASE OF VEHICLES	of which: Motor cars	of which: Motorcycles, bicycles and animal drawn vehicles
2013	120.2	126.0	102.8	102.3	108.0
2012	118.4	125.5	102.6	102.2	107.1
2011	115.4	121.0	102.3	101.9	106.7
2010	111.9	114.3	101.7	101.4	105.1
2009	109.6	108.4	101.2	100.9	103.7
2008	108.6	110.7	101.3	101.3	100.7
2007	104.7	105.6	101.6	101.7	100.3
2006	102.3	103.0	100.6	100.7	99.5
2005	100.0	100.0	100.0	100.0	100.0
2004	97.8	95.7	99.7	99.6	100.4
2003	95.6	92.6	98.9	98.7	100.3
2002	93.6	90.2	97.8	97.6	100.4

YEAR 2005 = 100	TRANSPORT SERVICES	of which: Passenger transport by railway	Passenger transport by road	Passenger transport by air	Passenger transport by sea and inland waterway	Combined passenger transport	Other purchased transport services
2013	138.8	138.1	133.9	131.3	144.6	135.1	112.2
2012	134.4	134.2	130.8	126.2	144.5	130.6	111.7
2011	128.1	128.5	125.7	120.3	140.3	124.5	109.8
2010	121.3	123.9	120.9	112.2	128.9	119.5	108.8
2009	117.2	118.0	117.9	110.0	128.0	116.5	109.4
2008	113.2	112.8	113.3	110.9	117.8	111.9	109.0
2007	106.6	108.4	107.8	100.3	113.2	107.0	105.7
2006	103.2	103.4	103.8	100.7	106.2	103.6	102.6
2005	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2004	95.4	96.5	95.5	94.5	100.2	96.5	97.8
2003	92.3	93.2	92.0	93.4	102.3	92.2	95.2
2002	89.0	90.4	88.0	91.8	99.6	89.3	93.1

Transport Performance





World Comparison

Comparison EU-28 – World: PASSENGER AND FREIGHT TRANSPORT

PASSENGER TRANSPORT

billion pkm	EU-28 2012	USA 2011	JAPAN 2012 (1)	CHINA 2012	RUSSIA 2012
Passenger car	*4613.0*	5866.0 (2)	766.7 (3)	1846.8 (4)	
Bus + trolley bus + coach	*525.7*	470.5	87.0		140.0
Railway	418.4	36.7	404	981.2	144.6
Tram + metro	*94.1*	18.2	(5)		51.4
Waterborne	*37.7*	0.6	4.4	7.7	0.6
Air (domestic / intra-EU-28)	*576.7*	926.4	77.9	502.6	195.8

FREIGHT TRANSPORT

billion tkm	EU-28 2012	USA 2011	JAPAN 2012	CHINA 2012	RUSSIA 2012
Road	*1692.6*	*2038.9*	210.0	5953.5	249.0
Rail	*407.2*	*2649.2* (6)	20.5	2918.7	2222.0
Inland waterways	*150.0*	464.7		2829.6	61.0
Oil pipeline	*114.8*	*968.6*		317.7 (7)	2453.0
Sea (domestic / intra-EU-28)	*1401.0*	263.1	177.6	5341.2	45.0

Comparison EU-28 – World: INFRASTRUCTURE AND VEHICLES

TRANSPORT INFRASTRUCTURE

1 000 km	EU-28 2011	USA 2011	JAPAN 2011 (1)	CHINA 2011	RUSSIA 2011
Road network (paved)	*5000*	4192	978	3454	841
Motorway network	71.4	91.8 (2)	7.9 (3)	84.9	51.0 (4)
Railway network	*216.2*	204.7 (5)	20.1	93.2	85.2
Electrified rail lines	*114.4*		12.4	34.3	43.2
Navigable inland waterways	*41.5*	40.2		124.6	101.0
Oil pipelines	*37.8*	295.1		83.3 (6)	51.0 (7)

VEHICLE STOCK

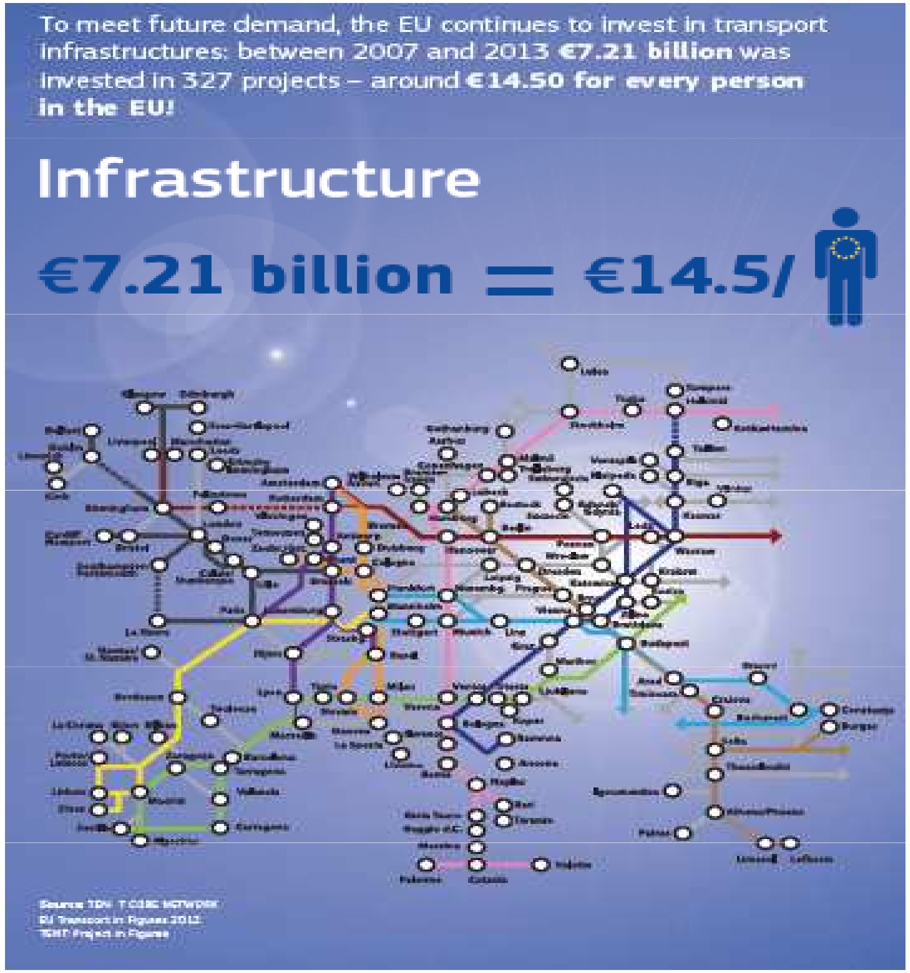
		EU-28 2012	USA 2011	JAPAN 2012	CHINA 2012	RUSSIA 2012
Passenger cars stock	million	246.3	234 (8)	70.3 (9)	59.9	36.9
Motorisation	cars / 1 000 persons	487	745	551	44	257
Commercial freight vehicles	million	*34.25*	10.27	6.07	17.88	5.75

TRANSPORT SAFETY

		EU-28 2012	USA 2012	JAPAN 2012	CHINA 2012	RUSSIA 2012
Road fatalities	number	28126	33561	4411	60000	28000
	per million inhabitants	56	107	35	44	195

Transport Infrastructure

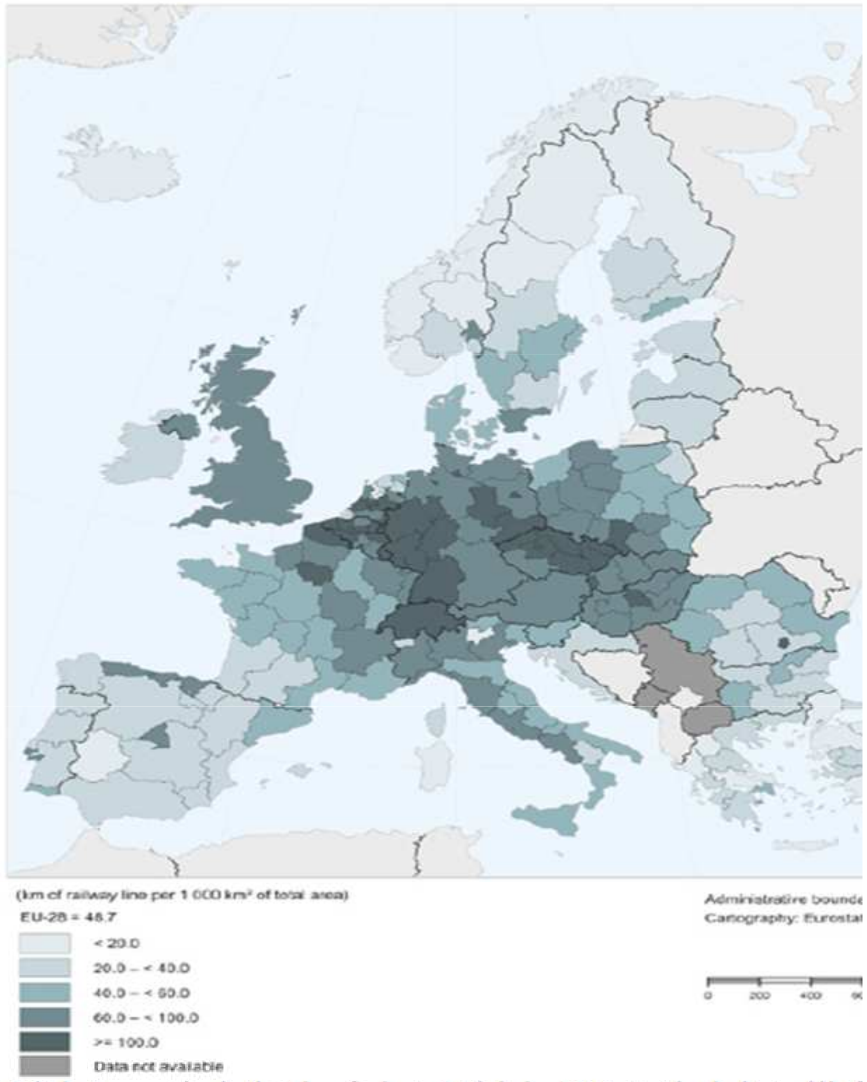
- The state must provide the needed physical capital in the way of roads, rail trackage, airports, ports and other infrastrucutre in order to facilitate the movement of people and goods across space.



Quality of transport infrastructure

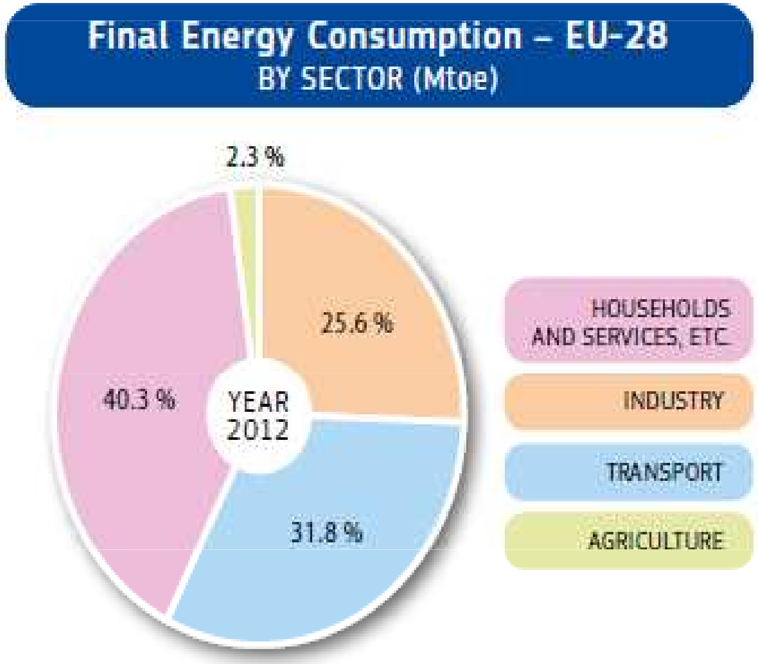
- How extensive are these networks and are they keeping up with the transport demands of the public?
- How well is the nation’s transportation network meeting the performance needs of shippers and travelers?
- Are users receiving safe and reliable service or is the system providing deteriorating services?

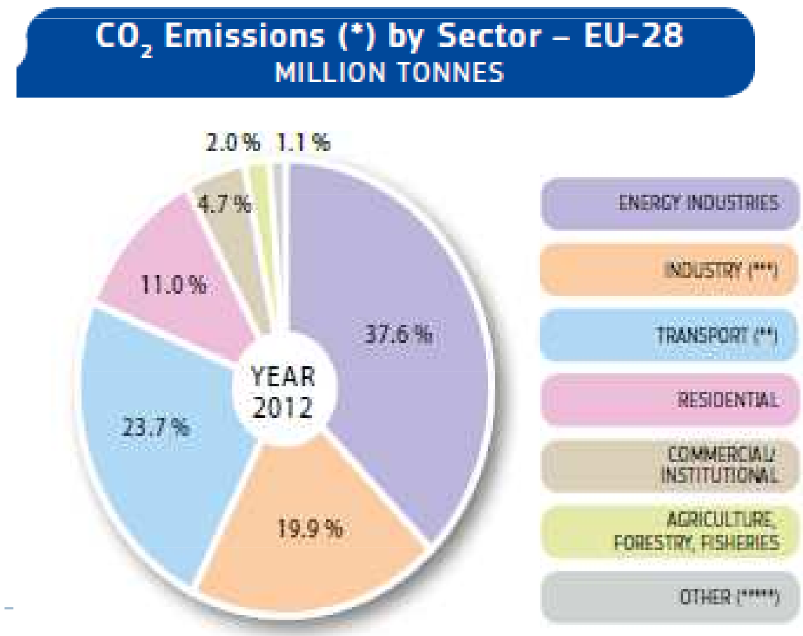
Map 10.5: Density of rail networks, by NUTS 2 regions, 2012 (¹)
(km of railway line per 1 000 km² of total area)



Transport and Energy

- In addition to its impact upon the economy and employment, transportation is a major user of energy
- Although transportation is a huge consumer of fuels, there have been dramatical technological imrovements in energy efficiency

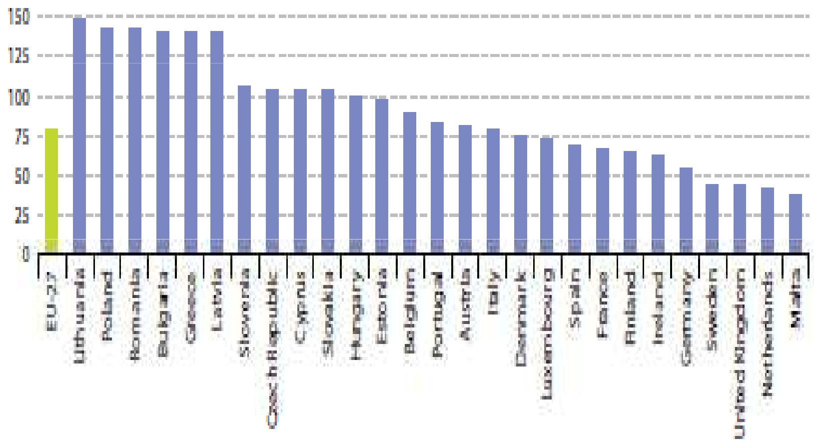




Transport Challenges

- Safety
- Mobility
- Economic growth and trade
- The human and natural enviroment

Figure 10.1.1: People killed in road accidents, 2008
(persons killed per million inhabitants)



1.3. The statistical analysis of economic relations

Economic model

- Economic model – simplified description of behavior which purports to identify primary cause and effect relationships between economic variables
- Economic models are:
  - Explanatory
  - Representative
  - Qualitative
- Models are useful in formulation of policy because they identify the important causal linkages between economic variables.

Econometric model

- An econometric model is a statistical specification of an economic model that enables the analyst to quantify the economic relationships identified in the theoretical framework.

An Econometric Model of Airline Demand

- To illustrate the relationship between an economic and econometric model, consider the following economic model of the demand for airline passenger miles:

Miles = f(Price per Mile, Per Capita Income)

$$= \beta_1 + \beta_2 \text{ Price Per Mile} + \beta_3 \text{ Per Capita Income} + \varepsilon$$

Least Squares Regression

- The method of obtaining parameter estimates by minimizing the sum of squared residuals is referred to as the method of least squares.
- The least squares estimator is the formula that is used to produce the least squares estimate.
- OLS estimator is unbiased, consistent and efficient

Estimating the Demand for Airline Travel

<u>Hypotheses:</u>

1. All else constant, an increase in Price per Mile is expected to reduce the quantity of passenger miles demanded
2. All else constant, an increase in Per Capita Income is expected to increase the demand for airline travel

<u>OLS estimation:</u>

$$\widehat{\text{Miles}} = 15.7 - 8.7 \text{ Price Per Mile} + 0.031 \text{ Per Capita Income}$$

Confidence Intervals

- Each estimated coefficient is a random variable that has an associated probability distribution
- A standard method that is used for determing how close each coefficient estimate is to the true parameter values is to construct a confidence interval around our estimate

t statistics

- It can be shown that statistics $(\hat{\beta}_i - \beta_i)/s_{\beta i}$ has a t-distribution with degrees of freedom equal to the sample size minus the number of parameters estimated.
- $s_{\beta i}$ is the square root of the estimated sample variance and is referred to as the standard error of the estimate.
- If we want to construct a 95% confidence interval, than we want to identify lower and upper bound numbers for the true parameter value

Confidence Intervals for Airline Travel

$$\widehat{Miles} = \underset{}{15.7} - \underset{(1.0)}{8.7}\ \text{Price Per Mile} + \underset{(0.0013)}{0.031}\ \text{Per Capita Income}$$

<u>Confidence intervals:</u>

Price per Mile (-10.80; -6.60)

Per Capita Income (0.0284; 0.0337)

Hypothesis tests

- A major objective of many empirical studies is to test hypothesis regarding the relationship between the dependent and independent variables.
- The methodology for hypothesis testing first requires that we identify two hypotheses, a null hypothesis (H_o) and an alternative hypothesis (H_a)

H_o: $\beta = 0$

H_a: $\beta \neq 0$

Issues in hypotheses testing

- One tail and two tail tests
- Type I and Type II error
- Significance level (1%; 5%; 10%)
- Reject x Not reject null hypothesis

Goodness of fit and R2

- In addition to examining whether our estimated model is consistent with the implications of economic theory, it is of interest to know how well model fits the data.
- <u>R2 = goodness of fit</u> = the statistics that gives the proportion of variation in the dependent variable that is due to all of the explanatory variables in the model

Cross section and time series data

- Cross section data reflect observation on individuals, households, firms, countries, or some other unit of analysis at a given point of time. Usual problem: heteroscedasticity → solution: robust standard errors.
- Time series data are different because each observation corresponds to a different time period. Problem (1): autocorrelation → solution: robust standard errors. Problem (2): unit roots → risk: spurious regression → solutions: trend inclusion; differencing, cointegration.

Model specification

- A time trend is a variable that is included in time series models to capture the influence of factors that are correlated with time but are excluded from the model because they are either unquantifiable or the data are unavailable. A time trend is often use to reflect technological change.
- A dummy variable is a variable that either has a value of 0 or a value of 1. It is often use for analysis of structural changes.

Functional Form

linear:
$$\text{Miles} = \beta_1 + \beta_2(\text{Price per Mile}) + \beta_3(\text{Per Capita Income}) + \varepsilon$$

log–linear:
$$\log(\text{Miles}) = \beta + \beta_1(\text{Price per Mile}) + \beta_2(\text{Per Capita Income}) + \varepsilon$$

linear–log:
$$\text{Miles} = \beta + \beta_1[\log(\text{Price per Mile})] + \beta_2[\log(\text{Per Capita Income})] + \varepsilon$$

double–log:
$$\log(\text{Miles}) = \beta + \beta_1[\log(\text{Price per Mile})] + \beta_2[\log(\text{Per Capita Income})] + \varepsilon$$

Marginal effects

Model	Marginal Effect*	Interpretation
Linear	$\frac{\Delta \text{Miles}}{\Delta \text{Price}} = \beta_2$	Change in the number of passenger miles from a unit increase in Price per Mile
Log–linear	$\frac{\Delta \log(\text{Miles})}{\Delta \text{Price}} = \frac{\Delta \text{Miles}/\text{Miles}}{\Delta \text{Price}} = \beta_2$	Percentage increase in passenger miles from unit increase in Price per Mile
Linear–log	$\frac{\Delta \text{Miles}}{\Delta \log(\text{Price})} = \frac{\Delta \text{Miles}}{\Delta \text{Price}/\text{Price}} = \beta_2$	Change in the number of passenger miles due to a 1% increase in Price per Mile
Double–log	$\frac{\Delta \log(\text{Miles})}{\Delta \log(\text{Price})} = \frac{\Delta \text{Miles}/\text{Miles}}{\Delta \text{Price}/\text{Price}} = \beta_2$	Percentage change in the number of passenger miles due to a 1% increase in Price per Mile

*Price is Price per Mile.

Elasticity measures

Model	Elasticity*
Linear	$\dfrac{\Delta\text{Miles}/\text{Miles}}{\Delta\text{Price}/\text{Price}} = \beta_2\left(\dfrac{\text{Price}}{\text{Miles}}\right)$
Log–linear	$\dfrac{\Delta\text{Miles}/\text{Miles}}{\Delta\text{Price}/\text{Price}} = \beta_2(\text{Price})$
Linear–log	$\dfrac{\Delta\text{Miles}/\text{Miles}}{\Delta\text{Price}/\text{Price}} = \beta_2\left(\dfrac{1}{\text{Miles}}\right)$
Double–log	$\dfrac{\Delta\text{Miles}/\text{Miles}}{\Delta\text{Price}/\text{Price}} = \beta_2$

*Price is Price per Mile.

The Airline Demand Model Revisited

Model 1 – linear model

$$\underset{}{\text{Miles}} = 13.17 - \underset{(-10.4)}{9.74}\ \text{Price per Mile} + \underset{(10.9)}{0.034}\ \text{Per Capita Income} - \underset{(-1.1)}{2.06}\ \text{Time} + \underset{(2.9)}{13.95}\ \text{Deregulation}$$

$R^2 = 0.9963$

Model 2 – log–linear

$$\log(\text{Miles}) = 4.56 - \underset{(-6.23)}{0.032}\ \text{Price per Mile} + \underset{(2.31)}{0.000039}\ \text{Per Capita Income} - \underset{(-5.33)}{0.054}\ \text{Time}$$

$$+\underset{(4.68)}{0.124}\ \text{Deregulation}$$

$R^2 = 0.9957$

The Airline Demand Model Revisited

Model 3 – linear–log

$$\text{Miles} = \underset{}{2.941} - \underset{(-9.35)}{115.8}\ \log(\text{Price per Mile}) + \underset{(2.56)}{386.3}\log(\text{Per Capita Income}) - \underset{(-5.88)}{39.1}\log(\text{Time})$$

$$-\underset{(-0.19)}{1.42}\ \text{Deregulation}$$

$R^2 = 0.9923$

Model 4 – double–log

$$\log(\text{Miles}) = 6.06 - \underset{(-8.67)}{0.40}\log(\text{Price per Mile}) + \underset{(17.9)}{1.36}\log(\text{Per Capita Income}) - \underset{(-1.76)}{0.043}\log(\text{Time})$$

$$-\underset{(2.46)}{0.070}\ \text{Deregulation}$$

$R^2 = 0.9958$

*t-statistics are in parenthesis below each explanatory variable's coefficient.

Elasticity measures

	Elasticity with respect to:	
Model	Price per Mile	Per Capita Income
1 Linear	−0.38	1.37
2 Log–linear	−0.25	0.32
3 Linear–log	−0.58	1.92
4 Double–log	−0.40	1.36

1.4. Summary

Summary (1)

- An economic model identifies the most important factors that explain the behavior of some underlying economic variable of interest. Economic models are explanatory, generally characterize average behavior, and identify the qualitative relationships between variables.
- An econometric model is a statistical model that enables one to quantify the casual relationships identified in an economic model. Econometric models are used to make statistical inferences on the importance of “explanatory variables” in explaining the variation in the “dependent” variable.

Summary (2)

- A common method for estimating parameters in an econometric model is the method of least squares. The “least-squares estimates” are estimates of an empirical model’s parameters obtained by minimizing the sum of squared errors from a sample of observations. Least-squares estimators are unbiased, consistent, and efficient.

Summary (3)

- Hypothesis tests are used to statistically determine whether variation in an explanatory variable explains at least part of the variation in a dependent variable. All hypothesis tests involve a null hypothesis, which identifies an hypothesized true value of the parameter, and an alternative hypothesis. If the alternative hypothesis specifies a two-sided effect (positive or negative), the hypothesis test is two-tailed; if the alternative hypothesis specifies a one-sided effect, the hypothesis test is one-tailed.

Summary (4)

- In regression models, *t*-statistics are used to test hypotheses on the statistical significance of the explanatory variables. In large samples (more than 120 degrees of freedom), if the calculated *t*-statistic under the null hypothesis was greater than 1.960 (2.576) in absolute value, then we would reject the null hypothesis at a 0.05 (0.01) level of significance. On a one-tail test, we would reject the null hypothesis at a 0.05 (0.01) level of significance if the calculated *t*-statistic was greater than 1.645 (2.326) in absolute value.

Summary (5)

- A regression model's goodness of fit gives the proportion of variation in the dependent variable which is "explained" by explanatory variables included in the empirical model.
- Cross-section and time series data are common forms of sample information used to estimate empirical models. Cross-section data provide information on observations units at a point in time. Time series data provide information on an observation unit over a period of time.
- Common statistical specifications for estimating empirical models are testing hypotheses on economic relationships include the linear model, the log–linear model, the linear–log model, and the double–log model.