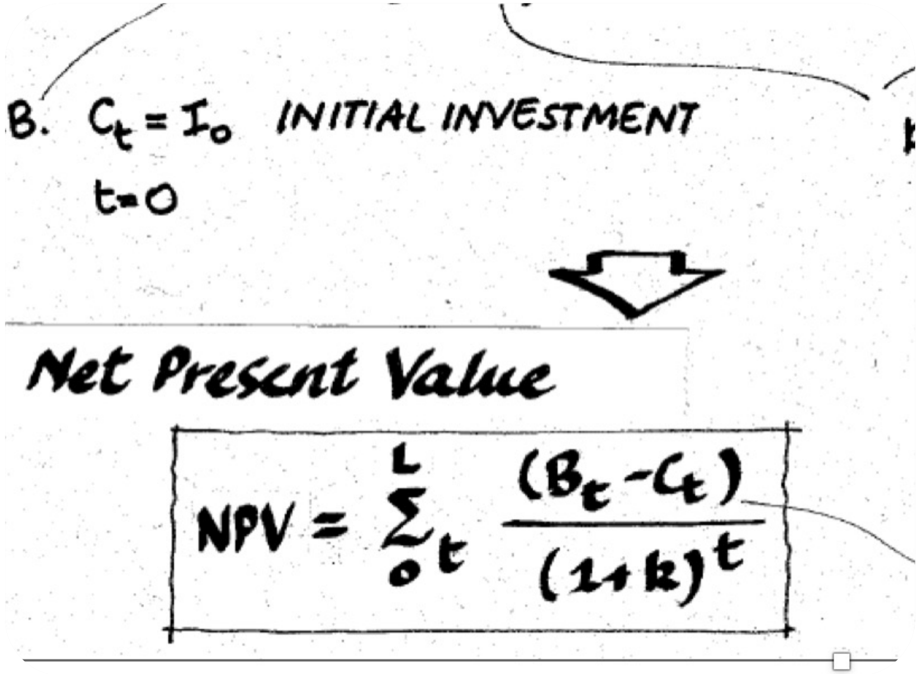
Water Resources Engineering and Management

(CIVIL-466, A.Y. 2024-2025)

5 ETCS, Master course



Lecture 10-1: Elements of engineering economics

Prof. P. Perona
Platform of hydraulic constructions

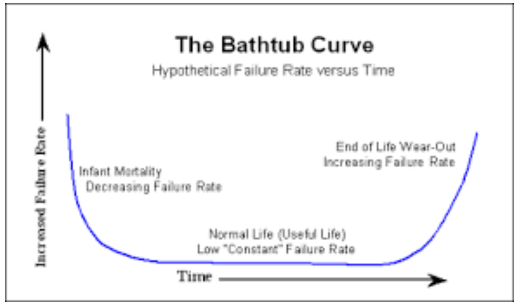
Project assessment criteria

Screening and ranking of projects is based on:

→ Technical feasibility

→ **Financial and economic feasibility**

→ Reliability analysis



→ Environmental Impact Assessment

Elements of engineering economics

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

We will learn some basic notions such as

- Simple interest
- Compound interest
- Net Present Values of benefits and costs
- Price elasticity of demand
- Marginal and total costs
- Economic demand functions for both market and non-marked goods

What will we be learning about engineering economics?

This will be propedeutical for future lectures with Dr. Martin Bieri

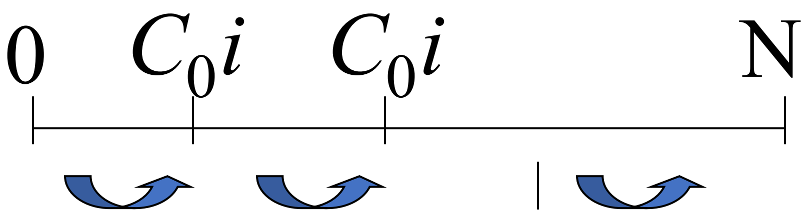
Capital and simple interest rate

- In the simple interest concept, the annual interest (payed or received) is constant and proportional to the initial capital C_0. After *N* years

What is the "simple interest" concept?

$$C_N = C_0(1 + Ni)$$

Annual interest progression



C_0 = Initial capital at period 0

C_N = Invested capital at the end of the period N

i = annual interest rate

See the short proof at the blackboard

Compound interest rate

- In the compound interest, the annual interest is calculated on the cumulated capital. After *N* years

$$C_N = C_0(1+i)^N$$

C_0 = Initial capital at period 0

C_k = Capital at period k

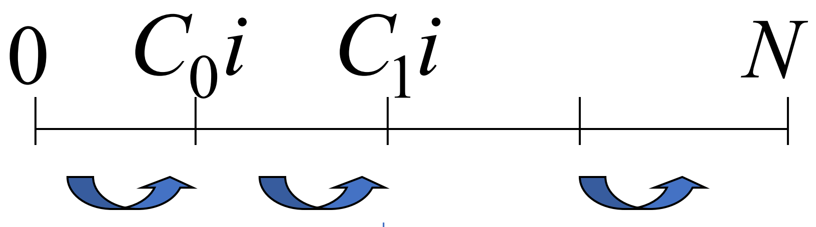
…

C_N = Invested capital at the end of the period N

i = annual interest rate

What is the "Compound interest" concept?

Annual interest progression



$$C_1 = C_0 + C_0 i = C_0(1+i)^1$$

See the short proof at the blackboard

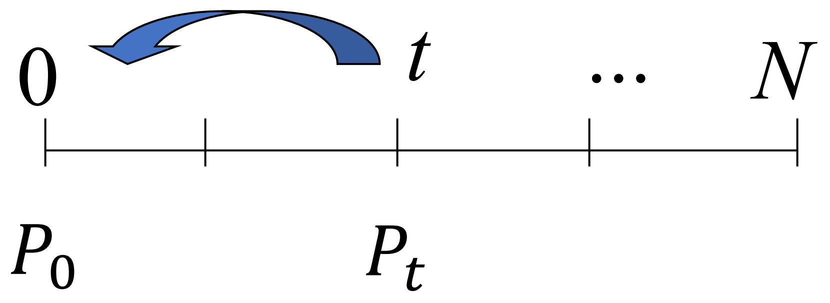
Present Value

Costs and benefits change their value with time and this depends on the capitalisation scheme and the discount factor that is the nominal cost of capital *r=i-e* (interest-inflation rate)
If capitalization follows the compound interest formula, then we can actualize the value of future capitals to today simply as follows

$$P_0 = \frac{P_1}{(1+r)^1}$$

$$P_t = \frac{P_t}{(1+r)^t}$$

Present value calculation



What is the "Present value" concept?

Costs and benefits at different times cannot be compared because they have different values due to the capitalization scheme.

In order to compare them they must be actualized to the same reference time, e.g. today --> Present Value

$$PCV = \sum_{t=0}^{L} \frac{C_t}{(1+r)^t}$$

Present Costs Value

$$PBV = \sum_{t=0}^{L} \frac{B_t}{(1+r)^t}$$

Present Benefits Value

$$NPV = \sum_{t=0}^{L} \frac{B_t - C_t}{(1+r)^t}$$

Net Present Value
(cashflow actualization)

How can costs and benefits at different times be compared?

This can be done by calculating all present values and summing them up to obtain the so-called Net Present Value or NPV

Initial conditions of the investment plan

t=0

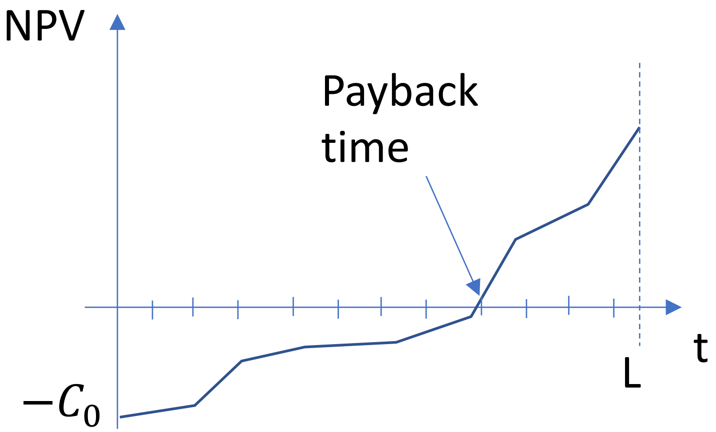
$$NPV(0) = -C_0 \qquad B_0 = 0$$

t=1

$$NPV(1) = \sum_{t=0}^{L} \frac{B_t - C_t}{(1+r)^t} = -C_0 + \frac{B_1 - C_1}{(1+r)^1}$$

t=N

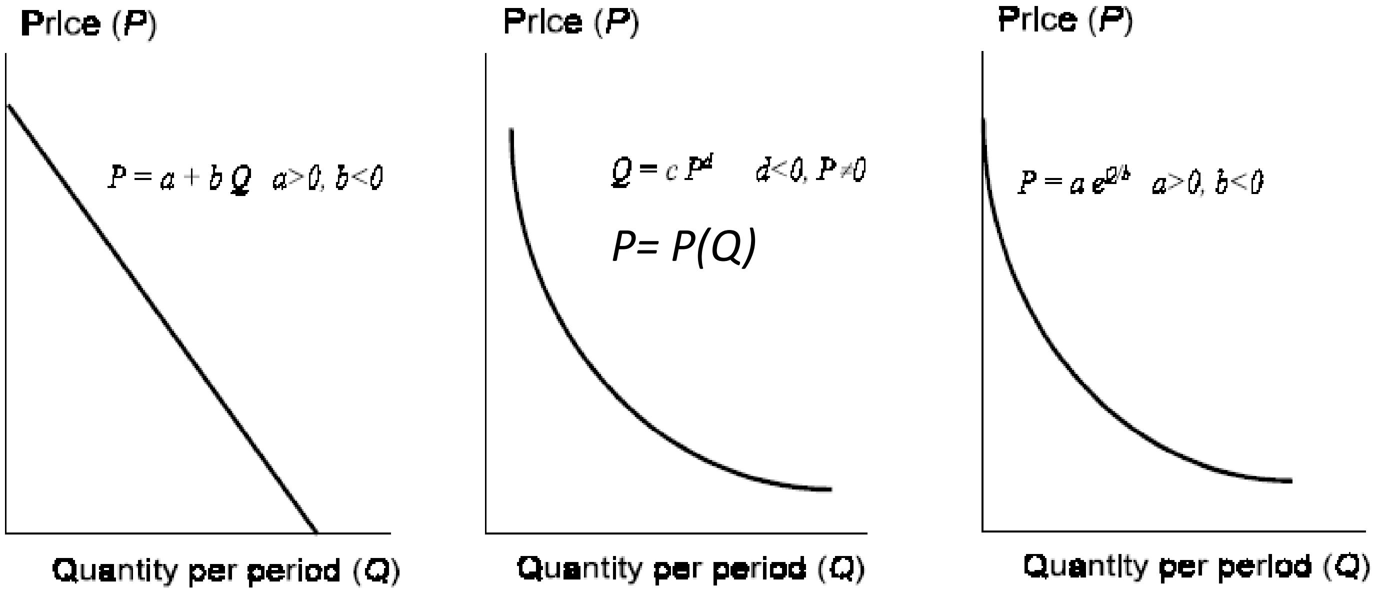
$$NPV(L) = \sum_{t=0}^{L} \frac{B_t - C_t}{(1+r)^t}$$



How should the NPV evolve in time?

NPV starts negative and grows as benefits begin to compensate costs. At the project lifetime, NPV must be positive or the project has financially failed. A number of other fundamental economic indexes will be derived in future lectures

Economic Price-Demand functions



Price-demand functions are typically monotonically decreasing functions

$$P= P(Q)$$

What is a price-demand function?

Price-demand functions (or cost-demand) express the change in price, *P*, as a function of the allocated quantity, *Q*, of a specific good

Price elasticity of demand

What is price elasticity?

- Given the price function $P=P(Q)$, price elasticity is the measure of responsiveness in the quantity demanded Q for a commodity as a result of change in price P of the same commodity

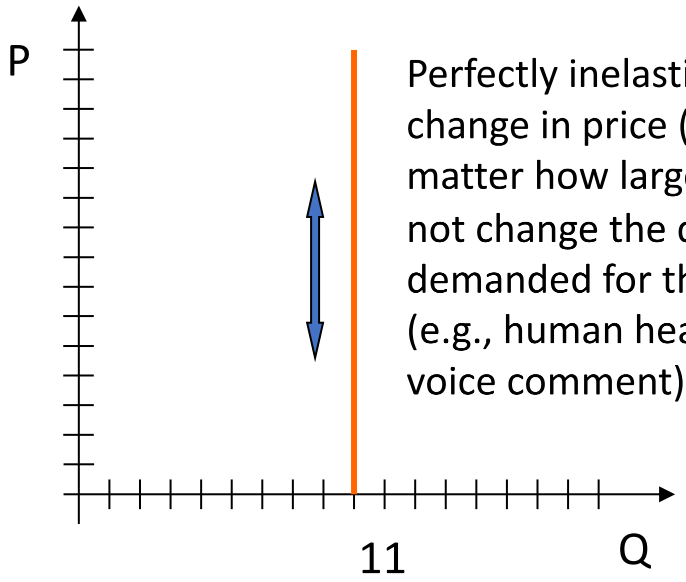
$$\varepsilon = -\frac{P}{Q}\frac{dQ}{dP} = -\frac{d\ln Q}{d\ln P}$$

Meaning: Elasticity expresses the percentage change in quantity demanded for a percentage change in price. The minus sign is to account that for increasing prices (dP>0), generically the demand diminishes (dQ<0). Other definitions do not contain the minus sign, hence $\varepsilon<0$.

What does price elasticiy of demand mean?

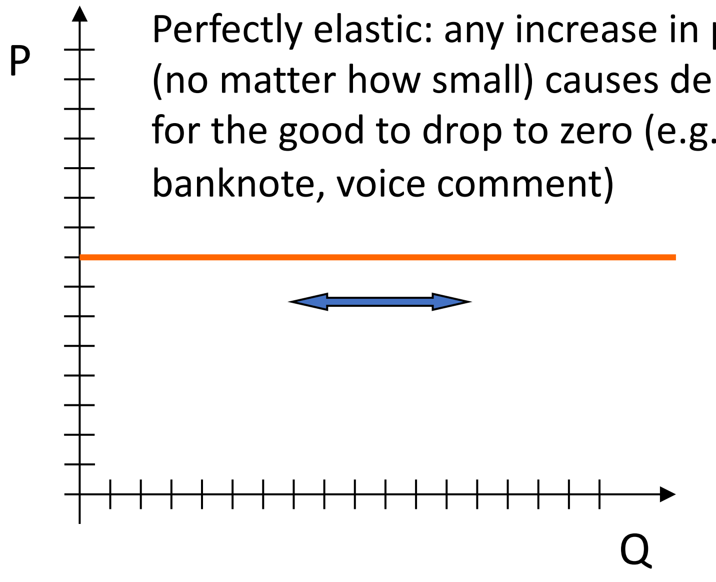
Value	Meaning
ε = 0	Perfectly inelastic
0 > ε > 1	Relatively inelastic
ε = 1	Unit (or unitary) elastic
1 > ε > ∞	Relatively elastic
ε = ∞	Perfectly elastic

Perfectly inelastic demand



Perfectly inelastic: any change in price (no matter how large) does not change the quantity demanded for the good (e.g., human heart, voice comment)

Perfectly elastic demand

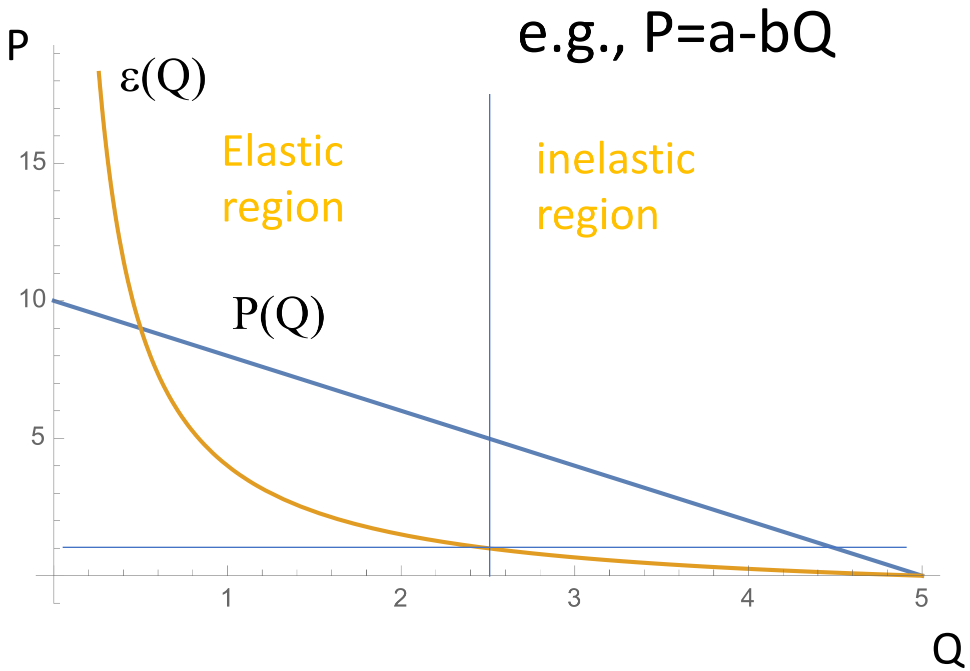


Perfectly elastic: any increase in price (no matter how small) causes demand for the good to drop to zero (e.g., banknote, voice comment)

<u>NOTE</u>: when the price elasticity for demand of goods is „inelastic“, the percentage change in quantity demanded is smaller than that in price and viceversa;

Does price elasticity vary with demand?

Yes, it does: price elasticity changes in relation to actual price and demand values!

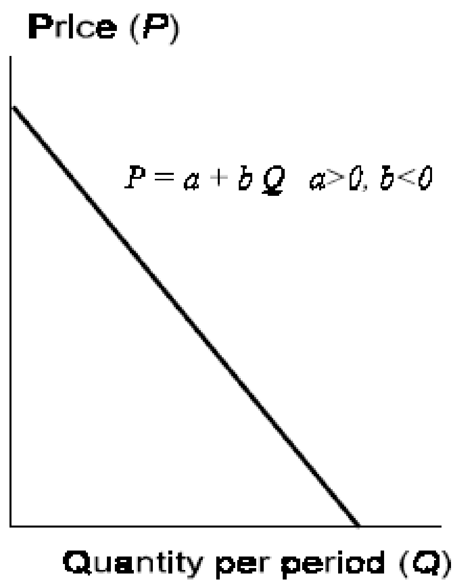


How does price elasticity for sugar compare to that of drinking water, for example?

- Demand for sugar is typically very elastic as the price of sugar increases, because there are many substitutions which consumers may switch to

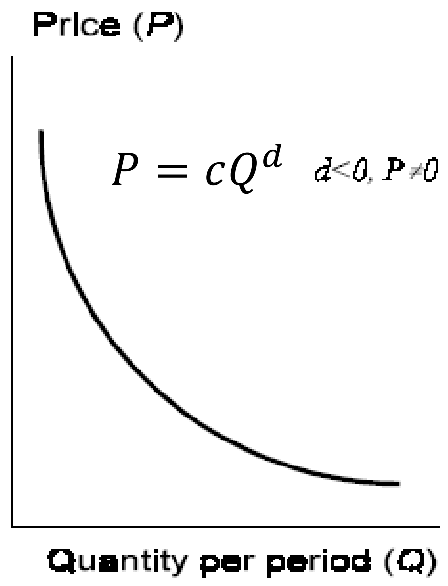
- Drinking water is instead a good with inelastic properties, cause people are ready to pay anything for it

Exercise: determine the price elasticity function



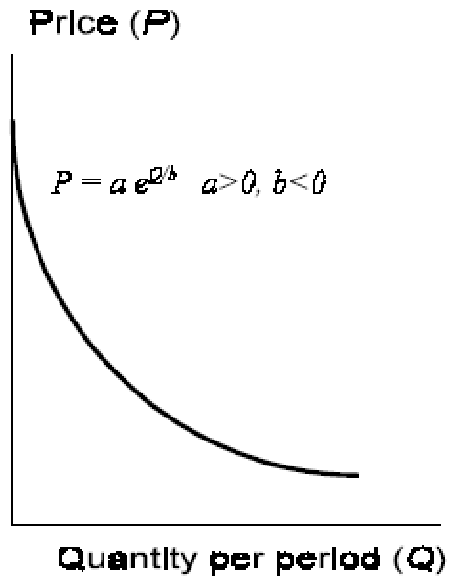
a) Linear demand curve

$$\varepsilon = -\frac{a + b\ Q}{b\ Q}$$



b) Constant elasticity demand curve

$$\varepsilon = -\frac{1}{d}$$



c) Exponential demand curve

$$\varepsilon = -\frac{b}{q}$$

How can price elasticity be determined?

Compute the differentials of the price demand function and relate them to price and quantity actual values (i.e., express them in percentage)

Example of water demand: irrigation and agricultural use

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

Irrigation is the largest water use worldwide

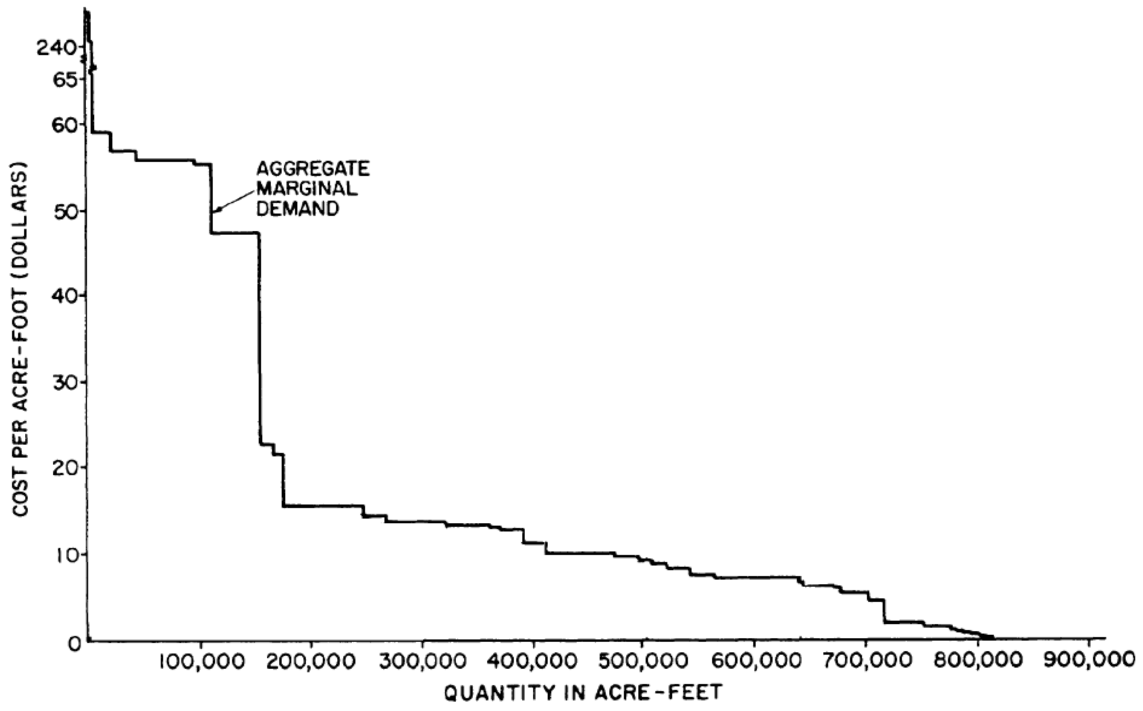


Table 2.2 Characteristics of estimated multi-crop water demand functions for the Western United States.

Author	Location	Method	Elasticity[a] Min[b]	Elasticity[a] Max[b]
Anderson et al. (1973)	Utah	Programming	-0.01	-7.0
Bernardo et al. (1987)	Washington	Programming	-0.14	-0.4
Booker & Young (1994)	Colorado	Programming	-0.6	-0.6
Frank & Beattie (1979)	Western U.S.	Econometric	-1.1	-1.1
Gisser (1970)	New Mexico	Programming	-0.17	-3.0
Heady et al. (1973)	Western U.S.	Programming	-0.36	-1.5
Howitt et al. (1980)	California	Programming	-0.46	-1.5
Kelso et al. (1973)	Arizona	Programming	-0.09	-1.2
Kulshreshtha & Tewari (1991)	Saskatchewan	Programming	-0.05	-3.1
Ogg et al. (1989)	Western U.S.	Econometric	-0.26	-0.26
Vaux & Howitt (1984)	California	Programming	-0.1	-10.

For some crops relatively elastic for others relatively inelastic

EPFL

Example of elasticity: water supply

Author	Location	Elasticity
Billings (1990)	Tucson, AZ	-0.57
Griffin (1990)	Texas	-0.37
Hanke & de Mare (1984)	Malmo, Sweden	-0.15
Jones & Morris (1984)	Denver, CO	-0.14 to -0.44
Martin & Thomas (1986)	5 cities in arid areas	-0.49
Nieswiadomy (1992)	Northeastern U.S.	-0.28
	Southern U.S.	-0.60
	Western U.S.	-0.45
Rizaiza (1991)	Saudi Arabia (4 cities)	-0.40, -0.78
Schneider et al. (1991)	Columbus, OH	-0.26 to -0.50
Stevens et al. (1992)	Massachusetts	-0.41 to -0.69
Williams & Suh (1986)	United States	-0.49

Relatively inelastic!