Models for Applied Environmental Economics

EDCE course ENV-723

Spring 2023

EPFL

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CGE models: basics

- Computable → numerical solution (empirical data)
- General → description of the whole economy
  - full economic cycle
  - all markets
- Equilibrium → demand equals supply
  - prices are adjusted to achieve market equilibrium
  - general: on all markets simultaneously
- Model → solvable set of equations

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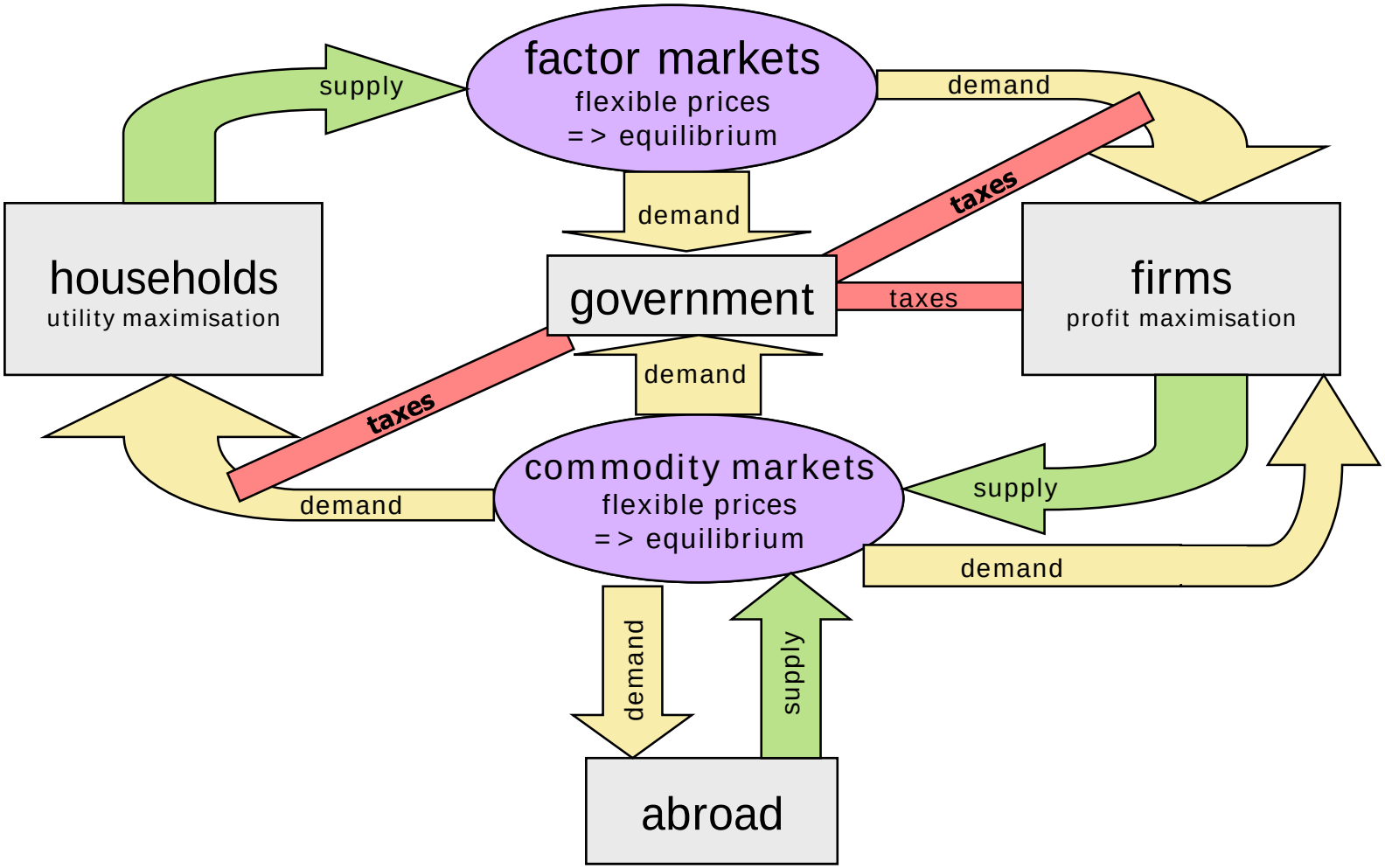
General equilibrium



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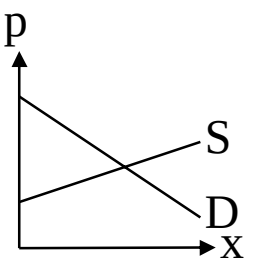
Perfect competition

- characteristics
  - homogeneous goods (no differences in quality, space, time)
  - perfect information
  - no transaction costs
  - no external effects
  - many small agents on the supply & demand side
  - rational behaviour (utility / profit maximisation)
  - customers do not prefer one supplier over another except for price reasons
- consequences
  - one single market equilibrium; no opportunities for arbitrage
  - equilibrium price = marginal cost of prouction => zero profit
  - all agents are price takers (=> they adjust quantities)
  - market clearance



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General equilibrium conditions

- market clearance: supply $\geq$ demand
- zero profit: cost $\geq$ revenue
- budget constraint: factor income $\geq$ expenditure

- complementary variables:
  - prices of factors, commodities and services
  - output of economic sectors
  - incomes of economic agents

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Hicks equivalent variation

- welfare measure used in general equilibrium models
- How much income would the household need to receive to achieve the same utility level as in the reference case?
- positive: income could be taken away
- expressed as a %age of total “welfare”
- largely consumption based way out of the dilemma that utility cannot be directly observed or measured

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Further assumptions in standard CGE models

- Data: base year Social Accounting Matrix (SAM)
  - based on input output table(s)
- Factors of production in limited supply
- Constant returns to scale
- Diminishing marginal product / marginal benefit
  - when only one input is increased
  - => downward sloping demand curves

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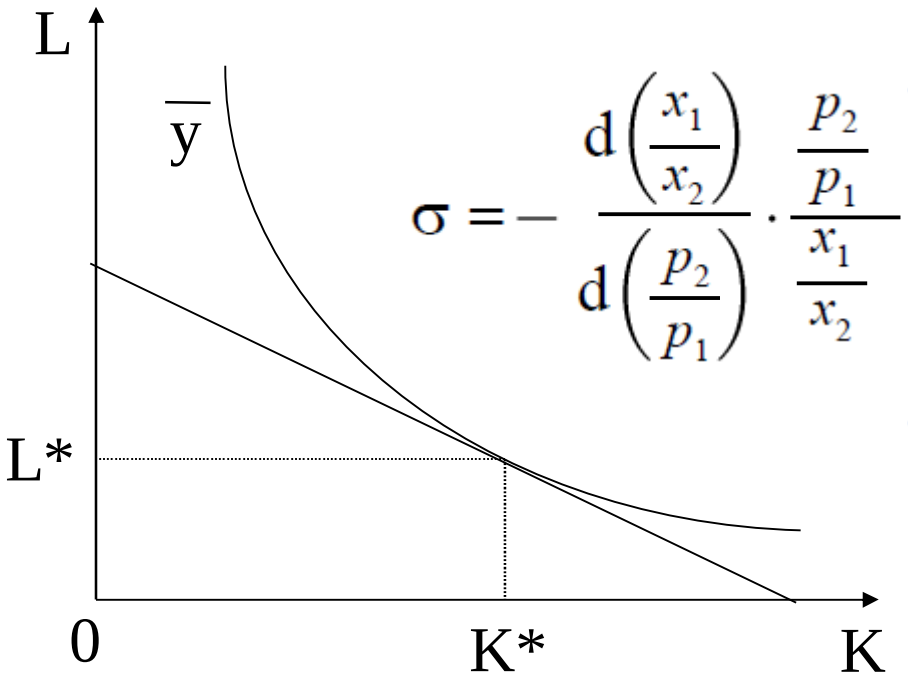
CES functions

- functions specify
  - technologies (production or cost functions)
  - preferences (utility or expenditure functions)
- most common in CGEs: nested CES (constant elasticity of substitution)



$$\sigma = - \frac{d\left(\frac{x_1}{x_2}\right)}{d\left(\frac{p_2}{p_1}\right)} \cdot \frac{\frac{p_2}{p_1}}{\frac{x_1}{x_2}}$$

- specifies how many % relative quantities demanded change when relative prices change 1% in the opposite direction.
- Where to get them from?
  - econometric estimates
  - calibrate to price elasticities
  - “standard” values from well-known models

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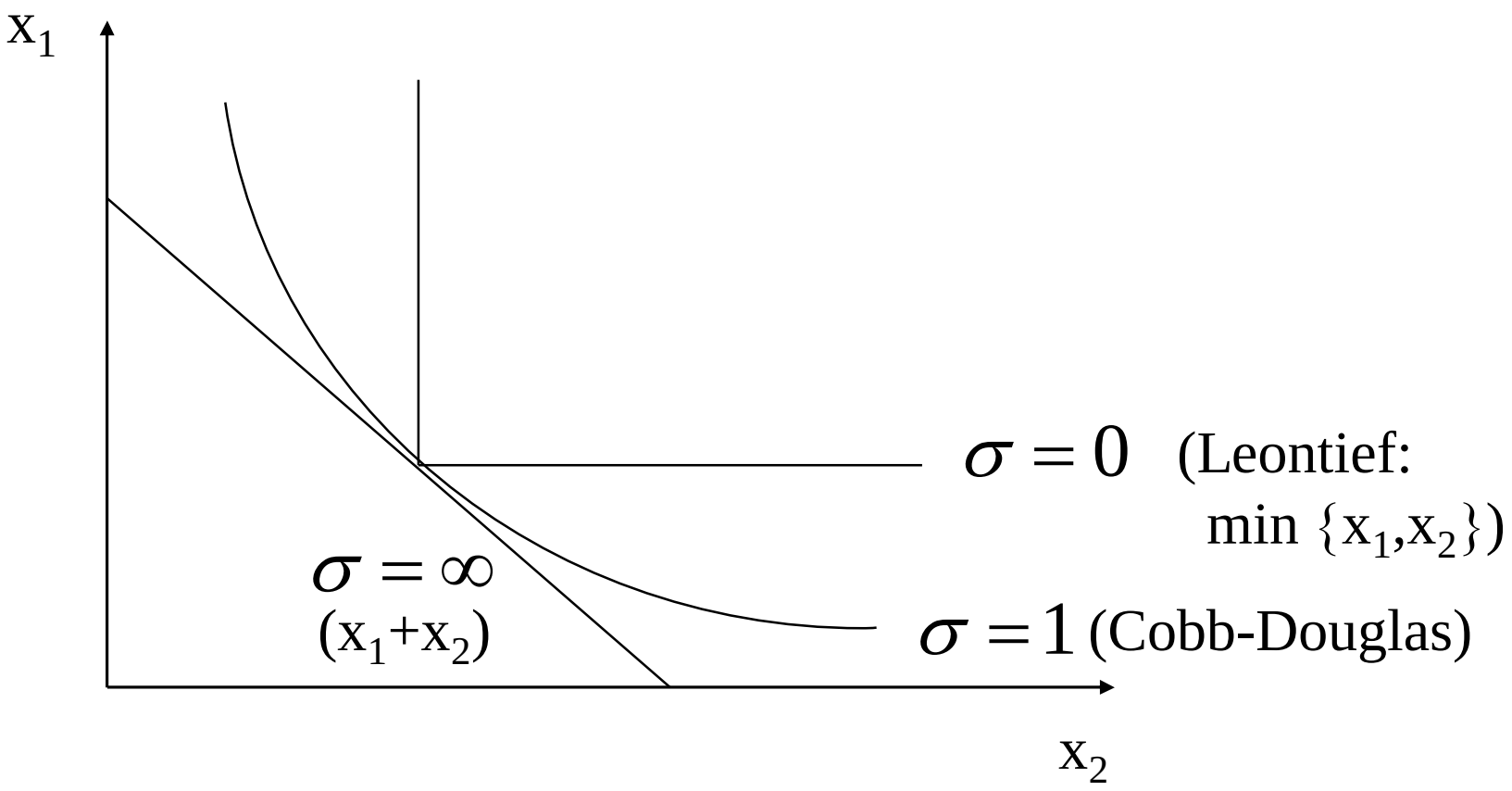
Special cases of CES functions



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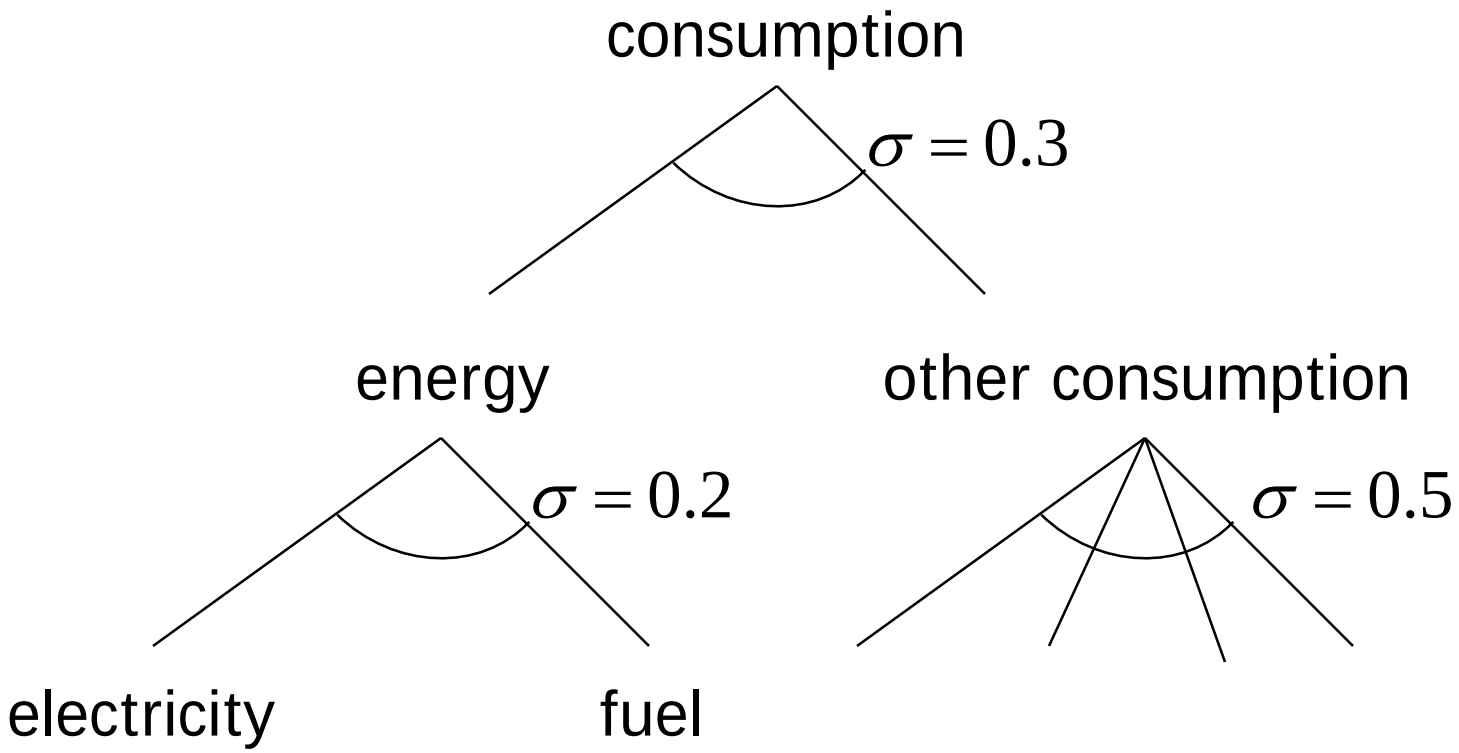
Nested CES functions



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Nested CES functions: formulae

2-level nested CES unit expenditure function:

$$E(P) = \overline{e} \cdot \left[\sum_j \theta_j \cdot f_j\left(P_j\right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \quad \text{with} \quad f_j\left(P_j\right) = \left[\sum_{k_j} \mu_{k_j} \cdot \left(\frac{P_{k_j}}{\overline{P}_{k_j}} \right)^{1-\rho_j} \right]^{\frac{1}{1-\rho_j}}$$

$$E(P) = \overline{e} \cdot \left[\sum_j \theta_j \cdot \left(\left[\sum_{k_j} \mu_{k_j} \cdot \left(\frac{P_{k_j}}{\overline{P}_{k_j}} \right)^{1-\rho_j} \right]^{\frac{1}{1-\rho_j}} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

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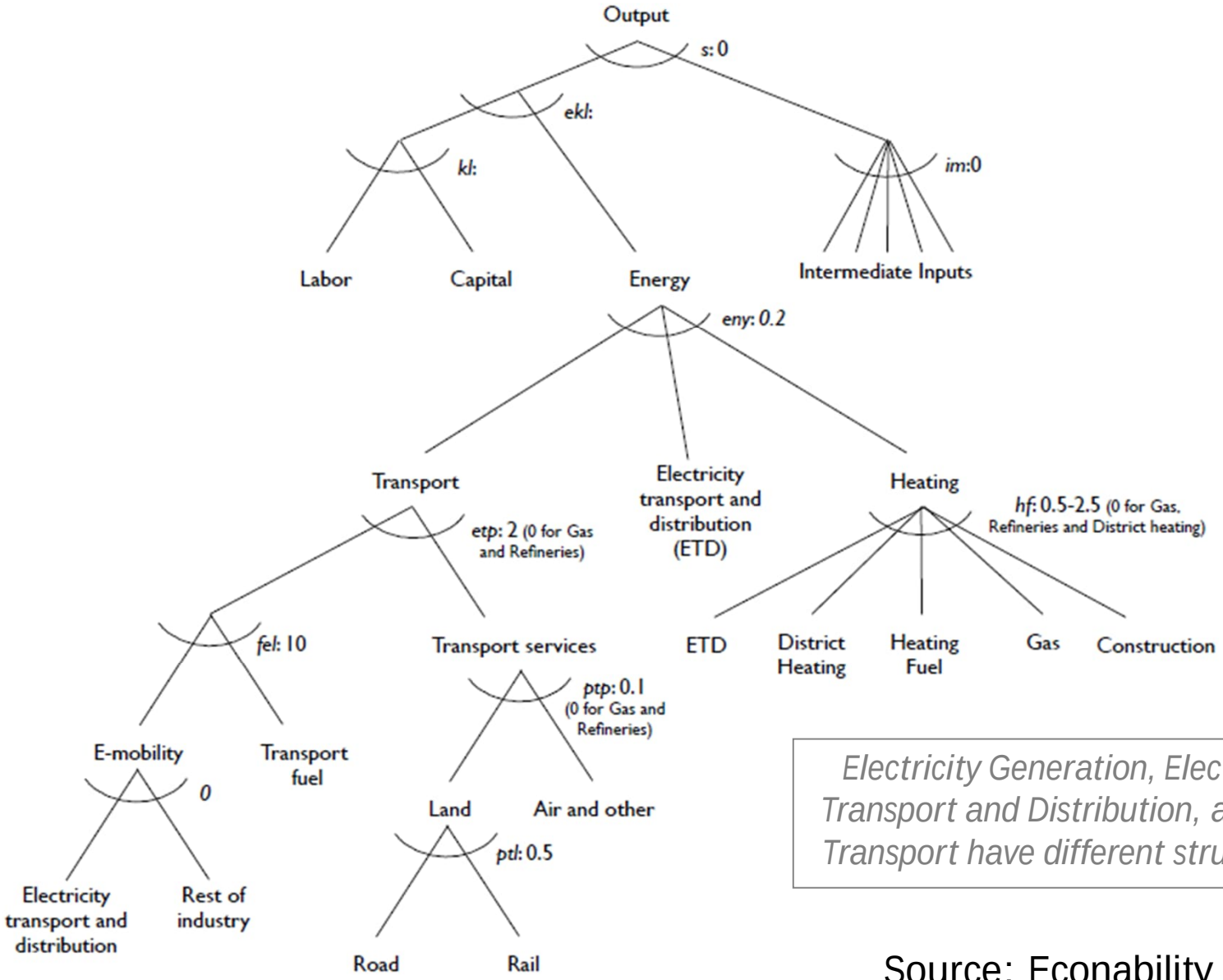
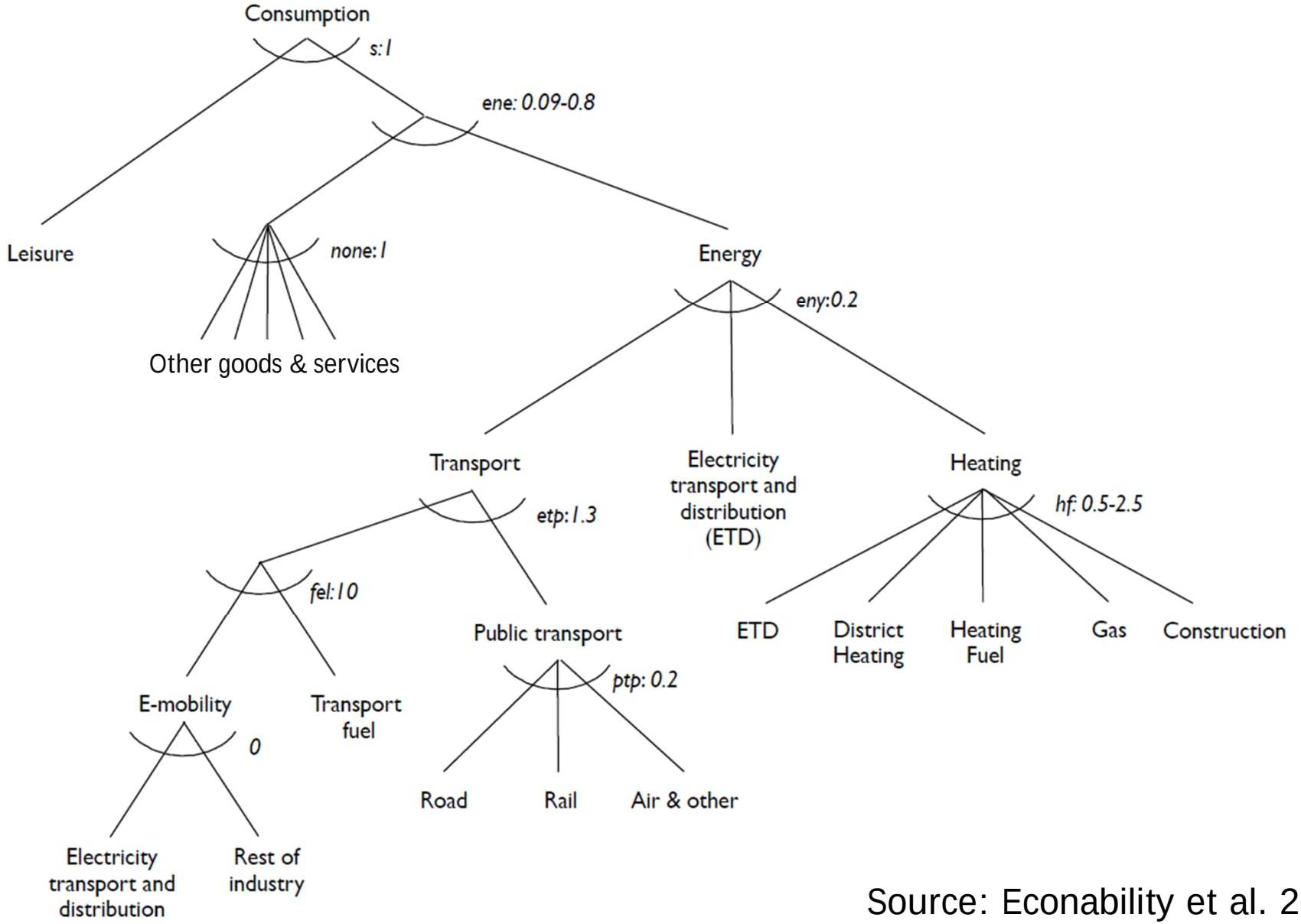
CES nesting in production (example: GENESwIS)



Electricity Generation, Electricity Transport and Distribution, and Rail Transport have different structures.

Source: Econability et al. 2015

CES nesting in consumption (example: GENESwIS)



Source: Econability et al. 2015

Standard features

- international trade
  - small vs. large open economy (single country vs. world trade model)
  - “Armington” trade: goods produced in different countries are imperfect substitutes => reciprocal multilateral trade
- government budget
  - revenues: taxes
  - expenses: transfers, subsidies, public goods provision
  - equal yield reforms: constant public goods provision
- labor market and unemployment
  - labor leisure choice
  - minimum/sticky wage unemployment
- exogenous technological change
  - Hicks-neutral / energy-saving /cost savings for technologies

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Advanced features

- endogenous technological change
  - learning by doing: cost depends on installed capacity or output
  - two factor learning curve: learning by doing + knowledge stock
  - spillovers
    - knowledge diffusion (R&D spillovers)
    - diffusion via international trade (embedded technological change)
- different household types
  - e.g.: income groups, families vs. singles, retired vs. working pop.
- imperfect competiton
  - oligopolistic competition
    - fixed costs and increasing returns to scale
    - exogenous or endogenous number of firms
  - monopolistic competition
    - heterogeneous goods and “love of variety”

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The environment

- impacts
  - emissions / immissions
  - environmental or climate modules (integrated assessment)
  - purification / abatement sectors
  - damages in utility functions and/or production functions
  - reporting of external costs and benefits
- disaggregated energy sector
  - further disaggregation of input output sectors
  - “hybrid CGEs” or coupling with energy systems model
- environmental policy intruments
  - quantity based, e.g.: efficiency targets, quotas, (tradable) permits
  - price oriented, e.g.: taxes, subsidies, price regulation
  - difficult to model: BAT, information campaigns

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Static versus dynamic CGE models

- static models
  - only one period
  - comparative static analysis
- recursively dynamic models
  - separate solution for each period
  - preference for savings => investment => capital stock in t+1
  - myopic expectations
- “Ramsey” models
  - simultaneous solution of all periods
  - intertemporal optimisation
  - rational expectations

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CGE models: pros & cons

- established theory
- analysis of complex, price-driven policies
- simultaneous analysis of efficiency and distribution

- do neoclassical assumptions suffice?
- top down benchmark approach to data
- danger of first best illusion

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