Chakravorty & Krulce. Heterogenous demand and order of resource extraction

Econometrica 62, 1445-1452

www.jstor.org

Earlier studies

- Herfindahl (1967), Solow & Wan (1976) ja Lewis (1982): use first resources which have the lowest extraction costs

Two resources, two markets

- Resources: Oil & Coal, extraction cost of coal higher
- Markets: Electricity & Transport
- Electricity can be produced similarly with both resources
- Oil can be used in transport without transformation costs

Results

- Phase I: Only oil is used (in both markets)

- Phase II: Oil for transport, coal for electricity

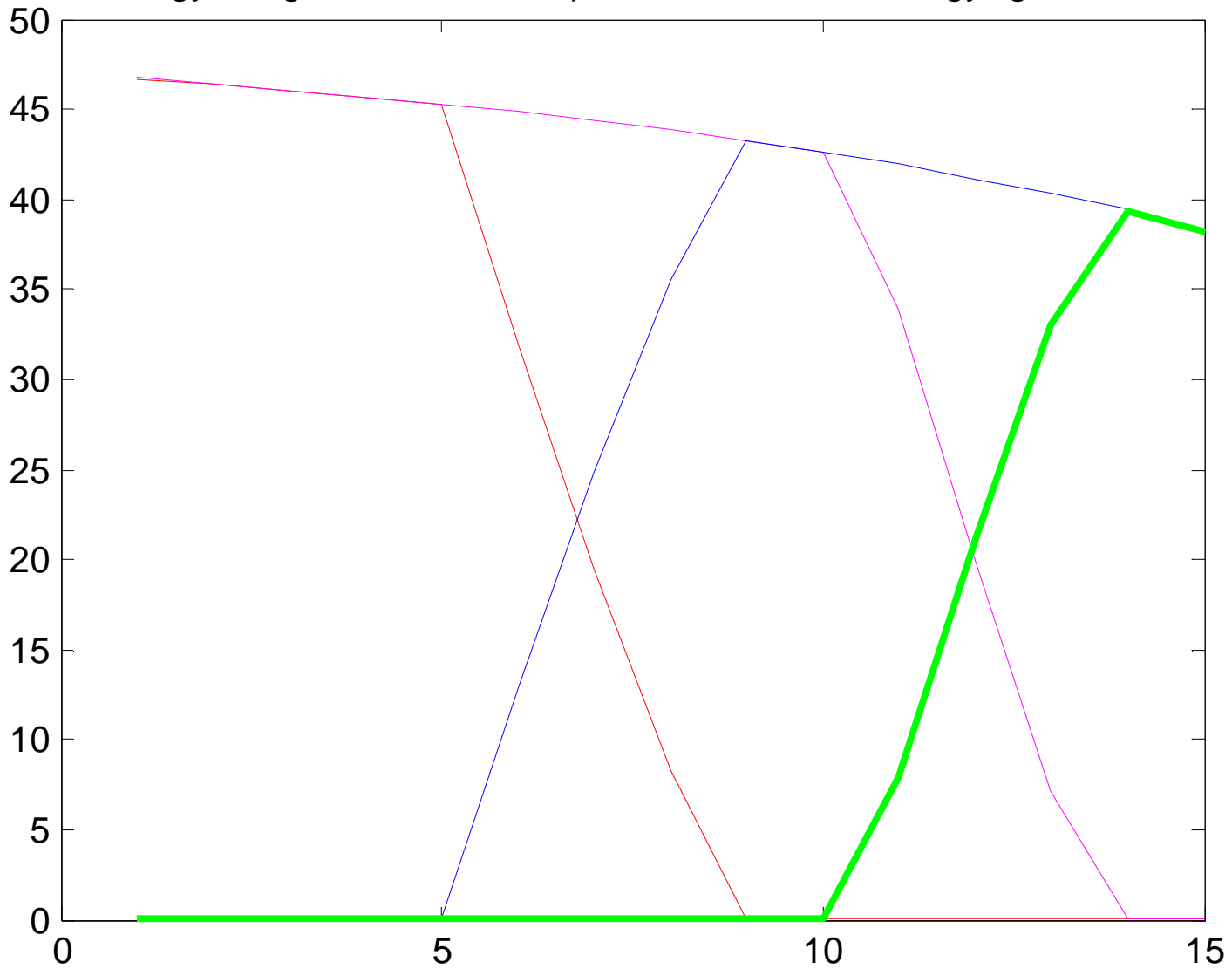- Phase III: Only coal is used

Model

$$\max \quad \int_0^{\infty} e^{-rt} [\, p_E(q_{OE}(t) + q_{CE}(t)) + p_T(q_{OT}(t) + q_{CT}(t)) - zq_{CT}(t)$$

$$- (q_{OE}(t) + q_{OT}(t))c_O - (q_{CE}(t) + q_{CT}(t))c_C$$

$$c_O < c_C$$

$$\text{st} \quad \dot{x}_O(t) = -q_{OE}(t) - q_{OT}(t)$$

$$\dot{x}_C(t) = -q_{CE}(t) - q_{CT}(t)$$

red=oil for energy, magenta=oil for transport, blue=coal for energy, green=coal for transp

More resources

- Chakravorty, Krulce & Roumasset (2005). Specialization and non-renewable resources: Ricardo meets Ricardo. Journal of Economic Dynamics & Control 29, 1517-1545

Results

- Allocate resources according to their comparative advantage (difference in costs is smaller)

- Order of extraction according to their absolute advantage (extraction cost smaller)

- m X n model, m resources, n markets

Results

- If a resource has an absolute advantage and there is enough of it only that resource willbe used in phase I

- If each resource has an absolute advantage in at least one market, then all resources are used at each point in time

- Only inferior resources are used in the last phase

Taxation

- Hotelling à extraction smaller

- In a two-sector model coal tax can lead to increase in oil consumption

- Fuel tax can lead to a switch from oil to coal

Price dynamics

- Hotelling à prices increase with the rate of discount

- In a two-sector model prices approach each other in time

Chakravorty, Magne & Moreaux

A Hotelling model with a ceiling on the stock of pollution

Journal of Economic Dynamics & Control 30 (2006) 2875–2904

Background

- Take into account environmental effects
- Renewable energy is expensive to produce but its cleaner
- Exhaustible energy is dirty but cheap
- Assume a stock constraint for environment, eg a limit for carbon dioxide in the atmosphere

Results

- Transition to renewable resources may be temporary

Tuloksia

- Hotelling: exhaustible resource price increases, and at T there is a switch to the backstop-technology
- Environmental constraint: switch to renewables before running out of eg oil
- When atmospheric carbon dioxide levels are fallen back below the constraint, it is optimal to start using fossile fuels again

Assumptions

- One market: energy
- Two resources: Oil or solar

Model

- Coal extraction x
- Solar energy consumption y
- Utility from energy consumption u(x+y)
- Emissions z = bx
- Equation of motion for carbon dioxide:

dZ/dt = bx - a - dZ

Optimal control model

$$\int_0^\infty e^{-rt}[u(x(t) + y(t)) - c_c x(t) - c_a a(t) - c_s y(t)]$$

$$c_c < c_s$$

$$\dot{x}(t) = -x(t)$$

$$\dot{z}(t) = bx(t) - a(t) - dZ(t)$$

Chakravorty, Moreaux, and Tidball: Ordering the Extraction of Polluting Nonrenewable Resources

Further readings (or articles for essay and presentation)

- Van der Werf, Edwin, and Sjak Smulders. "Climate Policy and the Optimal Extraction of High and Low Carbon Fossil Fuels." *Canadian Journal of Economics.*

- flow constraint for the emissions (instead of stock)

- *Canadian Journal of Economics/Revue canadienne d'économique, Vol. 41, No. 4, pp. 1421-1444, November/novembre 2008*