Resource Economics
Lecture 1

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Overview

Stylized facts

Basic models

Overview

- Exhaustible resources, 6 lectures (Daniel)
- Renewable resources 6 lectures (Florian)
- Bonus lecture, synthesis (Daniel &/or Florian)

- Seminars, 3 on exhaustibles and 3 on renewables (Torben)

Purpose & Setup - Exhaustibles

- Descriptive: E.g. What mechanisms are present on resource markets? What determines prices, supply and demand?
- Policy: E.g. How can these markets be regulated? What can/should be done with the profits?
- Theoretical research: E.g. Some basic tools for deeper analysis of resource markets.
- Empirical research: Some basic methods for analyzing the markets empirically.

Lecture overview

1. Stylized facts and basic model(s)
   - E.g. How have prices evolved in the last century? What does a basic model of resource scarcity predict about prices?

2. Sustainability. technology. exploration. substitutes
   - E.g. Will we run out of resources? Will technology save the day? How does exploration and substitutes affect prices?

3. Market structure. political effects and behavioral aspects
   - E.g. What does market structure imply for resource prices? Can political considerations distort resource markets? What about bounded rationality?

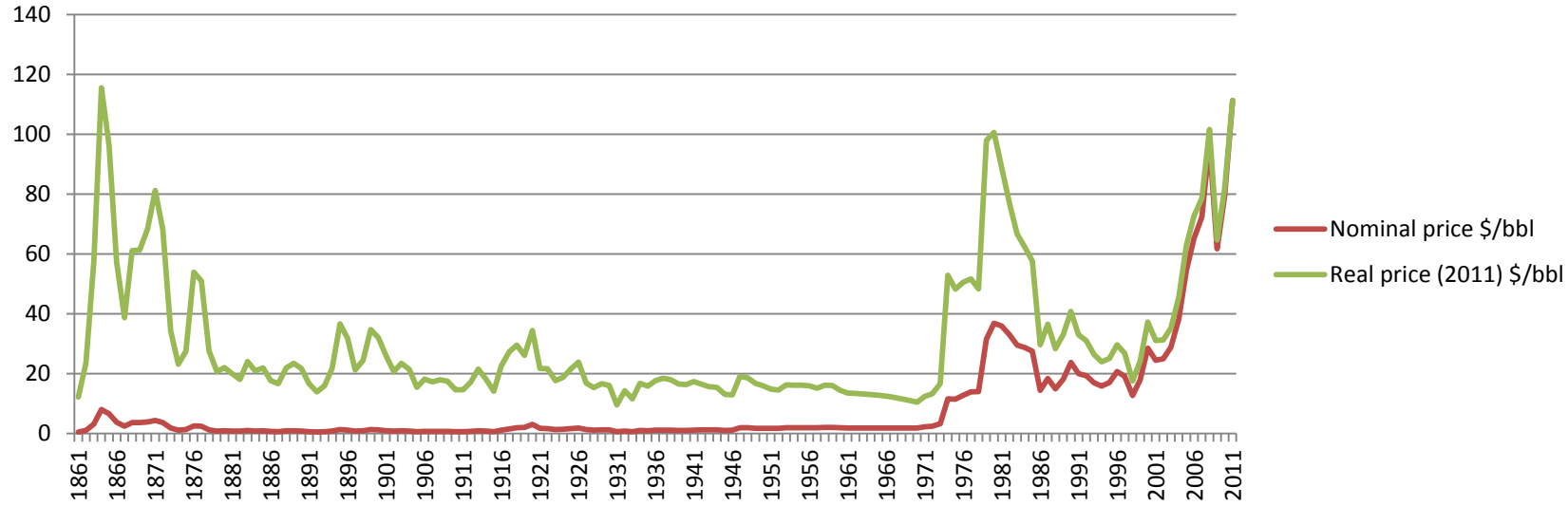
4. Short run mechanisms and empirical tests
   - E.g. How can different resource models be tested empirically? Does speculation play a role for oil prices?

5. The resource curse
   - E.g. Why are some resource rich countries doing so bad while others are doing so well?

6. Policy and regulation

   - E.g. How can a resource rich country stimulate extraction and take the profits? How would international taxes affect extraction?

Stylized facts -- Oil

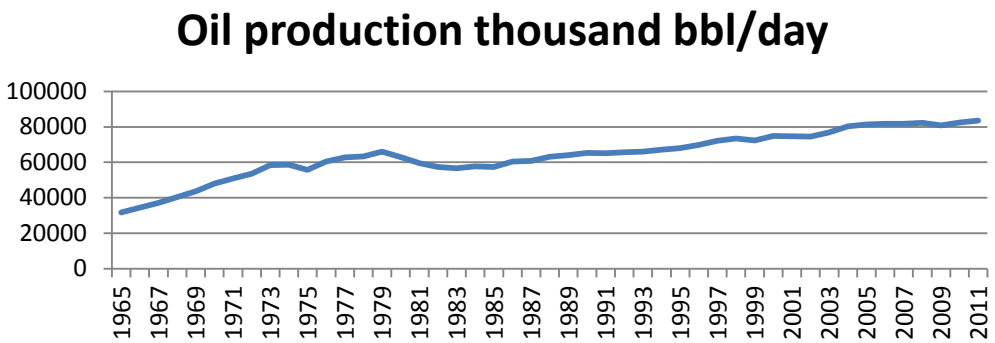


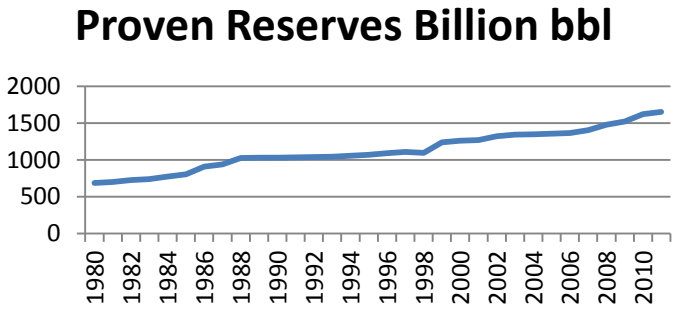
Real oil price:

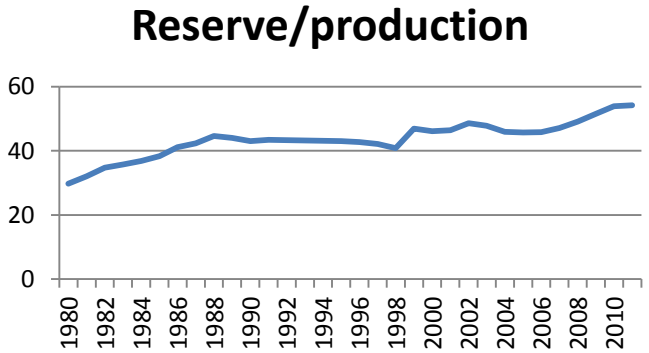
- falling for 110 yrs
- spiked during the oil crisis
- increased after yr 2000
- Substantial volatility

Around 5% of world GDP

Oil







Production has increased secularly

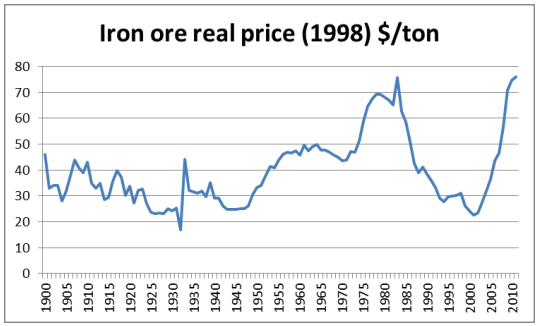
Proven reserves have increased secularly

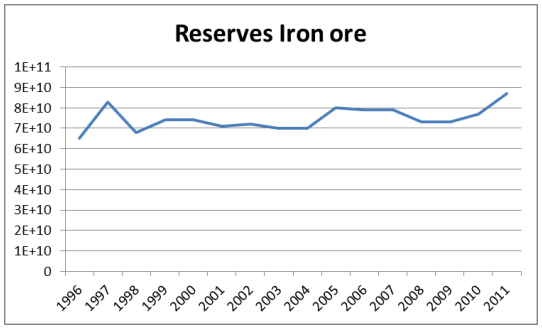
Reserve/production - a common (but crude) measure of scarcity, increased slightly

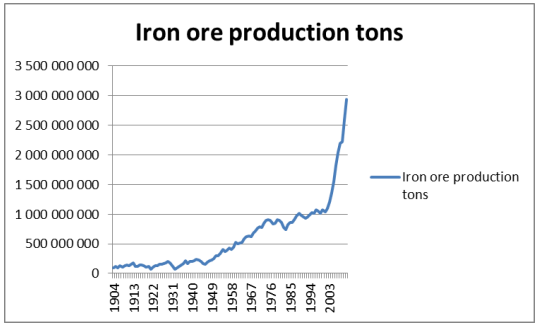
	Reserves		Production		
	Billion bbl	Share of world total	Thousand bbl/day	Share of world total	R/P
US	30.9	1.9%	7841	**8.8%**	10.8
Canada	175.2	**10.6%**	3522	4.3%	>100
Mexico	11.4	0.7%	2938	3.6%	10.6
Argentina	2.5	0.2%	607	0.8%	11.4
Brazil	15.1	0.9%	2193	2.9%	18.8
Colombia	2.0	0.1%	930	1.2%	5.9
Ecuador	6.2	0.4%	509	0.7%	33.2
Peru	1.2	0.1%	153	0.2%	22.2
Trinidad & Tobago	0.8	0.1%	136	0.1%	16.7
Venezuela	296.5	**17.9%**	2720	3.5%	>100
Norway	6.9	0.4%	2039	2.3%	9.2
Russian Federation	88.2	**5.3%**	10280	**12.8%**	23.5
United Kingdom	2.8	0.2%	1100	1.3%	7.0
Iran	151.2	**9.1%**	4321	5.2%	95.8
Iraq	143.1	**8.7%**	2798	3.4%	>100
Kuwait	101.5	6.1%	2865	3.5%	97.0
Oman	5.5	0.3%	891	1.1%	16.9
Qatar	24.7	1.5%	1723	1.8%	39.3
Saudi Arabia	265.4	**16.1%**	11161	**13.2%**	65.2
Algeria	12.2	0.7%	1729	1.9%	19.3
Angola	13.5	0.8%	1746	2.1%	21.2
Libya	47.1	2.9%	479	0.6%	>100
Nigeria	37.2	2.3%	2457	2.9%	41.5
Brunei	1.1	0.1%	166	0.2%	18.2
China	14.7	0.9%	4090	5.1%	9.9
India	5.7	0.3%	858	1.0%	18.2
Indonesia	4.0	0.2%	942	1.1%	11.8
Malaysia	5.9	0.4%	573	0.7%	28.0
Total World	1652.6	100.0%	83576	100.0%	54.2
OPEC	1196.3	**72.4%**	35830	**42.4%**	**91.5**
Non-OPEC	329.4	**19.9%**	34258	**41.0%**	**26.3**

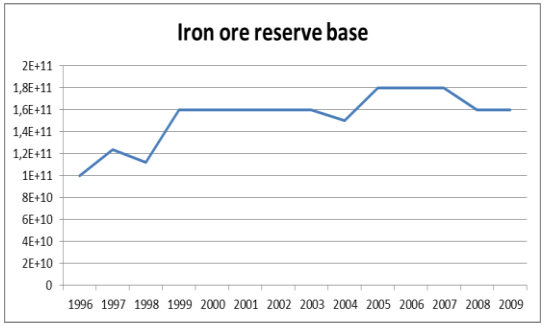
Market structure: Roughly 50 producing countries (not all in table).
Oligopoly (OPEC) with competitive fringe.

Iron ore



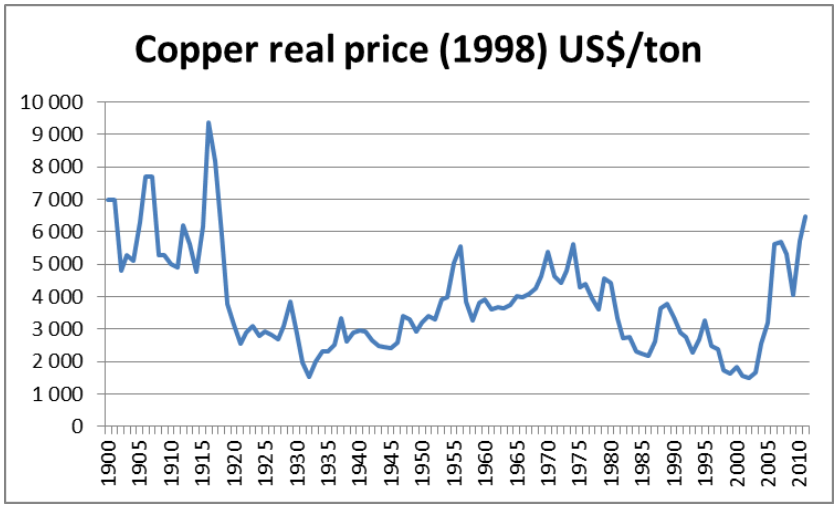


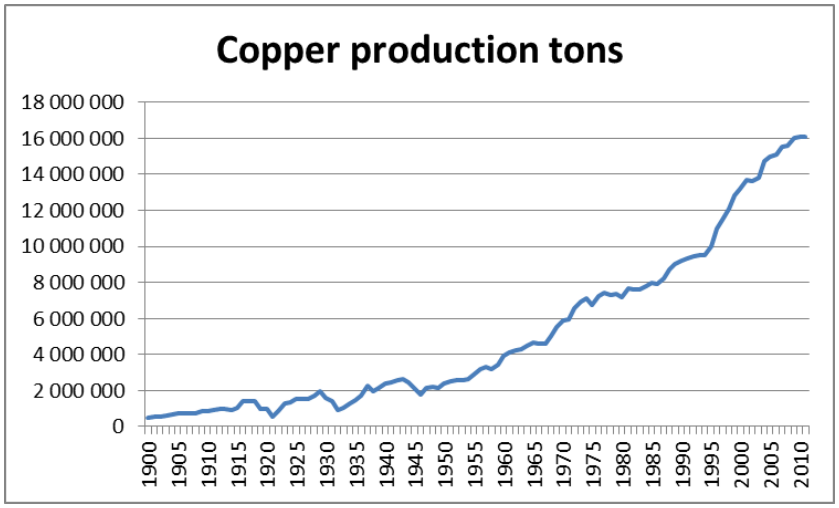




Price: Roughly constant for 50 yrs, hump for 40 yrs, increasing from 2000
Production: Roughly constant but volatile
Reserves: constant
Reserve base ("what can be profitably extracted with future technologies"): increasing
R/P 2011: 57 yrs
Share of world GDP: 0.4%
Market structure: 15 major producing countries (China, Australia, Brazil, India and Russia the largest).

Copper





Price: Roughly falling until yr 2000, then increasing

Production: Increasing

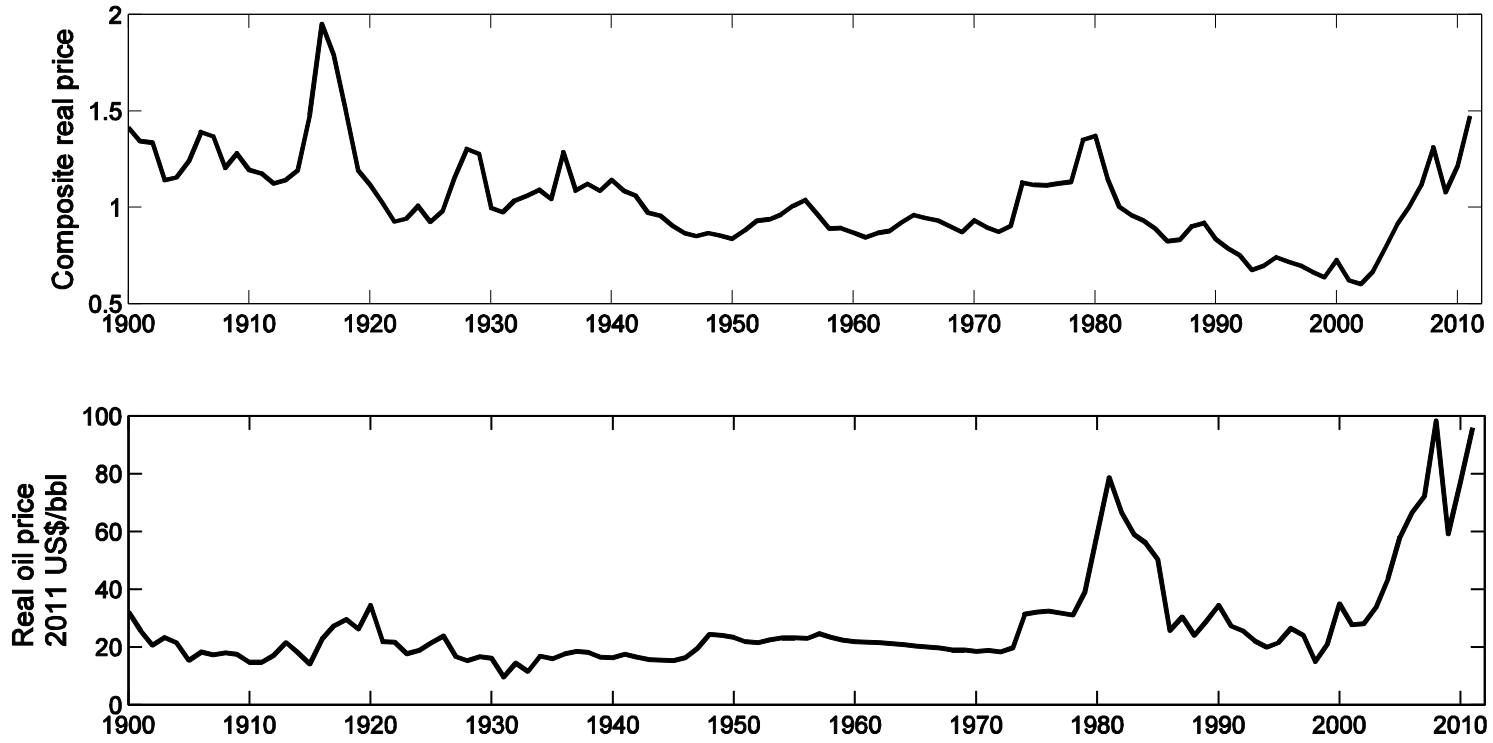
Reserves R/P: 39 yrs

Reserve base R/P: 62 yrs

Share of world GDP: 0.2%

Market structure: Many producing countries (Chile, China, US, Australia, Peru largest)

Stylized facts



Upper graph: a composite price made of prices from 57 exhaustible resources, weighted equally

Lower graph: real oil price in 2011 $/bbl

Stylized facts

Prices:
- were falling during the 20th century
- started increasing around 2000 (mainly energy resources)
- Substantial volatility

Production:
- Increasing
- Substantial costs need to be undertaken before mining starts
- Substantial running costs of extraction

Market structure:
- Substantial national control for exploration, production and profit sharing
- Sometimes cartels (oil)
- Mostly many producing countries
- Sometimes ill defined property rights (diamonds)

Reserves:
- New discoveries occur
- Sometimes within currently producing countries, sometimes new producers
- Recycling usually possible (non-energy) but often negligible

A misunderstanding

- Simplest microeconomic theory says:
- When supply increases then prices fall.
- Hence, the gradually increasing extraction and gradually falling prices are perfectly in line with theory…
- Or?

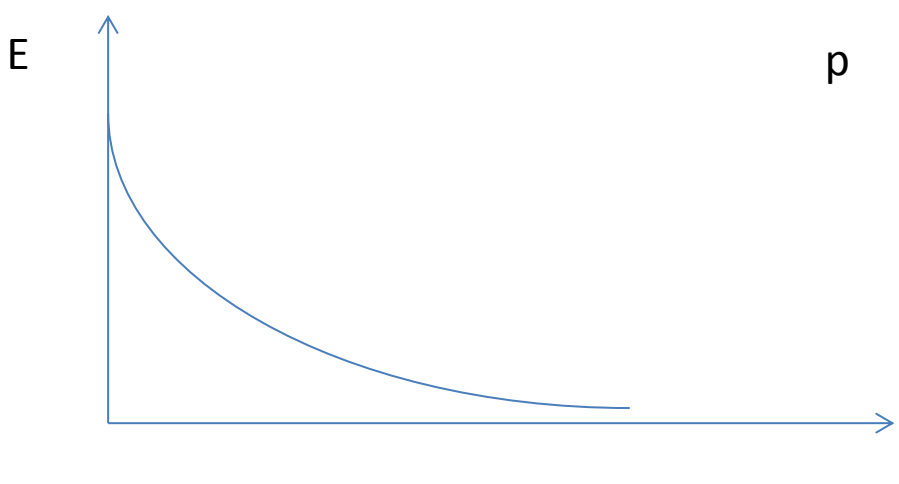
A basic model of exhaustible resources

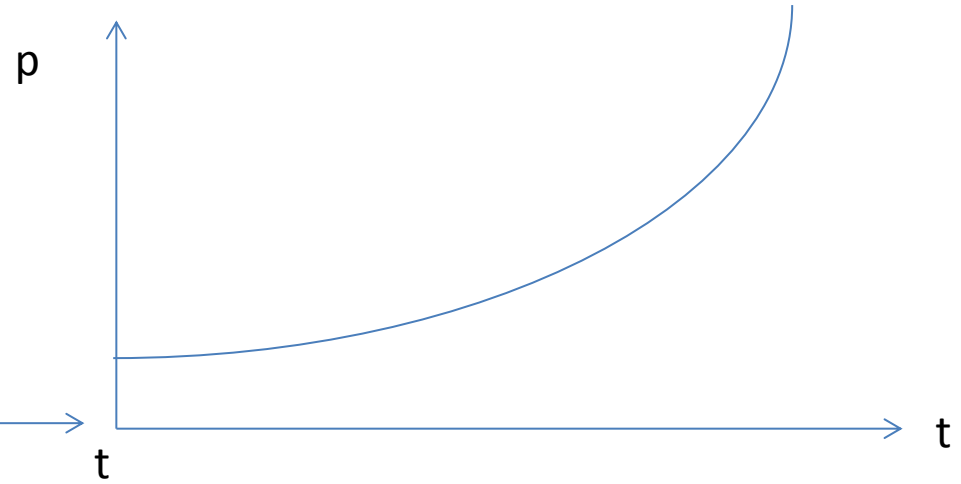
- Hotelling (1931), Dasgupta & Heal (1974)
- A sheik wants to maximize discounted total profits by extracting and selling a resource E.
- No cost of extraction
- Extraction leaves less of the stock, S, under ground.
- The resource is in finite total supply, S.
- There is an infinite number of infinitely small sheiks.
- Firms buy the resource and use in their production, F(E).

Results – Hotelling model

- Extraction falls over time, due to discounting.
- **Price rises exponentially over time at a speed equal to the "inverse of discount factor" (="interest rate").**
- Note: The reverse of the stylized facts.
- The price constitutes a pure profit – a.k.a. *scarcity rent*

Hotelling





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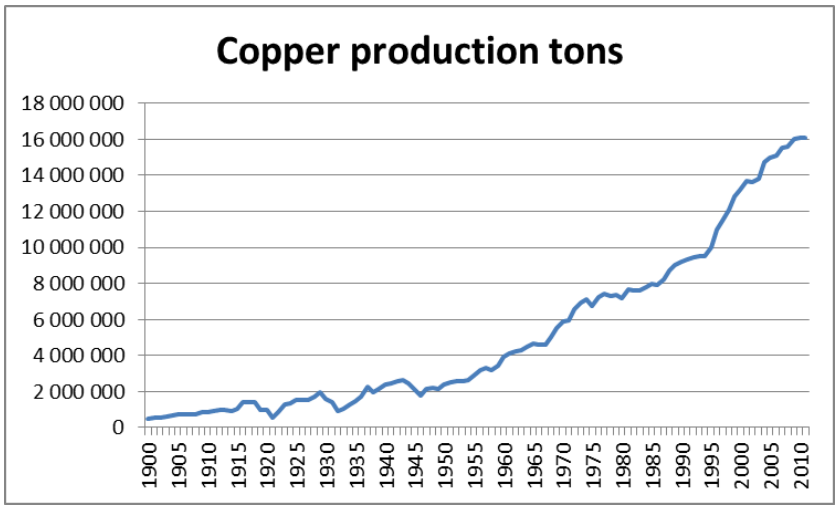
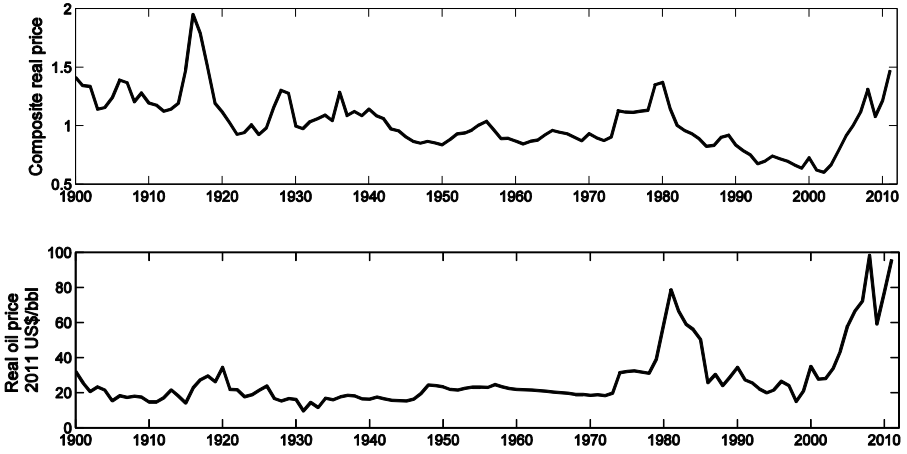




Hotelling + extraction costs

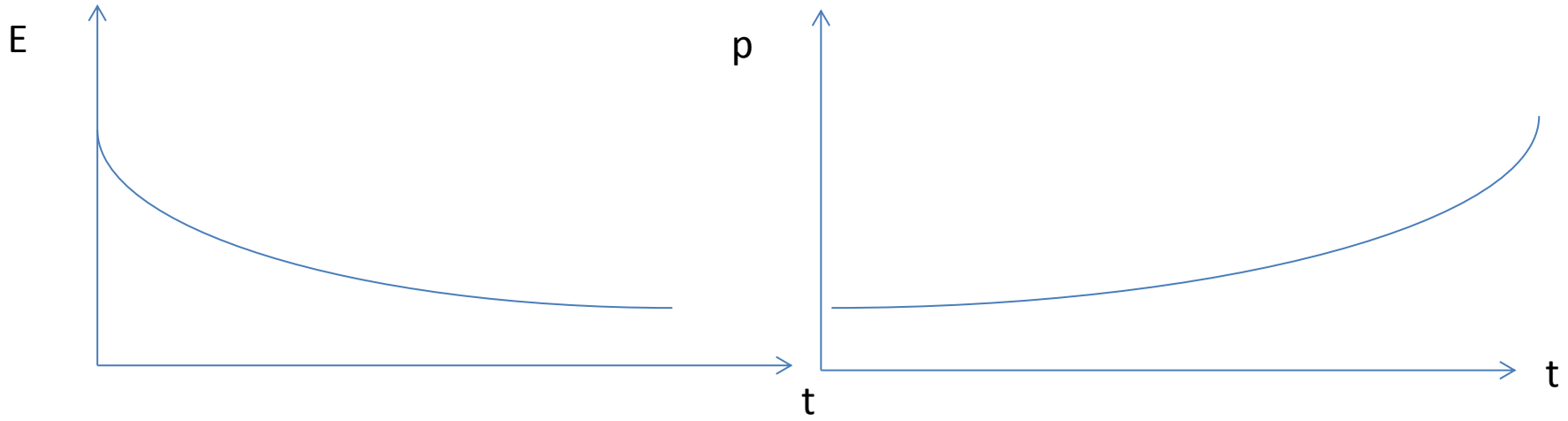
- Weinstein & Zeckhauser (1975)

- It costs M(E) to extract E units of the resource in a time period.

Results – Hotelling + Extraction costs

- Extraction falls over time.
- The price contains two elements:
  - The marginal cost of extraction
  - The scarcity rent
- **The scarcity rent increases at the rate of interest.→ A correlation between price growth and the interest rate level.**
- The extraction costs dampen the price growth,…
- … so the price initially grows less than exponentially but converges to exponential growth over time as the extraction costs play less and less of a role.
- Still counterfactual predictions.

Hotelling + Extraction costs



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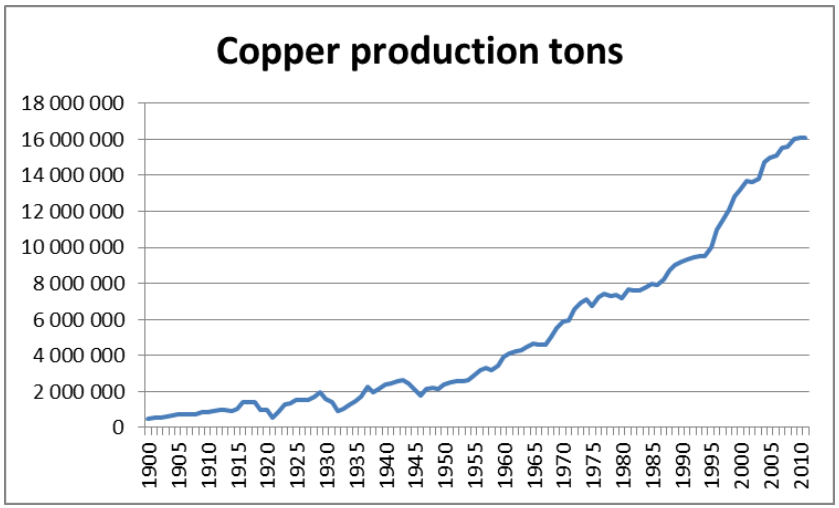
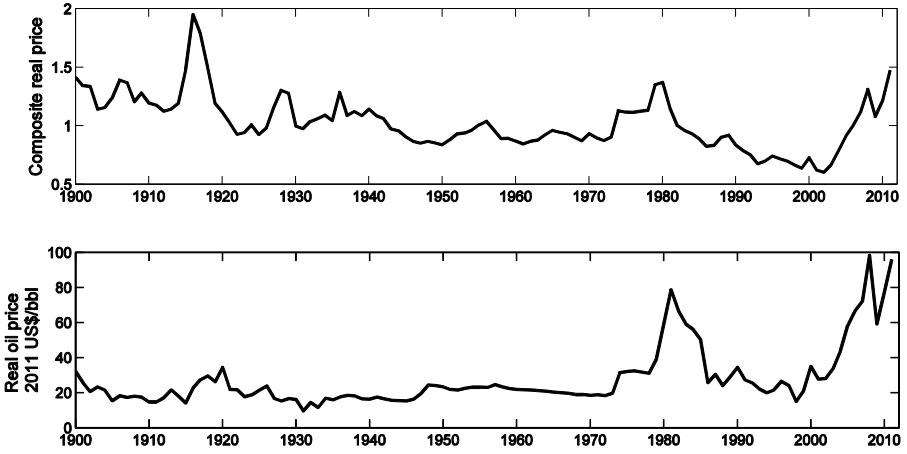




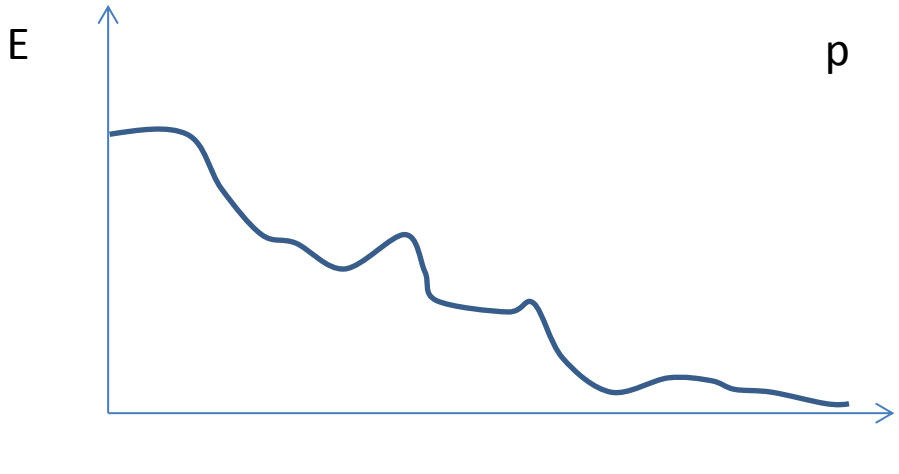
A model of an inexhaustible resource

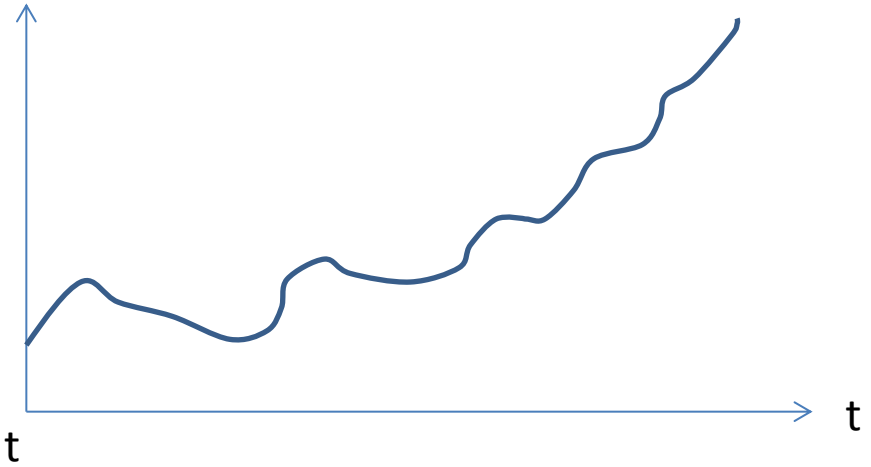
- Farzin (1992)
- There is an infinite amount of the resource.
  - E.g. World resources ("…economic extraction of a commodity from the concentration is currently or potentially feasible") of copper are $3*10^9$ tons → R/P=176 yrs
  - E.g. Lithium Reserves R/P=346 yrs
- But the more that is extracted the "deeper" one has to dig and hence costs go up.
- Note: we abstract from technical change

Results – Inexhaustible resource

- Extraction falls over time.
- The price contains two components:
  - One reflecting the current extraction costs
  - One reflecting that high extraction today increases extraction costs in *all* future periods – *the externality rent*
- Extraction costs increase over time due to digging deeper. This tends to increase prices.
- Externality costs may increase or decrease
- Price path may be non-monotonic, but is generally increasing due to increasing extraction costs.
- **Price growth depends negatively on the discount factor and hence positively on the interest rate.**
- After sufficiently long time the price path will follow the immediate costs of extraction – i.e. increase.
- No physical scarcity only economic scarcity (because extraction costs increase)

Inexhaustible resource





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