Resource Economics
Lecture 4

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Overview

Stylized facts

Basic models

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

4. 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?

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

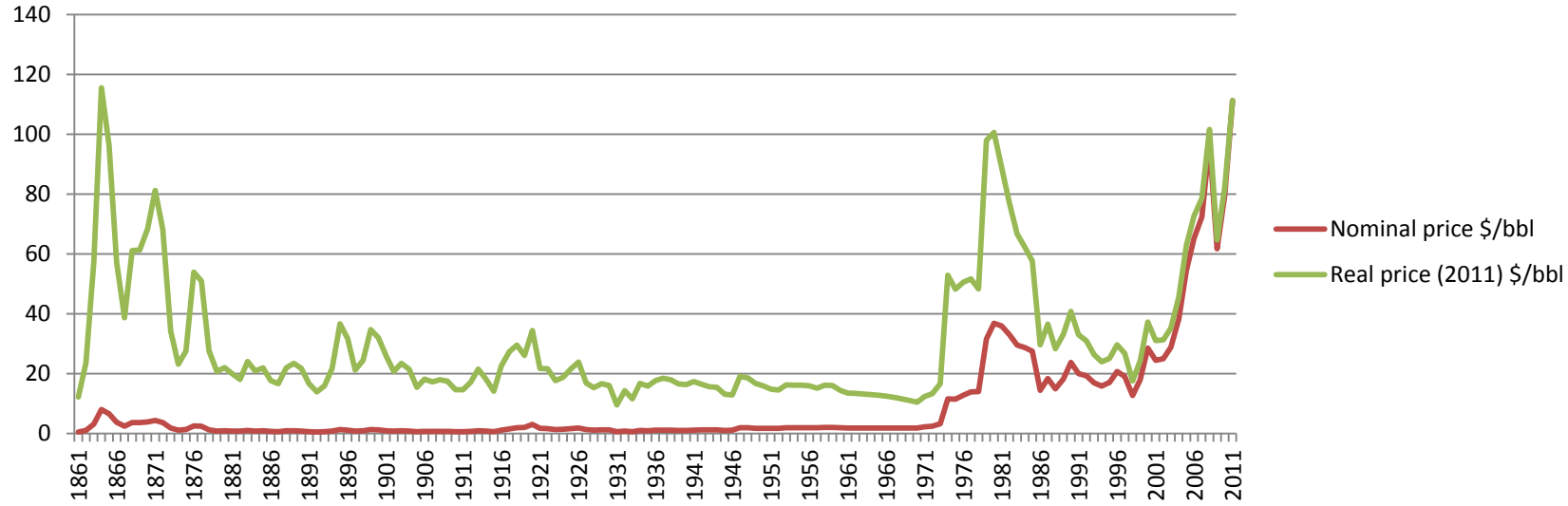
6. Market structure. political effects and behavioral aspects
   - E.g. What does market structure imply for resource prices? Can political considerations distort resource markets? What about bounded rationality?

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

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

9. Policy and regulation
   - E.g. How can a resource rich country stimulate extraction and take the profits?

Stylized facts -- Oil

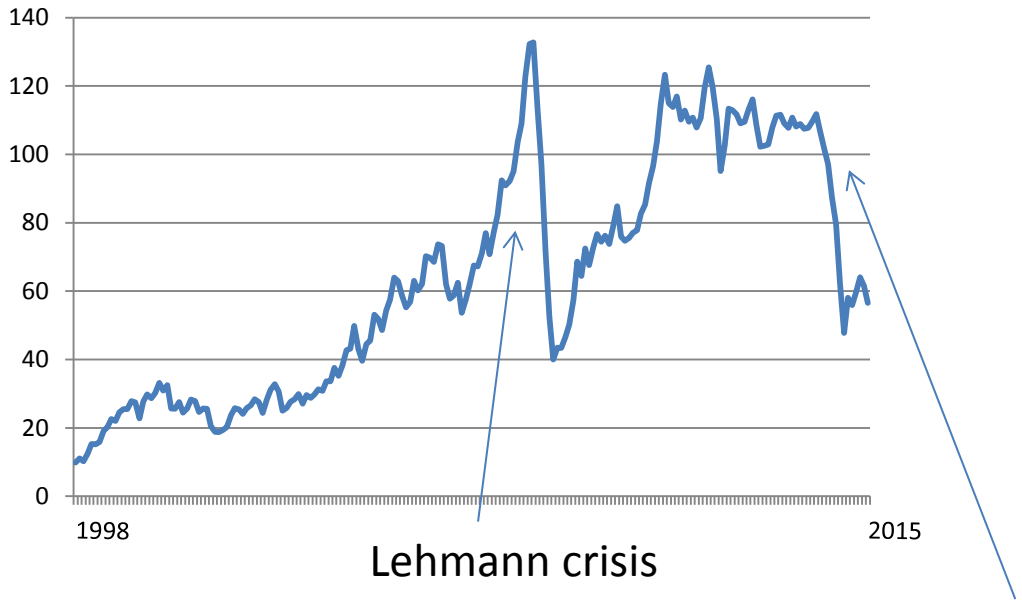


Real oil price:

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

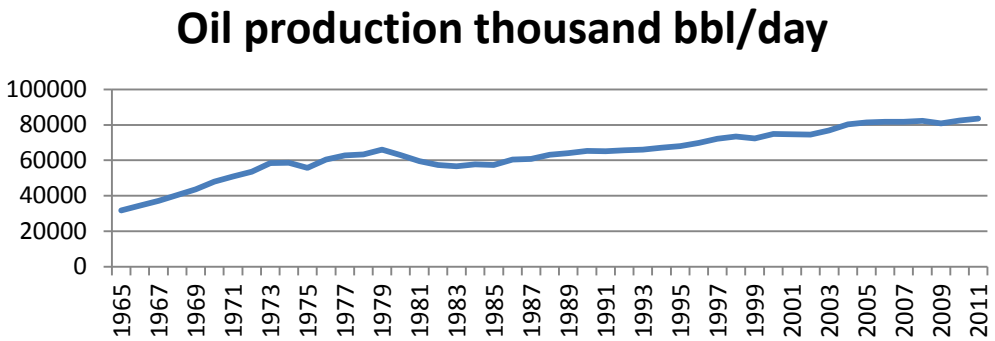
Oil market represents around 5% of world GDP

Oil puzzles

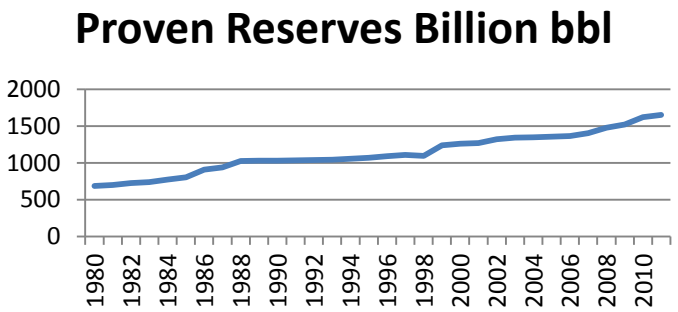


Why did the price fall during 2014?

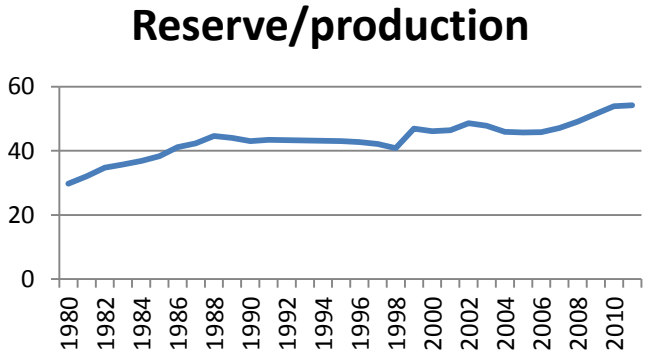
Oil



Production has increased secularly



Proven reserves have increased secularly

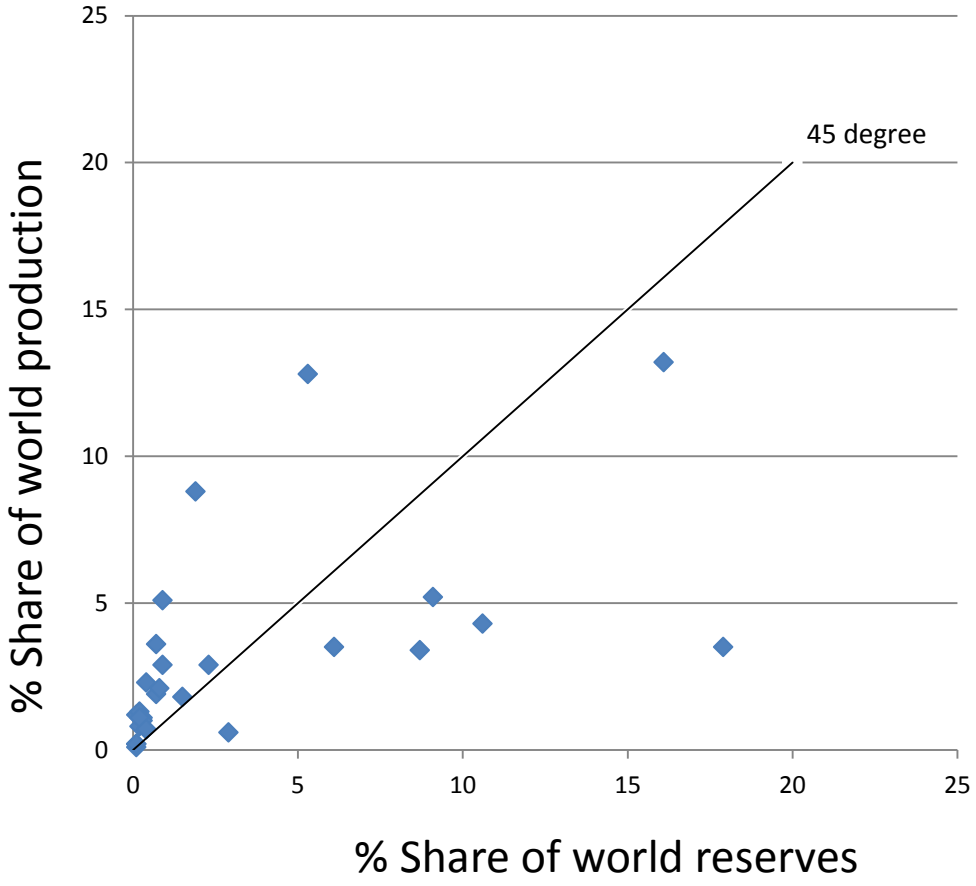


Reserve/production - a common (but crude) measure of scarcity, increased slightly

	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**

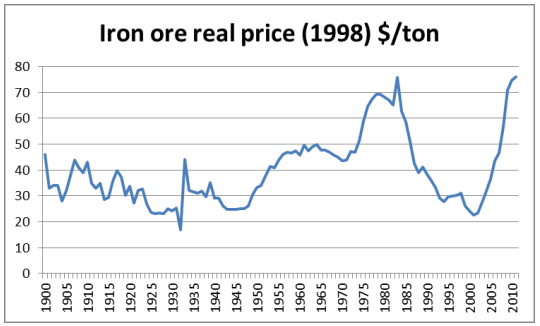
Market structure: Roughly 50 producing countries (not all in table).
Oligopoly (OPEC) with competitive fringe.

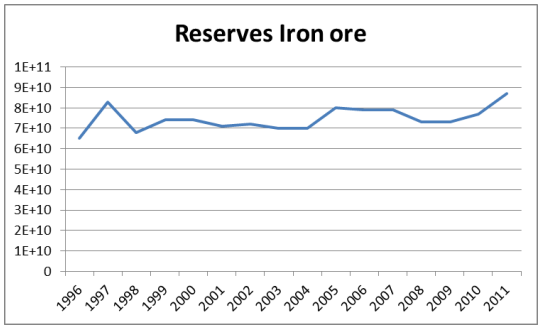
Reserves and production

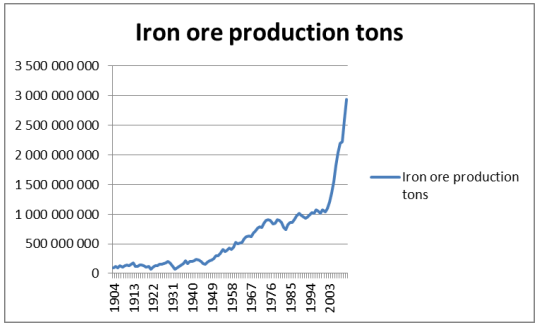


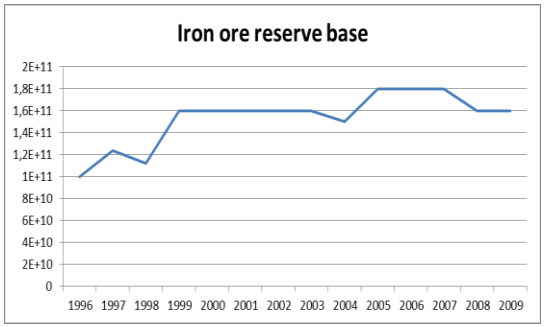
Those with large reserves are producing less intensively than those with small reserves.

Iron ore



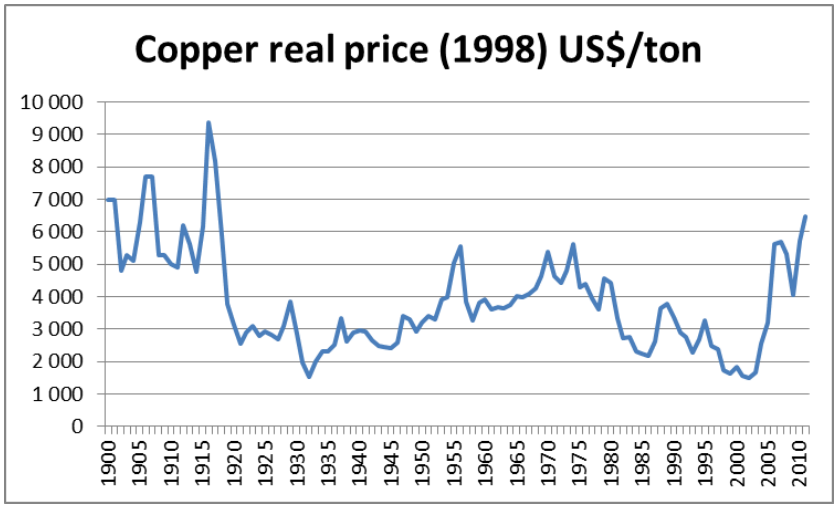


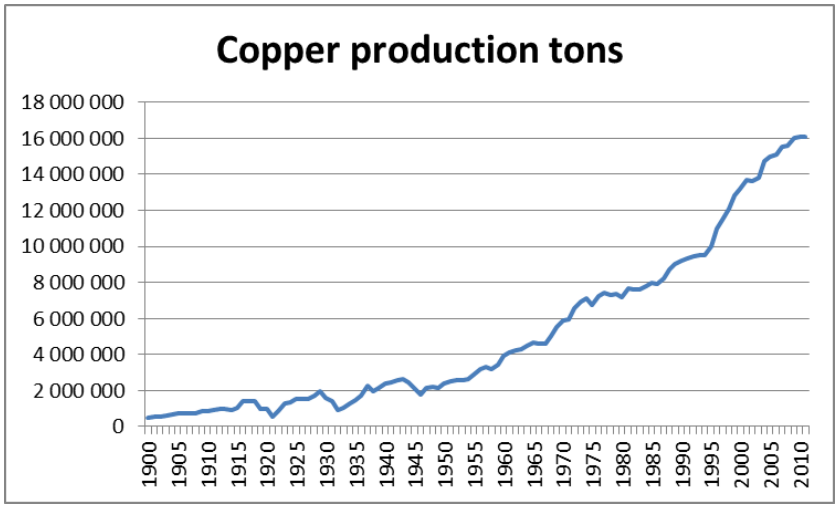




Price: Roughly constant for 50 yrs, hump for 40 yrs, increasing from 2000
Production: Roughly constant but volatile
Reserves: constant
Reserve base ("what can be profitably extracted with future technologies"): increasing
R/P 2011: 57 yrs
Share of world GDP: 0.4%
Market structure: 15 major producing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

Copper





Price: Roughly falling until yr 2000, then increasing

Production: Increasing

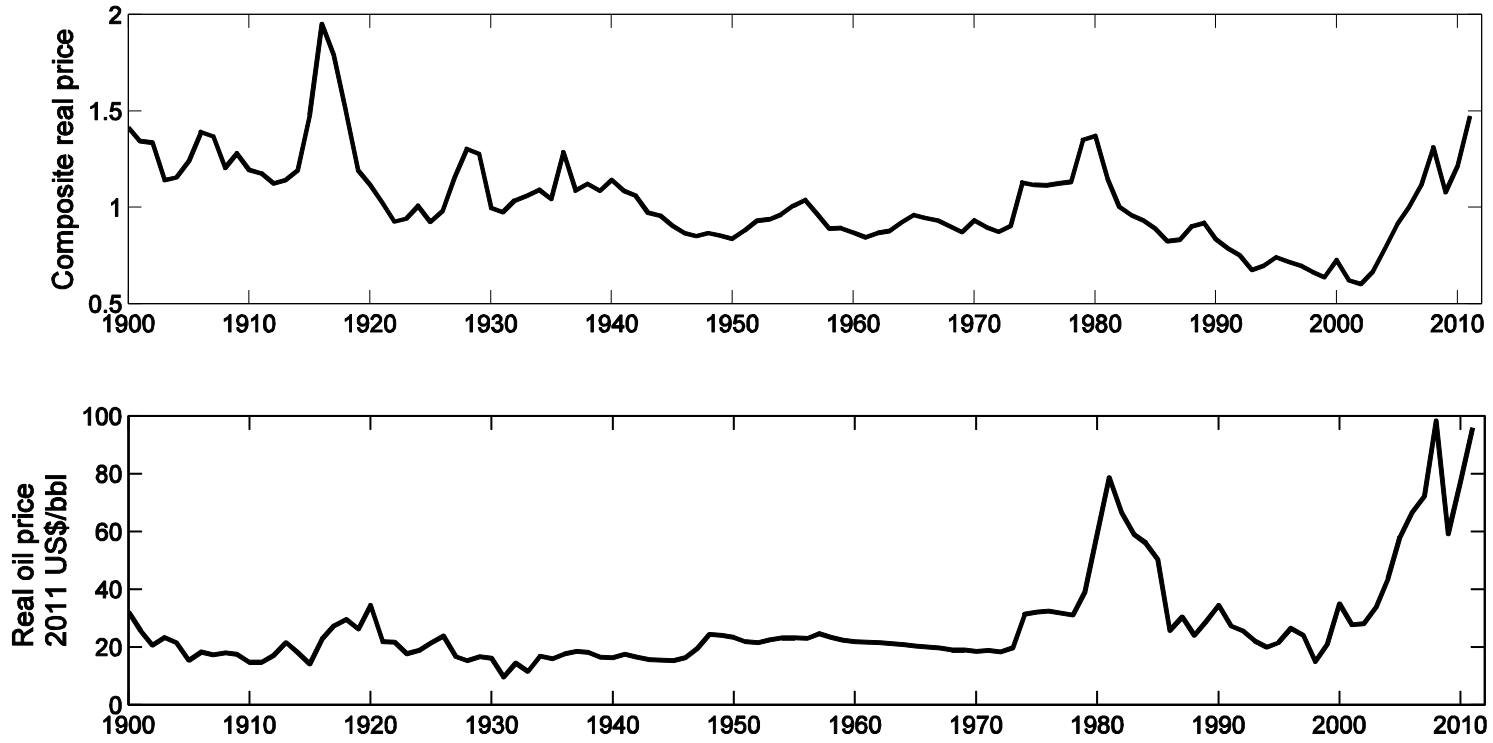
Reserves R/P: 39 yrs

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?

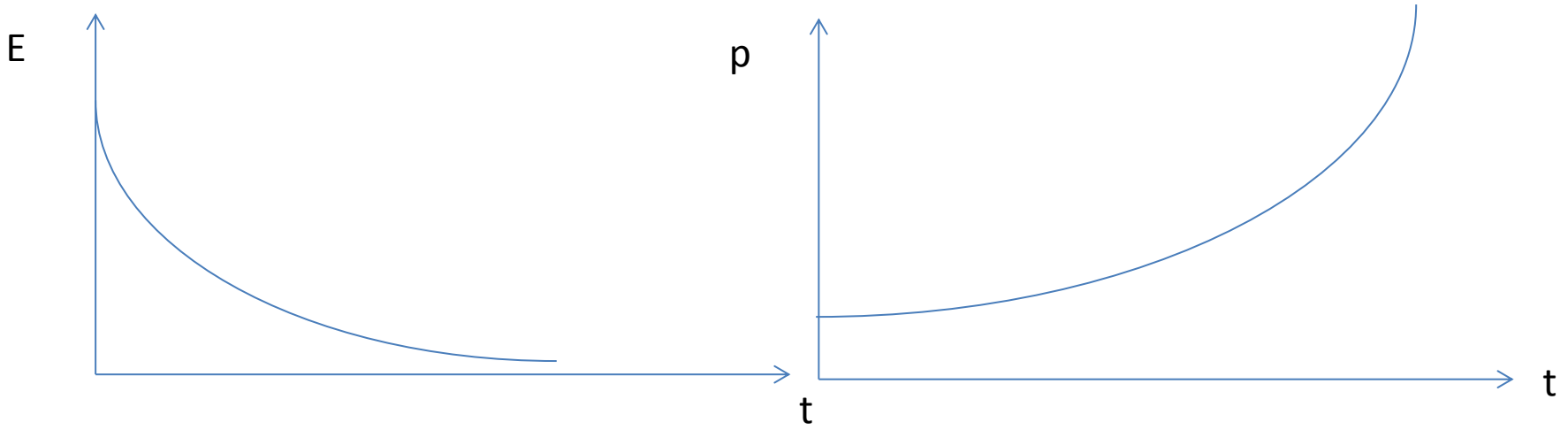
A basic model of exhaustible resources

- 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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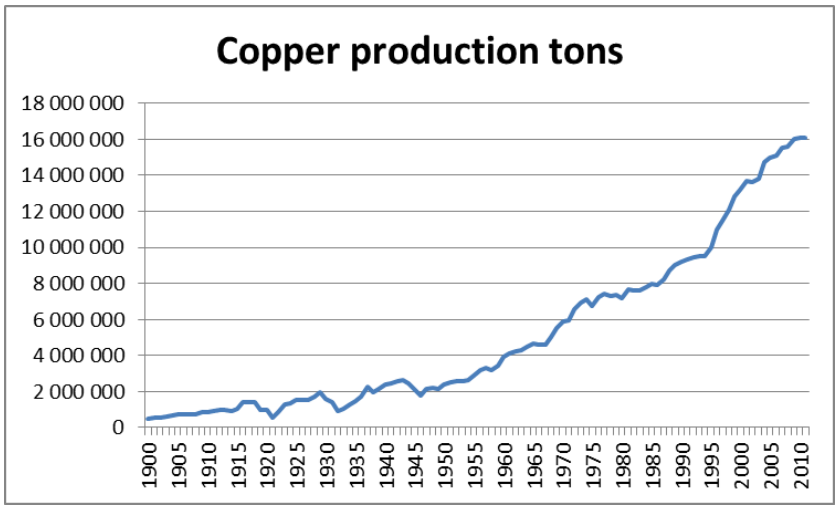
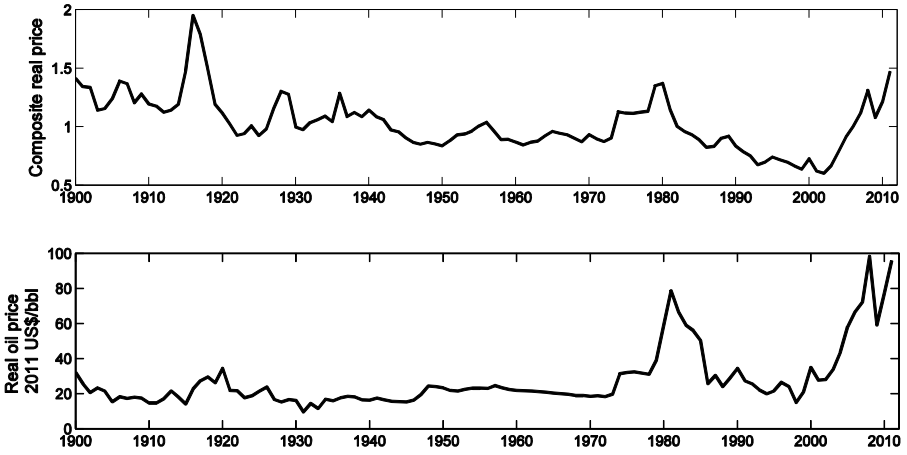




Hotelling + extraction costs

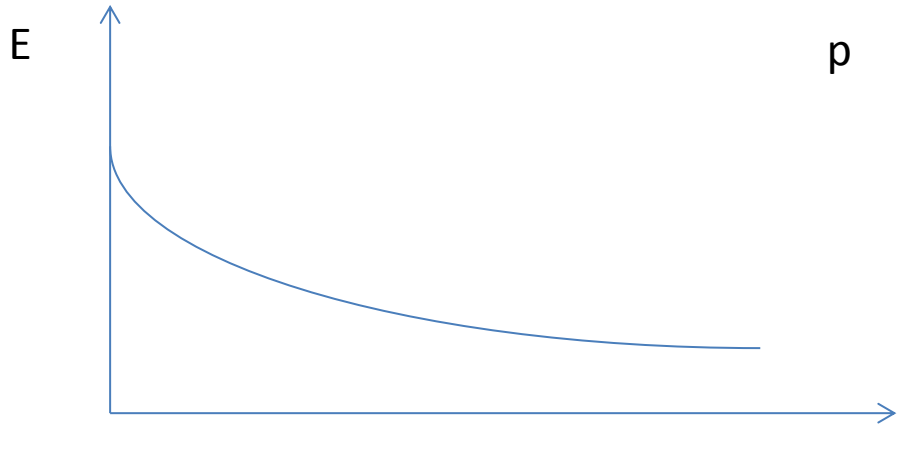
- Weinstein & Zeckhauser (1975)

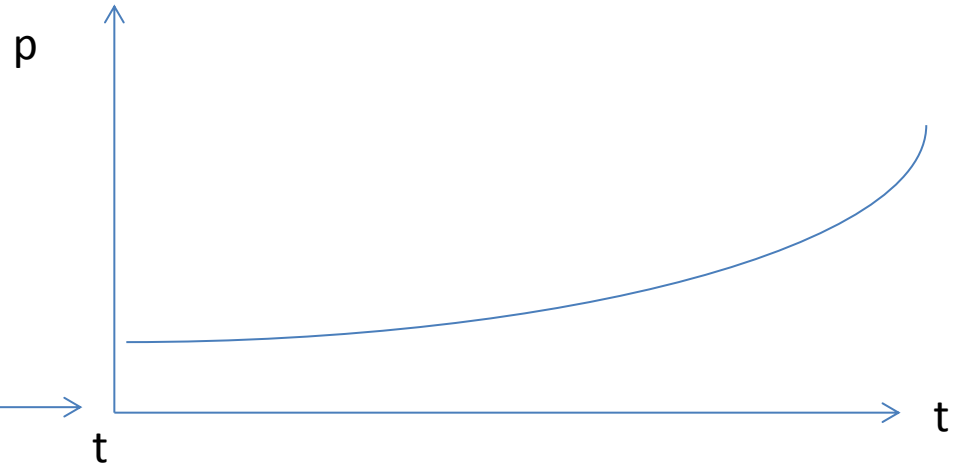
- It costs M(E) to extract E units of the resource in a time period.

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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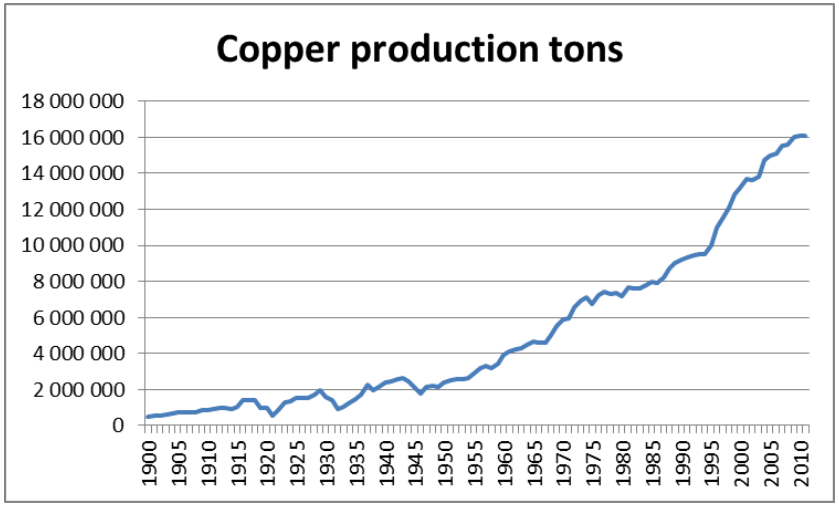
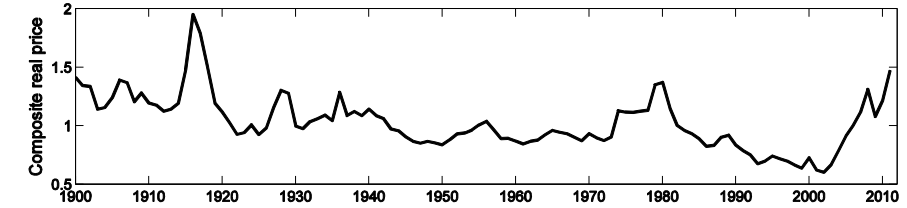
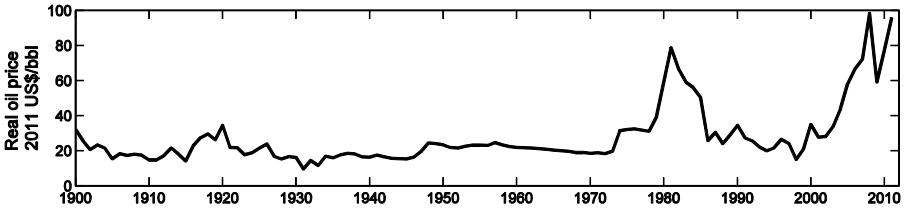






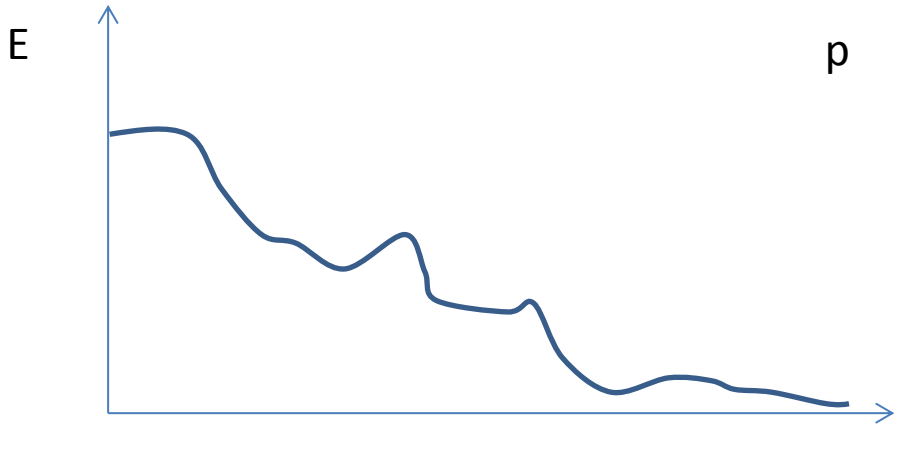
A model of an inexhaustible resource

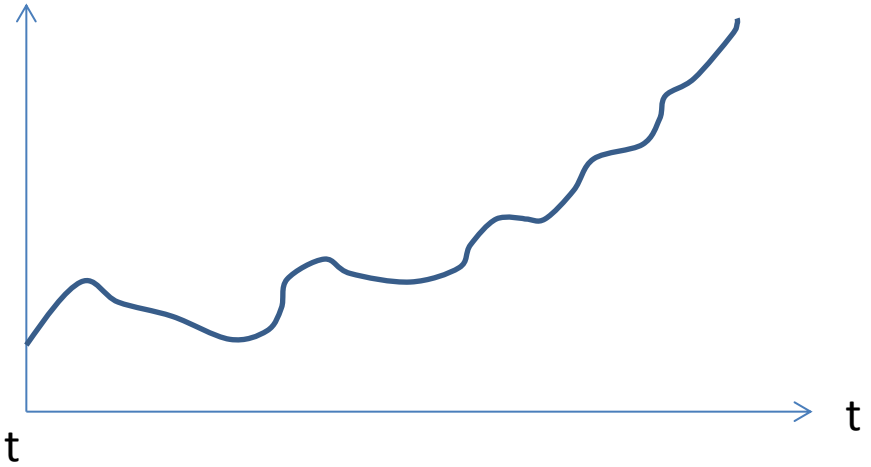
- Farzin (1992)
- There is an infinite amount of the resource.
  - E.g. World resources ("…economic extraction of a commodity from the concentration is currently or potentially feasible") of copper are $3*10^9$ tons → R/P=176 yrs
  - E.g. Lithium Reserves R/P=346 yrs
- But the more that is extracted 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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