Non-Renewable Resources, Extraction Technology and Endogenous Growth

Paper by Gregor Schwerhoff and Martin Stuermer

Discussion by Ryan Decker
Federal Reserve Board

The analysis and conclusions set forth here are those of the author and do not indicate concurrence by members of the Federal Reserve staff or the Board of Governors.

GeorgeMonbiot
@GeorgeMonbiot

You don't need to be a Marxist to oppose capitalism.
You need only be numerate.
It simply does not add up.

Dare to declare capitalism dead – before it takes us all down with it | George Mo...
The economic system is incompatible with the survival of life on Earth. It is time to design a new one, says Guardian columnist George Monbiot
theguardian.com

3:02 AM · Sep 23, 2019 · Twitter Web Client

885 Retweets **2.5K** Likes

Josh Hendrickson
@RebelEconProf

Economists: economic growth results from finding ways to produce the same amount of stuff with fewer resources.

You, an intellectual: economic growth requires infinite resources.

> **GeorgeMonbiot** @GeorgeMonbiot · Sep 23
> You don't need to be a Marxist to oppose capitalism.
> You need only be numerate.
> It simply does not add up.
> theguardian.com/commentisfree/...
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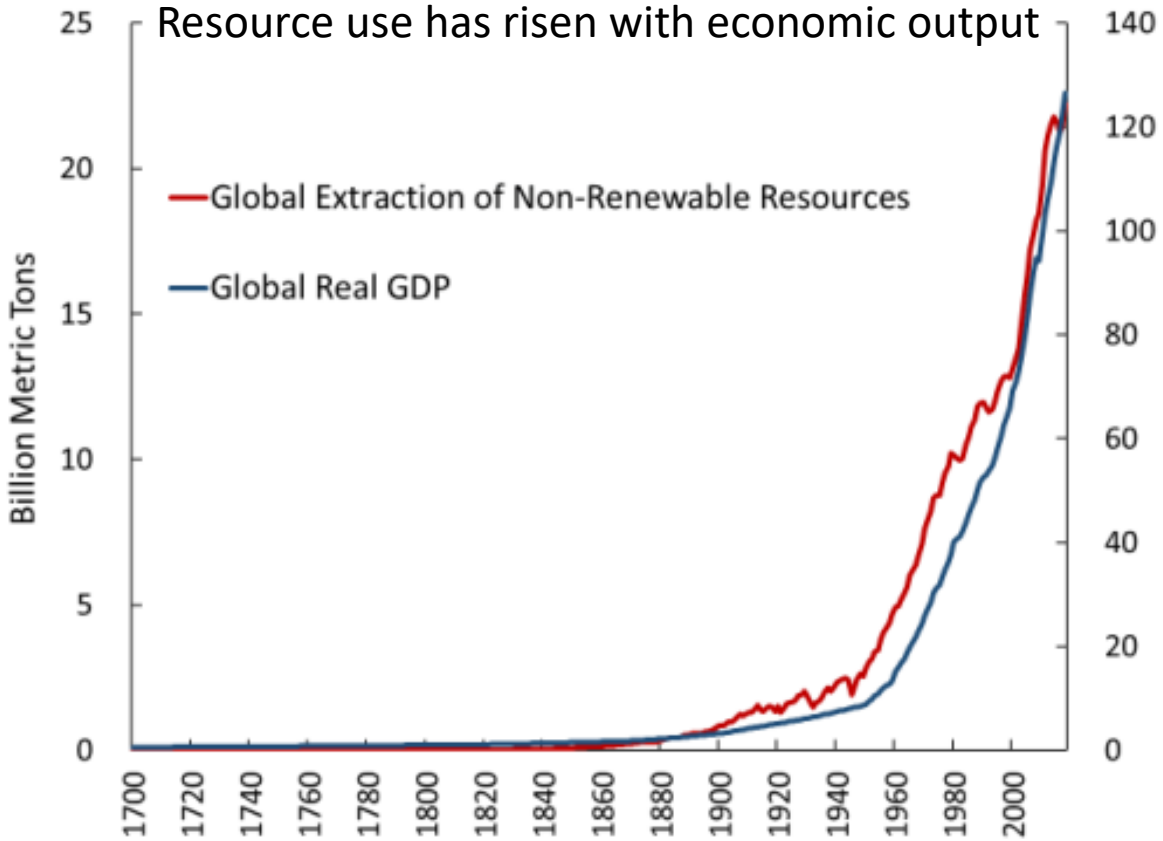
A timely topic

- What limits are imposed on economic growth by non-renewable resource scarcity?
  - One view: continued growth is impossible; capitalism “does not add up”
  - Common economists’ view: We never run out of resources because price will rise
  - Schwerhoff & Stuermer: “A flat long-run aggregate supply curve of fossil fuels and metals is a reasonable assumption”

Empirical motivation

Resource use has risen with economic output



Resource prices have not

Empirical motivation

Resource presence in earth's crust is large relative to current and likely usage

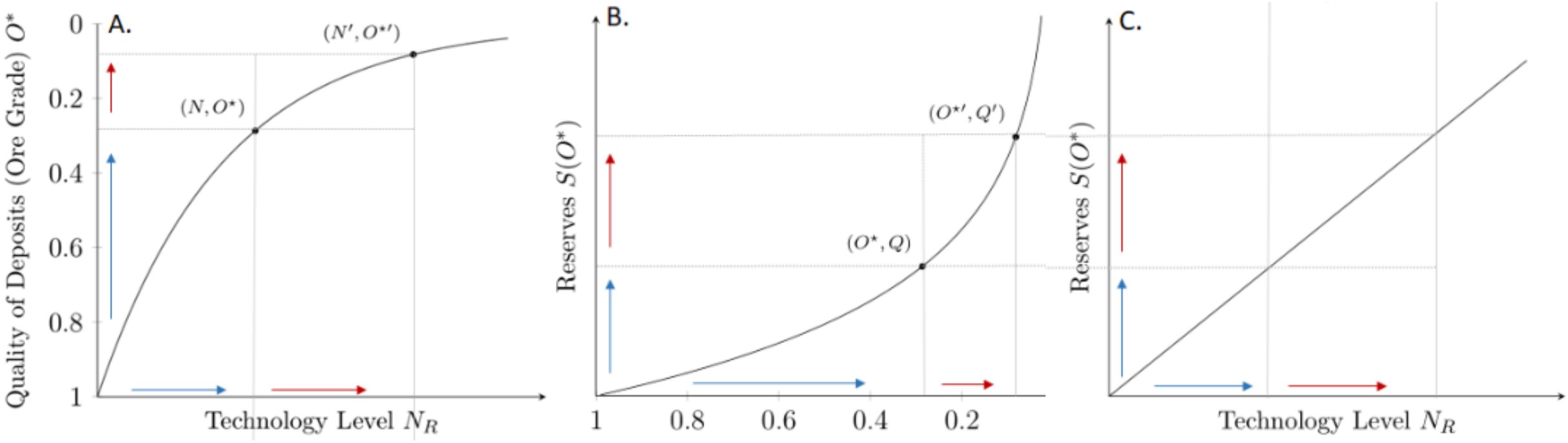
	Crustal Abundance (Bil. mt)	**Reserves** (Bil. mt)	**Annual Output** (Bil. mt)	**Crustal Abundance/ Annual Output** (Years)	**Reserves/ Annual Output** (Years)
Aluminum	1,990,000,000[e]	30[b1]	0.06[a]	491	42[1]
Copper	1,510,000[e]	0.8[b]	0.02[b]	483	26
Iron	1,392,000,000[e]	83[b2]	1.2[a]	580	39[2]
Lead	290,000[e]	0.1[b]	0.005[b]	1,099	16
Tin	40,000[e]	0.005[b]	0.0003[b]	1,405	14
Zinc	2,250,000[e]	0.23[b]	0.013[b]	668	14
Gold	70[e]	0.00005[b]	0.000003[b]	925	15
Coal[3]	15,000,000[f]	511[d]	3.9[d]	558	63[c]
Crude Oil[4]		241[d]	4.4[d]		41[c]
Nat. Gas[5]		179[d]	3.3[d]		34[c]

Model: critical components

Gains in exploitable deposits decline with technology

Gains in reserves increase with difficulty of grade

→ Linear returns of reserves with respect to innovation



Model

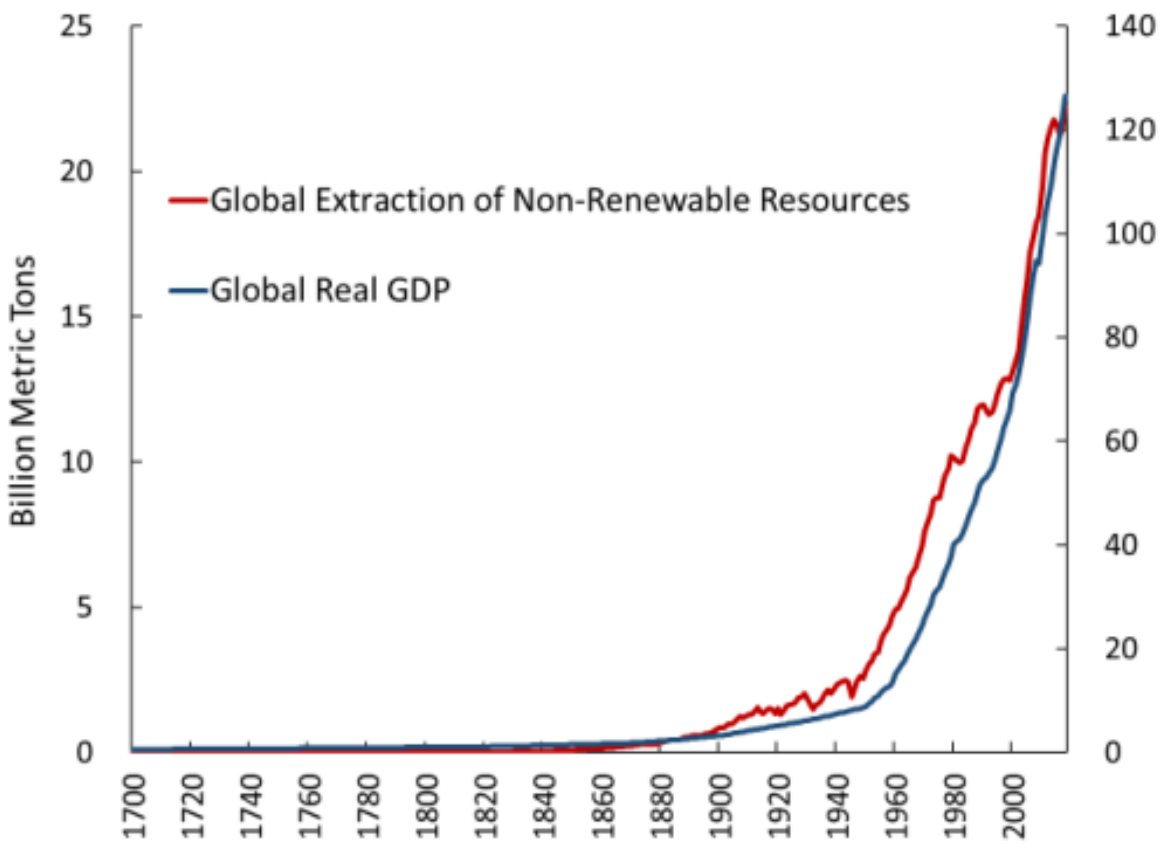
- Embed resource extraction sector in endogenous growth model with directed technological change
  - Decreasing returns of grade to technology
  - Increasing returns of reserves to grade
  - Rate of GDP growth is determined by parameters governing these
- Can generate a constant resource price on a balanced growth path
  - No need for the common “depletion effect”
  - Direction of tech change depends on elasticity of substitution between resources and other intermediates in the economy

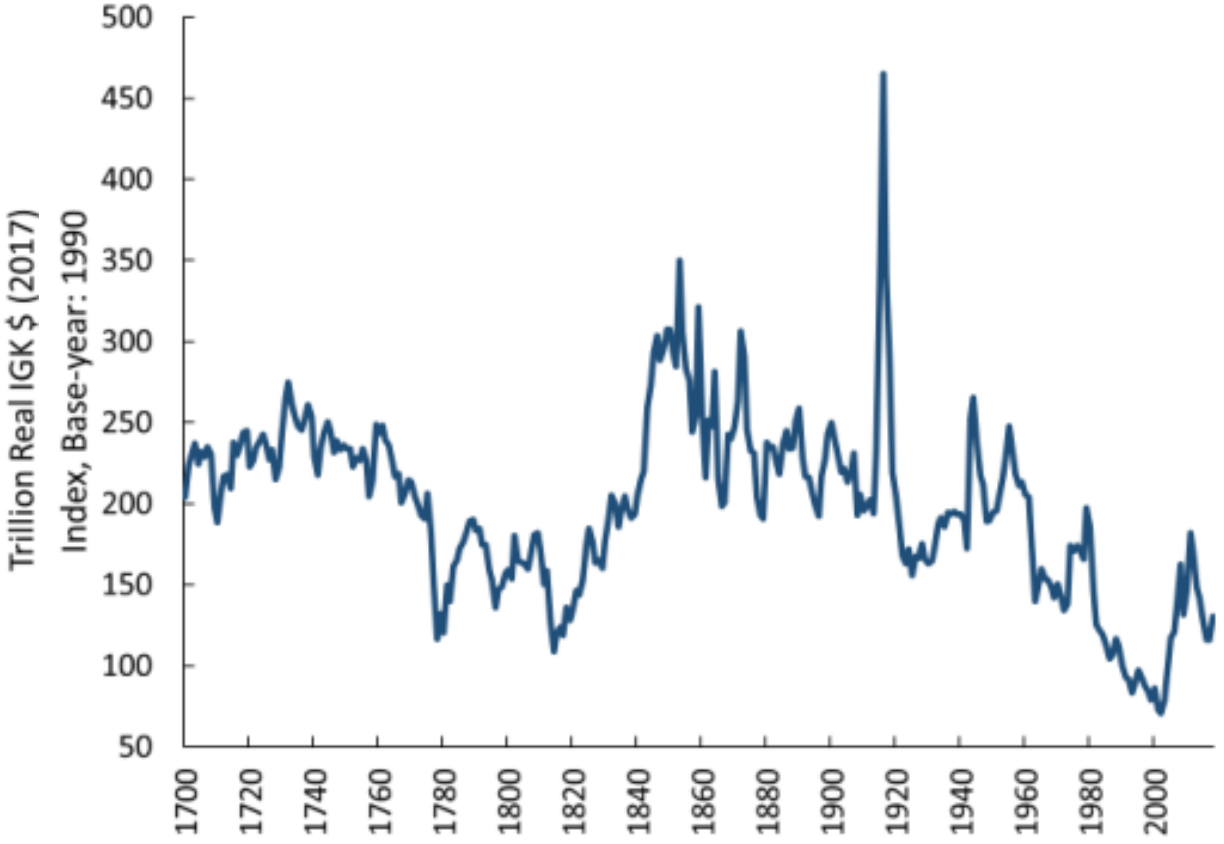
Reactions

- A very thorough paper
  - Significant empirical contribution
  - Useful modeling innovation
- Three comments:
  - Heterogeneity across resources
  - Heterogeneity over time
  - Policy

1. Resource heterogeneity

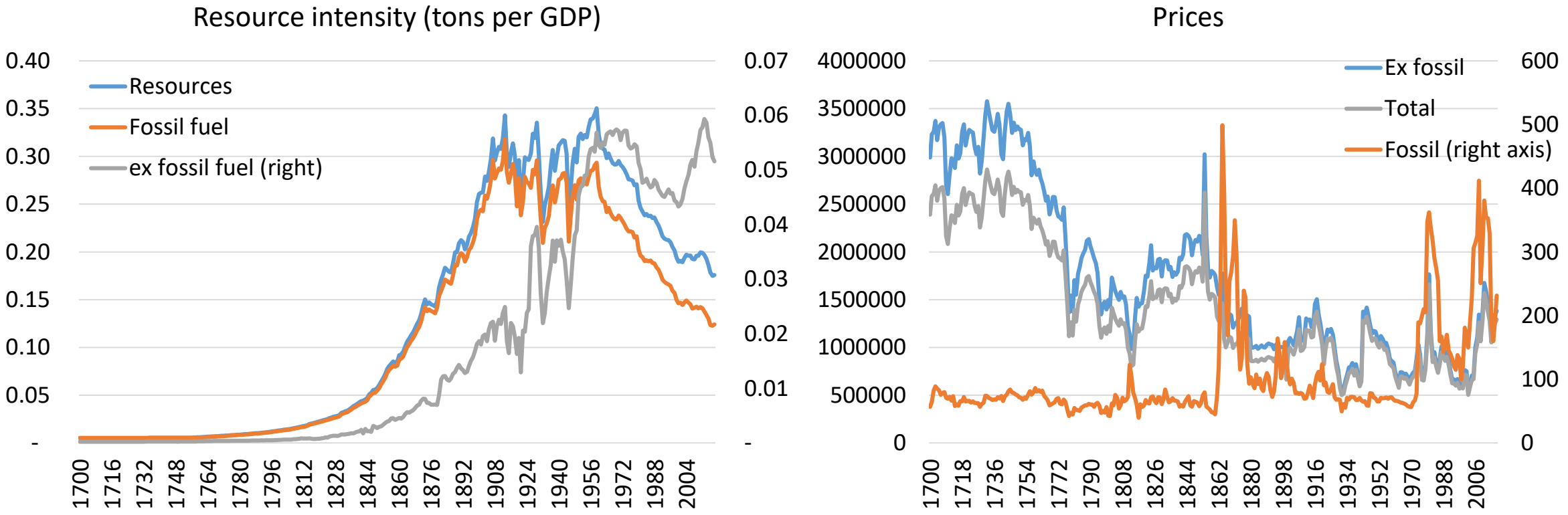
- Main empirical and modeling exercises focus on “resources” as a single factor





1. Resource heterogeneity

- But the different resources have different stories



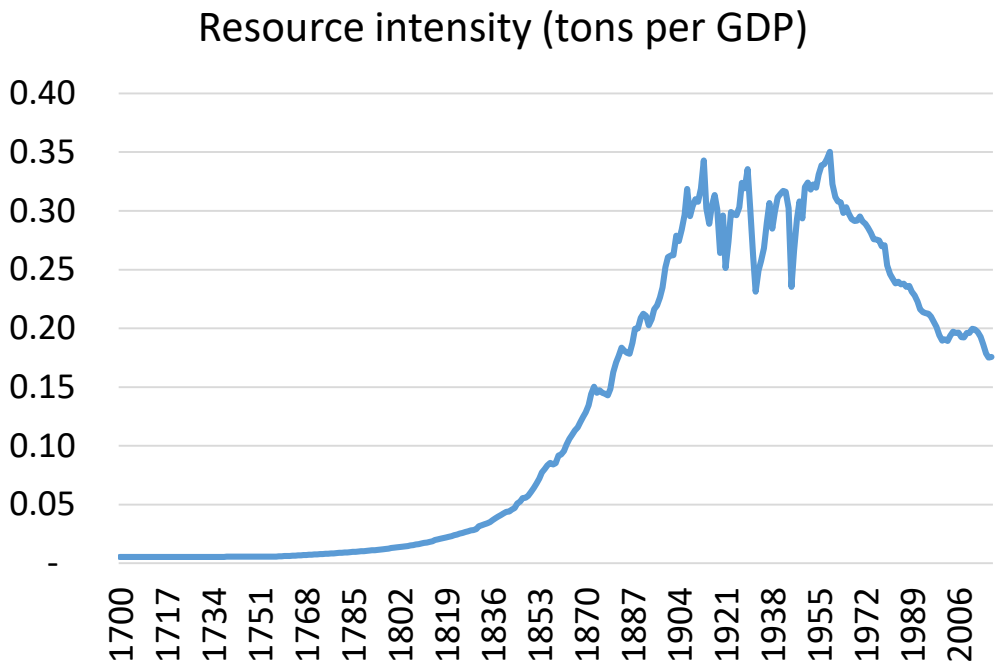
Source: The authors' excellent data packet

1. Resource heterogeneity

- A short two-resource extension buried in Appendix
- But resource heterogeneity matters a lot for how we use the model and interpret the data
  - Are resources complements or substitutes with other intermediate goods?
    - Complements: resource abundance (through returns to grade or tech) → more R&D in other intermediate goods (e.g.: metals and renewables)
    - Substitutes: resource abundance → more R&D in non-renewable resources/less in other intermediates (e.g., fossil fuels and renewables)
  - Different resource intensity of GDP and price patterns across resources
    - What does this imply for empirical values of model parameters?
    - Are some prices rising, consistent with depletionist views?

2. Heterogeneity over time

- General view of paper:
  - Resource use rises with GDP (on balanced growth path)
  - Flat resource prices
- In the data:
  - Resource use:
    - 1700-1900: UP
    - 1900-1950: FLAT
    - 1950-2018: DOWN
  - Prices
    - Trend decline since 1860?
      - (Is this the best price index?)
- Can we combine these facts with the model to draw inference about underlying parameters?
  - Returns to grade?
  - Returns to technology?
  - Can we set up identification? Can the model generate these facts simultaneously?



3. What are policy implications?

- Conclusion hints at policy implications
- A useful next step would be to model these explicitly
  - Including resource heterogeneity
- What is optimal policy if:
  - Some resources create externalities (pollution, climate change)
    - …And some resources are complements with renewables
  - Some resource activities generate positive knowledge/other spillovers
    - (Is there a literature here? Aside from Michael Bay's blockbuster film *Armageddon*)

Thanks