NON-RENEWABLE RESOURCES, EXTRACTION TECHNOLOGY AND ENDOGENOUS GROWTH

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Overview

Technological change involving resource extraction is at the heart of the current boom in oil and shale gas production. It is a not a new phenomenon but has strongly affected the production of all non-renewable resources in the past (see e.g. Managi et al, 2004). Nordhaus (1974) and others argue that technological change helps overcome scarcity by increasing the extractable stock of non-renewable resources.

However, the resource economics literature since Hotelling (1931) primarily builds on the assumption of a fixed-stock. In growth models with non-renewable resources the implied scarcity is primarily overcome by technological change in the use of resources and by substitution by capital. These models typically predict growth in output, decreased non-renewable resource extraction, and increasing prices, but which we do not observe empirically.

Our paper provides stylized facts about the historical trends in technological change, prices, production, and the underlying geology of different non-renewable resources, including crude oil and different base metals, since the beginning of the 19th century. We develop a theory of technological change in the extraction of non-renewable resources and analyze the relationship between long-run technological change, geology, and growth.

Methods

We modify the standard endogenous growth model of expanding varieties and directed technological change by Acemoglu (2002). We add an extractive sector to the model such that aggregate output is produced from a non-renewable resource and intermediate goods. In the extractive sector, firms can reduce their resource stocks through extraction, but also increase stocks through R&D investment in extraction technology.

Results

Our model replicates historical trends in the prices and production of major non-renewable resources such as crude oil and metals, as well as world output. Exponential aggregate output growth triggers R&D investment in extraction technology. The extraction and use of non-renewable resources increase exponentially whereas its price stays constant in the very long run.

We show that under reasonable assumptions the resource stock increases linearly with R&D in extraction technology as two effects offset each other. R&D expenditure increases exponentially in order to make deposits of lower grades extractable. At the same time, the quantity of non-renewable mineral resources in the earth's crust increases exponentially as the grade of its deposits decreases. It follows that there are constant returns from R&D investment in extraction technology.

Conclusions

This paper proposes that R&D investment in extraction technology is helping meet and offsetting increasing demand for non-renewable resources from industrializing countries like China. This makes extraction from deposits of lower grades possible. If historical trends continue, R&D in extraction technology might offset the depletion of current resources. Even if non-renewable resource use and production increase exponentially, resource prices might stay constant in the very long run.

References

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Bibliographies

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