WHAT IS THE OPTIMAL EXHAUSTION PACE OF LITHIUM RESOURCES IN SOUTH AMERICA?

[Diana Roa Rubiano, PhD student, NMBU, +47 9533 1848, diru@nmbu.no]
[Knut Einar Rosendahl, Professor, NMBU, +47 9952 2521, knut.einar.rosendahl@nmbu.no]

Overview

This paper presents a simulation of the global market of lithium, with focus on lithium supply from South America. Lithium is a necessary material in the production of batteries that power electric cars, among other electronic artefacts. The Andean region integrated by Argentina, Bolivia and Chile (The ABC triangle) holds the world's biggest lithium reserves ever known. These countries have the intent to explore their natural resources on its own and in a sustainable way. We will investigate to what extent wealth maximizing strategies of these countries imply a slower global energy transition towards electric cars and other use of batteries for energy storage. Since lithium is a durable and recyclable resource, there is need to know what is the efficient amount of recycling lithium batteries as well. So, what is the optimal exhaustion rate of lithium? Moreover, what is the future role of lithium suppliers for the diffusion of clean energy?

Scholars have extensively analyzed optimal resources depletion. However, as far as we know, there are no previous economic studies about how to estimate the optimal exploitation of lithium resources considering the possibility of recycling. This paper defines an emerging problem for energy transitions and try to fill the gap in existing knowledge about reusing lithium resources.

Methods

A global market for lithium is formulated as a Mixed Linear Complementarity Model - MCP. In order to know what is the optimal exhaustion rate of lithium resources in South America we draw on the economic theory of exhaustible resources. We develop an analytical and numerical simulations (using GAMS) model of the global lithium market under perfect competition and incorporate different assumptions about technological development of electric vehicles, batteries disposability and recycling.

The model is constituted by three building blocks: supply, demand and recycling marketplace. We consider N demand regions and one or two sectors in each region (transport and possibly energy storage in the power market). The demand function depends on lithium prices, income and prices of other goods, where the elasticity of substitution between lithium and other materials or products are important.

On the supply side, we consider M producers (starting with M=4, Chile, Argentina, Bolivia, Rest-of-world). Initially, we assume a competitive supply where each producer considers the prices as given. Afterward, we will consider Cournot supply. Constant unit costs are measured to represent the cost of lithium production. The cost function will change when taking into account both accumulated supply and exogenous technological progress.

In the recycling marketplace, we analyse the efficient amount of reusing lithium by exploring cost of disposal, quality and prices of the recycled material. The efficient amount would define to what extent recycled lithium is a (perfect) substitute of primary lithium. Some environmental costs related to lithium disposal and waste can be included and used to asses to what extent an efficient amout of recycled lithium can be produced automatically by the market without government intervention.

The key assumption of this problem is that lithium is a durable resource. This has two implications: first, the demand of a durable resource is for quantities of stock in circulation, rather than for flows of production (Levhari and Pyndick, 1981). And second, the price of a durable good in any period is a function not only of current and past production, but also of acticipated future production, since that future production and current recycling will affect prices (Stewart, 1980).

The traditional theory of exhaustible resources has focused on deducing what is the optimal extraction path over time for any particular non-renewable resource stock. Only a few papers have focused on the impact of durable exhaustible resources on pricing, inter-temporal production and efficiency conditions (Schulze (1973), Stewart (1980), Levhari and Pindyck (1981) and Chilton (1984)).

The literature provides a discussion on the major characteristics of durable exhaustible resources, and an examination of the models for resources exhaustion regarding different optimization settings, and private and public concerns as well.

The durability of an exhaustible resource can be defined by a group of physical characteristics and, correspondingly, by its demand and supply patterns. In general, a durable exhaustible resource is re-usable at some future date. There is a possibility of “mining” accumulated stocks of waste or scrap minerals to extend the time horizon of resource availability (Schulze 1974). Therefore, there is also an opportunity of supplanting extraction with waste recovery and release tensions about scarcity and dependency concerns. In addition, a durable exhaustible resource does not wear out during the firm’s planning horizon (Stewart, 1980, p.100). So, the purchaser of a durable product would frequently not re-enter the market until his earlier purchase has “worn out” (Ibid.)

The problem of exhaustible and durable resources can lie on scheduling its production (Stewart ,1980). In many industries, including extractive industries, firms may find that their most important competition comes not from other firms’ products, but from their own earlier production. This is due to the existence of efficient second-hand markets or the frequency of purchasing products with long lasting use. However, recycling does not guarantee an increasing availability of resources when taking into account the declining quality of the second hand resource. Weinstein et al. (1974) discuss additional patterns for depletable and recyclable resources. They examine the behavior of markets with depletable resources where market interest rates are determined endogenously with zero cost of recycling and constant costs of extraction.

Results

We resolve how prices of primary and second hand lithium are determined and how lithium companies and other market players behave. We develop a case study of the ABC Triangle of lithium and analyse the challenges of these countries to prosper and survive in the ever-changing international energy system. This paper also includes a discussion about optimal resource extraction, where optimality and sustainability are congruent notions.

Conclusions

This study is important for regulatory reasons and to anticipate challenges for energy transitions as well. On one hand, if lithium production tends to be concentrated, market power may lead to a too slow diffusion of lithium batteries. On the other hand, recycling can be used as a defensive way (behavior) for consumers (importers) against market power. This study can be used to discuss some policy measures for lithium exhaustion and recycling in a circular economy.

References

Chilton, J. (1984). "THE PRICING OF DURABLE EXHAUSTIBLE RESOURCES - COMMENT." Quarterly Journal of Economics 99(3): 629-637.

Levhari, D. and R. S. Pindyck (1981). "The Pricing of Durable Exhaustible Resources." Quarterly Journal of Economics 96(3): 365-377.

Malueg, D. A. and J. L. Solow (1990). "MONOPOLY PRODUCTION OF DURABLE EXHAUSTIBLE RESOURCES." Economica 57(225): 29-47.

Schulze, W. D. (1974). "Optimal use of non-renewable resources - Theory of extraction " Journal of Environmental Economics and Management 1(1): 53-73.

Stewart, M. B. (1980). "MONOPOLY AND THE INTERTEMPORAL PRODUCTION OF A DURABLE EXTRACTABLE RESOURCE." Quarterly Journal of Economics 94(1): 99-111.

Weinstein, M. C. and R. J. Zeckhauser (1974). "Use patterns for depletable and recycleable resources." The Review of Economic Studies: 67-88.