The paradox of the circular economy in the raw materials industry

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Abstract Circular economy has, in the case of some raw materials, its own drawbacks. The principle states that reuse is basic to reduce primary production, thus in a healthy circular economy we should recycle as many elaborated raw materials as possible (in the case of aluminium i.e., tins, window frames, etc). The new products from these sources will then cost less and it appears as if growth could be unlimited as we recycle residues and produce new resources. And statistics should then show that thanks to the new supply from recycling, we will need less raw materials. We are now confronted with the facts that were anticipated by Jevons paradox: an improved efficiency will lower the price of the commodity and because of this; instead of a reduction we see a clear increase in the use of the resource.

1 Introduction

In one of the cases studied in this paper, even though aluminium recycling in Europe has grown from 1962 to 2018 around 2,000 % from 250,000 t to 5.3 Mt and such increase should have produced a direct reduction in the production of primary aluminium (from mining operations and imports), this has not happened. Aluminium mining production has gone from 1,02 Mt to 4.1 Mt, which means a growth of 4,000 %. European aluminium production was 1.49 Mt in 1962 and dropped to 519,000 t in 2018; this meant a reduction to 1/3 of the aluminium production from European sources, which represented 63% in 1962 and dropped to 3% in 2018. A continuous growth in a circular economy framework has produced an effect contrary to the desired. The increase in aluminium demand produced a growth in the primary bauxite source production. Because European sources are more expensive, due to the environmental and social restrictions, it limited the competitiveness of European sources forcing them to either foreclose or delay the opening of new operations, at the same time making imports from outside Europe more competitive.

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2 Jevons Paradox

Blake Alcott summarized in his paper [1] "Ecological economics" the coal question posed by [2] William Stanley Jevons who supported that the gains in technological efficiency, specifically the more "economical" use of coal in engines carrying out mechanical tasks, did in fact increase the general consumption of coal, iron and other resources instead of producing savings as many have stated before. The theory of economic growth of the XX century also considers the technological change as the main reason of the increase in production and consumption although some previous writers such as [3] Hotelling (1931, p. 64) and [4] Domar (1962, p. 605) pointed out that the efficiency, sales, and use of a resource grow together. The current debate was opened by [5] Brookes (1990) and [6] Khazzoom (1980) and followed by [7] Lovins (1988), [8] Saunders, 1992, [9] Saunders, 2000, [10] Schipper and Meyers (1992) , [11] Schipper y Grubb (2000) , [12] Brookes (2000).

Table 1. Relationship between the increase in recycled aluminum and the increase in primary production, from 1962 to 2018 in Europe (in million t)

YEAR	1962	2018	% CHANGE
RECYCLED	250	5303	2121%
PRIMARY PRODUCTION	1020	4099	402%
TOTAL PRODUCTION	1626	16577	1019%

For example, a car that consumes less fuel allows a longer drive. This universally known phenomenon is called "rebound" (or retro feed, devolution or rexpenditure), shown in figure 1. There is a difference between the "direct" rebound effect, "micro" or "own", something that can be measured for goods and services produced in the most efficient way, and the elusive "indirect", "secondary" or "in all the economy" rebound.

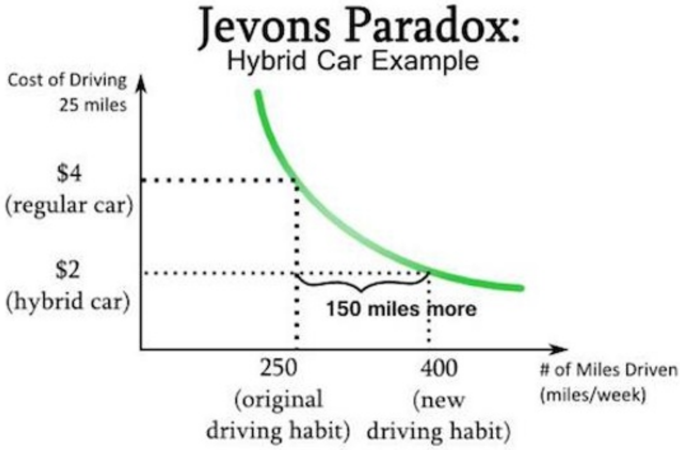

Figure 1: Paradox of a hybrid car. Source: CFO University

To define it, we need to understand the meaning of savings in engineering. Savings in engineering is the difference between two averages: The first one indicates the supply of material/energy by unit of product or service before; and the second one indicates the supply of material/energy by unit of product or service after a reduction in the income per unit produced obtained technologically.

When we multiply the demand previous to the change by the difference of these percentages, we obtain a physical quantity: when the travelling distance in kilometres of the car and the tons of steel can be obtained with a 20% reduction in energy, then 0,20 of the amount of materials consumed previously, produces the real amount of energy that could be saved.

Such gains reduce immediately the consumption of matter and energy inputs for these products, but, as we make more and cheaper products, the demand increases and, in turn, production and consumption also increases. If such increase in demand is bigger enough, more people consume more, no real matter or energy savings are produced, and we find ourselves with a paradox.

The environmental efficiency strategy -to reduce the T factor in the I = PxAxT equation to reduce I this way- must accept this paradox, first identified by Jevons. I = (PAT) is the mathematical notation of a formula put forward to describe the impact of human activity on the environment.

However, the analysis of the rebound shows that maintaining a constant demand is free. The savings are only theoretical because lower costs increase demand. In spite of this, rebound is defined as the rate between the savings of the engineering in % and the new and old consumed quantities, corrected by the change of efficiency.

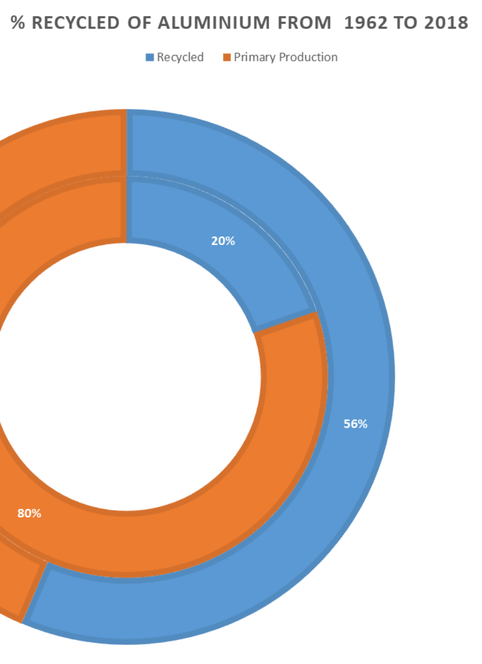

Figure 2: Relationship between the increase in recycled aluminum and the increase in primary production, from 1962 to 2018 in Europe. source: own design

A similar thing happens in the case of raw materials, where the increase in recycling, quite on the contrary to the expected effect, makes the products obtained from them become more competitive in the markets, increasing its fields of applications and in turn, making insufficient the recycling of the obtained products from these raw materials and then increasing the need of new sources of raw materials to cover the demand, as the case of aluminium shows quite clearly. Figure 2 shows the example of the recycled aluminium.

3 Conclusions

Circular economy applied to mineral resources might have economic drawbacks not well evaluated.

In one of the cases studied, even though aluminium recycling in Europe has grown from 1962 to 2018 around 2,000 % from 250,000 t to 5.3 Mt and such increase should have produced a direct reduction of the production of primary aluminium (from mining operations and imports), this has not happened. Aluminium mining production has gone from 1,02 Mt to 4.1 Mt, which means a growth of 4,000 %. European aluminium production was 1.49 Mt in 1962 and dropped to 519,000 t in 2018, a reduction to 1/3 of aluminium production from European sources, which represented 63% in 1962 and dropped to 3% in 2018.

A continuous growth in a circular economy framework will probably produce an effect contrary to that desired. i.e., the increase in aluminium demand produced a growth in the primary bauxite source production. Because European sources are more expensive, due to the environmental and social restrictions, it limited the competitiveness of European sources forcing them to either foreclose or delay the opening of new operations, at the same time making imports from outside Europe more competitive.

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