Introducing material flows into macro-evolutionary models: a study of the circular economy

Abstract

We observe an unprecedented growth in demands for raw materials worldwide, driven by the rapid industrialization of emerging economies and high levels of material consumption in developed countries. During the last century, global materials use increased 8-fold; material intensity measured as the amount of materials required per unit of GDP declined, while materials use per capita doubled. Economists have studied the possibility of de-linking economic activity from energy and material use. Yet, research shows that with the exception of fields of electronics and biotechnology, dematerialization has not been observed. The EU has promoted measures to reduce the material-dependence of the economy. One of such measures is the circular economy, which relies on recovering materials from old products and re-using them as inputs for production for as long as possible.

There are concerns that the circular economy may be conducive to the rebound effect, where energy and material savings from recycling materials are offset by energy use to recover them and by an increase in demand. However, these effects have not been yet examined rigorously using a macroeconomic model. This relates to the fact that raw materials and material demands have been largely ignored in the macroeconomic analysis. Few models that account for flows of raw materials rely on the assumptions of representative agents and equilibrium conditions. They adopt a linear view on consumption-production, where input use is optimized to maximize the GDP growth. This approach does not capture feedback loops involved in the processes of reuse, repair and recycling of products. The aim of this project is to propose a generic macro-evolutionary framework for the analysis of material flows in the economy. Formally, we will extend macro-evolutionary models by input-output tables and material flow analysis. Macro-evolutionary models go beyond a single representative agent. They make use of an agent-based modelling (ABM) technique, where many heterogeneous, boundedly-rational agents interact with each other. Such interactions are characterised by increasing effects, learning and path dependencies. Macro-evolutionary models are used to study macro phenomena emerging from interactions of many boundedly rational agents within networks. They have proved capable of explaining core economic phenomena like economic growth, technological change, and business cycles. In this project, we will develop a generic macro-evolutionary model to study material flows in the economy and a related-set of models to study: (1) the economy-wide consequences of the circular economy, including the rebound effect; (2) the evolution of consumption- and production-based emissions to examine the leakage effect, and (3) the impact of demand for raw materials and on the financial market.