IEooc_Methods3_Exercise1: Dynamic model of the German steel cycle, 1800-2008

Goal: *Develop systems understanding regarding the development of flows and stocks in material cycles, using the example of the steel cycle in Germany. Estimation of steel stocks using dynamic stock modelling.*

This exercise shall make you familiar with dynamic stock modelling and give you and overview of the magnitude of steel use and in-use stocks of steel in society. There is no statistical data on steel stocks for individual countries. That is why they have to be estimated with the help of statistics for steel production, trade, and scrap flows. Estimations are labour intensive as data from a variety of sources have to be gathered and reconciled. Here, calculations shall be performed for a simplified model of steel consumption in Germany.

In the supplied Excel file „IEooc_Methods3_Exercise1_RawData.xlsx" data on estimated final consumption of steel in Germany since 1800 are provided, distributed into the four product categories vehicles, machinery, buildings and infrastructure, and consumer products. Final consumption refers to the steel that enters the in-use stocks in form of machines, vehicles, buildings and infrastructure, or consumer products. Additionally, the following parameters are given: The average life span of the steel-containing items in the four product categories, the share of obsolete products in the end-of-life product flows (end-of-life products that accumulate in obsolete stocks and do not enter the waste management industries), the recovery rate for steel scrap from steel-containing products in the waste management industries, and the historic population.

Solve the following tasks using the given data:

1) Draw a graphical system definition for the consumption, use, disposal, and waste management of steel-containing products!
2) Use the method of dynamic stock modelling that was introduced in the lecture to estimate the in-use-stock of steel by product category as a function of time! Assume normally distributed product lifetimes. (Hint: The problem can be broken down into the following steps: a) Determine the probability distribution of a product leaving the in-use stock for a given product age (Excel-function NORM.VERT or NORM.DIST), b) Calculate, for every year and every age-cohort, the amount of steel leaving the in-use stock. (For equation see lecture, for a suggested scheme see sheet 'Stock model vehicles', Excel-function SVERWEIS or VLOOKUP), c) Calculate the total amount of steel leaving the use phase in a given year by summing up over all age-cohorts, d) Calculate the accumulation of obsolete stocks and the amount of steel scrap recovered from end-of-life products with the given parameters for obsolete stock formation and scrap recovery. Write down a mathematical equation for each calculation step!
3) Evaluate and discuss your results! How large were the per capita steel stocks in the four product groups in Germany in 1850, 1900, 19040, 1970, and 2008? How large were steel stocks in Germany in 2008, total, per product group, and per capita? What is the ratio between steel stocks and steel consumption (unit?)? How do steel in-use-stocks relate to the obsolete steel stocks and steel stocks in landfills?