Input-output MFA as a tool for sustainable management of material stocks with application to capital matrix

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The operation of an economy is supported by the stock of materials in the form of durables such as machinery, equipment, buildings, and structures. With the recent surge in prices of non ferrous metals, we witness an increasing need for proper information about the material content of city mines (stock of durables) as a possible source for material recovery.

The amount of durables or “capital stock” in the economy in time t, say K(t), is usually measured in monetary terms based on the data on capital expenditure, say, I(t),..,I(t-n), some estimates of the rate of depreciation, δ, and the initial value K(0):

$$K(t) = I(t) + (1-\delta)K(t-1).$$

In spite of its wide use, this measure of “capital stock” is of very limited use for sustainable management of material stock (such as metals, plastics, and construction materials) because of its neglect of physical properties such as the mass and material composition. In physical terms, the mass of a durable does not necessarily decrease over time, and the material composition of durables would be different due to changes in technology. In short, for the purpose of sustainable management of physical stocks in the economy, the applicability of the traditional measure based on monetary terms is questionable.

This paper proposes a new method of measuring the stock of durables in terms of the mass of its materials. This method is based on the WIO-MFA method (Nakamura et al. Journal of Industrial Ecology 11-4, 2007). The stock of capital consists of durables of different vintages, the physical composition of which may not be the same. Different industry sectors such as steel mills, petrochemicals, electronics, and car manufacturing, will be characterized by different configuration of durables. We therefore distinguish I(t) by sectors (engaged in investment) and by its composition, as well. This is facilitated by use of the capital formation matrix, C, the i-th row and j-th column element of which denotes the amount of investment for product i by sector j.

Capital stock in monetary terms is not well suited to consider physical differences among its vintages due to differences in the technologies embodied. A simple mass of capital stock neglecting its composition will suffer from a similar problem. Because of its explicit

consideration of material composition, our approach is void of these problems.

The method is applied to the Japanese input-output data with 400 sectors, with 9 types of metals (iron, ferroalloy, copper, zinc, lead, tin, aluminum, silver, and gold) and 8 types of plastics (thermo-setting resins, PE (low), PE (high), PS, PP, PVC, high-performance resins, other resins) occurring as materials. It was found that on average capital formation in year 2000 weighs 430kg per million Japanese Yen (9100 US$) in metals and plastics. Substantial variations exist among sectors: water transportation is the heaviest with more than 1027kg followed by rail transport, while electronics (electric computing equipment, application device, and measuring instrument) and air transport weigh less than 190kg.