Disaggregating the Steel Sector in MRIO: Global Supply Chain Variations in BF-BOF and EAF Steelmaking

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Global crude steel production in 2023 is estimated at approximately 1,900 million tons. SMS Group predicts that iron and steel demand will increase by 24% from 2024 to 2050. Steel is essential to daily life, with 52% of global steel products used in buildings and infrastructure and 12% in automobiles. This indicates the widespread use of iron and steel across industries. In 2023, about 280 million tons of steel were traded through global supply chains (GSCs), representing 15% of total steel usage that year.

However, the iron and steel sector is a major CO2 emitter, with direct emissions estimated at 2.6 billion tons of CO2, accounting for 7% of global CO2 emissions. These emissions arise from domestic final demand, such as household consumption, and global final demand from sectors like construction and automotive. Identifying CO2 emission hotspots in GSCs within the steel sector is crucial for reducing sector-wide emissions.

Many studies have analyzed CO2 emissions from GSCs using multi-regional input-output (MRIO) tables. However, conventional MRIO frameworks aggregate crude steel production and steel products into a single sector, failing to capture differences in steelmaking processes. The blast furnace-basic oxygen furnace (BF-BOF) and electric arc furnace (EAF) methods differ significantly in raw materials (BF-BOF: coke; EAF: steel scrap) and applications (BF-BOF: structural frames for buildings, infrastructure, and automobile bodies; EAF: rebar and steel plates). These distinctions result in significant differences in environmental impact and supply chain structures.

This study clarifies GSC differences between BF-BOF and EAF and variations in GSCs among countries using the same steelmaking technology. A key contribution of this research is the use of TransitionZero's Global Steel Cost Tracker (GSCT) to disaggregate the steel sector in GLORIA for six countriesâ€"China, India, Japan, South Korea, Russia, and the United Statesâ€"into four subsectors: pig iron, basic oxygen furnace (BOF), electric arc furnace (EAF), and steel products.

This study utilizes 2021 GLORIA MRIO data, covering 164 countries and 120 sectors. To expand the steel sector into four subsectorsâ€"pig iron, BOF, EAF, and steel productsâ€"the following data sources were used: (1) global steel production data and BF-BOF to EAF ratios from the World Steel Association, (2) country-specific steel production cost data from GSCT, including raw materials (coke, direct reduced iron [DRI], iron ore, scrap), energy (electricity, fuel), labor, and other costs, and (3) Japanâ€™s 2015 input-output table, which disaggregates the steel sector similarly.

Our findings highlight key differences in intermediate input structures between BF-BOF and EAF. In the BF-BOF process, iron ore and coke dominate intermediate inputs, accounting for over 70%. In contrast, in the EAF process, electricity and wholesale/retail trade contribute approximately 25%, demonstrating significant structural differences. A comparison of Japan and Chinaâ€™s BF sectors shows that China sources about 50% of its iron ore domestically, while Japan imports approximately 96% of its iron ore, underscoring Japanâ€™s heavy reliance on imports.

Across countries, BF-BOF consistently depends on iron ore and coke, but EAF input structures vary significantly. In Japan, domestic retail and electricity sectors rank among the top three input sources for EAF. In Russia, domestic gas supply and natural gas extraction are among the largest inputs. These differences likely stem from technological and resource variations. Japanâ€™s EAF primarily relies on steel scrap, whereas Russiaâ€™s EAF incorporates direct reduced iron (DRI) produced with reducing gas, leading to substantial differences in input structures.

These findings emphasize that steelmaking method selection impacts raw material use and that input structures vary significantly across countries, even within the same steelmaking process. By leveraging GSCT data, this study successfully disaggregates the steel sector in GLORIA by steelmaking method, revealing distinct input structures and cross-country differences. The results contribute to a better understanding of GSC-related CO_2 emissions and provide insights for policymakers and industry stakeholders seeking to reduce emissions in the steel sector.