

QUESTION: Suppose Korea imports a lot of Copper from the rest of the world in UN Comtrade HS code for raw copper. But that copper is value-added in the Korean economy by a lot of different sectors - electronics, cars, munitions, batteries etc. How can we use input-output tables to estimate what share of the imported copper is used for different uses? ([my grok prompt here](#))

ANSWER:

Use Input-Output (IO) tables to trace embodied imported copper through supply chains to final uses. Input-Output tables (from sources like OECD TiVA, WIOD, Eurostat, or Korea's Bank of Korea / K-Statistics) are ideal for this because they map inter-industry flows, including how a raw material like copper is used as an intermediate input across sectors and ultimately embodied in final outputs (electronics, vehicles, batteries, munitions, construction, exports, etc.).

Core Idea

Imported raw copper enters the Korean economy primarily as intermediate inputs to the "Basic Metals" sector (or a specific copper products sub-sector) or directly to fabricators. These sectors then supply other industries. The Leontief inverse (total requirements matrix) lets you propagate the copper requirements backward from final demand categories or forward from the copper input.

Step-by-Step Approach

1. Align Data Sources

- Map UN Comtrade HS copper imports (e.g., 7401–7405 for ores, concentrates, unwrought/refined copper) to the IO industry/commodity classification (ISIC Rev. 4 or KSIC used in Korean tables).
- Get a recent Korean IO table (ideally with 100+ sectors for granularity: electronics, motor vehicles, machinery, fabricated metal products, electrical equipment, etc.).
- Prefer tables that separate domestic vs. imported intermediates (many modern tables do, or provide import shares by sector).

2. Prepare the Matrices

- A = Domestic technical coefficients matrix (intermediate inputs from domestic suppliers / total output).
- M = Import coefficients matrix (imported inputs / total output), or at least the row/vector for copper imports.
- x = Vector of total industry output.
- y = Vector of final demand (by category: household consumption, investment, government, exports — and ideally by product).
- Identify the copper row/column (e.g., sector "Manufacture of basic metals" or a more detailed "Copper" commodity).

3. **Calculate Total Copper Requirements (Embodied Flows)** The fundamental equation is the Leontief model: Total output required = $(I - A)^{-1} y$ For imported copper specifically:

- Let m_c be the row vector (or scalar if highly aggregated) of imported copper input coefficients (imported copper per unit of output of each sector).
 - Total imported copper embodied in final demand = $m_c \times (I - A)^{-1} \times y$
4. This gives you the total imported copper attributed to each final demand category (e.g., exports of electronics, domestic car consumption, battery investment, etc.).
- 5. Break Down by Sector / Use**
- By producing sector: Multiply the copper input coefficients by each sector's output to see direct use (e.g., how much copper goes directly into electronics assembly vs. wire & cable vs. auto parts).
 - By final product group: Use the Leontief inverse columns for key sectors (electronics, motor vehicles, batteries if available, other transport, machinery, construction, defense/munitions if separated). This captures direct + indirect use.
 - By end-use category: If the IO table has final demand broken down by product (e.g., "Computers and electronic equipment", "Motor vehicles", "Other transport equipment"), you can allocate shares directly.
- 6. Example interpretation:**
- 35% of imported copper ultimately embodied in electronics & semiconductors exports.
 - 25% in motor vehicles (batteries + wiring + components).
 - 15% in batteries/energy storage.
 - X% in munitions/defense (often under government final demand or specific machinery).
- 7. Refinements for Accuracy**
- Import proportionality assumption: If only total (not imported-by-sector) data is available, assume imported copper is distributed in the same proportion as total copper inputs across using sectors.
 - Multi-regional IO (MRIO): Use OECD TiVA or similar to better distinguish Korean domestic production vs. foreign value-added, though for raw copper imports this is less critical.
 - Capital stock / investment: Copper in batteries or infrastructure often appears in gross fixed capital formation (GFCF) — treat investment as a final demand category.
 - Scrap/recycling: Standard IO tables usually treat secondary copper separately or ignore it; you may need to adjust manually using trade data on scrap.
 - Update for recent years: IO tables are often lagged; combine with recent Comtrade import totals and sectoral output data to scale.

Practical Tools & Data Sources

- Bank of Korea or Statistics Korea IO tables (most detailed for Korea).
- OECD ICIO / TiVA database (good for international comparisons and import content).
- WIOD (World Input-Output Database).
- Software: Python (pandas + numpy for matrix inversion), R, or specialized tools like PyIO or GAMS.

- For visualization: Create a “copper flow Sankey diagram” showing imports → basic metals → fabricating sectors → final products.

Limitations

- Aggregation: Copper may be buried inside “Basic Metals” — disaggregation helps.
- Assumption of fixed coefficients: Reality has substitution (e.g., aluminum for copper), but good for medium-term shares.
- Direct imports by end-users: Usually minor for raw copper.
- Munitions/defense: Often classified under government spending or specific sectors; may need supplemental data.

This method is standard in “embodied resource” or “material footprint” studies (e.g., similar to how researchers calculate embodied CO₂, water, or rare earths). With a reasonably detailed Korean IO table, you can get credible percentage shares of imported copper going into electronics, automotive/EVs, batteries, and other uses. If you have access to a specific table year or want help with matrix formulas in code, provide more details.