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7-Digit Product-level SUTs & IOTs using ASI Data

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Overview

1. Introduction: Why SUTs & IOTs Matter
2. Methodology Part 1: Generating Input & Output Flows
3. Methodology Part 2: From SUTs to Symmetric IOTs
4. Mathematical Transformation: Industry Technology Assumption
5. Analytical Power: The Leontief Inverse
6. Estimation Part 1: DVA & FVA in Production/Exports
7. Estimation Part 2: Employment Linkages
8. Analysis of India's Mobile Phone Sector (NPCMS 4722200), 2016-2021
9. Conclusion & Way Forward

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- A summarised version is published in Economic Survey 2023-24 (Ch. 10, p. 360)

Why SUTs & IOTs Matter

- **Context:** The System of National Accounts (SNA 2025) underscores the centrality of SUTs and IOTs (Chapters 15 & 36) for contemporary economic analysis and policy-making, especially in the era of global value chains.
- **Relevance:** These tables are indispensable tools for understanding complex economic structures, tracking inter-sectoral flows, and analysing the impacts of policies or shocks. They help address modern challenges like digitalisation and climate change.
- **This Paper's Contribution:** Constructs highly granular, 7-digit product-level SUTs and symmetric IOTs for India (2016-2021) using ASI microdata. This offers unprecedented detail compared to previously available tables.
- **Key Focus:** Methodology for table construction, transformation using the Industry Technology Assumption, and application to analyse Domestic Value Added (DVA) and employment linkages, particularly through a case study of the mobile phone sector.

Generating Input & Output Flows (1)

- **Foundation:** Input and output flows are meticulously mapped using National Product Classification for Manufacturing Sector (NPCMS) codes (7-digit) and National Industrial Classification (NIC) sector codes (5-digit).
- **Challenge & Solution:** Reconciling different classification systems (NPCMS for manufacturing inputs/outputs, NIC for others) requires a robust NPCMS-NIC concordance.
- **Data Sources & Aggregation:**
 - **Registered Manufacturing:** Uses detailed data from ASI Blocks I, H, F (inputs) and J, G (outputs). Data is aggregated to NIC-sector codes. Unidentified inputs (e.g., "other basic materials") are consolidated. Unidentified inputs (e.g., "other basic materials") are consolidated.
 - **Unregistered Manufacturing:** Uses product data-assigned sector codes via concordance; linked to KLEMS results for time consistency (2016-17 to 2021-22).

Generating Input & Output Flows (2)

- **Input Flow Matrix (Use Table):** Captures inter-industry transactions at purchaser prices. Rows show product utilisation, and columns show industry inputs. Includes raw materials, chemicals, and maintenance supplies. Requires careful allocation (manual balancing) for unidentified items.
- **Output (Make) Matrix:** Details industry-specific product outputs, consolidating registered and unregistered sectors. Organised as an industry-by-product matrix. Combined with production flows from primary/service sectors. Uses same data sources as input flows.

From SUTs to Symmetric IOTs (1)

- **The Transformation Problem:** SUTs are often rectangular (more products than industries). Converting them to square, symmetric IOTs (product-by-product or industry-by-industry) requires assumptions about production technology.
- **SUT Framework (Conceptual - UN Handbook):**
 - **Supply Table:** Shows product supply from domestic industries (Make Matrix, V^T) and imports (m), summing to total supply (q). $q = V^T i + m$ (where i is a summation vector).
 - **Use Table:** Shows product use as intermediate consumption by industries (U , broken down by domestic U_d and imported U_m) and final demand (Y , domestic Y_d and imported Y_m), plus value added W by industry, summing to total industry output (g^T).
 $g = U i + W i$; $q = U i + Y_d + Y_m$.

Integrated Supply and Use Framework

	Industries	Output	Imports	Supply
Products	V^T	x	m	q
Output	g^T			

Supply Table

	Industries	Final use	Use
Domestic products	U_d	Y_d	x
Imported products	U_m	Y_m	m
GVA	W		w
Output	g^T	y	

Use Table

	Domestic products	Industries	Final use	Total
Domestic products		U_d	Y_d	x
Imported products		U_m	Y_m	m
Industries	V			g
GVA		W		w
Total	x^T	g^T	y	

Integrated Supply and Use Framework

From SUTs to Symmetric IOTs (2)

- **Technology Assumptions:**

- **Product Technology:** Assumes a unique input structure for each product, regardless of the producing industry.
 - **Think:** steel requires the same inputs whether made by a primary steel mill or as a secondary product elsewhere.
- **Industry Technology:** Assumes a unique input structure for each industry, applied proportionally to all products it makes.
 - **Think:** a chemical plant uses its specific input mix, proportionally allocated across its primary chemicals and any by-products. Often considered suitable for by-products.

- This paper uses the Industry Technology Assumption.

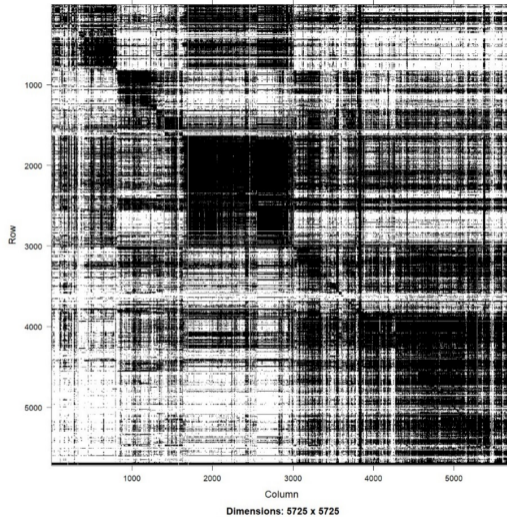
Industry Technology Assumption (1)

- **Objective:** Convert industry-by-product (Make) and product-by-industry (Use) data into a product-by-product matrix (A)
- **Key Matrices & Vectors:**
 - U : Intermediate Use Matrix (product-by-industry)
 - V : Supply/Make Matrix (industry-by-product)
 - g : Column vector of gross industry output
 - x : Column vector of gross product output
 - W : Row vector(s) of value added components

Industry Technology Assumption (2)

- **Steps (Following Mahajan et al., 2018; Eurostat, 2008):**
 1. **Product Mix Matrix (C):** Share of each product in an industry's total Output.
 - **Equation:** $C = V^T(\hat{g})^{-1}$ (where \hat{g} is the diagonalized vector g).
 2. **Transformation Matrix (T):** Converts industry inputs to product inputs under industry technology assumption.
 - **Equation:** $T = C^T$.
 - If C is industry-by-product; typically T would be related to market shares or similar.
 - This effectively assumes an industry's input structure applies proportionally to all products it makes.
 3. **Input Coefficient Matrix (A):** Input product i required per unit of output product j . Core of the product-by-product IOT.
 - **Equation:** $A = UT(\hat{x})^{-1}$.
 4. **Value Added Coefficient Matrix (R):** Primary inputs per unit of product output.
 - **Equation:** $R = WT(\hat{x})^{-1}$

Structure of 7-digit Product-level IOT



The Leontief Inverse

- **The Symmetric IOT (Matrix A):** Represents the direct input requirements per unit of product output. It preserves the fundamental economic identities from the SUTs.
- **The Leontief Inverse:** The cornerstone of IO analysis.
 - **Equation:** $(I - A)^{-1}$, where I is the Identity Matrix and A is the domestic input coefficient matrix (A_d if distinguishing imports).
 - **Interpretation:** The $(I - A)^{-1}$ matrix captures the total (direct and indirect) input requirements needed across the entire economy to produce one unit of final demand for a specific product.
 - **Applications:** Enables powerful analysis of Economic interdependencies, Output, value-added, and employment multipliers, Impact analysis of policy changes or external shocks (e.g., changes in exports, investment), Tracing Global Value Chains (GVCs), etc.
- **Hawkins-Simon conditions (necessary and sufficient):** all principal minors of $I - A$ are positive (original Hawkins-Simon conditions) \equiv the leading principal minors of $I - A$ are positive (economical Hawkins-Simon conditions) \equiv all eigenvalues of A are less than 1 in absolute value

Estimating DVA & FVA in Production/Exports (1)

- **Objective:** Quantify the Value added domestically through production and export activities, tracing backward linkages.
- **Methodology (Veeramani et al. 2023; Veeramani and Dhir 2022):** Uses the Leontief inverse framework.
- **Core Equation:** $dva = v(I - A_d)^{-1} \hat{X}$
- **Components:**
 - dva : $(1 \times n)$ vector of DVA embodied in production/exports for each sector n .
 - v : $(1 \times n)$ vector of direct value-added-to-output ratios for each sector.
 - $(I - A_d)^{-1}$: Leontief inverse based on the domestic coefficient matrix (A_d). A_d shows domestic input i per unit of output j .
 - \hat{X} : $(n \times n)$ diagonal matrix of production or exports for each sector n .

Estimating DVA & FVA in Production/Exports (2)

- **FVA:** Calculated by subtracting DVA from gross exports.
- **Core Equation:** $fva = \hat{X}i - dva$ (where i is a summation vector, assuming X is exports).
- **Decomposition:** Total DVA ($\sum dva_j$) can be broken down into:
 - **Direct DVA** (dva_d): Value added within the exporting sector itself.
 - **Indirect DVA** (dva_{bw}): Value added generated in upstream sectors supplying inputs (backward linkages).
 - **Example:** Mobile exports generate DVA in the chip/plastics/machinery sectors.

Estimating Employment Linkages (1)

- **Objective:** Estimate the number of direct and indirect jobs (and associated wages) supported by production/exports.
- **Methodology:** Parallels the DVA estimation, focusing on labour inputs.
- **Core Equation:** $e = l(I - A_d)^{-1} \hat{X}$
- **Components:**
 - e : $(1 \times n)$ vector of jobs supported by production/exports in each sector.
 - l : $(1 \times n)$ vector of employment coefficients (labour/output ratio) for each sector. Can represent different employment types.
 - $(I - A_d)^{-1}$: Leontief inverse (as before). A_d is the domestic coefficient matrix.
 - \hat{X} : Diagonal matrix of production or exports.

Estimating Employment Linkages (2)

- **Decomposition:** Total employment ($e = \sum e_j$) is decomposed into:
 - **Direct Employment (e_d):** Jobs within the producing/exporting sector.
 - **Indirect Employment (e_{bw}):** Jobs created in upstream sectors supplying inputs (backward linkages).
 - **Example:** Mobile exports create jobs in the steel, plastics, and machinery sectors.
 $e_{bw} = e - e_d$.
- **Key Insight:** Employment embodied in exports can exceed total employment in the exporting sector because it includes indirect effects.
- **Data Sources Used in Paper:** ASI (organised sector), KLEMS (organised + unorganised), and NSSO (unorganised) for the period 2016-2021. ASI provides the basis for SUTs/IOTs. The distinction between domestic/imported inputs in ASI-derived tables is crucial.

India's Mobile Phone Sector (NPCMS 4722200), 2016-2021

- **Context:** A key sector for India's manufacturing ambitions (Make in India, PLI schemes). Analysis compares averages for 2016-18 vs 2019-21 to identify shifts (potentially linked to policies like NPE 2019).
- **Output & Trade Dynamics:**
 - **Output Growth:** Significant increase, average up 66% (\$19.7B to \$32.7B).
 - **Import Substitution:** Imports decreased; average value down 41% (\$3.1B to \$1.8B). The imports/Output ratio fell from around 30% to 5.7%.
 - **Export Surge:** Explosive growth; average value up 554% (\$0.67B to \$4.38B). Exports/Output share rose from 1.3% to 16.4%.

Value Addition (DVA vs FVA) (1)

- **DVA Trends:**

- Direct DVA (ASI) grew significantly (avg. +118%) but remained a small share of Output (1-6%).
- Indirect DVA grew even faster (KLEMS: +501%, ASI: +223%), suggesting strengthening domestic linkages.
- Total DVA (KLEMS) grew 327%; ASI Total DVA grew 155%.
- **Puzzle:** DVA share of Output peaked in 2019 then dipped slightly (ASI), while KLEMS showed a higher share (around 25% in 2019). It warrants methodological review.

Value Addition (DVA vs FVA) (2)

- **FVA Trends:**

- Direct FVA share decreased, but average Value still rose 11%.
- Indirect FVA surged (+507%), indicating continued reliance on imported components/inputs.
- The total FVA average rose 29%, but its share of output fell (90% to 70%).

- **Value Added in Exports:**

- DVA share: Rose dramatically from around 9% to 30% (avg. value +1846%).
- FVA share: Declined from around 91% to 70% (avg. value still +416%).
- **Key Finding:** A significantly larger portion of export value is now generated domestically.

Employment & Wages (1)

- **Overall Employment:** Significant growth; average total employees +75% (583k to 1.02M). Export-related jobs surged +411%.
- **Composition Shifts:**
 - **Contractualization:** Contractual workers (+138%) grew much faster than Regular Workers (+22%).
 - **Female Participation:** Total female workers (+52%) grew much faster than male (+6.7%). Female share in direct regular jobs rose, though it peaked pre-2021.
 - Non-workers vs. Workers shares remained relatively stable.

Employment & Wages (2)

- **Wage Trends:**

- Average total wages (KLEMS) +33%
- Wages for Contractual Workers surged +311%, far outpacing Regular Workers (+89%).

- **Backward Linkages (Inputs):**

- **Domestic:** Services (Trade, Business, Financial, Construction, Rental), wires, plastic/metal parts, PCBs, ICs. Trade Services (F11) significant.
- **Foreign:** Cellular parts (4740100 still notable), transmission apparatus, various electronic components (PCBs, ICs, LCDs), batteries, plastics.

Conclusion & Way Forward (1)

- **Methodological Advancement:** The paper presents a framework for constructing high-resolution (7-digit) SUTs and IOTs for India using ASI data aligned with SNA guidelines. This is a significant empirical contribution.
- **Key Findings (Mobile Sector Data Case Study):**
 - Strong output growth, import substitution, and export surge.
 - Increased DVA, particularly its share in exports (9% to 30%), though overall DVA/FVA dynamics are complex.
 - Substantial employment growth (+75% avg.), driven heavily by exports (+411% jobs).
 - Major shifts in labour structure: rise of contractual work (+138%) and increased female participation (+52%).

Conclusion & Way Forward (2)

- **Policy Relevance:** These detailed tables provide a critical foundation for evidence-based policy analysis regarding industrial strategy, GVC integration, and employment impacts.
- **Limitations & Future Research:** The Industry Technology Assumption was used; exploring alternatives could be valuable. Applying the framework to other sectors.
- **Final Thoughts for Discussion:** How can these granular tables help policymakers design targeted interventions to deepen domestic value addition further and promote quality job creation in sectors like electronics? What further research is needed to fully understand the long-term implications of the observed shifts in labour composition and wages?