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7-digit Product-level Supply-Use and Input-Output Tables Using ASI Data

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Abstract: This paper constructs 7-digit product Supply-Use Tables (SUTs) and symmetric Input-Output Tables (IOTs) for the Indian economy using microdata from the Annual Survey of Industries (ASI) for the period 2016-2021. We outline the methodology for generating input flows and reconciling registered and unregistered sector data via NPCMS-NIC concordance. The transition from SUTs to IOTs is explained using the Industry Technology Assumption. We apply this framework to analyse the economic impact—specifically Domestic Value Added (DVA) and employment influenced by production and exports. A case study of India's mobile phone sector reveals significant output growth, import substitution, an increase in exports, a shift in DVA/FVA shares, notable employment growth, with a leaning towards contractual labour, and increased female participation. These tables are valuable for analysing sectoral interdependencies and industrial policy effectiveness in India.

Keywords: Supply-Use Tables (SUTs), Input-Output Analysis, Annual Survey of Industries (ASI), Manufacturing Sector, Domestic Value Added (DVA), Employment Linkages, Backward Linkages, Mobile Phone Industry, NPCMS, KLEMS, Industry Technology Assumption

Introduction: The System of National Accounts 2025 (SNA 2025) emphasises the importance of the Supply-Use and Input-Output Tables, located in Chapters 15 and 36, respectively, highlighting their role in policy-making within the context of global value chains. These tables are vital for tackling modern challenges, such as digitalisation and climate change, and they aid in assessing national economies and their interrelations, especially when refining data metrics over the last twenty years. In compiling input-output statistics, it is essential to consider the attributes and methods of symmetric input-output tables during the creation of supply and use tables. Effectively structuring and organising these tables can provide a valuable database for national accounts, enabling efficient data conversion to symmetric input-output tables (Eurostat, 2008). A recommended three-step process includes compiling supply and use tables, preparing input-output data for analysis, and calculating standard analytical results, highlighting the growing trend towards utilising these tables in economic analysis (Thage & Ten Raa, 2007).

Generation of input flow matrices, make matrix and associated matrices (UN, 2015; National Accounts Statistics, 2012a; UN, 2008)

Input and output flows across sectors are meticulously established using National Product Classification for Manufacturing Sector (NPCMS) codes for manufacturing and NIC sector codes for all other sectors. When NPCMS codes are used for input products, they are converted to NIC sector codes through a developed NPCMS-NIC concordance, ensuring reliable results you can trust. Input and output flows for registered and unregistered manufacturing industries are separately analysed using detailed NPCMS input data from ASI and KLEMS results. Detailed ASI results (2016- 22) for the registered manufacturing sector are available in our directory, organised by ASI item codes. Data records are aggregated to NIC-sector codes for both industries and products using the concordance of (i) NIC Industries (5-digit)-NIC sectors and (ii) NPCMS products (7-digit)-NIC sectors, considering NIC sector coverage.

Input flow Matrix

Registered manufacturing aggregates data from Blocks I, H, and F by industry sub-group, including outputs from Blocks J and G. Products are classified into NIC sectors, consolidating sub-groups with unidentified inputs, such as "other basic materials" and "other chemicals." Unregistered manufacturing utilises product data and assigns sector codes through concordance tables; uncoded products are assigned NIC codes. Adjustments convert data from 2016-17 to

2021-22, linking unorganised manufacturing to KLEMS. Combined flows of registered and unregistered manufacturing yield total sector flows.

The input flow matrix connects primary and service sectors, categorising 5,000 products. Final demand vectors fall outside these inter-industry transactions. The input flow at purchaser prices reveals inter-industry flows. Sectoral gross value added appears below total industry inputs, forming a transactions table with totals reflecting product utilisation. Column sums indicate industry output at ex-factory prices, while row sums detail inter-industry totals. Row totals may not align with column totals after balancing, revealing product-by-industry transactions and emphasising the need for independent industry classification by output. Input flow includes raw materials, chemicals, and maintenance supplies. Other chemicals are redistributed among sectors. Maintenance materials link closely to construction, while machinery maintenance is connected to specific components through sector transfers. Manual balancing allocates unidentified items to their respective sectors.

Output Matrix

To balance the table, outputs are classified by industry and product, as shown in the Make matrix. Output flows for registered and unregistered manufacturing industries are derived from coded output data and consolidated into a single matrix for the entire sector. The same data sources for input flows are used for industry-specific product details, organised into an industry-by-product matrix by merging output from both manufacturing sectors and production flows from primary and service industries.

The Input-Output Table (IOT) is balanced to ensure that discrepancies between generated and estimated totals do not exceed 5 percent. Estimated row totals include distributive margins added to product outputs from the Make Matrix. The Absorption and Make matrices are key to the input-output system, enabling product-to-product or industry-to-industry tables under various technology assumptions. This report focuses on the product-by-product matrix, assuming industry technology.

Mathematical Expression on the Methodology of Construction of Input-Output Tables (Mahajan et al., 2018; National Accounts Statistics, 2012b; Eurostat, 2008)

The transition from the potentially rectangular SUTs (where the number of products often exceeds the number of industries) to a square IOT requires careful mathematical treatment and explicit assumptions about production technology. This paper provides a concise mathematical

exposition of this transformation process, clarifying the underlying identities, assumptions, and algebraic manipulations involved.

The Supply-Use Framework and Fundamental Identities

The SUT framework comprises two interlinked tables, as illustrated conceptually in the UN Handbook's figures. The Supply Table shows the supply of products by domestic industries (output, possibly including secondary products) and imports. Refer to the UN Handbook's figure of the Supply Table for a simplified structure and a matrix representation involving the Make matrix. V^T (output of products by industry), total product output x , total imports m , and total supply q . The table shows the use of products as intermediate consumption by industries and by final demand categories (consumption, investment, and exports). It also incorporates components of value added by the industry. See the UN Handbook's Figures of Use Table for a simplified structure and a matrix representation involving intermediate use of domestic (U_d) and imported (U_m) products, final use (Y_d, Y_m), value added (W), and total industry output (g^T).

Mathematical Transformation to Input-Output Tables

Transforming SUTs into a symmetric IOT (as illustrated in the UN Handbook's figure of product-by-product simplified IOT) involves converting industry-by-product and product-by-industry information into either a product-by-product or industry-by-industry matrix. This requires assumptions about production technology. Product Technology Assumption assumes that each product has a unique input structure, regardless of the industry in which it is produced. Industry Technology Assumption assumes each industry has a unique input structure, regardless of its product mix. This is often considered suitable for by-products. Hybrid Approaches combine elements of both assumptions.

Let us focus on the Industry Technology Assumption, as outlined by Mahajan et al. (2018). We need to derive input coefficient matrices. Let U be the total intermediate use matrix (sum of U_d and U_m if distinguishing domestic/imports, or the total use table if not), V be the Supply (or Make) matrix (rows = industries, columns = products), W be the row vector(s) of value added components, g be the column vector of gross industry output, and x be the column vector of gross product output. Superscript T denotes transition, and the use of superscript $^{\wedge}$ indicates the diagonalisation of a vector.

Product Mix Matrix (C) represents the share of each product in an industry's total output. $C = V^T (\hat{g})^{-1}$. (Note: UN handbook uses V^T For the Supply matrix, where rows are industries and columns are products. The Transformation Matrix (T), under the assumption of industry technology, facilitates the conversion of industry-based inputs into product-based inputs. It is given by $T = C^T$. This assumes an industry's input structure applies proportionally to all products it makes. Input Coefficient Matrix (A) represents the amount of input product i required per unit of output product j. $A = UT(\hat{x})^{-1}$. A rigorous derivation requires careful dimension tracking based on the specific SUT layout. Input coefficients value added Matrix (R): Represents primary inputs per unit of product output. $R = WT(\hat{x})^{-1}$. The resulting matrix A forms the core of the product-by-product IOT, satisfying the identity: Total Input = Total Output for each product.

Analytical Implications

The choice of transformation assumption (Industry vs. Product Technology) is not neutral and depends on the nature of secondary production and data availability. Once the IOT is constructed, represented primarily by the coefficient matrix A, the standard Leontief inverse $(I - A)^{-1}$ can be calculated. This inverse encapsulates the total direct and indirect input requirements necessary to satisfy one unit of final demand for each product, enabling powerful analyses of economic interdependencies, multipliers, and the impact of policy or external shocks – analyses that are more complex to perform directly on the SUTs. The mathematical transformation ensures that the fundamental economic identities holding in the SUTs are preserved consistently within the derived IOT framework.

Input-Output Methodology for Estimating Output/Export-Supported Domestic Value Addition, Jobs, and Wages/Salaries (Veeramani et al. 2023; Veeramani and Dhir 2022)

The Input-Output (IO) approach is a quantitative economic technique that illustrates interdependencies between sectors of a national economy. It illustrates how one industry's output can serve as the input for another, tracing the flow of goods and services. Estimating domestic value addition (DVA) and job creation through production and exports involves analysing backward connections. This uses a vector of value-added-to-output ratios, a diagonal matrix of sectoral exports, and the inverse Leontief matrix to measure product uses.

The formula estimates the Domestic Value Added (DVA) embodied in exports from n Sectors using the equation: $dva = v(I - A_d)^{-1}\hat{X}$. Where v is a $(1 \times n)$ Vector containing the value-

added-to-output ratio for each sector. \hat{X} is an $(n \times n)$ diagonal matrix representing production or exports from n Sectors. $(I - A_d)^{-1}$ is the inverse Leontief matrix, which measures the total direct and indirect uses of each product by each sector. Domestic Coefficient Matrix A_d is a $(n \times n)$ matrix where each element a_{ij} indicates the amount of domestic input from the sector i required to produce one unit of output in the sector j . Identity Matrix I is a matrix with ones on the diagonal and zeros elsewhere. It facilitates the inversion process in the Leontief matrix. DVA Content of production or exports $(1 \times n)$ is a vector that quantifies the DVA content of each sector's production or exports.

The methodology utilises Leontief's (1936) The input-output approach is a fundamental economic model that depicts the interdependencies among various sectors of an economy. Multiple scholars have expanded upon this approach (Hummels, Ishii, and Yi 2001; Koopman, Wang, and Wei 2014; Timmer et al., 2014; Los, Timmer, and de Vries 2015; Borin & Mancini, 2019). This explanation outlines the methodology used to estimate DVA and job creation through production and exports, with a focus on the complex interrelationships between various economic sectors.

The Foreign Value Added (FVA), denoted as fva , is calculated by subtracting the Domestic Value Added (DVA), dva , from the corresponding vector of gross exports. By summing the appropriate elements of these vectors, we can obtain the disaggregate values of DVA and FVA for the entire economy. The aggregate estimates of DVA are denoted as $\sum dva_j$, where dva_j represents the individual elements of the vector dva . Total DVA can be divided into direct and indirect (backward linkage) effects. The vectors dva_d and dva_{bw} represent the direct and indirect DVA content of exports from n sectors, respectively. Backward linkages measurement is the vector dva_{bw} measures the Domestic Value Added (DVA) attributed to the sector j 's backward linkages with all upstream sectors i . Within the economy, when mobile phones are exported, they generate domestic value addition not only within the mobile phone industry (dva_d) but also in other upstream sectors (dva_{bw}) such as printed circuit boards, plastics and rubber, and electrical machinery, whose outputs are used as inputs by the mobile phone sector. This detailed breakdown explains the methodology for calculating and decomposing DVA and FVA, emphasising the significance of backward linkages in understanding the domestic value addition in exports.

The following section explains the Input-Output methodology used to estimate the employment impact of Indian mobile phone production and exports, with a focus on the interconnections

across various sectoral components. It relies on backward linkages involving connections between a specific sector and other economic sectors. This helps in understanding how the output of one industry influences the demand for inputs from different sectors. The estimation of the number of direct and indirect jobs and corresponding wages/salaries supported by production/exports from n sectors are determined using the equation: $e = l(I - A_d)^{-1}\hat{X}$. The vector l contains employment coefficients, representing the labour/output ratios for different types of employment for each sector. These coefficients indicate the labour required per unit of output in each industry. The matrix \hat{X} represents exports from the n sectors, helping in isolating the export values for each industry. The inverse Leontief matrix $(I - A_d)^{-1}$ measures the total direct and indirect uses of each product by each sector. It is derived from the identity matrix I and the domestic coefficient matrix A_d . The domestic coefficient matrix A_d represents the amount of domestic input from the sector i required to produce one unit of output in the sector j . The identity matrix I serves as a baseline for the calculations. The resulting vector e indicates the number of jobs supported by exports in each sector. By summing the elements of this vector, one can obtain the aggregate number of jobs supported by exports.

The aggregate estimates of export-related employment are denoted as $\sum e_j$, where e_j are the individual elements of the vector e . This summation provides a comprehensive view of the impact of exports on employment. Total export employment is decomposed into direct and indirect effects using Leontief's input-output approach, where direct employment e_d is within the sector, and indirect employment e_{bw} is from upstream sectors. The Leontief inverse matrix helps estimate input requirements from various sectors for a unit increase in final-use output, indicating the interconnectedness of industries. Employment in gross exports can exceed total employment in a sector due to contributions from direct employment and indirect employment from upstream sectors supplying inputs. Total employment e associated with exports can be divided into direct employment e_d and indirect (backward linkage) employment e_{bw} . This breakdown is crucial for comprehending the comprehensive impact of exports on employment across various sectors. So, $e = e_d + e_{bw}$ implies $e_{bw} = e - e_d$. As usual, e represents total employment, e_d is direct employment and e_{bw} is indirect employment. The vectors e_d and e_{bw} denote direct and indirect employment linked to exports from n sectors. Direct employment e_d refers to employment within the exporting industry itself, while indirect employment e_{bw} pertains to employment in upstream sectors that supply inputs to the exporting industry.

The term e_{bw} quantifies the employment associated with a sector's backward linkages to all upstream economic sectors. For instance, the mobile phone manufacturing sector's exports create jobs in the industry and related sectors such as iron and steel, plastics and rubber, and electrical machinery. The employment embodied in the industry's gross exports can exceed the total jobs in the industry j . This is because it includes both direct employment in the exporting sector and indirect employment in upstream domestic industries that supply inputs to industry j . Two sets of employment and wage estimates for Indian mobile phone production and exports are provided: one from MOSPI's ASI database (2016-2021), encompassing all organised enterprises, and another from RBI's KLEMS database (2016-2021), covering both organised and unorganised sectors. The KLEMS database, released in 2024, offers employment estimates linked to production across all sectors. We select data from 2016 to 2021 to present a comprehensive view of employment trends in production and exports. KLEMS estimates are derived from MOSPI's ASI database for organised enterprises and NSSO database for unorganised ones. ASI is an official economic statistics set compiled by India's Central Statistics Office (CSO) under MOSPI, analysing production processes in the economy across all industrial sectors. We use ASI for direct and KLEMS for indirect estimates of value-added components, employment types, and wages.

The IO approach quantifies the structure of a national economy by using technical input coefficients to measure input requirements per unit of output. Input-output (IO) tables and Supply-Use Tables (SUTs) provide data for these coefficients. The latest IO table utilises the ASI database from 2016-17 to 2021-22, and annual SUTs are also available from the ASI database for the same period. SUTs classify sector outputs as inputs for other sectors, final demand by households, governments, firms, or exports. Estimating job creation related to exports requires the domestic coefficient matrix, A_d . Additionally, the IO tables and SUTs derived from ASI distinguish between imported and domestic inputs, which is a significant advantage. To estimate domestic job creation, the study uses a proportionality assumption to separate imported inputs, creating a time series of domestic use tables (DUTs) from ASI-derived SUTs.

Selected Data Analysis: Value Addition, Employment Dynamics, and Structural Shifts in India's Mobile Phone Manufacturing Sector (NPCMS 4722200) for 2016-2021

India's electronics manufacturing sector, especially mobile phones, is a key focus of policies aimed at boosting domestic production, value-added output, and job creation. This paper

reviews the sector's development under NPCMS 4722200 from 2016 to 2021. It analyses production, trade trends, value addition (domestic vs. foreign contributions), and employment dynamics. We compare average performance between 2016-2018 and 2019-2021 to identify shifts related to policy changes, such as the NPE 2019. The study utilises secondary data from charts and tables for the years 2016-2021. Key variables include output, imports, exports, domestic and foreign value added, employment (various categories), wages, and quality indicators. Differences in ASI and KLEMS methodologies reflect varied approaches in estimating contributions. Comparisons focus on averages for 2016-2018 and 2019-2021.

Output and Trade Dynamics

The sector's output grew significantly from \$13 billion in 2016 to \$38 billion in 2021, representing a 66% increase in the triennial average, which rose from \$19.667 billion (2016-18) to \$32.667 billion (2019-21). Imports fluctuated but decreased notably, with the annual average value dropping 41% from \$3,088 million (2016-18) to \$1,833 million (2019-21). Imports as a percentage of output decreased from 30% in 2016 to approximately 5.7% in 2019-21, indicating a shift towards import substitution through local assembly and manufacturing. Exports surged from \$166 million in 2016 to \$6,218 million in 2021, with the average annual export value increasing by 554% from \$670 million (2016-2018) to \$4,384 million (2019-2021). The exports' share of output increased from 1.3% in 2016 to 16.4% in 2021, highlighting India's growing role as an exporter in this sector.

Value Addition: Domestic (DVA) vs. Foreign (FVA)

Direct DVA (ASI) increased by 118% from \$757 million (2016-18) to \$1,650 million (2019-21), with an output share of 1%-6%. Indirect DVA grew 501% from \$906 million to \$5,448 million, while ASI's indirect DVA rose 223%, showing stronger domestic linkages. Total DVA (KLEMS) increased 327% from \$1,663 million to \$7,099 million; ASI Total DVA grew 155% from \$1,170 million to \$2,986 million. Despite this, DVA's output share peaked at 11% in 2019 before slightly declining, while KLEMS showed a higher DVA share of 25% in 2019, indicating the need for a methodological review. The direct FVA decreased from 83% to 93% (2016-18) to 41% to 69% (2019-21), yet the average direct FVA increased by 11% (\$17,263 million to \$19,244 million). Indirect FVA increased by 507% (\$626 million to \$3,800 million), indicating a greater reliance on imports. Total FVA rose by 29% on average, from \$17,890 million to \$23,044 million, but its output share fell from 90% to 70%. Domestic Value Added in Exports surged 1846% on average, from \$65 million to \$1,265 million, with its share rising

from about 9% to 30%. Foreign Value Added in Exports increased by an average of 416% (\$605 million to \$3,119 million). However, its share declined from approximately 91% to 70%, indicating that a more significant proportion of export value is now domestically generated.

Employment Dynamics

Total employment in the sector increased significantly, with the average number of employees rising by 75% (from 582,878 to 1,020,376). Export-related jobs surged by 411%, while direct employment grew by 383%. Despite increases in direct and indirect jobs, the share of direct employment in total jobs rose slightly, as indirect jobs still account for the majority in KLEMS estimates. The data distinguishes 'Workers' and 'Non-Workers', with Total Non-Workers rising by 76% and Total Workers by 75%. The share of non-workers among total employees remained stable at roughly 11-15%, dipping to 9% in 2019. A key trend is the rise of contractual workers; the number of Total Contractual Workers increased by 138%, compared to a 22% rise for Regular Workers, indicating a shift toward contractualization. Female participation trends indicate that the number of total female workers increased by 52%, while the number of total male workers rose by only 6.7%. In direct employment, both male and female regular workers increased, with female employment surging by 179% compared to 108% for males. The female share of direct regular workers peaked in 2018-19 before declining.

Wages and Salaries

Wages and salaries increased significantly with employment growth. Average total wages (KLEMS Production) increased by 33% (\$1,709 million to \$2,279 million). Wages for Non-Workers increased more slowly than for Workers. Notably, average wages for Contractual Workers surged 311% (\$223 million to \$917 million), far exceeding the 89% growth for Regular Workers (\$458 million to \$864 million). This trend, alongside the growing share of contractual workers, highlights complex wage structures and potential precariousness.

Backward Linkages

Key domestic components include Trade Services (F11), Business Services (F3, F1), Financial Services (F10), Construction (F4), and Rental (F6), as well as various copper and aluminium wires, plastic and metal parts, and electronic components such as PCBs and ICs. Key foreign components include cellular set parts, transmission apparatus, consumables (9922100), and various electronic items (PCBs, valves, ICs, digital cameras, monitors, LCDs), as well as batteries and plastics. Tracking the shifts in component shares can provide valuable insights

into supply chain changes, particularly the replacement of foreign inputs with domestic ones. For example, foreign cellular set parts (4740100) maintain a notable share, while domestic trade services (F11) are a significant input.

Conclusion

This research presents 7-digit product-level supply-use and input-output tables for India based on ASI data from 2016 to 2021. By mapping input and output flows in manufacturing and applying the Industry Technology Assumption, we developed an analytical framework aligned with SNA guidelines. Analysis of India's mobile phone sector showed a 66% average output increase, a decrease in import dependency from 30% to 5.7%, and a 554% rise in exports. Domestic Value Added (DVA) increased, with its share relative to Foreign Value Added (FVA) needing careful interpretation. Notably, DVA's share in exports rose from 9% to 30%. Export-driven employment grew by 75% on average, with export-related jobs surging by 411%. This highlights shifts in the labour market, including a 138% increase in contractual workers, a 22% increase in regular jobs, and a rise in female participation. Concurrently, wages for contractual workers rose significantly. The new high-resolution Supply-Use Tables (SUTs) and Input-Output Tables (IOTs) represent a methodological advancement, providing crucial detail for policy analysis in industrial strategy, global value chain integration, and employment impacts. While the Industry Technology Assumption aids transformation, future research could explore alternative methods and apply this framework to other manufacturing sectors. These tables establish a critical empirical foundation for evidence-based policymaking, promoting sustainable industrial growth and quality job creation.

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