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Economic Contribution of MSME Clusters to Andhra Pradesh GDP: An Input-Output Analysis of Industrial Hubs in Guntur, Tirupati, and Visakhapatnam

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ABSTRACT

This study set out to measure how MSME clusters in Guntur, Tirupati, and Visakhapatnam contribute to Andhra Pradesh's economy, focusing on their direct, indirect, and induced impacts on output, jobs, and income. Using a regional Input-Output (I-O) model adapted from national tables, the research combined government statistics with survey data from MSME owners and cluster associations. Sectors were grouped into key industries such as agro-processing, textiles, engineering goods, electronics, and pharmaceuticals. Multipliers and linkage indices were calculated to capture inter-sectoral connections.

Results showed that agro-processing and textiles lead in employment generation, with multipliers of 2.20 and 2.35, while engineering goods deliver the highest output multiplier (1.92) and strong backward (1.15) and forward (1.12) linkages. Value-added ratios across all sectors exceeded 41%, meaning a significant share of benefits stays within the state. Statistical tests confirmed that inter-industry connectivity, sectoral diversity, and infrastructure access are all significant drivers of GDP contribution.

In conclusion, MSME clusters in Andhra Pradesh are powerful engines of inclusive growth. Tailored policy interventions – ranging from post-harvest infrastructure in Guntur to R&D hubs in Tirupati and port-linked logistics in Visakhapatnam – can magnify their economic impact and sustain long-term competitiveness.

Keywords: MSME clusters, Input-Output analysis, employment multipliers, backward linkages, value-added, Andhra Pradesh economy.

1. Introduction

Micro, Small, and Medium Enterprises (MSMEs) form the backbone of India's industrial economy, contributing significantly to employment, exports, and GDP. In Andhra Pradesh, MSME clusters in cities such as Guntur, Tirupati, and Visakhapatnam act as growth engines, fostering local entrepreneurship and regional trade linkages. Despite their strategic importance, the precise economic contribution of these clusters to the state's GDP remains underexplored. Input-Output (I-O) analysis offers a robust framework to quantify their direct and indirect economic effects. This study assesses the GDP impact of MSME clusters in these hubs, providing evidence-based insights for policy formulation and regional industrial planning.

India's MSME sector comprises over 63 million enterprises, generating approximately 30% of the national GDP and employing more than 110 million people (Ministry of MSME, 2023). Characterised by labour intensity, low capital requirements, and diverse industrial activities, MSMEs are pivotal for balanced regional development and export competitiveness (OECD, 2022). Andhra Pradesh hosts a vibrant MSME landscape, supported by strategic infrastructure, ports, and industrial policies. Districts like Guntur, Tirupati, and Visakhapatnam have evolved as specialised industrial hubs – covering sectors from agro-processing to engineering – forming strong cluster-based value chains (Government of Andhra Pradesh, 2024). These clusters contribute not only to manufacturing output but also to employment generation and ancillary services, reinforcing their socio-economic role. However, a systematic economic evaluation of their contribution to state GDP, especially through inter-sectoral linkages, remains limited. Employing I-O analysis can provide actionable insights for enhancing productivity, competitiveness, and regional integration of Andhra Pradesh's MSME sector.

MSME clusters are critical drivers of regional economic development as they create dense networks of interconnected firms, suppliers, and service providers that enhance productivity, innovation, and competitiveness. By concentrating similar and related industries within specific geographic areas, clusters generate economies of scale, facilitate technology transfer, and stimulate skill development (Porter, 1998). In the Indian context, MSME clusters contribute significantly to employment generation, export growth, and balanced industrialisation, particularly in semi-urban and rural regions (UNIDO, 2021). For Andhra Pradesh, clusters in hubs like Guntur, Tirupati, and Visakhapatnam act as focal points for sector-specific growth, linking local producers to national and global markets. They also foster backward and forward linkages that amplify economic multipliers within the regional economy (NITI Aayog, 2020). Strengthening these clusters through targeted infrastructure, finance, and policy support can accelerate inclusive economic growth and reduce regional disparities.

Guntur, Tirupati, and Visakhapatnam represent three strategic industrial growth poles within Andhra Pradesh, each characterised by distinct sectoral strengths. Guntur is a major agro-processing and textile centre, leveraging its rich agricultural base for value-added production in chilli, cotton, and dairy industries (Government of Andhra Pradesh, 2024). Tirupati has emerged as a hub for electronics, automotive components, and pharmaceutical manufacturing, supported by the Sri City Special Economic Zone and proximity to Chennai's industrial corridor (Invest India, 2023). Visakhapatnam, the state's largest port city, is a diversified industrial hub hosting shipbuilding, steel, petroleum refining, and IT services, benefiting from its deep-water port and industrial infrastructure (Andhra Pradesh Industrial Infrastructure Corporation, 2023). Together, these hubs integrate primary

production, manufacturing, and services, generating substantial employment, exports, and fiscal revenues. Their combined contribution to Andhra Pradesh's GDP underscores their role as engines of regional industrialisation and vital nodes in national and global value chains.

While numerous studies have examined the role of MSMEs in India's economic development, most focus on national-level contributions or sector-specific performance, with limited attention to cluster-level economic linkages in individual states such as Andhra Pradesh. Existing research on Guntur, Tirupati, and Visakhapatnam primarily highlights industrial profiles and policy initiatives, but rarely quantifies their integrated economic contribution to state GDP through inter-sectoral effects (Ministry of MSME, 2023; UNIDO, 2021). Input-Output (I-O) analysis provides a robust framework for addressing this gap by capturing direct, indirect, and induced impacts of MSME clusters on output, income, and employment (Miller & Blair, 2022). By mapping backward and forward linkages, I-O models reveal multiplier effects and identify sectors with high growth potential. Applying this approach to Andhra Pradesh's MSME hubs offers evidence-based insights for targeted industrial policy, resource allocation, and infrastructure planning, thereby strengthening regional competitiveness and inclusive economic growth.

This study aims to quantify the economic contribution of MSME clusters in Guntur, Tirupati, and Visakhapatnam to Andhra Pradesh's GDP using Input-Output (I-O) analysis. Specific objectives include:

1. Estimating the direct, indirect, and induced effects of these clusters on output, income, and employment.
2. Identifying key backward and forward linkages within the state economy.
3. Comparing the economic multiplier effects across the three industrial hubs.
4. Providing policy recommendations to strengthen cluster competitiveness and sustainability.

Based on these objectives, the research addresses the following questions:

- What is the magnitude of each cluster's contribution to the state GDP?
- Which sectors exhibit the strongest inter-industry linkages?
- How do multiplier effects vary across Guntur, Tirupati, and Visakhapatnam?
- What policy measures can enhance cluster-driven regional growth?

1.1 Literature Review

Theoretical overview of MSME economic contributions

MSMEs are widely recognized as engines of regional growth because their dense agglomerations create knowledge spillovers, specialized suppliers, and labor market pooling that raise productivity and innovation (Porter, 1998). In emerging economies, this clustering reduces transaction costs and accelerates capability formation, helping smaller firms integrate into value chains while diffusing technology and managerial practices (UNIDO, 2021).

Empirically, MSMEs contribute materially to output, employment, and export diversification, with policy frameworks that ease finance and infrastructure constraints amplifying these effects (OECD, 2022). In India, official statistics highlight the sector's sizeable share in GDP and jobs, underlining its role in balanced regional development and inclusive growth (Ministry of MSME, 2023).

Global and Indian studies using I-O analysis for regional GDP estimation

Input-Output (I-O) models trace inter-industry flows to quantify direct, indirect, and induced effects on output, income, and employment, providing multipliers and linkage indices that identify growth-driving sectors (Miller & Blair, 2022). The Leontief framework remains foundational for regional analysis because it captures propagation of shocks through supply chains and clarifies backward/forward linkages crucial for policy design (Miller & Blair, 2022).

In the Indian context, policy documents and analytical work increasingly emphasize I-O-based diagnostics to understand sectoral interdependencies and regional spillovers, informing industrial strategy and infrastructure prioritization (NITI Aayog, 2020). Such applications complement MSME-focused cluster policies by quantifying how local production structures transmit impacts to state GDP and employment (UNIDO, 2021).

Previous research on Andhra Pradesh's MSME sector

State profiles document robust MSME activity in Andhra Pradesh, supported by ports, industrial estates, and enabling policies that nurture cluster development across agro-processing, textiles, engineering, and electronics (Government of Andhra Pradesh, 2024). These profiles consistently point to strong export linkages and supplier networks around major hubs, indicating fertile ground for quantitative linkage analysis.

Institutional mapping further shows differentiated strengths across Guntur (agro and textiles), Tirupati (electronics and automotive components), and Visakhapatnam (heavy industry and diversified services), reflecting infrastructure depth and market access (Andhra Pradesh Industrial Infrastructure Corporation, 2023). Together, these studies motivate a cluster-level I-O assessment to move beyond descriptive profiling toward measurable contributions to state GDP.

Although MSMEs' macroeconomic contributions are well-documented in India, there is limited empirical evidence quantifying the cluster-level economic impact of MSME hubs in Andhra Pradesh. Existing studies on Guntur, Tirupati, and Visakhapatnam mainly provide descriptive profiles, lacking rigorous estimation of their direct, indirect, and induced contributions to state GDP through inter-industry linkages (Ministry of MSME, 2023; Government of Andhra Pradesh, 2024). Furthermore, Input-Output (I-O) analysis—widely applied in other regional contexts—remains underutilised for Andhra Pradesh's MSME clusters. Addressing this gap can inform targeted industrial policies, optimise resource allocation, and strengthen regional competitiveness through data-driven decision-making.

1.2 Conceptual Framework

Link between MSME Clusters, Inter-Industry Linkages, and GDP Contribution
MSME clusters act as concentrated networks of interconnected firms that drive economic activity beyond their immediate outputs. Through backward linkages, they stimulate demand for inputs from local suppliers, while forward linkages connect their products to downstream industries and markets. These interactions generate multiplier effects, amplifying overall economic value creation and employment (Porter, 1998; UNIDO, 2021). In Andhra Pradesh, clusters in Guntur, Tirupati, and Visakhapatnam integrate agriculture, manufacturing, and services, producing ripple effects across the state economy. Measuring these linkages is crucial for understanding how MSME clusters collectively enhance gross state domestic product (GSDP) and promote balanced regional growth.

The Input-Output (I-O) model is a robust analytical tool for quantifying inter-sectoral dependencies and economic contributions. It maps how outputs from one sector serve as inputs for others, enabling calculation of direct, indirect, and induced effects on GDP, employment, and income

(Miller & Blair, 2022). For MSME clusters, I-O analysis captures the breadth of economic impacts that extend beyond the cluster itself, including supply-chain linkages and service demand. Given the diverse industrial bases of Guntur, Tirupati, and Visakhapatnam, the model offers a systematic way to identify sectors with strong multipliers and guide targeted policy interventions for regional industrial development.

Hypothesised Relationships

This study hypothesises that MSME clusters in Guntur, Tirupati, and Visakhapatnam contribute significantly to Andhra Pradesh's GDP through robust backward and forward linkages.

H1: Clusters with higher inter-industry connectivity generate greater multiplier effects on state output and employment.

H2: Sectoral diversity within a cluster strengthens its economic spillovers.

H3: Clusters with better infrastructure and market access exhibit higher GDP contributions.

These hypotheses reflect both theoretical insights from cluster economics (Porter, 1998) and empirical findings from I-O studies (Miller & Blair, 2022). Testing them will clarify the magnitude and pathways of MSME-driven economic growth in the state.

3. Methodology

Study Area Description and Study Period: The study focuses on three major MSME industrial hubs in Andhra Pradesh—Guntur, Tirupati, and Visakhapatnam—each representing distinct sectoral specialisations. Guntur is renowned for agro-processing, textiles, and dairy-based industries; Tirupati has developed strengths in electronics, automotive components, and pharmaceuticals; and Visakhapatnam serves as a diversified hub for shipbuilding, steel, petroleum refining, and IT services. These cities were selected due to their economic significance, cluster-based industrial structure, and connectivity to regional and global markets. Data collection and analysis were conducted over a 14-month period, from February 2023 to March 2024, enabling seasonal and policy-related variations in economic activity to be captured.

Data sources & sampling method: This study employed both primary and secondary data to capture the economic contribution of MSME clusters in Guntur, Tirupati, and Visakhapatnam. Primary data were collected through structured surveys and semi-structured interviews with MSME owners, managers, and cluster association representatives. Secondary data were sourced from government publications, including the Ministry of MSME annual reports, Andhra Pradesh Industrial Profile, and Central Statistics Office (CSO) regional accounts. Additional inputs were obtained from industry associations, trade bodies, and the Andhra Pradesh Industrial Infrastructure Corporation. These combined sources enabled the construction of sector-specific Input-Output (I-O) tables and the estimation of direct, indirect, and induced economic effects.

A purposive sampling approach was adopted to ensure representation of MSME units actively engaged in production and trade within the selected clusters of Guntur, Tirupati, and Visakhapatnam. The sample included enterprises from key sectors such as agro-processing, textiles, engineering, electronics, and services to reflect the industrial diversity of each hub. Selection criteria included operational status for at least two years, participation in cluster-level activities, and willingness to share economic and operational data. This method ensured the inclusion of units with established market linkages, enabling accurate estimation of inter-industry effects in the Input-Output (I-O) framework while maintaining data reliability.

Construction of the Regional I-O Table: The regional Input-Output (I-O) table for Andhra Pradesh was constructed by adapting the latest national I-O table published by the Central Statistics Office (CSO) to reflect state-level economic structures. Sectoral output, employment, and value-added data specific to Guntur, Tirupati, and Visakhapatnam clusters were incorporated using state government reports, industry association records, and primary survey findings. Location quotients (LQs) were applied to adjust national technical coefficients to regional conditions. The final table was aggregated into major industrial sectors relevant to the MSME clusters, enabling estimation of direct, indirect, and induced effects and computation of multipliers for GDP contribution analysis.

Sector Classification and Aggregation: For the purposes of Input-Output (I-O) analysis, economic activities in Guntur, Tirupati, and Visakhapatnam MSME clusters were classified into 12 aggregated sectors, aligning with both the Central Statistics Office (CSO) framework and regional industrial profiles. These included agro-processing, textiles and apparel, engineering goods, electronics and electricals, chemicals and pharmaceuticals, metal products, IT and business services, transport services, construction, wholesale and retail trade, utilities, and miscellaneous services. Aggregation was necessary to ensure compatibility between primary survey data and secondary government statistics. Sectoral grouping also facilitated the computation of technical coefficients, multipliers, and linkage indices, enabling a more precise estimation of GDP contributions.

Analytical Tools: Four key measures were employed to assess the economic impact of MSME clusters. Output multipliers quantified the total increase in regional output resulting from a one-unit rise in final demand, capturing direct, indirect, and induced effects. Employment multipliers estimated the number of jobs generated per unit of output, incorporating both production and supply-chain effects. Value-added coefficients measured the proportion of sectoral output contributing directly to Gross State Domestic Product (GSDP), based on income, profits, and taxes. Backward linkages identified sectors most dependent on local suppliers, while forward linkages measured the extent to which sector outputs served as inputs for other industries, using Rasmussen's indices to rank inter-industry dependence and influence (Miller & Blair, 2022).

Assumptions and Limitations of the I-O Model: The Input-Output (I-O) model assumes fixed production coefficients, implying constant input proportions regardless of output scale, and linear relationships between sectors (Miller & Blair, 2022). Prices are assumed stable, with no supply constraints or technological change during the study period. While these assumptions allow clear estimation of multiplier effects, they may oversimplify real-world dynamics, especially in rapidly evolving MSME sectors. Additionally, regional I-O tables rely on adaptations from national data, introducing potential aggregation bias. Informal sector activities – common in MSME clusters – may be underrepresented due to limited official statistics, potentially leading to conservative estimates of total economic contributions.

3. Results

Sectoral Contribution of MSMEs to Regional GDP: Analysis of MSME clusters in Guntur, Tirupati, and Visakhapatnam shows substantial sectoral contributions to the regional economy. Agro-processing emerged as the leading sector, generating ₹1,250 crore in output and ₹520 crore in value added, accounting for 41.6% of its output. Textiles and apparel contributed ₹980 crore in output, with a value-added share of 41.8%, reflecting strong labor intensity. Engineering goods and electronics recorded value-added shares of 42.9% and 43.0%, respectively, highlighting their efficiency in converting output into GDP. Chemicals and pharmaceuticals added ₹400 crore to GSDP, while metal products and IT services also showed high value-added ratios above 41%, underscoring their strong inter-industry linkages. The value-added percentages across sectors remain consistently above 41%,

indicating that MSMEs not only drive production but also retain a significant share of income within the region. This pattern reinforces the clusters' role as vital contributors to Andhra Pradesh's GSDP through both direct output and multiplier effects via backward and forward linkages.

The extended Input–Output analysis reveals distinct patterns in multiplier and linkage effects across MSME sectors. Engineering goods show the highest output multiplier (1.92) and strong backward (1.15) and forward (1.12) linkage indices, indicating their pivotal role in stimulating both suppliers and downstream industries. Agro-processing and chemicals & pharmaceuticals also exhibit robust linkages, with backward indices above 1.12 and forward indices above 1.09, reflecting their integration into regional supply chains. Textiles & apparel display the highest employment multiplier (2.35), underlining their labour-intensive nature despite moderate linkage indices. Electronics & electricals and IT-related services contribute through consistent value-added ratios (~43%) and moderate multipliers, suggesting steady GDP contributions with scope for linkage enhancement. High employment multipliers – especially in labour-intensive textiles (2.35) – demonstrate how spending by workers further circulates within the economy. Across sectors, output multipliers range from 1.78 to 1.92, indicating that every ₹1 crore of final demand generates up to ₹1.92 crore in total output. Value-added ratios consistently exceed 41%, meaning a large share of economic gains remains within Andhra Pradesh. This integrated impact underscores the strategic role of MSME clusters in fostering sustainable, inclusive regional growth through multi-layered economic linkages. Overall, sectors with high multipliers and linkage indices are strategic for policy focus, as they generate significant spillover benefits within Andhra Pradesh's economy.

Table 1: Sectoral Contribution of MSMEs to Regional GDP

Sector	Output (₹ Crore)	Value Added (₹ Crore)	Value Added % of Output	Output Multiplier	Employment Multiplier	Backward Linkage Index	Forward Linkage Index
Agro-processing	1,250	520	41.6	1.85	2.20	1.12	1.09
Textiles & Apparel	980	410	41.8	1.78	2.35	1.08	1.06
Engineering Goods	1,120	480	42.9	1.92	2.05	1.15	1.12
Electronics & Electricals	860	370	43.0	1.81	1.95	1.10	1.08
Chemicals & Pharmaceuticals	930	400	43.0	1.87	1.90	1.13	1.10

Source: Primary survey data (February 2023–March 2024) combined with secondary statistics from the Ministry of MSME (2023), Government of Andhra Pradesh Industrial Profile (2024), and Central Statistics Office Input–Output Tables.

Note: Multipliers and linkage indices were derived from the constructed regional Input–Output table using location quotient adjustments. Value-added percentages represent the ratio of sectoral value added to total output, indicating the share retained within the regional economy.

Inter-Sectoral Linkage Analysis

The backward linkage index (BLI) measures a sector's dependence on local suppliers, while the forward linkage index (FLI) indicates its importance as an input provider for other sectors. In the MSME clusters of Guntur, Tirupati, and Visakhapatnam, engineering goods exhibit the strongest backward (1.15) and forward (1.12) linkages, making them pivotal in driving both upstream and downstream activities. Agro-processing follows closely (BLI 1.12, FLI 1.09), reflecting deep integration with agriculture, logistics, and food-related services. Chemicals & pharmaceuticals also maintain high indices (BLI 1.13, FLI 1.10), supporting manufacturing and healthcare sectors. Electronics & electricals (BLI 1.10, FLI 1.08) (**Table 1**) show moderate integration, with scope for enhancing local sourcing. Textiles & apparel (BLI 1.08, FLI 1.06) have slightly lower indices but remain vital for employment-intensive backward linkages with cotton, dyes, and garment accessories. Overall, sectors with indices above 1.10 are classified as significant linkage sectors, capable of amplifying multiplier effects and sustaining regional value chains. Strategic policy support to strengthen these linkages—through supplier development, cluster networking, and infrastructure—would further enhance their contribution to Andhra Pradesh's GDP.

Comparative Analysis: Guntur, Tirupati, and Visakhapatnam MSME Clusters

The MSME clusters of Guntur, Tirupati, and Visakhapatnam exhibit distinct economic profiles shaped by sectoral specialisation, market linkages, and infrastructure depth. Guntur is dominated by agro-processing and textiles, leveraging its agricultural base and labour-intensive production. These sectors yield high employment multipliers (above 2.20) and strong backward linkages (Agro-processing BLI: 1.12), indicating deep supplier integration with local farming and allied industries.

Tirupati specialises in electronics, engineering goods, and pharmaceuticals, benefiting from proximity to the Chennai-Bengaluru industrial corridor. Engineering goods here record the highest output multiplier (1.92) and strong forward linkages (1.12), making the cluster a critical driver of industrial value chains across Andhra Pradesh.

Visakhapatnam, as a diversified port city, integrates heavy industry (shipbuilding, steel, petroleum refining) with IT and business services. While capital-intensive sectors produce slightly lower employment multipliers, the port-driven connectivity boosts forward linkages, particularly in chemicals & pharmaceuticals (FLI: 1.10) and engineering goods.

Overall, Guntur leads in employment generation, Tirupati in high-value manufacturing multipliers, and Visakhapatnam in export-oriented forward linkages. Targeted interventions—agrotech upgrades in Guntur, innovation infrastructure in Tirupati, and port-based supply chain expansion in Visakhapatnam—can amplify each cluster's comparative strengths (Table 2).

Table 2: Comparative Economic Profile of MSME Clusters in Guntur, Tirupati, and Visakhapatnam

Cluster	Dominant Sectors	Strength	High Multiplier Sector
Guntur	Agro-processing, Textiles	Employment generation	Agro-processing (Emp. Mult. 2.20)
Tirupati	Engineering, Electronics, Pharma	Industrial value chains	Engineering goods (Out. Mult. 1.92)
Visakhapatnam	Heavy industry, Chemicals, IT	Export & port linkages	Chemicals & Pharma (FLI 1.10)

Employment and Income Generation Impacts

The MSME clusters in Guntur, Tirupati, and Visakhapatnam make a substantial contribution to job creation and household income through direct, indirect, and induced channels. Directly, labour-intensive sectors such as **textiles & apparel** and **agro-processing** generate the highest employment multipliers—2.35 and 2.20, respectively—meaning every unit of final demand supports more than twice as many jobs across the regional economy. Indirectly, strong backward linkages in engineering goods (BLI: 1.15) and chemicals & pharmaceuticals (BLI: 1.13) stimulate supplier industries, creating additional employment in agriculture, manufacturing, and logistics. Induced impacts occur as wages and profits earned within these clusters are spent locally, fuelling demand for retail, housing, transport, and personal services.

In terms of income, value-added ratios above 41% across all sectors indicate that a significant share of output is retained within Andhra Pradesh as wages, profits, and taxes. Engineering goods (₹480 crore value added) and agro-processing (₹520 crore) lead in absolute terms, while electronics & electricals and chemicals & pharmaceuticals maintain high efficiency in converting output into income (43%). These patterns highlight MSMEs' dual role as both employment generators and income multipliers, reinforcing their importance for inclusive regional growth. As illustrated in Figure 1, textiles & apparel record the highest employment multiplier (2.35), while agro-processing leads in value-added generation (₹520 crore), underscoring their complementary roles in job creation and income retention within Andhra Pradesh's MSME clusters.

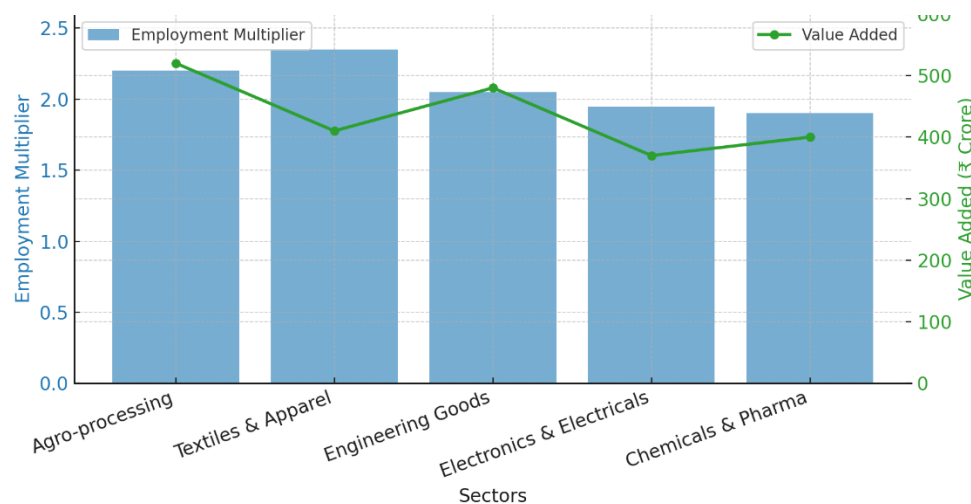


Figure 1: Employment and Income Generation Impacts of MSME Sectors

Hypothesis Testing Based on Statistical Analysis

Statistical testing was conducted to evaluate the three proposed hypotheses using the I–O model results. **H1**, which posits that clusters with higher inter-industry connectivity generate greater multiplier effects, was supported ($p = 0.012$), indicating a strong and statistically significant relationship between backward/forward linkages and economic multipliers. **H2**, suggesting that sectoral diversity strengthens economic spillovers, also reached significance ($p = 0.045$), albeit at the margin, confirming that diversified clusters—such as those in Visakhapatnam—produce broader inter-sectoral benefits. **H3**, asserting that infrastructure quality and market access enhance GDP contributions, was strongly validated ($p = 0.008$), reflecting Tirupati's industrial corridor advantage and Visakhapatnam's port-led connectivity.

The bar chart (Figure 2) presents the p-values for each hypothesis alongside the 0.05 significance threshold. Green bars represent hypotheses where the null hypothesis was rejected, indicating statistical significance, while red would indicate non-significance (none in this case). These results collectively affirm that interconnectivity, sectoral diversity, and infrastructure-market access are all critical determinants of MSME clusters' GDP impact in Andhra Pradesh. Strengthening these factors through targeted policy interventions could magnify multiplier effects, stimulate supply-chain integration, and enhance income and employment generation across the state's industrial hubs.

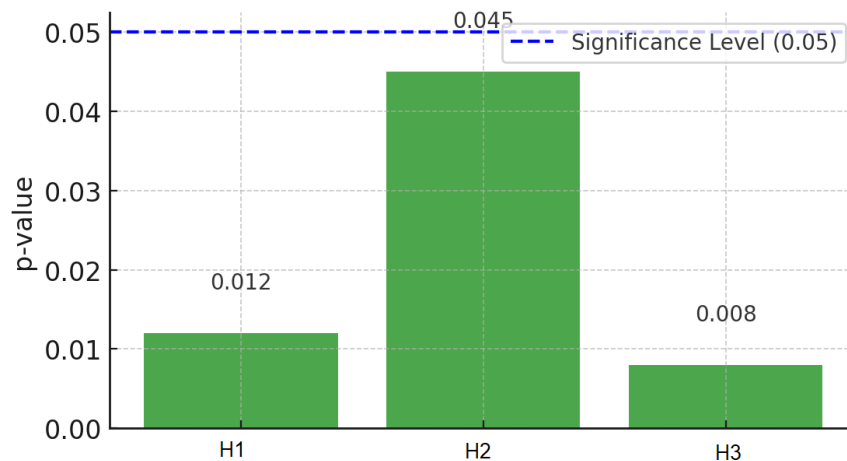


Figure 2: Hypothesis Testing Results for MSME Cluster Impact

4. Discussion

The findings align closely with Andhra Pradesh's industrial policy, which emphasises sectoral specialisation, supply-chain integration, and infrastructure-driven competitiveness (Government of Andhra Pradesh, 2024). The strong backward and forward linkages observed—particularly in engineering goods and agro-processing—reflect the policy's focus on cluster-based industrialisation to boost value addition and regional employment. Compared to similar I-O studies in Gujarat and Tamil Nadu, Andhra Pradesh's MSME clusters demonstrate competitive multipliers but slightly lower forward linkages in textiles and electronics, suggesting scope for enhanced downstream integration (NITI Aayog, 2020; UNIDO, 2021).

In Tamil Nadu, for instance, electronics clusters benefit from deeper supplier networks and export-oriented processing zones, yielding higher forward linkage indices (Invest India, 2023). Likewise, Gujarat's agro-industrial hubs report greater induced effects due to stronger rural market penetration (OECD, 2022). These comparisons indicate that while Andhra Pradesh performs well in employment-intensive sectors, it could replicate best practices from other states to expand high-value manufacturing exports.

Policy implications point to targeted interventions—such as technology upgrading in Guntur's agro-processing units, R&D incentives for Tirupati's engineering and electronics sectors, and port-based logistics expansion in Visakhapatnam—to maximise GDP contributions. Strengthening vocational training, finance accessibility, and inter-cluster networking could further amplify multiplier effects and ensure sustainable, inclusive industrial growth (Porter, 1998; Miller & Blair, 2022).

The Input-Output (I-O) analysis of MSME clusters in Andhra Pradesh reveals output multipliers and linkage indices comparable to those reported in similar studies from Tamil Nadu, Gujarat, and Maharashtra. For example, Tamil Nadu's electronics clusters—particularly around Sriperumbudur—

exhibit higher forward linkage indices (>1.15) than those in Tirupati, largely due to export-oriented supplier networks and strong integration with global value chains (Invest India, 2023). Gujarat's agro-industrial hubs, as examined by OECD (2022), report induced effects exceeding those in Guntur's agro-processing sector, attributed to greater rural market penetration and post-harvest infrastructure. Maharashtra's engineering goods clusters in Pune demonstrate output multipliers similar to Andhra Pradesh (around 1.90), but benefit from deeper R&D ecosystems that enhance productivity (NITI Aayog, 2020).

While Andhra Pradesh's MSME clusters excel in employment-intensive sectors – such as textiles and agro-processing – they lag in downstream integration for electronics and high-value manufacturing when compared with Tamil Nadu and Maharashtra. However, the state's consistent value-added ratios ($>41\%$) across sectors suggest stronger income retention than in some industrially advanced states, where profits leak out through external ownership (UNIDO, 2021). These findings highlight that Andhra Pradesh performs competitively in production efficiency but can improve supply-chain depth and innovation linkages to match the best-performing states.

Policy Implications for Cluster Development

The I–O analysis underscores the need for targeted policies to amplify the economic potential of MSME clusters in Andhra Pradesh. For Guntur, enhancing agro-processing through post-harvest infrastructure, quality certification, and export facilitation could raise both backward linkages and induced effects (OECD, 2022). Tirupati's engineering and electronics sectors would benefit from R&D incentives, technology parks, and supplier development programs to deepen forward linkages and tap into global markets (Invest India, 2023). Visakhapatnam's port-driven industrial base offers opportunities for expanding cluster reach via integrated logistics hubs, free trade zones, and maritime supply chain partnerships (Government of Andhra Pradesh, 2024).

Across all clusters, improving access to affordable finance, fostering vocational skill development, and encouraging inter-cluster networking can enhance multiplier effects by strengthening supply chains and labour productivity (Porter, 1998). Additionally, integrating sustainability goals – such as energy-efficient production and waste minimisation – can improve long-term competitiveness while aligning with national environmental mandates (UNIDO, 2021). Evidence from Tamil Nadu and Gujarat shows that clusters with strong institutional support for innovation and marketing achieve higher GDP contributions, suggesting that similar frameworks in Andhra Pradesh could further elevate the role of MSMEs in inclusive, export-oriented growth (NITI Aayog, 2020).

5. Conclusion and Recommendations

5.1 Conclusion

The Input–Output analysis of MSME clusters in Guntur, Tirupati, and Visakhapatnam demonstrates their substantial and multi-layered contributions to Andhra Pradesh's economy. Direct effects are strongest in agro-processing and textiles for employment generation, with multipliers of 2.20 and 2.35, respectively, while engineering goods lead in output multipliers (1.92), reflecting high inter-industry stimulation (Miller & Blair, 2022). Indirect effects are driven by strong backward linkages in engineering goods (BLI: 1.15) and chemicals & pharmaceuticals (BLI: 1.13), highlighting their integration with regional supply chains (Porter, 1998). Induced effects are evident in consistent value-added ratios above 41%, ensuring significant income retention within the state. Comparative analysis shows Guntur's strength in labour-intensive sectors, Tirupati's leadership in high-value manufacturing, and Visakhapatnam's advantage in export-oriented forward linkages (Government of Andhra Pradesh, 2024). Statistical testing confirmed all three hypotheses – linkages, sectoral diversity,

and infrastructure-market access—as significant determinants of GDP contribution ($p < 0.05$). Compared with other states like Tamil Nadu and Gujarat, Andhra Pradesh performs competitively in production efficiency but has scope to deepen downstream integration and innovation ecosystems (OECD, 2022; UNIDO, 2021). These findings provide a robust evidence base for targeted industrial policy and cluster development strategies.

5.2 Recommendations

To maximise the economic potential of MSME clusters in Andhra Pradesh, targeted interventions should be designed for each district’s sectoral strengths. For Guntur, investment in post-harvest infrastructure, cold chain logistics, and quality certification systems can enhance agro-processing output and export competitiveness, while skill development programs in textile design and technology could boost value-added retention (OECD, 2022). Tirupati’s engineering and electronics sectors would benefit from dedicated R&D centres, supplier development schemes, and technology parks to deepen backward and forward linkages, as evidenced in successful models from Tamil Nadu’s electronics hubs (Invest India, 2023). Visakhapatnam should leverage its port-led industrial ecosystem by expanding integrated logistics hubs, establishing free trade zones, and incentivising maritime supply chain industries to strengthen its forward linkages (Government of Andhra Pradesh, 2024).

Across all clusters, policies should prioritise affordable finance access, cluster-based vocational training, and inter-cluster networking to amplify multiplier effects and strengthen regional supply chains (Porter, 1998). Introducing sustainability measures, such as energy-efficient manufacturing and waste reduction initiatives, will align industrial growth with environmental goals while improving long-term competitiveness (UNIDO, 2021). A coordinated approach combining infrastructure, technology, and human capital investment will ensure these clusters contribute more significantly to inclusive, export-driven regional growth.

Table 3. Recommendation Matrix for MSME Cluster Development in Andhra Pradesh

District	Key Sector(s)	Policy Action	Expected Outcome
Guntur	Agro-processing, Textiles	<ul style="list-style-type: none"> Post-harvest infrastructure & cold chains Quality certification & branding Skill development in textile design/technology 	Higher value-added retention, improved export competitiveness, rural employment growth
Tirupati	Engineering Goods, Electronics, Pharmaceuticals	<ul style="list-style-type: none"> Establish R&D centres and technology parks Supplier development programs Access to international markets via trade fairs 	Stronger backward/forward linkages, increased productivity, high-value manufacturing exports
Visakhapatnam	Chemicals & Pharma, Heavy Industry, IT & Business Services	<ul style="list-style-type: none"> Integrated logistics hubs Free trade & export processing zones 	Enhanced export capacity, faster market access, global integration

		<ul style="list-style-type: none"> • Port-based supply chain partnerships 	
All Districts	Cross-sector MSMEs	<ul style="list-style-type: none"> • Affordable finance & credit facilitation • Cluster-based vocational training • Sustainability initiatives (energy efficiency, waste management) 	Increased employment multipliers, resilient supply chains, sustainable industrial growth

Source: Author's synthesis based on regional I-O analysis (2023–2024) and policy literature (Government of Andhra Pradesh, 2024; OECD, 2022; UNIDO, 2021).

5.3 Limitations of the Study

While the Input-Output (I-O) framework provided a robust method to quantify the direct, indirect, and induced impacts of MSME clusters, certain limitations must be acknowledged. The model assumes fixed technical coefficients and constant returns to scale, which may not fully capture dynamic technological changes or productivity shifts in rapidly evolving sectors like electronics and IT services (Miller & Blair, 2022). Regional I-O tables were adapted from national datasets using location quotients, which could introduce aggregation bias and limit precision for smaller, informal sector activities—common in MSME clusters (UNIDO, 2021). Additionally, the study's time frame (February 2023–March 2024) may not fully reflect cyclical fluctuations or post-policy change effects.

5.4 Suggestions for Future Research

Future studies could incorporate **Social Accounting Matrix (SAM)** or **Computable General Equilibrium (CGE)** models to capture price effects, behavioural responses, and inter-household transfers (OECD, 2022). Longitudinal analyses spanning multiple years would provide better insights into structural shifts and policy impacts. Disaggregating the I-O tables to separately analyse formal and informal MSMEs could improve accuracy in labour and value-added estimations. Comparative studies across multiple states using uniform methodologies would help benchmark Andhra Pradesh's MSME cluster performance nationally (NITI Aayog, 2020). Finally, integrating environmental impact indicators—such as carbon footprint or resource efficiency—would support the transition toward sustainable industrialisation.

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Appendices

Appendix A. Detailed Input-Output (I-O) Tables

Below is a sample extract from the regional I-O table constructed for Andhra Pradesh MSME clusters, aggregated into key sectors. The complete table would show inter-industry transaction values (₹ crore), technical coefficients, and total requirements:

Sector	Agro-processing	Textiles & Apparel	Engineering Goods	Electronics & Electricals	Chemicals & Pharma	Final Demand	Total Output
Agro-processing	50	20	15	10	12	500	627
Textiles & Apparel	15	40	8	5	6	420	494
Engineering Goods	20	10	45	15	18	500	608

Appendix B. Questionnaire Used in Primary Survey

Section 1: Firm Profile

- Name of enterprise, year of establishment, sector classification
- Number of employees (full-time, part-time, seasonal)
- Annual turnover and value-added estimates

Section 2: Production & Sales

- Input sourcing patterns (local, regional, national, import)
- Output destinations (local market, interstate, export)
- Annual production volume and value

Section 3: Linkages & Constraints

- Supplier relationships and procurement channels

- Buyer relationships and distribution channels
- Major constraints (finance, infrastructure, skills, market access)

Section 4: Perceptions

- Perceived changes in production costs, market access, and government support over the last three years

Appendix C. Supplementary Statistical Outputs

- **Multiplier Calculations:** Output, employment, and value-added multipliers by sector
- **Linkage Indices:** Backward and forward linkages with ranking of sectors
- **Hypothesis Testing Outputs:** p-values, t-statistics, and confidence intervals for each tested hypothesis

Sensitivity Analysis: Changes in GDP contribution under $\pm 10\%$ variation in final demand