LEVERAGING GLOBAL PRODUCTION NETWORKS
Evidence from the Vizag–Chennai Industrial Corridor

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NO. 51

May 2017

ADB SOUTH ASIA WORKING PAPER SERIES

ASIAN DEVELOPMENT BANK

ADB South Asia Working Paper Series

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No. 51 | May 2017

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www.adb.org

ISSN 2313-5867 (Print), 2313-5875, (e-ISSN)
Publication Stock No.WPS178792-2
DOI: http://dx.doi.org/10.22617/WPS178792-2

Notes:
1. In this publication, "$" refers to US dollars.
2. Corrigenda to ADB publications may be found at http://www.adb.org/publications/corrigenda

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ACKNOWLEDGMENTS

The authors thank the Asian Development Bank India Resident Mission, Atul Sanganeria for facilitating field research in Andhra Pradesh, and Kyle Onda for his help with figures and value chain maps. The authors also gratefully acknowledge the useful comments of two anonymous reviewers. All errors of fact and interpretation are the authors' responsibility.

ABBREVIATIONS

ASI	–	Annual Survey of Industries
FDI	–	foreign direct investment
GVC	–	global value chain
LQ	–	location quotient
NIC	–	National Industrial Classification
OEM	–	original equipment manufacturer
PRC	–	People's Republic of China
R&D	–	research and development
Rs	–	Indian rupees
SAM	–	social accounting matrix
SEZ	–	special economic zone
SMEs	–	small and medium-sized enterprises
VCIC	–	Vizag–Chennai Industrial Corridor

I. INTRODUCTION

1. Economic corridors have emerged as a new way of coordinating investment in the development of integrated regional infrastructure networks covering transport, freight, and a variety of urban services focused on a specific geography (Brunner 2013). With an emphasis on connecting—indeed anchoring—economic activity within urban landscapes and transport networks (rail, road, ports) to create regional production networks, economic corridors stand in contrast to special economic zones (SEZs), which carve out isolated pockets of productive investment with rules and regulations that depart from those in the surrounding domestic tariff area. The underperformance of SEZs in many developing and emerging economies, other than the People's Republic of China (PRC), has led to a search for more connected and integrated production landscapes that seek to leverage the network effects of coordinated economic, logistical, and urban investments.[1] These hubs can then connect with other domestic and global networks to deepen economic synergies that foster wider spatial development.

2. This study explores the conditions under which India's new economic corridors can benefit from strategic participation in global value chains (GVCs) and integration with global production networks. How and through what mechanisms can engagement with global chains improve domestic capabilities and support industrial upgrading and job creation? This study argues that this calls for linking the land, infrastructure, and industrial development components of economic corridor development with the occupational and capability formation effects of network trade associated with participation in global production networks.[2] We explore this issue through the lens of the development of the Vizag–Chennai Industrial Corridor (VCIC) in coastal Andhra Pradesh. We specifically ask how state and private actors in the proposed economic corridor can leverage regional and global networks to realize the economic, employment, and skills benefits of global integration; and how these nested global and local relationships can deepen economic multipliers and enhance the urban and economic competitiveness of the VCIC region. We use a mix of quantitative and qualitative (institutional) analysis to probe these questions.

3. GVCs and global production networks have emerged as the central organizing principles of international trade. In the wake of falling trade barriers and the rise of the World Trade Organization (Sturgeon et al. 2013b), trade today involves not only the exchange of finished goods and services between economies, but also an intricate, networked exchange of parts, components, subassemblies, and processes involving a variety of intermediate goods and tasks across different production sites in different economies and along nodes of extensive value chains. The growth of trade in parts, components, and intermediate goods has exceeded the growth rate of final goods exports since the late 1980s and early 1990s (Feenstra 1998, Gereffi 2005). GVCs are an assembly of linked independent firms, each of which produces on contract for intermediaries higher up the chain until reaching the final buyers or lead firms, including branded multinationals and global buyers, who drive these chains. Global production networks are the sites and spatial platforms located in and across economies in which GVCs intersect and become embedded.

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[1] The PRC's success in crafting policies that helped anchored SEZ's within regional economies is well documented in the literature.

[2] As different segments of the production process in a value chain are concentrated in particular regions, it creates demand for skills and managerial capabilities associated with the occupational needs of that sector or subsector. The skills and capabilities thus generated in the labor market spill over into the wider region.

4. The process of integration driven by these value chains and production networks has led many economies to tap into the expertise, skills, and value far beyond their existing capabilities. By linking with GVCs and participating in global production networks, economies benefit from the globalization of production and the fragmentation of trade. The PRC's emergence as the factory of the world and Japan's ascent to a leadership role in manufacturing were closely tied to their insertion into wider East Asian and global production networks. Many scholars have written about GVCs and global production networks as providing a development pathway to economies that may start out in the low-value segments of these chains before gradually building up and innovating their way to higher-value-added and more skills- and technology-intensive segments of GVCs and industrial sectors. As firms move up these chains, they can pull along their local and regional economies through the creation of critical backward and forward linkages that are locally embedded and globally incorporated. That said, the creation of these linkages and the ability of firms and economies to improve their position in GVCs and global production networks are neither easy nor automatic. Strategic public policies matter, as do the capabilities of local firms, the skills structure of the local workforce, and the quality of the local business environment. But how are domestic capabilities formed and how can they be cultivated in the context of participation in global networks?

5. The recent literature on network trade has referred to the capabilities that come from participation in vertically specialized trade as "task trade" (Kemeny and Rigby 2010). This literature argues that the relationship between trade patterns and the occupational structure of local and regional labor markets in supplier and host economies that are linked by GVCs will determine what kinds of capabilities are formed in each location as a result of their participation in networked trade. In this view, the components, segments, and tasks along a product's value chain that are either outsourced, insourced, or traded away in vertically specialized trade relationships can crucially shape firm capabilities and worker skills at the local level. The spatial and organizational effects on local economies of the distribution of tasks along value chains and the variation in their knowledge and skill intensity can, in turn, influence capability formation. If through participation in global production networks, domestic firms give up the production of activities and tasks that are skill-and-learning-intensive or embody knowledge that has the capacity to help build out high-value segments of an industry later, then important capabilities are lost. By contrast, if firms collaborate with higher-value global partners in ways that can bring important technologies or skills to domestic firms (insourcing) in nonlinear ways that involve trust-based relational ties, then capabilities are enhanced even in the context of participation in vertically specialized trade in GVCs.

6. A second, slightly different strand of the literature on growth dynamics (Hausmann and Rodrik 2003, Hidalgo and Hausmann 2008) argues that the fastest-growing economies are no longer those that specialize in certain sectors or finished goods. Rather, the fastest-growing economies are those that have a complex mix of specializations centered on an unbundled set of capabilities in tasks that can feed into multiple sectors and multiple products, particularly value-adding sectors embedded in national and global production regimes. Both strands of the literature provide important insights into understanding the development of local, place-based capabilities and skills in the context of globally networked trade. However, they do not speak to each other. This study connects these two strands of literature and draws on their joint insights to explore how Andhra Pradesh can build domestic capabilities and benefit from strategic partnerships in global production networks, particularly in Asia.

7. The central argument is twofold. The first argument is that while participation in GVCs is neither a panacea nor a fetish that must be pushed by policy makers for its own sake, GVCs define global trade so centrally that it is strategic for economies to figure out how best to navigate global production networks in ways that can boost domestic capabilities and lead to industrial upgrading.

GVC participation can help firms in emerging economies access new markets and technologies. Under certain conditions, they can become especially meaningful avenues for learning, knowledge creation, and innovation. Therefore, how one participates in GVCs, not merely whether one participates, will make a difference. The gains for supplier firms in lower-income economies will not be automatic, as studies have shown. A pragmatic view of GVC ties is increasingly warranted in part because several studies have shown that the majority of value (share of value-added) generated within GVCs and in trade linked to global production networks accrues to the richer economies where most of the lead firms that drive GVCs are anchored (Schmitz 1999, Bair 2008, Kraemer et al. 2011, Dedrick et al. 2011). Participation in GVCs is more than a reflection of how trade and production is structured in today's global world. It is also a reflection of how knowledge is created, accessed, and diffused across regions and borders. The dynamics of global production networks present both challenges and opportunities for supplier firms in emerging and low-income economies that are seeking to upgrade. In a world where access to markets and technologies often depends on inter-firm ties beyond national borders and on participation in regional networks, the global production network framework is an important lens through which development policies can be viewed to help firms and national economies navigate these globally networked relationships more strategically.

8. The second argument is that the key to navigating global markets strategically is to look inward toward the domestic market in strategic ways to build domestic capabilities while simultaneously embedding global ties within strong domestic backward and forward linkages. To build capabilities, firms need both scale and diversity of demand. Given the small current volumes of vertically specialized trade in India in general (Tewari and Veeramani 2016), and in the VCIC region in particular, the extent of upgrading that can be realized through participation in global and regional production networks may be narrow in the short-run. Furthermore, limited local capabilities may lock firms (and the region) into relatively low-value-added segments of GVCs. To guard against this and create the conditions needed to progressively access higher functional nodes in the production chain, scale and strategic specialized diversification will be needed. In the case of VCIC (as well as other Indian agglomerations), this can come from building ties to the large domestic market at the same time as firms build ties with GVCs; that is, by exploiting economies of scale and economies of scope by connecting global production networks with domestic production networks.

9. Thus, leveraging the strength of GVC participation involves more than looking outward toward global buyers, lead firms, and networks. It requires skillfully harnessing domestic demand in the large Indian market to build domestic institutions—both sectoral and spatial—that can help deepen domestic capacities through backward and forward linkages. The idea of the economic corridor—which does not simply segment places into self-contained SEZs, but also creates important links between agglomerations of firms and proximate towns, communities, and cities—has the potential to embed economic development much more centrally than isolated greenfield sites. To that extent, policies that help build coordinated and well-managed connections between the new manufacturing hubs of the local economy—through logistics networks (road, rail, and port) and networks of sectoral institutions that provide skills in demand-driven ways and support industrial upgrading—will be important if the promise of economic corridors is to be realized.

10. This study took a pragmatic and institutional approach to analyze the industrial dynamics of the VCIC through the lens of global production networks and GVCs, and provide grounded policy advice on how the mechanisms of learning that are implicit in the dynamics of task trade can be fruitfully leveraged by local actors (public and private) to build out and upgrade industrial skills and capabilities. The study asked the following questions: Which linkages matter more than others? What sequencing of actions and economic activities, including infrastructural and spatial, might crowd in

investment and set the stage for fostering backward and forward linkages? What kinds of institutional structures, institutional supports, and regulatory mechanisms might create the institutional and economic ecosystem to generate growth and innovation that is also employment enhancing?

A. Choice of Sectors

11. To examine prospects for the incorporation of the VCIC into global production networks in ways that create possibilities for growth, upgrading, and development for particular sectors and firms, and for the state of Andhra Pradesh as a whole, the study selected three sectors that are of critical policy importance to Andhra Pradesh: (i) pharmaceuticals, (ii) chemicals, and (iii) electronics. Together, these sectors account for nearly 13% of Andhra Pradesh's manufacturing employment, almost a quarter (24%) of total output, more than half (57%) of all exports, and over a third (35%) of all imports in the manufacturing sector.[3] Even though these are pre-bifurcation figures, the main hubs for the chemicals and pharmaceutical sectors remain within the new borders of Andhra Pradesh.

Table 1: Sectoral Shares of Manufacturing in Andhra Pradesh

Sector	Employment (%)	Output (%)	Exports (%)	Imports (%)
Pharmaceuticals	6.2	8.0	39.8	4.3
Chemicals	4.1	12.5	6.7	24.4
Electronics	2.3	3.4	11.1	5.8
Total	**12.6**	**23.9**	**56.5**	**34.5**

Source: Government of India, Central Statistics Office. Annual Survey of Industries, 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx

12. Table 1 shows that all the three sectors we have chosen have significant trade linkages with global markets. Exports outpace imports in the pharmaceuticals and electronics sectors, indicating the existence of domestic backward and forward linkages as well as a degree of domestic value-addition. The chemicals industry is linked to global markets through the processing of imported inputs (both for re-export and for the domestic market) and has strikingly high output levels.

13. Pharmaceuticals is an important sector to study not only because it is the most export-intensive sector in Andhra Pradesh, accounting for almost 40% of manufacturing exports, but because it also is an important job generator. It contributes the most to employment of the three sectors chosen for this study (6%) and accounts for the lowest share of imports (4%). Clearly, domestic input chains are important for this sector and these inputs have export linkages. Driven by large exporters such as Dr. Reddy and Hetero Drugs, the pharmaceuticals sector is already a major component of Andhra Pradesh's economy and one that has the potential to grow considerably given strong global demand for generics.

[3] Data are taken from the Annual Survey of Industry for 2010–2011, which include figures prior to the bifurcation of Andhra Pradesh (i.e., including Telengana).

14. The chemicals industry is interesting because of its emphasis on processing. The sector's output is dominated by the processing of (mainly) imported inputs, primarily for the domestic market along with some exports. Thus, it relies heavily on imports, but has the potential to both expand exports as well as diversify its input base, while striving for functional upgrading in global markets.

15. Electronics, meanwhile, is a complex sector that has significant growth potential, especially through participation in global networks. Andhra Pradesh's electronics sector currently accounts for a relatively large share of manufacturing exports (11%), which is almost entirely attributable to the export of batteries. However, as this study shows, important specialization is emerging within this sector in Andhra Pradesh and the selection of the electronics sector was therefore deliberate. Coastal Andhra Pradesh is a favorable location for this sector's growth with respect to both linkages to the global industry, especially in East Asia, and the domestic market. Recent investments by key global suppliers such as Foxconn (and others) in Sri City have begun to lay an important foundation for the sector's growth. Even if these investments are in relatively simple and low-value activities, they provide jobs and can become the basis for strategic expansion later.

16. In picking these three sectors, the study asked two broad questions: How can deeper integration into global production networks boost the growth of these sectors, foster upgrading, and contribute to the transformation of the state's economy through backward and forward linkages and employment effects? To answer this, the study relied on detailed sector- and product-level analysis of each sector using firm-level Annual Survey of Industries (ASI) data, input–output tables, and trade data (Comtrade).

17. The second question was how can policy support the transformation of the state's economy? To answer this, the study explored how the three sectors are currently organized, how they are linked to export and import markets, and what policies might help deepen their strategic linkages to GVCs. The emergent literature on industrial policies and GVCs (Gereffi and Sturgeon 2013, Gereffi 2014) suggests that upgrading through GVC integration requires policies that differ in important ways from traditional industrial policies that supported import substitution and export-oriented manufacturing. Following this literature, the study looked beyond policies related to SEZs, localization, local content rules, and export promotion to examine what the current structure of production in each of our study sectors is and how different segments of these industries are linked to global markets. The study asked questions covering six themes related to the organization of production and trade in these sectors:

(i) Is the current global incorporation of the sector mainly through the production of intermediates and components or final goods preparation?
(ii) What are the end markets to which the sector's exports are linked? Are these exports linked to supplier firms (e.g., Foxconn) or to final goods producers (e.g., Apple)? Similarly, what is the structure of imports—how does the share of basic inputs, subcomponents, and high-value inputs or capital goods break out? This will determine the nature and sequence of any potential localization of the value chain.
(iii) Which of the industry segments—intermediates vs. final goods preparation—generates the most employment? Which generates the most exports? Which absorbs the most imports?
(iv) How are domestic inputs and markets integrated into the sector? This often determines the nature of regional multipliers; that is, how the global growth of a sector can generate secondary growth, employment, and innovation in domestic segments of the chain, and how it spills over into other parts of the economy.

(v) Which segments of the electronic, chemicals, and pharmaceuticals GVCs are currently found within Andhra Pradesh? Conversely, what is Andhra Pradesh's position in each sector's GVC? How does the value chain of the sector in Andhra Pradesh compare to the complete GVC of that sector?

(vi) What is the structure of firms in these networks, both locally and globally? Who are the lead firms in the sector? What does their complete value chain look like? What is their current role in the VCIC region? This will help determine how many degrees removed the linkages of the region's value chain are from the lead firm that drives the GVC in a particular sector.

B. Structure of the Paper

18. The rest of the paper is organized as follows. The three sectors are analyzed sequentially in each section. Chapter 2 examines the relative specialization of each sector in Andhra Pradesh by measuring each sector's relative specialization in comparison to India as a whole through a detailed location quotient analysis. This section also analyzes the current structure of the global linkages of each of our three sectors. Chapter 3 presents the product profile of each sector clarifying what they produce, what they export and import, and how these are valued across the production chain. Chapter 4 examines the domestic backward and forward linkages of the study sectors. Chapter 5 maps out the value chain structure of each sector and clarifies the position of Andhra Pradesh in the relevant GVCs. It analyzes prospects for upgrading the domestic segments in these sectors through deeper insertion in global production networks. Each of these aspects is analyzed for all three sectors included in this study. Chapter 6 presents comparative global case studies and the final section provides the conclusion. The paper dwells briefly on the employment and skill implications of the growth and upgrading of the study sectors through the integration of VCIC into global networks and examine the industrial policies that could help Andhra Pradesh make the most of its participation in global production networks.

II. ANALYZING ANDHRA PRADESH'S GLOBAL LINKAGES: A LOCATION QUOTIENT ANALYSIS

A. Identifying Leaders, Laggards, and Emergent Subsectors

19. The analysis began with an examination of the spatial concentration of each of the three study sectors within Andhra Pradesh. How prominent are the study sectors in Andhra Pradesh relative to the national presence of these same sectors? Are these sectors nascent, emergent, or mature in the state? This issue is important because different kinds of policies and industrial linkages will be needed to nurture the growth of sectors that are at different stages of growth and degrees of development. Similarly, different strategies may be required to connect sectors that are either leaders or laggards to global networks. Also, the scale and size of a sector in a region relative to other regions in an economy will determine its degree of specialization and potential competitiveness.

20. The study measured the spatial concentration of the pharmaceuticals, chemicals, and electronics sectors through a simple descriptive technique by calculating their location quotients.[4] Location quotients are an indication of the relative spatial concentration (or specialization) of a variable of interest, such as employment or output, for a sector or set of productive activities within a particular geography. A location quotient is calculated as a ratio of ratios. For example, the location quotient of employment in, for example, intermediates production in the pharmaceuticals sector in Andhra Pradesh is computed by dividing this sector's share of total employment in Andhra Pradesh by the share of total employment for these same activities in all of India. If the location quotient is greater than 1.0 for Andhra Pradesh's pharmaceutical intermediates, then it can be inferred that this activity is more concentrated in Andhra Pradesh than in the overall Indian economy, indicating specialization. If the ratio is less than 1.0, then it means that Andhra Pradesh is less specialized in this activity than the Indian economy at large. If it hovers close to 1.0, then the concentration of the activity in Andhra Pradesh is about average relative to the Indian economy. Therefore,

$$LQ_{E,i} = \frac{e_i/e}{E_i/E}$$

where:
e_i = employment in state economy in sector i,
e = employment in state economy in all sectors,
E = employment in national economy in all sectors, and
E_i = employment in national economy in sector i.

21. The location quotients for our three study sectors are calculated with respect to employment (e), output (y), exports (x), imports (m), and domestic inputs (n):

$$LQ_{e,i} = \frac{e_i/e}{E_i/E};\ LQ_{y,i} = \frac{y_i/y}{Y_i/Y};\ LQ_{x,i} = \frac{x_i/x}{X_i/X};\ LQ_{M,i} = \frac{m_i/m}{M_i/M};\ LQ_{n,i} = \frac{n_i/n}{N_i/N}$$

22. We calculate these for the production of final goods and intermediates in the pharmaceuticals, chemicals, and electronics sectors. The results are reported in Table 2. To preview the results, we continue with the example noted above of pharmaceutical intermediates in Andhra Pradesh versus the Indian economy. From Table 2, we find that the share of employment in these activities in Andhra Pradesh (1.7%) is 2.3 times greater than the share for India (0.73%). Therefore, the location quotient of employment in pharmaceutical intermediates is 2.3. This indicates that (formal) employment in this subsector (intermediates) is relatively concentrated in Andhra Pradesh compared to all of India,

[4] Location quotients are useful in analyzing the economic and spatial concentration of industries in an area. They help in analyzing whether industries in an area are large or small, whether they drive local or regional growth, or are national leaders in key sectors or subsectors that the region specializes in, whether they are emergent or nascent industries and whether they can be influenced by policy and so on. We adopt this method to examine the local and export content of industries in addition to size and specialization to identify global linkages as well as the potential for backward and forward linkages in a sector. The well-known limitations of this method are that they are descriptive and data driven so that the findings are as good as the quality of the data that the analysis is based on. For example, our use of the survey of formal industries in the Annual Survey of Industries, natually leaves out data on informal economic activities in the sectors we are studying. Location quotients also provide analysis at a point in time, rather than tracing the evolution of industrial structure over time. The simplicity of this method carries both strengths and some limitations. The findings reported in the rest of this section should therefore be interpreted with this caveat in mind. That said, the location quotient is a very useful heuristic tool that enables us to conduct industry targeting, industry characterizing, and cluster/linkage identification analysis that has clear policy relevance.

indicating specialization of pharmaceutical intermediates in Andhra Pradesh. Given that specialization is also interpreted as comparative advantage, Andhra Pradesh has a comparative advantage in this subsector relative to India as a whole. The larger the location quotients, the greater the degree of specialization and comparative advantage in the region.

23. To account for global integration, the study looked at exports and imports. The location quotients for exports and imports provide an indicator of the intensity of integration of each industry into broader global production networks in comparison to the rest of India. Table 2 shows that the share of exports from the intermediate pharmaceuticals segment in Andhra Pradesh is 4.3 times as large as the share of exports from these activities for all of India, indicating that exports from Andhra Pradesh are relatively more concentrated in these activities than are exports from the economy as a whole.

24. Table 2 identifies leaders as those segments with a location quotient greater than 3, laggards as those with a location quotient less than 0.5, nascent or potential specializations as those with a location quotient between 0.5 and 1.0, and emerging sectors as those with a location quotient between 1.0 and 3.0.

Table 2: Location Quotients for Andhra Pradesh's Pharmaceuticals, Chemicals, and Electronics Sectors

	Employment		Output		Exports		Imports		Domestic Inputs	
	Share (%)	LQ	Share (%)	LQ	Share (%)	LQ	Share (%)	LQ	Share (%)	LQ
Pharmaceuticals Intermediate	1.7	2.3	1.5	2.8	8.7	4.3	0.5	1.0	1.9	4.3
Pharmaceuticals Final	4.5	1.7	6.5	3.2	31.1	5.7	3.8	4.6	6.3	4.6
Chemicals Intermediate	1.4	0.7	5.1	1.0	2.7	0.7	11.4	2.1	3.1	0.7
Chemicals Final	0.6	0.2	1.2	0.4	0.6	0.2	0.8	0.6	1.2	0.4
Electronics Intermediate	1.9	1.9	2.4	3.4	11.1	6.0	4.4	4.9	2.0	2.9
Electronics Final	0.3	0.3	0.6	0.3	0.0	0.0	0.6	0.2	1.0	0.7

0 < LQ < 0.5 (No specialization)	1 < LQ < 3 (emerging specialization–EMERGING)
0.5 < LQ < 1 (nascent specialization)	LQ > 3 (Strong specialization–LEADERS)

> = greater than, < = less than, LQ = location quotient.
Source: Authors' calculations based on data from the Government of India, Central Statistics Office. Annual Survey of Industries, 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx

25. Based on this classification, Andhra Pradesh's leading segments (with a location quotient greater than 3.0) are pharmaceuticals final goods and electronics intermediates, with the state having a strong spatial specialization and comparative advantage in both. Pharmaceutical intermediates and

chemical intermediates are emerging (location quotient > 1.0) in Andhra Pradesh with respect to output, but neither of these segments are yet strongly connected to global production networks other than via imports. Thus, there is potential for further growth in global ties in both. Chemicals final goods and electronics final goods are areas of nascent specialization in Andhra Pradesh (location quotient between 0.5 and 1.0).

26. With respect to employment, only the pharmaceuticals sector has a strong specialization in Andhra Pradesh. The employment-intensity of pharmaceuticals suggests wider variation in firm size and relative labor intensity within the sector, while the chemicals and electronics sectors are more capital intensive. However, all three sectors have significant potential for growth through insertion in global production networks. The study examines each of these sectors in turn.

B. Pharmaceuticals

27. Pharmaceuticals production, both in terms of the intermediate and final segments of the value chain, is quite specialized in Andhra Pradesh as evidenced by location quotients greater than 3.0 for both activities. The fact that the location quotient for output is higher than that for employment suggests that pharmaceuticals production in Andhra Pradesh is relatively capital intensive. While both segments appear competitive in Andhra Pradesh, final goods production in pharmaceuticals is especially strong as the shares of all variables, especially of output and exports, are relatively high in this segment. (The share of Andhra Pradesh's pharmaceutical final products output is 5.7 times larger than the share for similar activities in India.) According to our analysis of firm-level product data in Andhra Pradesh, the most important final products manufactured in the state with respect to both output and exports are antibiotics, biochemical medicines, and vitamins (Appendix Tables A.1 and A.4).

28. Both segments of the pharmaceuticals sector are well connected to global networks and also serve as relatively important markets for domestically made inputs. Therefore, they are integrated in both domestic and global (export and import) networks. Compared to the pharmaceutical intermediates industry in India, production in Andhra Pradesh uses domestic inputs (but not imports) quite intensively. Thus, the continued development of such activities in the state can be expected to generate further backward linkages to the domestic market. For the intermediates segment, major domestically sourced inputs include antibiotics and basic chemicals, and imported inputs include steroids and other basic chemicals. For the final goods segment, key domestic inputs include HIV treatments, vitamins, and other pharmaceutical preparations, while major imports are blood thinners, antibiotics, and other medicaments (Appendix Tables A.2 and A.3). The development of backward linkages can help facilitate a more broad-based anchoring of the final goods segment in the region.

C. Electronics

29. The second leading segment in Andhra Pradesh is electronics intermediates. While it is yet a small and relatively narrow segment in Andhra Pradesh with only one lead firm, the manufacture of intermediate products within electronics value chains constitutes an important specialization for Andhra Pradesh and an important comparative advantage. Compared to the overall Indian economy, the share of output in electronics intermediates in Andhra Pradesh is 3.4 times larger. More importantly, intermediate electronics production in Andhra Pradesh constitutes a relatively significant source of exports (about 11% of the state's exports, corresponding with a location quotient of 6.0) and therefore is connected to global markets and networks. Dry cell batteries are the main export product (Appendix Table A.4). This sector also imports more on average than similar firms in the rest of the economy.

30. The main domestic inputs for the electronics intermediate segment are minerals, principally lead and lead compounds, which are inputs in battery production, the largest and most important intermediate activity in the electronics value chain in Andhra Pradesh with respect to employment, output, and exports. However, these inputs are all accounted for by production in only one firm, indicating that the state's specialization is itself attributable to production within a single organization. This suggests an opportunity for diversification and growth in the sector. By contrast, key domestic inputs into final electronics production are more diffused, including picture tubes, metal cabinets and fixtures, and integrated circuits (semiconductors). Relative to intermediates, however, the assembly and production of final goods appears weak in the data and is not yet concentrated in the state. This is ironic because most East Asian economies that dominate electronics exports worldwide began the process with the assembly of finished goods. As such, this is an area of potential growth.

D. Chemicals

31. The chemicals sector is not particularly specialized in Andhra Pradesh. Neither intermediates nor final chemicals production demonstrate a specialization across any of the variables in Table 2, except for imports within the intermediate segment. The relatively high concentration of imports within the intermediate segment is driven by imports of phosphorous compounds, which are used as inputs in fertilizer production, an important anchor of the state's chemicals industry. Nevertheless, intermediates chemicals production constitutes a notable share of output (5.1%) and exports (2.7%) in the state's manufacturing sector and therefore this output base constitutes an important potential growth platform.

E. Summary

32. This initial analysis of location quotients suggests that the pharmaceuticals, electronics, and chemicals sectors are integrated into domestic and global production networks in different ways. Both segments of the pharmaceuticals sector are well connected to export and import markets, while also being embedded strongly in domestic markets. The electronics sector, though small, has a significant export share and is strong in intermediates. The chemicals industry is linked to global markets primarily through imports. The state has a comparative advantage in at least two of the sectors (pharmaceutical and electronics) and a substantial presence in one (chemicals). Moreover, fieldwork and interviews revealed evidence of continued investment and employment growth in all three sectors beyond the 2010–2011 period covered by the data. All three of these core sectors are poised to play an important role in anchoring industrial growth and job creation in Andhra Pradesh's new economic corridors. All three have the potential to upgrade through more strategic insertions into global markets.

33. Subsequent sections examine the product-level characteristics of each sector and map their value chains to draw further lessons about the structure of the industries and the nature of their domestic and global linkages.

III. SECTOR PROFILES AND VALUE CHAIN MAPS

34. To understand how to improve the global ties of each sector in ways that build up competitiveness and upgrade value added, the study sequentially analyzed each sector's product profile and the nature of its value chain. The study also identified which firms are leaders in each sector and if they are already globally embedded.

A. Pharmaceuticals

35. Of the three manufacturing sectors in Andhra Pradesh being investigated, the study identified the pharmaceuticals sector as having especially strong potential to strategically deepen integration with global production networks.[5] As Table 3 shows, there were 132 firms in Andhra Pradesh's pharmaceuticals sector in 2010–2011, up from 80 firms in 2000–2001. The final goods segment (final preparations) generated far more employment and output than the intermediates segment (active pharmaceuticals ingredients) in 2010–2011. Total employment was 37,000 in final preparation manufacturing versus 14,000 in active pharmaceuticals ingredients manufacturing. Total output was Rs12,300 million in final preparation manufacturing versus Rs2,790 million in active pharmaceuticals ingredients manufacturing. This amounts to a share of 4.5% in the final preparations segment, nearly three times that of the ingredients segment (1.7%); a share of 6.5% in Andhra Pradesh's total manufacturing output; and a striking 31.1% of total manufacturing exports. By comparison, pharmaceutical intermediates accounted for only 1.5% of Andhra Pradesh's manufacturing output and 8.5% of manufacturing exports. Thus, at the product level, final preparations lead the pharmaceuticals sector in Andhra Pradesh.

Table 3: Pharmaceuticals Value Chain Segments in Andhra Pradesh

Value Chain Segment	Active Ingredients			Final Preparations			
NIC code	21001			21002			
Number of Firms	45			87			
Location Quotient	2.26			1.68			
Number of Exporters	7 (16%)			21 (24%)			
Number of Importers	16 (29%)			41 (47%)			
	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average (2011)	Average (2001)	Share of Total Andhra Pradesh Manufacturing (%)
Employees	13,977	311	1.7	36,972	425	259	4.5
Output	27,900	620	1.5	123,000	1,410	280	6.5
Exports	12,300	270	8.7	43,800	500	n.a.	31.1
Domestic Inputs	14,400	320	1.9	48,800	560	120	6.3
Imported Inputs	2,210	50	0.5	15,800	180	90	3.8
Fixed Assets	19,200	430	0.2	43,200	500	190	0.4

n.a. = not applicable, NIC = National Industrial Classification. All values in Rs. Million.
Note: Location quotient is calculated for Andhra Pradesh with respect to all of India.
Source: Government of India, Central Statistics Office. Annual Survey of Industries, 2000–20001 and 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx

[5] There are several other sectors with potential for integration, including food processing (rice and palm oil, coffee, seafood); textiles and apparel; leather; and information technology and information technology-enabled services. These sectors are outside the scope of the current study.

36. In addition to having more firms and greater output, the pharmaceuticals final preparations segment is also more linked to the domestic economy than the intermediates segment, accounting for a 6.3% share of all inputs in Andhra Pradesh's manufacturing sector procured locally, compared with less than 2.0% for the intermediates segment. Similarly, firms in the final preparations segment are larger in terms of employment and investment, and they both import and export more on average than intermediates manufacturers. Firms in the final preparation segment represent a major source of exports for Andhra Pradesh, comprising 31.1% of all manufacturing exports (and 6.5% of all manufacturing output). The pharmaceuticals value chain generated a trade surplus for Andhra Pradesh in 2010–2011. Thus, it is the final goods segment of Andhra Pradesh's pharmaceuticals sector that is currently driving global integration.

37. At the same time, the final goods segment rests on a narrow product regimen of primarily the preparation and export of Heparin and other antibiotics as well as contributions to non-retroviral drugs, suggesting that there is significant scope for the further development of this sector by (i) deepening scale economies in existing product areas to lower costs of production and expand end markets, and (ii) branching out to other final preparations and building a bigger base in intermediates.

38. Despite the pharmaceuticals sector's strong potential for growth via global integration and domestic expansion, there are also weaknesses that will need to be addressed as the sector grows more complex and organizationally sophisticated. For example, while the pharmaceuticals sector has the greatest number of firms of our three study sectors, it also has the thinnest local value chain because its growth in the state rests more on the production and export of a relatively narrow set of finished goods—primarily antibiotics, vitamins, and antiretroviral drugs—for which inputs are imported. All three of these products are very important to the regional economy and have strong global markets. Demand is therefore likely to rise, which will fuel growth. However, there is relatively low value added in the sector at present, signifying strong potential for upgrading. Although manufacturers in the pharmaceuticals sector import a great deal of their inputs, they also rely a fair amount on local inputs, indicating that this sector, though narrowly focused on a few key products, is integrated in global and domestic markets both for outputs (exports) and inputs (imports). Both arenas have promising growth potential.

39. Field interviews conducted for this study show the evolution of the firm structure of this sector in recent years. Firms with a leading position in domestic and export markets and a long history in Andhra Pradesh include Hetero Drug and Dr. Reddy. TIL is a major domestically-owned exporter of vitamins with manufacturing plants in Andhra Pradesh. Andhra Pradesh has also gained a reputation as the leading state in India for active pharmaceutical ingredients manufacturing, especially thanks to the emergence of several innovative small and medium-sized enterprises (SMEs). While many of India's key local SMEs are headquartered in Hyderabad, several, such as Laurus Labs, own manufacturing facilities in Andhra Pradesh. Ramky Pharma City, a single-product industrial park (SEZ and domestic tariff area) located outside of Visakhapatnam, has attracted investment from both multinational firms and local SMEs. These developments are worth building on and consolidating through strategic policies and infrastructure development, particularly to support research and development (R&D), clean manufacturing, and the broad-based diffusion of quality and safety standards and good manufacturing practices across the sector.[6]

[6] The upgrading of standards and sector-wide adoption of good manufacturing practices was central to the PRC's successful restructuring of its pharmaceuticals sector in the 1990s, which served as a prelude to export growth.

1. Pharmaceuticals Product Profile

40. A closer look at the structure of imports, exports, and domestic linkages, as well as firm size helps clarify the emerging structure of the pharmaceuticals sector in Andhra Pradesh and identify opportunities for future growth (Table 4).

Table 4: Product Profile of the Pharmaceuticals Value Chain in Andhra Pradesh

Intermediate Goods					
Product	Share of Total Manufacturing Output (%)	Share of Total Domestic Inputs to Manufacturing (%)	Share of Total Manufacturing Imports (%)	Share of Total Manufacturing Exports (%)	Share of Total Manufacturing Employment (%)
Antibiotics and preparations thereof, n.e.c.	1.46	0.92	0.93	6.83	1.04
Biochemic mixed medicines	0.37	0.35	0.41	0.97	0.20
Trimethoprim-sulfamethoxazole (co-trimoxazole)	0.23	0.16	0.06	0.00	0.06
Boric powder	0.17	0.11	0.00	0.00	0.07
Final goods					
Product	Share of Total Manufacturing Output (%)	Share of Total Domestic Inputs to Manufacturing (%)	Share of Total Manufacturing Imports (%)	Share of Total Manufacturing Exports (%)	Share of Total Manufacturing Employment (%)
Biochemic mixed medicines	1.27	0.80	0.55	2.72	0.40
Antibiotics and preparations thereof, n.e.c.	3.61	1.84	1.38	11.49	1.20
Other vitamins in tablet or injectable form	0.53	0.04	0.02	2.45	0.31
Amoxicillin and ampicillin with and without cloxacillin	1.29	0.93	0.63	4.03	0.47

n.e.c. = not elsewhere classified.
Note: All values in Rs. million.
Source: Authors' compilation based on data from the Government of India, Central Statistics Office.. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx (accessed 18 February 2015).

41. Several points stand out from Table 4 related to outputs, inputs, exports, and imports in the pharmaceuticals sector.

2. Output

42. On the output side, as noted earlier, antibiotics are a major product within both the intermediate and final goods segments in Andhra Pradesh.[7] In terms of value of production, antibiotics are the top product category among producers of intermediate goods (Rs14,030 million), comprising 1.5% of total manufacturing output and the second most important category among producers of final goods (Rs12,790 million). Combining both categories, antibiotics comprise 1.4% of total output in the Annual

[7] ASI product code data do not differentiate between intermediate and final antibiotic medicaments; that is, between intermediates and final preparations.

Survey of Industries (ASI) sample. While manufacturers of antibiotic intermediates produce in only a few other product categories, producers of final products in antibiotics chains tend to be multiproduct firms. As indicated in Table 4, these firms comprise 3.6% of the state's manufacturing output, 1.4 percentage points of which are accounted for by antibiotics. More firms are involved in the production of antibiotics than any other product category among the three value chains that the study analyzed.

3. Inputs

43. Producers of final goods also account for more domestic inputs than producers of intermediate goods. Aside from "other pharmaceutical products" (a residual category), the most important domestic input for the pharmaceuticals industry is antiretroviral, which account for nearly 0.5% of the value of all domestic inputs in the ASI sample.[8]

4. Exports

44. Antibiotics are the leading export category in the pharmaceuticals sector, with 62% of antibiotics output destined for export markets. Antibiotics alone account for 5.1% of total exports in the ASI sample.

5. Imports

45. Interestingly, pharmaceuticals do not account for a large share of imports in the ASI sample; rather, producers rely primarily on a base of domestic suppliers, inputs, and raw materials. The top imported products are (i) heparin and (ii) other pharmaceutical products. These are both ingredients that are used in the production of final goods. Producers of final goods account for more imported inputs than producers of intermediate goods. Producers of final goods also account for more domestic inputs than producers of intermediate goods. Aside from other pharmaceutical products, the most important domestic input for the pharmaceuticals industry in Andhra Pradesh is antiretroviral intermediates, which account for nearly 0.5% of the value of all domestic inputs in the ASI sample.[9]

46. This analysis suggests that, while antibiotics and biochemics are currently the most prominent product categories in the pharmaceuticals sector in Andhra Pradesh (and the production of these final products is dominated by larger firms), there is significant scope for growth through diversification via ties with global buyers in related products. To understand where this scope lies in relation to global production networks, we look at Andhra Pradesh's pharmaceuticals value chain in relation to the structure of the industry globally.

6. Pharmaceutical Global Value Chain Maps

47. What is the place of Andhra Pradesh in the pharmaceuticals global value chain (GVC)? What does Andhra Pradesh's pharmaceuticals value chain look like? In this subsection, we examine the structure of Andhra Pradesh's pharmaceutical GVC (Figure 1) and compare it with the GVC of the sector as a whole (Figure 2). Through this comparison, we identify the scope for upgrading in Andhra Pradesh's pharmaceuticals value chain.

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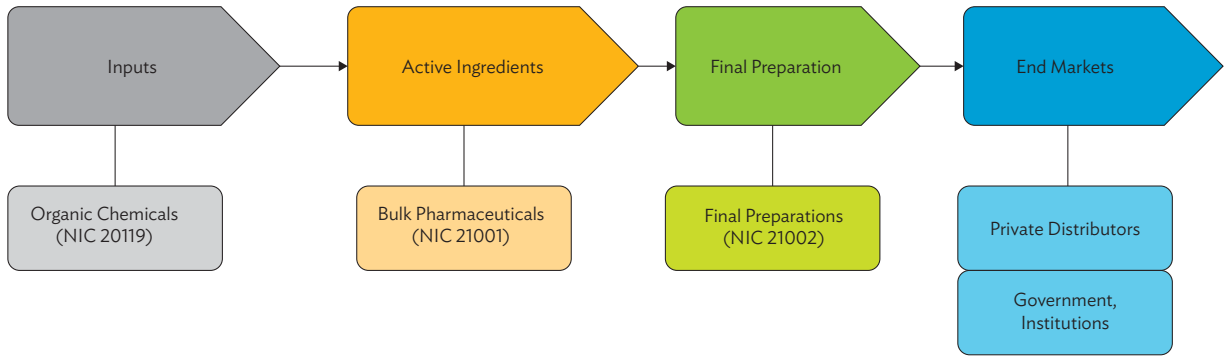
[8] The prominence of antiretrovirals among Andhra Pradesh's domestic inputs could reflect Hetero Drugs, which is based in Hyderabad and owns manufacturing facilities outside of Visakhapatnam, and is one of the world's leading producers of low-cost antiretroviral drugs.

[9] The ASI does not separate pharmaceuticals from chemicals. Therefore, the authors were unable to break down the input analysis further, but will turn to it again under the discussion on chemicals.

48. Figure 1 shows that Andhra Pradesh's pharmaceuticals value chain has three main areas: (i) inputs, primarily organic chemicals; (ii) the active ingredients segment, which is the sector's intermediates niche, currently limited to bulk pharmaceuticals; and (iii) final products related to final preparations (antibiotics, diabetes preparations, and antiretroviral drugs). Antibiotics are also associated with bulk pharmaceuticals in the active ingredients segment.

Figure 1: Andhra Pradesh's Pharmaceuticals Value Chain



NIC = National Industrial Classification.
Source: Authors' compilation based on interviews and data from Government of India, Central Statistics Office. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx (accessed 18 February 2015).

49. The primary end markets of the sector are private distributors, who are responsible for exports as well as domestic sales. The other larger buyers are hospitals and government institutions, and larger multilaterals such as the World Health Organization who more typically source directly from manufacturers rather than purchase through distribution intermediaries. The fact that private distributors are an important gateway for Andhra Pradesh's trade suggests that Andhra Pradesh's firms are not original equipment manufacturers (OEMs) or first-tier suppliers to the world's leading pharmaceutical companies. The relationship between Andhra Pradesh's manufacturers and the sector's (global) lead firms is mediated by other tiers of subcontractors and distributors except perhaps in a handful of cases such as Hetero Drugs. This is another potential area of growth where upgrading may be targeted—to find ways to develop OEM linkages with major buyers. A small number of medium-sized multinationals, such as Pharmazell based in Germany, have manufacturing facilities in Andhra Pradesh. Firms like this could be a place to start.

50. Since the generics market is an important niche for Andhra Pradesh's exporters, another area of growth is to deepen and widen the sector's linkages with buyers in other economies in the Global South—including in Africa, Latin America, the Middle East, and parts of South Asia and Southeast Asia—through upgrading ties with institutional buyers in new markets and covering new drug preparations. Interviews confirmed that the process of complying with market access requirements in these regions is easier than exporting to highly regulated markets in the European Union, Japan, and the United States.

51. Table 5 provides a list of the major buyers and leading global firms in the pharmaceuticals sector, a majority of which are headquartered in Europe and the United States. Many of these firms spend a large share of their revenues—often as much as 20%—on R&D activities.

Table 5: Top 15 Global Firms in the Pharmaceuticals Sector by Revenues

Name	Headquarters	Pharmaceutical Sales, 2014 ($ billion)	Pharmaceutical R&D Spending, 2014 ($ billion)
Novartis	Switzerland	46.1	9.3
Pfizer	United States	44.5	7.2
Roche	Switzerland	40.1	8.6
Sanofi	France	38.2	6.2
Merck & Co.	United States	36.6	6.5
Johnson & Johnson	United States	30.7	6.0
GlaxoSmithKline	United Kingdom	30.3	4.9
AstraZeneca	United Kingdom	25.7	4.9
Gilead Sciences	United States	24.5	2.7
AbbVie	United States	19.9	3.3
Amgen	United States	19.3	4.1
Teva Pharmaceutical Industries	Israel	17.5	1.5
Bayer	Germany	16.4	0.5

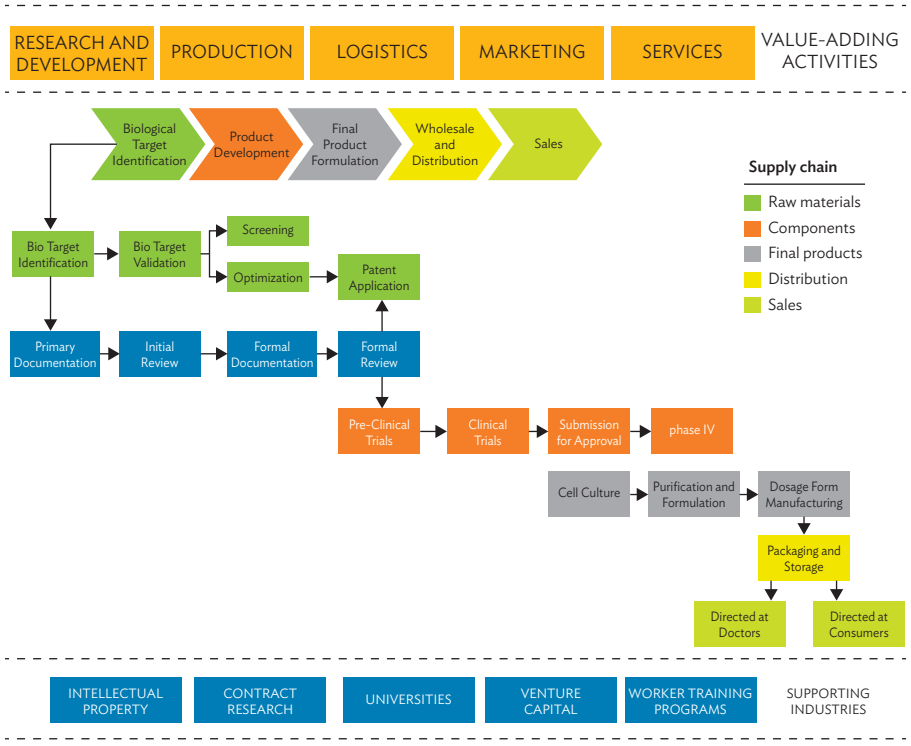
R&D = research and development.
Source: EvaluatePharma. 2015. *World Preview 2015*. London: Evaluate Group.

52. Figure 2 outlines the complete GVC of the pharmaceutical industry. Currently, Andhra Pradesh's pharmaceuticals sector occupies the purple box above final product formulation and some intermediates activity as well as two of the purple boxes in the lower right corner. A comparison between Figure 1 and Figure 2 underscores the narrowness of Andhra Pradesh's pharmaceuticals value chain, suggesting that it is still a nascent industry with significant growth potential that can be realized through strategic integration with various segments of the pharmaceuticals GVC. Specifically, this includes (i) strategic expansion to a wider palette of activities through product- and process-level upgrading, both in the intermediates segment and the more profitable and regionally more productive finished goods segment; and (ii) through functional upgrading to OEM status in global markets.

53. Figure 3 expands our understanding of the areas in which future growth in the sector is possible. By separating the segments and activities by function and level of complexity, it shows a potential pathway to upgrading.

54. Figure 3 suggests that Andhra Pradesh's pharmaceuticals industry is in the right lower quadrant of the diagram under generics. There is tremendous potential to progressively move up and to the left within the diagram by overcoming the challenges related to entry barriers; R&D investment and the quality of research, including the ability to conduct clinical trials and contract research in cost effective ways; becoming OEM suppliers to lead firms in the global market; and eventually moving up the product development hierarchy to become own-brand producers. For the foreseeable future, Andhra Pradesh's pharmaceuticals sector's greatest scope lies in

Figure 2: The Pharmaceuticals Global Value Chain



Source: North Carolina in the Global Economy. Value Chain. Drugs & Pharmaceutical Value Chain 2012. www.ncglobaleconomy.com/NC_GlobalEconomy/biotechnology/value.shtml

Figure 3: Potential for Growth: Identifying Specific Strands of the Pharmaceuticals Global Value Chain

Parametres for differentiation of the three strands	Branded products	Quality generics	Low-value generics
End-markets	Industrial countries High income groups e.g., in India, PRC	Industrial countries Middle class groups in developing countries	Developing countries Government tenders Sub-Saharan Africa
Products	Patented and global blockbusters	Life-style diseases Branded generics	Antiinfective, off-patent, tropical diseases
Producers	Vertically integrated, research, marketing-intensive companies in Europe and US	Outsourcing by R&D and marketing intensive companies to low-cost product sites	Developing country-based companies, (some outsourcing within the strand)
Research and development	In-house product development, some in-sourcing from biotech companies	In-house or outsourced process development, contract research	Some process development, and development of fixed-dose combinations
Governance and entry barriers	**Producer-driven** Entry barriers: cost of R&D and marketing	**Buyer-driven** Entry barriers: international approval	**Not driven** Entry barriers: price and WHO quality

PRC = People's Republic of China, R&D = research and development, US = United States, WHO = World Health Organization.

Source: S. J. Haakonsson. 2009. The Changing Governance Structures of the Global Pharmaceutical Value Chain. *Competition and Change.* 13 (1). pp. 75–95.

(i) expanding the quality and quantity of its penetration into the global generics market;
(ii) progressively upgrading to become OEM suppliers via strategic collaboration with select first-tier suppliers in the sector through participation in their global production networks and/or through partnerships via inward investment;
(iii) eventually tying up with lead firms as OEM suppliers;
(iv) augmenting the sector's own R&D capabilities and skills through strategic incentives for R&D investment, skills development, and the provision of sector-focused public goods and infrastructure as well as improvements in the quality of generics manufacturing infrastructure;
(v) the upgrading of quality and safety standards, which is key in this sector that is closely related to public health and, hence, is stringently monitored in the largest global markets; and
(vi) greater linkages with Andhra Pradesh's chemicals industry and nascent life sciences industry to help diversify and enrich the sector's linkages and trade volume.

B. Chemicals

55. In comparison to pharmaceuticals, the chemicals sector in Andhra Pradesh is well established and has a richer tier of localized subsegments. As Table 6 shows, the dominant segment in the industry is basic chemicals and compounds, followed by chemical products. The basic chemicals segment has more than double the number of firms than in the specialized products segment (79 basic chemicals segment firms versus 37 specialized products segment firms), a larger export base, and a larger share of imports. By contrast, the finished goods firms are larger on average and less labor intensive.

Table 6: Structure of the Chemicals Value Chain in Andhra Pradesh

Segment	Basic Chemicals				Specialized Chemical Products			
NIC codes	2011, 2012, 2013				2021, 2022, 2023, 2029, 2030			
Number of Firms	79				37			
Location Quotient	0.67				0.23			
Number of Exporters	8				4			
Number of Importers	16				6			
	Total (2011)	Average (2011)	Average (2001)	Share of total Andhra Pradesh Manufacturing (%)	Total (2011)	Average (2011)	Average (2001)	Share of total Andhra Pradesh Manufacturing (%)
Employees	11,559	146	140	1.4	5,239	249	184	0.6
Output	96,450	1,970	320	5.1	22,210	1,060	430	1.2
Exports	3,820	480	n.a.	2.7	870	220	n.a.	0.6
Domestic Inputs	23,760	300	60	3.1	9,620	460	100	1.2
Imported Inputs	47,630	2,980	360	11.4	3,180	530	660	0.8
Fixed Assets	37,850	480	280	0.3	5,000	240	210	0.0

n.a. = not available.
Note: All monetary values are in Rs million.
Source: Compiled from Government of India, Central Statistics Office. Annual Survey of Industries 2000–2001 and 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx (accessed 18 February 2015).

56. Table 6 shows that the basic compounds segment (intermediate goods) generated more employment and output than the specialized chemical products segment (final goods). Basic chemicals represented 5.1% of total manufacturing output and 1.4% of manufacturing employment in 2010–2011. Final chemical products accounted for 1.2% of total manufacturing output and 0.6% of total trade. Average employment per firm is smaller among basic compounds firms compared to final chemical producers, but average output is higher. Basic chemicals firms represent roughly twice the investment value compared with chemical product firms on average. Within basic compound manufacturing, fertilizer and nitrogen compound production represents the most output (Rs63,900 million), though basic chemicals manufacturing accounts for more employment.

57. Overall, the chemicals industry imports more than it exports (Rs47,630 million in imports versus Rs3,820 million in exports), primarily due to large imports of phosphoric acid and other phosphorous compounds. Combined, these account for over 6% (about Rs30,000 million) of material imports to Andhra Pradesh's manufacturing sector. In terms of broad categories, the single largest segment in the entire industry is the fertilizer and nitrogen compound subsector. Representing 3.4% of total manufacturing revenues in Andhra Pradesh, this subsector has the highest output of all subsectors in the chemicals industry, though as a highly capital-intensive portion of the sector it employs slightly fewer workers (0.6% of all manufacturing employment) than the basic chemicals subsector. The vast majority (Rs39,500 million) of chemicals imports is accounted for by the fertilizer and nitrogen compound subsector, which represents 9.5% of imports of basic products to the manufacturing sector. However, only 3 out of 21 fertilizer and nitrogen compound firms are importers, which indicates that a few large firms dominate the segment.

58. Tables 7, 8, and 9 show the subsectors of the intermediates (basic chemicals and compounds) and final goods segments (products) broken out by National Industrial Classification code.

Table 7: Intermediates—Basic Chemicals and Compounds

	Basic Chemical Compounds			Fertilizers and Nitrogen Compounds		
NIC Code	2011			2012		
Number of Employees	49			21		
Number of Exporters	6			0		
Number of Importers	12			3		
	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)
Employees	5,896	120	0.7	5,133	244	0.6
Output	25,000	510	1.3	63,900	3,040	3.4
Exports	3,810	640	2.7	0	0	0.0
Domestic Inputs	12,400	250	1.6	10,800	510	1.4
Imported Inputs	2,390	200	0.6	39,500	13,170	9.5
Fixed Assets	10,200	210	0.1	26,900	1,280	0.2

NIC = National Industrial Classification.
Note: All monetary values are in Rs million.
Source: Authors' compilation based on data from the Government of India, Central Statistics Office. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx (accessed 18 February 2015).

1. Chemicals Intermediates

59. Basic chemicals compounds and fertilizers and nitrogen compounds are the top intermediates in Andhra Pradesh's chemicals industry. In 2010–2011, Andhra Pradesh had 49 basic chemicals firms and 21 fertilizer firms, which were mainly oriented toward the domestic market. However, both subsectors (especially basic chemicals) are linked to global networks through imports. About a third of these firms rely on imported inputs, including the largest three fertilizer firms in Andhra Pradesh. Anchored in the domestic market in terms of end markets (especially fertilizers), the two subsectors are also the largest employers. They provide a robust base on which to build deeper global linkages, particularly through joint ventures and output markets.

2. Chemicals Final Goods

60. As Tables 8 and 9 indicate, there are a series of final goods segments in the chemicals industry that are diversified but still have a small presence in the state. Paints and varnishes and detergents lead the segment in terms of number of firms (13) and employment (15). They are entirely domestically oriented at present. Other firms in the final goods segment include primary plastics (9 firms), agrochemicals (7 firms), and synthetic fibers (3 firms), all of which are tied into both export markets and domestic end markets and input markets. Agrochemicals, paints and varnishes, and synthetic fiber firms are of a larger scale than other types of firms in the segment. The largest category is the catch-all category of "other chemicals" with 24 firms, which includes relatively large firms with an average size of 116 employees.

Table 8: Final Chemical Products I

	Primary Plastics			Agrochemicals			Paints and Varnishes		
NIC Code	2013			2021			2022		
Number of Firms	9			7			13		
Number of Exporters	2			2			0		
Number of Importers	1			2			1		
	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)
Employees	530	59	0.1	613	880	0.1	1,062	82	0.1
Output	755	840	0.4	4,200	600	0.2	6,590	510	0.3
Exports	1	10	0.0	400	200	0.3	0	0	0.0
Domestic Inputs	56	60	0.1	1,200	170	0.2	3,360	260	0.4
Imported Inputs	574	5,740	1.4	360	180	0.1	820	820	0.2
Fixed Assets	75	80	0.0	2,240	320	0.0	520	40	0.0

NIC = National Industrial Classification.
Note: All monetary values are in Rs million.
Source: Authors' calculations based on data from the Government of India, Central Statistics Office. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx (accessed 18 February, 2015).

Table 9: Final Chemical Products II

	Detergents			Synthetic Fibers			Other Chemical Products		
NIC Code	2023			2030			2029		
Number of Firms	15			3			24		
Number of Exporters	0			1			1		
Number of Importers	1			0			7		
	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)
Employees	525	35	0.1	265	88	0.0	2,774	116	0.3
Output	209	140	0.1	470	160	0.0	8,860	370	0.5
Exports	0	0	0.0	270	270	0.2	200	200	0.1
Domestic Inputs	42	30	0.1	300	100	0.0	4,340	180	0.6
Imported Inputs	102	1,020	0.2	0	0	0.0	980	140	0.2
Fixed Assets	52	30	0.0	420	140	0.0	1,300	50	0.0

NIC = National Industrial Classification.
Note: All monetary values are in Rs million.
Source: Authors' calculations based on data from the Government of India, Central Statistics Office. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx (accessed 18 February 2015).

61. The chemicals sector in Andhra Pradesh is the most diverse and well-developed of the three sectors examined in this study. Its end markets are varied and it is both domestically and export oriented. It has the deepest labor market and firms that are of medium and large scale, although it is a capital-intensive sector so opportunities for job creation are limited. These firms form a rich base on which to build more vibrant production networks, with the potential for forward linkages into a variety of end markets, including in the pharmaceuticals and defense sector. In the next subsection, we identify the product profile of the intermediate and final segments of the chemicals sector to better understand how they are positioned within global and domestic production networks.

3. Product Profile of the Chemicals Value Chain in Andhra Pradesh

62. Table 10 presents intermediate and final goods produced in Andhra Pradesh's chemicals sector.

63. Two clear patterns are observable in Table 10. First, given that fertilizers and nitrogen compounds are Andhra Pradesh's most prominent segment in the chemicals sector, urea is the most important chemicals product in terms of output. Besides fertilizers, it is used in the production of pharmaceuticals. Phosphate diammonium is used in the production of non-organic fertilizers. Both are intermediate goods. Diammonium phosphate, which is a different molecular configuration, is also an input for non-organic fertilizers. It is not surprising therefore that intermediates lead the chemicals sector's performance and output.

Table 10: Product Profile of the Chemicals Value Chain in Andhra Pradesh

Intermediate Goods					
Product	Share of Total Manufacturing Output (%)	Share of Total Domestic Inputs to Manufacturing (%)	Share of Total Manufacturing Imports (%)	Share of Total Manufacturing Exports (%)	Share of Total Manufacturing Employment (%)
Urea	2.45	0.94	0.00	0.00	0.32
Phosphate diammon, others	3.08	0.18	0.00	0.00	0.13
Diammonium hydrogenorthophosphate (diammonium phosphate) n.e.c	3.11	0.20	0.00	0.00	0.16
Polystyrene, PS, Thermocol	0.64	0.04	0.01	0.00	0.03
Final Goods					
Product	Share of Total Manufacturing Output (%)	Share of Total Domestic Inputs to Manufacturing (%)	Share of Total Manufacturing Imports (%)	Share of Total Manufacturing Exports (%)	Share of Total Manufacturing Employment (%)
Catalyst, chemical	0.52	0.38	0.66	0.00	0.02
Paints, enamels	0.59	0.42	0.33	0.00	0.10
Paints epoxy, epoxy powder and liquid	0.58	0.42	0.33	0.00	0.09
Varnish (all types)	0.58	0.42	0.33	0.00	0.08

Source: Authors' calculations based on data from the Government of India, Central Statistics Office. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx (accessed 18 February 2015).

64. This profile of Andhra Pradesh's chemicals sector, with its heavy emphasis on urea and fertilizers, is consistent with national trends. India's fastest-growing subsector in chemicals, which has progressively integrated with global networks, especially East Asian regional production networks, is fertilizers and nitrogen compounds and organic chemicals. However, significant new capacity in this sector is being created in Latin America and the Middle East. As a result, there are both challenges and opportunities for Andhra Pradesh to pursue expansion and upgrading.

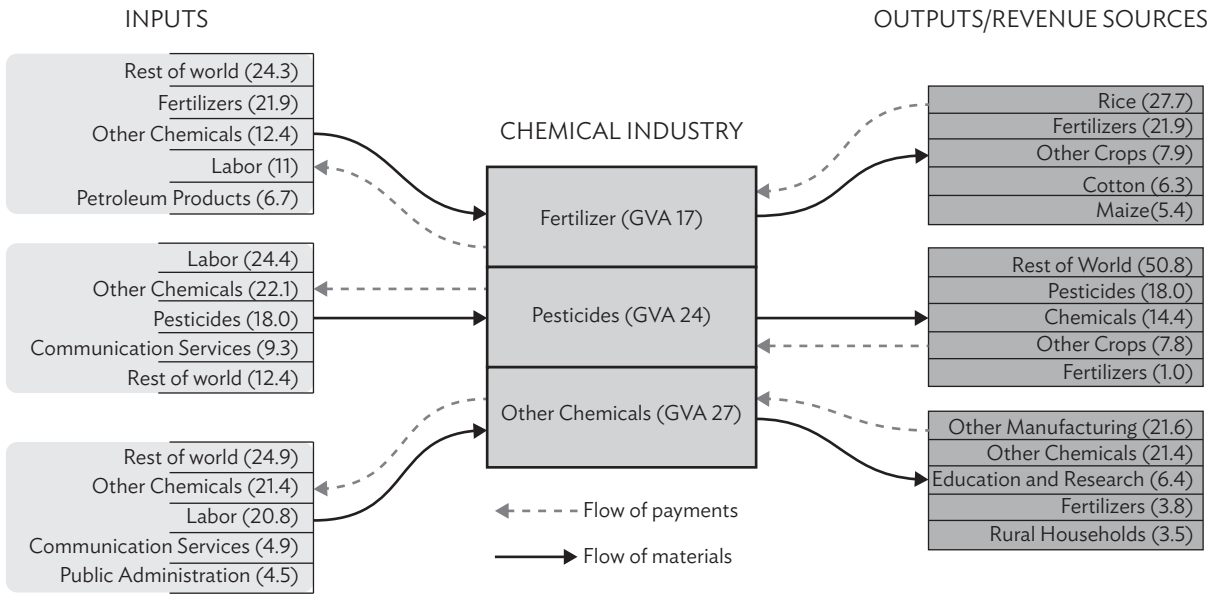
65. The second pattern that stands out is that, after fertilizer inputs, the most important chemical products in Andhra Pradesh in terms of output are final goods: chemical catalysts and enamel paints. While these products are important in the sector's output, they are not significantly incorporated into global production networks given that the flow of trade is only one way (imports). Field interviews indicate that the PRC is a key source of inputs—often providing more than 50% of inputs—for several of these firms. Exports are negligible and the subsector relies heavily on domestic inputs as well.

66. In the next subsection, we examine the backward and forward linkages that are implied by these patterns.

4. Forward and Backward Linkages

67. Figure 4 maps forward and backward linkages in the chemicals sector based on the social accounting matrix (SAM) for Andhra Pradesh compiled by Saluja (2014).[10] The chemicals-related industries included in the SAM are fertilizers, pesticides, and other chemicals (a residual category). The electronics-related industries are batteries, communications equipment, and electronic equipment.[11] The SAM allows one to identify flows of payments and materials to and from other sectors that are sources of inputs (backward linkages) as well as the destinations of outputs (forward linkages). Backward linkages also include destinations of payments, while forward linkages include sources of revenue. The top five backward and forward linkages for chemical industries, as well as the share of payments in either direction that these linkages represent, are depicted in Figure 5. The data presented in Saluja (2014) also allows one to calculate the share of sectoral output represented by value-addition. These shares are included in the middle section of Figure 4.

Figure 4: Input–Output Flows in the Chemicals Industry in Andhra Pradesh *(%)*



GVA = gross value added.
Source: Authors' compilation based on input–output tables in M. R. Saluja. 2014. Construction of Social Accounting Matrix for Andhra Pradesh for 2007–08. *Review of Market Integration.* 6 (2). pp. 175–235.

68. Across the three chemicals-related subsectors contained in the input–output table, the three most significant sources of inputs are the rest-of-world, other chemicals, and labor. The importance of the rest-of-world as a source of costs for the fertilizers, pesticides, and chemicals subsectors indicates a reliance on imports, which is corroborated by the Annual Survey of Industries (ASI) data. However,

[10] The tables in Figure 4 represent flows of inputs and outputs (payments and revenues) in 2007. As with the ASI, the data contained in these tables are for pre-bifurcated Andhra Pradesh (i.e., including Telangana).

[11] The SAM does not include pharmaceuticals as an independent sector. Instead, pharmaceuticals production is mostly subsumed within the residual category of "other manufacturing" and thus cannot be reliably broken out for separate analysis.

the significance of other chemicals in each of the three subsectors, especially pesticides, indicates the presence of intrastate backward linkages as well. The significance of labor costs could reflect relatively high wages that are linked to the skills and credentials required of manufacturing workers. With respect to outputs, the other chemicals and fertilizers subsectors are key markets for fertilizer, pesticide, and chemical firms. This indicates that end markets are primarily domestic and that much of output flows into agricultural value chains. This indicates that there are untapped opportunities for innovative firms to develop export markets and penetrate higher value-added domestic end markets.

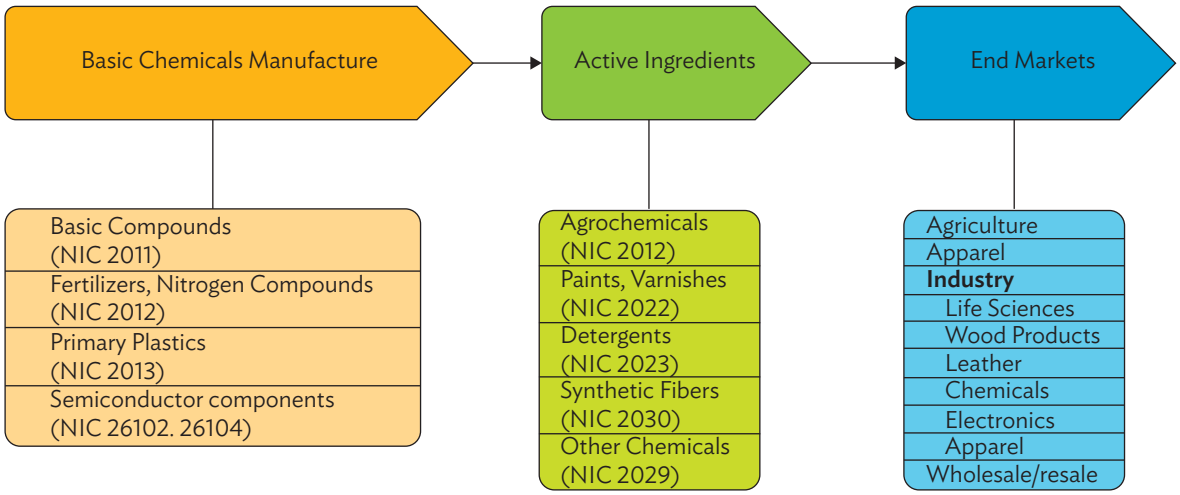
69. In sum, firms in the chemicals industry draw heavily on inputs from other chemicals and petrochemicals manufacturers, as well as on services. Labor represents an important source of inputs, given the relatively high level of wage payments.

70 In terms of backward linkages with domestic inputs, natural gas is the top imported product in the Andhra Pradesh chemicals industry. Many firms mentioned the importance of natural gas in interviews and complained about the relatively high cost and inconsistent supply of this important input. In part this is because firms in Andhra Pradesh are bypassed by the natural gas pipeline owned by Reliance that runs through the state. Expanding access to natural gas would bring down costs and help promote larger-scale production. Phosphoric acid is the second-largest domestic input for the chemicals industry, indicating that there may be scope for import substitution of phosphoric compounds if the domestic industry were to grow more competitive.

5. Mapping Andhra Pradesh's Chemicals Value Chain

71. Figure 5 below maps Andhra Pradesh's value chain in the chemical industry. In comparison with the pharmaceuticals value chain, the chemicals value chain is more extensive, features a broader set of product categories and final markets, and has more segments localized or at least present in Andhra Pradesh.

Figure 5: Value Chain Map for the Chemicals Industry in Andhra Pradesh



NIC = National Industrial Classification.
Source: Based on interviews and data from the Government of India, Central Statistics Office. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx

72. The most striking feature of Figure 5 is the variety of end markets that the chemicals industry is already tied into, both in terms of exports and domestic linkages. However, the value of chemical products is relatively low, leaving much room for growth, especially by diversifying and functionally upgrading product capabilities to mid-tech segments. There is also significant scope for growth in the paints segment where there is important existing capacity. Table 11 shows the leading global firms in this sector.

Table 11: Top 15 Global Firms in the Chemicals Sector by Revenues, 2013

Name	Headquarters	Chemical Sales, 2013 ($ billion)	Chemical Sales as % of Total Sales	Chemicals Capital Spending, 2013 ($ billion)
BASF	Germany	79	80	5.4
Sinopec	PRC	61	13	3.0
Dow Chemical	United States	57	100	2.6
SABIC	Saudi Arabia	44	87	n.a.
Shell	The Netherlands	42	9	n.a.
ExxonMobil	United States	39	9	1.0
A major plastics company	Taipei,China	38	60	n.a.
LyondellBassel Industries	The Netherlands	33	76	0.9
DuPont	United States	31	87	1.8
Mitsubishi Chemicals	Japan	27	74	1.3
Bayer	Germany	26	50	1.3
Ineos Group Holdings	Switzerland	23	100	n.a.
LG Chem	Republic of Korea	21	89	n.a.
AkzoNobel	The Netherlands	20	100	1.1
Sumitomo Chemical	Japan	19	78	1.1

n.a. = not available, PRC = People's Republic of China.
Source: A. Tullo. 2014. Global Top 50 Chemical Firms for 2014. *Chemical and Engineering News.* 92 (30). pp. 10–13.

73. Table 11 shows that besides the traditional chemicals industry leaders based in Germany, Japan, the Netherlands and other parts of Europe, and the United States. Three of the top 15 leaders are in East Asia, including one in the PRC (Sinopec, which is the second largest in the world based on 2013 revenues), and one in the Middle East. These firms are among the most rapidly growing in the industry, signaling the growth of demand in these new and rapidly growing end markets in the Global South.

74. As noted earlier, the growth path of Andhra Pradesh's chemicals value chain lies not only in deeper linkages with the home market by offering an expanded set of products, but also through strategic growth in and beyond fertilizers and nitrogen compounds. Given the high global demand for

these product categories, there is plenty of scope for growth and upgrading within the organic chemicals and fertilizers subsectors. Exports may follow if firms can identify and exploit innovative niches. The existing volume of exports is very modest and in the face of growing global demand and large-scale capacities that are coming on board in Latin America, Central Asia, and the Middle East, there is room for much more aggressive growth in exports in this segment. However, upgrading within the existing urea-based subsectors, whose agricultural end markets do not present strong opportunities for innovation, has limited possibilities. Diversification, or chain-upgrading, is an important strategy to pursue and is consistent with the pathways followed by the global firms listed in Table 11.

75. Similarly, paints and plastics are currently present in Andhra Pradesh. These subsectors could grow rapidly and diversify with greater GVC participation and technical and functional upgrading, especially if investment in R&D is facilitated as a quasi-public good. However, new product development in areas linked to the pharmaceuticals sector, life sciences, medical products, apparel, foods, and other end markets is important for the future growth of the sector. The large number of medium-sized firms in Andhra Pradesh's chemicals industry provides a promising platform from which to gain access to these niche areas. This will require closer engagements with markets and key buyers, and supportive policies at home.

C. Electronics

76. Of the three manufacturing sectors focused on in this report, electronics has the smallest presence in Andhra Pradesh in terms of its contribution to the state's manufacturing output (3% of the total compared with 24% for chemicals) and exports (11% of the total compared with 39% for pharmaceuticals). The sector's imports are also low compared with the other two sectors, indicating a low degree of integration into GVCs. However, the electronic instrumentation subsector (e.g., medical devices) has some of the highest levels of value-added in the sector and strong potential for future growth. Table 12 lays out the current structure of the electronics value chain in Andhra Pradesh.

77. Table 12 shows that while there are roughly the same number of firms in the components and final product segments of the electronics industry in the ASI sample, components are far more important in terms of employment, output, investment, exports, and backward linkages to domestic and foreign material suppliers. The components segment represents roughly five times as much employment as final product manufacturing. Investment in fixed assets per firm is, however, relatively small for firms in electronics, particularly those active in the production of final goods. Tables 13, 14, and 15 break down the sector into its component subsegments in both the intermediate and final product segments.

78. Tables 12–15 suggest several points related to the components and final goods segments of the electronics sector. With respect to components, battery manufacturing is by far the most important segment of the electronics value chain in Andhra Pradesh. Batteries represent 48% of employment, 54% of output, 99% of exports, 63% of imports, and 44% of domestic inputs in the electronics industry. Components for peripherals and other devices is the second-largest segment within component production in terms of employment (32%), output (18%), imports (13%), and domestic inputs (20%). Compared with batteries manufacturing, peripherals, and other devices manufacturers were more likely to use domestic rather than imported inputs.

Table 12: The Production Structure of Andhra Pradesh's Electronics Value Chain

Value Chain Segment	Components and Subsystems				Final Products			
NIC Codes	26101, 26102, 26103, 26104, 26105, 26106, 26107, 26109, 27201				2620, 2630, 2640, 2650, 2660, 2651, 2652, 2670, 2680			
Number of firms	25				24			
Location Quotient	1.88				0.31			
Number of Exporters	6				0			
Number of Importers	17				12			
	Total	Average	Average (2001)	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average	Average (2001)	Share of Total Andhra Pradesh Manufacturing (%)
Employees	15,916	637	666	2	3,107	155	109	0
Output	46,570	1,550	750	3	17,240	860	60	1
Exports	15,630	2,610	N/A	11	0	0	N/A	0
Domestic Inputs	15,510	620	320	2	8,360	420	10	1
Imported Inputs	18,510	1,090	110	4	5,590	470	40	1
Fixed Assets	10,140	410	320	0	3,250	160	70	0

NIC = National Industrial Classification.
Note: All monetary values are in Rs million.
Source: Authors' compilation based on interviews and data from the Central Statistics Office, Government of India. Annual Survey of Industries, 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx (accessed 18 February 2015).

Table 13: Electronic Subcomponents I

Value Chain Segment	Electronic Components			Semiconductor Components and Integrated Circuits			Components for Peripherals and Other Devices		
NIC code	26101			26102, 26104, 26103, 26107			26105, 26106, 26109		
Number of Firms	3			2			10		
Number of Exporters	0			0			3		
Number of Importers	1			2			7		
	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)
Employees	179	60	0.0	582	291	0.1	6,031	603	0.7
Output	160	50	0.0	410	210	0.0	11,600	1160	0.6
Exports	0	0	0.0	0	0	0.0	130	40	0.1
Domestic Inputs	50	20	0.0	180	90	0.0	4,780	480	0.6
Imported Inputs	80	80	0.0	20	10	0.0	3,210	460	0.8
Fixed Assets	70	20	0.0	90	50	0.0	1,690	170	0.0

NIC = National Industrial Classification.
Note: All monetary values are in Rs million.
Source: Authors' calculations based on data from the Central Statistics Office, Government of India. Annual Survey of Industries, 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx (accessed 18 February 2015).

Table 14: Electronic Subcomponents II

Value Chain Segment	Batteries			Computers and Peripherals			Communications Equipment		
NIC code	27201			2620			2630 (exc. 26350)		
Number of Firms	10			4			5		
Number of Exporters	3			O			0		
Number of Importers	7			1			3		
	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)
Employees	9,124	912	1.1	346	87	0.0	1,306	261	0.2
Output	34,400	3,440	1.8	330	80	0.0	2,210	440	0.1
Exports	15,500	5,170	11.0	0	0	0.0	0	0	0.0
Domestic Inputs	10,500	1,050	1.4	150	40	0.0	470	90	0.1
Imported Inputs	15,200	2,170	3.7	40	40	0.0	2,340	780	0.6
Fixed Assets	8,290	830	0.1	120	30	0.0	620	120	0.0

NIC = National Industrial Classification.
Note: All monetary values are in Rs million.
Source: Authors' calculations based on data from the Central Statistics Office, Government of India. Annual Survey of Industries, 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx (accessed 18 February 2015).

Table 15: Electronic Subcomponents III

Value chain segment	Consumer Electronics			Medical Electronics			Instruments and Equipment		
NIC code	2640			2660			2651, 2652, 2670, 2680		
Number of Firms	2			3			10		
Number of Exporters	0			0			0		
Number of Importers	1			2			5		
	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)	Total	Average	Share of Total Andhra Pradesh Manufacturing (%)
Employees	359	180	0.0	297	99	0.0	799	80	0.1
Output	8,220	4,110	0.4	5,790	1,930	0.3	690	70	0.0
Exports	0	0	0.0	0	0	0.0	0	0	0.0
Domestic Inputs	6,590	3,300	0.9	780	260	0.1	370	40	0.0
Imported Inputs	120	120	0.0	3,020	1510	0.7	70	10	0.0
Fixed Assets	1,550	780	0.0	580	190	0.0	380	40	0.0

NIC = National Industrial Classification.
Note: All monetary values are in Rs million.
Source: Authors' calculations based on data from the Central Statistics Office, Government of India. Annual Survey of Industries, 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx (accessed 18 February 2015).

79. The semiconductors industry in Andhra Pradesh is very small, comprising only 3% of total electronics employment and 1% of total output. This is an area where there is significant room for growth given India's interest in establishing domestic capabilities. Collaboration with participants in semiconductor GVCs in East Asia and other areas—both suppliers and lead firms—will be an important avenue in the future.

80. Final product manufacturing accounts for less employment than components production, as well as fewer employees and fixed assets per firm on average. There are no exports of electronic final products from Andhra Pradesh, at least among firms in the ASI sample on which this study is based. The two subsectors that account for the most activity in final products manufacturing are communications equipment (7% of total electronics employment) and the manufacture of precision instruments and equipment (3%). Though mobile phone production comprises a minimal share of Andhra Pradesh's electronics sector, the recent attraction of a Foxconn contract manufacturing facility for mobile phones could generate a great deal of employment and (possibly) promote the creation of significant backward linkages into components manufacturing among contract manufacturers and producers of semiconductors and other parts.

1. Product Profile of the Electronics Value Chain in Andhra Pradesh

81. Table 16 allows us to unpack the product categories in electronics by their share in output, exports, imports and use of domestic inputs as well as assets. The patterns that emerge are listed below.

Table 16: Product Profile of the Electronics Value Chain in Andhra Pradesh

Intermediate goods					
Product	Share of total Manufacturing Output (%)	Share of Total Domestic Inputs to Manufacturing (%)	Share of Total Manufacturing Imports (%)	Share of Total Manufacturing Exports (%)	Share of Total Manufacturing Employment (%)
Battery dry cells	1.80	1.11	0.30	4.72	0.48
Electronic Integrated Circuits	0.93	0.57	1.06	0.00	0.53
Other surveying, hydrographic, oceanographic, hydrological, meteorological or geophysical instruments	0.85	0.01	0.01	5.36	0.19
Electronic waste	0.49	0.23	0.08	0.94	0.40
Final goods					
Product	Share of Total Manufacturing Output (%)	Share of Total Domestic Inputs to Manufacturing (%)	Share of Total Manufacturing Imports (%)	Share of Total Manufacturing Exports (%)	Share of Total Manufacturing Employment (%)
Television cameras	0.73	0.84	0.00	0.00	0.03
Electronic Integrated Circuits	0.53	0.10	0.00	0.00	0.02
Solar collector and parts thereof of aluminium	0.11	0.04	0.00	0.00	0.06
Point of sale terminals and ATMs	0.07	0.01	0.01	0.00	0.05

Source: Authors' calculations based on data from the Government of India, Central Statistics Office. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx

82. With respect to output flows, dry cell batteries, an intermediate product, are the top electronics product. Roughly 35% of dry cell batteries output is exported. Scientific instruments account for the third most important product category in terms of output. Most scientific instruments (82% of the subsector's output) are exported by firms identified in the ASI as being active in the intermediate goods segment. Integrated circuits are a major source of output among firms coded as participating in both the intermediate and final goods segments of the value chain. With respect to final goods, television cameras are the most important product category in terms of output.

83. With respect to export flows, scientific instruments are the most important export category for firms in the electronics value chain, accounting for roughly 3.5% of all ASI exports from Andhra Pradesh. The next most important product category is dry cell batteries (intermediate goods), which account for 3.2% of the state's manufacturing exports. Primary cells, which are components used in battery production, are the third most important electronics export, but only account for 0.1% of exports in the ASI sample. About half of the value of batteries produced in Andhra Pradesh is destined for the domestic market (Table 12).

84. Among import flows in the electronics industry, solar collectors and parts thereof are the top product category for both the intermediate and final good segments. Most imports are raw materials accounted for by producers of batteries (intermediate goods). Mobile phone (final product) manufacturers represent the other major source of imports of solar collectors. Solar collectors constitute just less than 2% of total ASI imports. The next most important import is lead (white lead and lead alloys), which is used in the production of batteries. These are also major domestic inputs, indicating that there may be opportunities for import substitution.

85. With respect to domestic inputs (Figure 6), lead products (white lead, lead alloys, and lead oxide) are the three top domestic inputs for producers of intermediate goods. Manufacturers of batteries are the main users of these inputs. Some electronics firms use domestic suppliers of solar collectors. This is the most important product category of imports in the electronics industry, indicating a possible opportunity for domestic producers to expand their role. The top domestic input for producers of final goods is picture tubes, which are used by firms that manufacture televisions and computer monitors.

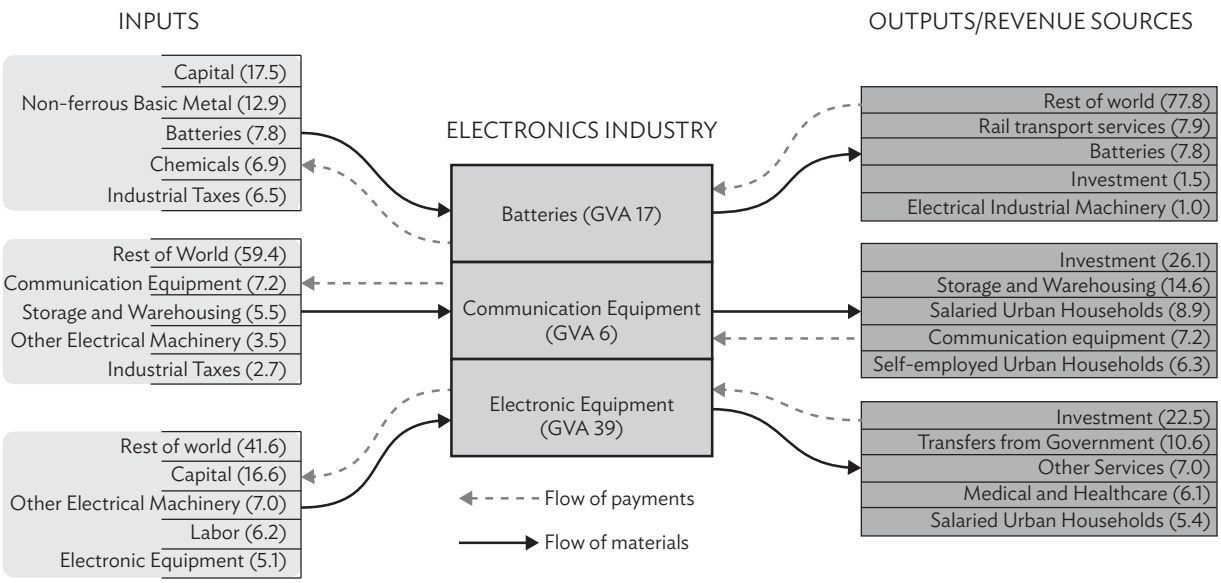
2. Backward and Forward Linkages in Andhra Pradesh Electronics

86. Figure 6 maps inflows and outflows of material and payments in the electronics sector in Andhra Pradesh based on the SAM compiled by Saluja (2014).

87. The data indicate the flows for each of the main subsectors of the electronics sector represented in the SAM (batteries, communications equipment, and electronic equipment).

88. The top five sources of inputs for the batteries subsector sources are capital (17.5%), non-ferrous basic metals (12.9%), batteries (7.8%), chemicals (6.9%), and (payments of) industrial taxes (6.5%). This distribution of inputs reflects the relative capital-intensity of battery manufacturing and indicates the presence of backward linkages with non-ferrous metals manufacturers (most likely producers of lead, according to the ASI data) and chemical producers in Andhra Pradesh, as well as other battery manufacturers. The top five sources of inputs for the electronic equipment subsector are (payments to the) rest of world (41.6%), capital (16.6%), other electrical machinery (7.0%), labor (6.2%), and electronic equipment (5.1%)

Figure 6: Inflows and Outflows in the Electronics Sector in Andhra Pradesh *(%)*

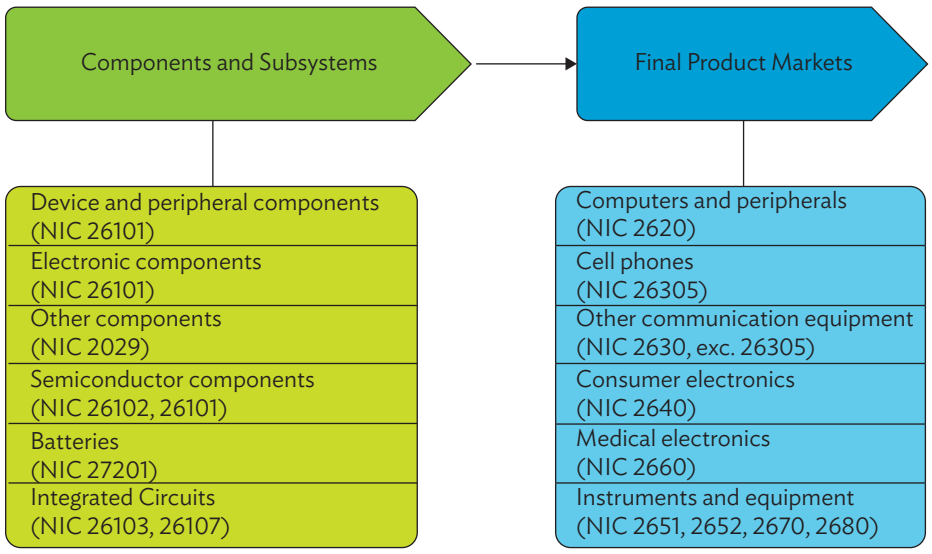


Source: Authors' compilation from Andhra Pradesh's input–output tables in M. R. Saluja. 2014. Construction of Social Accounting Matrix for Andhra Pradesh for 2007–08. *Review of Market Integration.* 6 (2). pp. 175–235.

89. Electronics manufacturing activities in Andhra Pradesh are relatively capital intensive; capital costs are an even greater share of total input costs than in the chemicals industry. Among the three subsectors identified in the SAM, the high share of payments to the rest of the world, especially in the electronic equipment and communications equipment subsectors, indicates that the state's electronics industry relies heavily on imports of intermediate goods and/or that (branch) firms repatriate large profits to foreign headquarters. Of the three subsectors, the SAM indicates that battery manufacturing has the most backward linkages to other industries in Andhra Pradesh, particularly metals and chemicals. However, backward linkages with firms located within Andhra Pradesh are relatively weak in electronics, compared to the chemicals industry.

90. With respect to output and revenue, the batteries subsector appears to lead the other two subsectors in value-addition. The net output for battery intermediates is Rs23,960 million and the gross value-added is a relatively significant 17% of output (compared with Rs26,070 million in output and 6% value-added in communications equipment and Rs1,7910 million and 39% in electronics equipment). The top destinations for outputs of the batteries sector are primarily sales (transfers from) the rest of world (77.8%), rail transport services (7.9%), batteries (7.8%), investment (1.5%), and electrical industrial machinery (1%). The high share of transfers from the rest of the world could indicate the activity of multinationals in the sector. The high proportion of income from the rest of the world further suggests that battery manufacturing is linked to international markets through exports, a claim which is further supported by the ASI estimates of export values. Electronic equipment, on the other hand, appears to have the strongest forward linkages with key sectors within Andhra Pradesh, including the government, healthcare, and services sector. These forward linkages represent opportunities with respect to future market growth for Andhra Pradesh's electronics industry, both within the domestic market and for exports.

Figure 7: Global Value Chain Map of Andhra Pradesh Electronics



NIC = National Industrial Classification.
Source: Authors' compilation based on interviews and data from the Government of India, Central Statistics Office. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx (accessed 18 February 2015).

91. Andhra Pradesh's electronics GVC map shows that components drive the industry and its linkages with the global economy. Although the electronics industry is active in producing several subcomponents (at least six) and covers another six final product markets, the only prominent export presence of Andhra Pradesh is in the batteries subsector and (to a lesser degree) in semiconductor components. It is surprising that mobile phones form such a small share of Andhra Pradesh's electronics GVC. It is an area primed for growth, as are medical electronics and information technology-enabled services, and deeper GVC and global production network linkages, especially with East Asian industry leaders.

92. Indeed, the list of the world's top 15 firms in the electronics industry show that the majority of global leaders in this area—10 out of 15—are East Asian firms (Table 17). Given the "look east" focus of the global linkages strategy of the Vizag–Chennai Industrial Corridor , this is an opportunity that should be harnessed in strategic and substantive ways.

Table 17: Top 15 Global Firms in the Electronics Sector by Revenues, 2011

Name	Headquarters	2011 Revenues ($ billion)
General Electric	United States	152
Samsung Electronics	Republic of Korea	134
Hewlett-Packard	United States	126
Hitachi	Japan	109
Siemens	Germany	103
Contract Manufacturers		
Foxconn Electronics	Taipei,China	93
Quanta Computer	Taipei,China	36
Compal Electronics	Taipei,China	28
Flextronics	United States, Singapore	27
Winston	Taipei,China	20
Semiconductor Manufacturers		
TSMC	Taipei,China	17
GlobalFoundries	United States	4
UMC	Taipei,China	4
Samsung	Republic of Korea	3
SMIC	People's Republic of China	2

Source: T. Sturgeon, G. Gereffi, A. Guinn, and E. Zylberberg. 2013. *Brazilian Manufacturing in International Perspective.* www.cggc.duke.edu/pdfs/CNI_Brazil_GVC_Report_Final_2013-09-05.pdf

IV. CROSS-CUTTING THEMES

93. This section examines a set of issues that cut across all sectors, primarily the export drivers, and asks: Are they intermediates or final goods? What does that imply for the integration strategies for each sector?

94. Within the chemicals and electronics sectors, exports (as well as production) are currently being driven by intermediate goods rather than by final goods. That is, exports of intermediates exceed those of final goods in these sectors. In the chemicals sector, intermediate exports are fairly diversified across several products, while intermediate exports in the electronics sector involve a significant amount of value-added. Within the pharmaceuticals sector, final goods drive exports.

95. Electronics firms not only have high gross value-added in their intermediates, signifying a level of sophistication in both exports and output, but the electronics sector in Andhra Pradesh is also the most integrated into global production networks of the three sectors reviewed in this study. Even though the sector has a relatively small presence in Andhra Pradesh in terms of number of firms and output (relative to chemicals and pharmaceutical), electronics firms are the most engaged in global value chain networks and import and export the most as a share of output among all three sectors. Nearly 60% of the electronics intermediate manufacturers (four of seven) export more than 25% of

output, compared with half of pharmaceutical firms (four of eight) and a third of chemical firms (three of nine). The emerging electronics sector is more outward-oriented than the other two sectors included in this study. With respect to imports, over 57% of the electronics manufacturers import more than 25% of inputs. By contrast, just 12% of pharmaceuticals manufacturers import more than 25% of inputs and only 10% of chemicals manufacturers do so.

96. Table 18 reports results from a survey conducted by PriceWaterhouseCooper (PWC) that show the electronics sector is the most capital intensive of all three sectors, with the highest share of fixed costs in total costs: 33% compared with 15% for chemicals and 13% for pharmaceuticals. In the chemicals and pharmaceuticals sectors, which are largely continuous-process industries, raw materials make up the most important source of costs—more than half in both cases. The electronics sector is also more technology-intensive than other sectors and has a relatively low share of raw material costs in total costs: only 36% relative to 61% in pharmaceuticals and 57% in chemicals. This once again suggests that there is relatively high value-added in the electronics sector in comparison with the other two sectors under review.

Table 18: Share of Total Production Costs by Sector (%)

	Pharmaceuticals	Chemicals	Electronics
Fixed costs	13	15	33
Labor	12	11	11
Technology	1	2	4
Logistics	2	3	2
Branding and Packaging	1	1	3
Electricity and Fuel	8	12	10
Raw Materials	61	57	36
Damages and Losses	2	1	1
R&D and Product Development	1	0	0
Others	0	1	0

R&D = research and development.
Source: Authors' compilation based on data from PriceWaterhouseCooper. 2015. *Survey of Firms in Andhra Pradesh*.

97. The pharmaceuticals sector is the largest of the three being studied in this paper. In contrast with the electronics and chemicals sectors, it is well-developed and produces a wide range of intermediate and finished goods. At the same time, it is dominated by final goods firms that are linked to both domestic and export end markets. In the ASI sample, there are 118 pharmaceuticals firms involved in the production of the top 4 intermediate goods and the top 4 final goods, compared with 15 firms in chemicals and 14 firms in electronics, indicating the presence of relatively strong specializations within the sector (especially antibiotics, antiretrovirals, and vitamins).

98. With respect to total exports, the share of pharmaceuticals, led by final goods exports, exceed those of both chemicals and electronics. Electronics exports exceed chemicals. Yet, in terms of output, the chemicals sector leads both pharmaceuticals and electronics, indicating that output from the chemicals sector is more tied to the domestic market than output from the other two sectors. To make

the most of these existing linkages, growth through integration with global value chains have to be linked to domestic demand and domestic supply networks.

99. What then are some of the barriers to deeper integration with global and domestic networks? The next section discusses the results of a 2015 survey that PWC conducted of a large sample of firms in Andhra Pradesh to answer this question.

V. SECTORAL CHALLENGES AND OPPORTUNITIES: INSIGHTS FROM THE FIELD

100. The PriceWaterhouseCooper survey (2015) broadly found that the lack of available proximate testing facilities and quality assurance processes, lack of available training facilities, and price fluctuations of raw materials are challenges that run across all the three sectors. Lack of access to basic urban services (sewer, water, drainage, and transport) and lack of labor housing are two of the other barriers to global competitiveness and rapid integration with production networks that are pervasive across all sectors.

101. One of the central lessons from 20 years of global value chain research is that sectoral policies and sectoral institutions and regulatory support matter a great deal to an industry's evolution and global competitiveness. It is therefore important to note the sectoral variations in challenges as well as the strategies that will help the various sectors integrate better with global networks.

102. The survey identified the top four challenges facing Andhra Pradesh's pharmaceuticals sector as (i) raw materials price fluctuations; (ii) lack of available in-house or proximate testing and quality assurance facilities; (iii) lack of available training and skills development facilities, which is also a key problem for firms across all three industries in the study; and (iv) high costs and excessive time required to transporting raw materials by road. The top four improvements suggested by firms in the survey included (i) development of integrated logistics and warehousing centers; (ii) review of development control regulations for industrial infrastructure to optimize land use; (iii) development of common testing and a Quality Assurance and Quality Control center; and (iv) upgrading of internal infrastructure of industrial parks (roads, sewage, drainage, transportation, and lighting). Improved logistics and warehousing infrastructure and testing facilities are important industrial public goods that could promote growth in the sector. Interviews underlined the importance of timely and accurate quality assurance facilities and procedures for reaching new export markets (e.g., managing compliance with diverse health and safety regulations in destination economies). Firms also indicated that effective quality assurance is primarily a function of access to skilled labor, which is in short supply. The short supply of skilled labor is not only a function of missing training and human capital formation strategies; it is also a function of a lack of proximate and affordable housing for workers and supervisors with requisite amenities such as schools, retail centers, and health care.

103. Much of the growth in these sectors is occurring within the SEZs scattered throughout the state, yet the provision of urban and social amenities surrounding the zones lags far behind the development of infrastructure and production facilities within the zones themselves. While ad hoc strategies, such as providing private transportation services or basic health clinics for shop-floor workers, can help stabilize the production workforce, several of the interviewed firms indicated that the distance between their SEZ and cities with well-developed social infrastructure made it difficult to attract workers with the requisite skills and education, thus posing a barrier to value-addition. This theme is common across all sectors. A manager in a pharmaceuticals firm, for example, said that he

faced high turnover rates in skilled production positions and difficulties recruiting highly educated pharmacists. This undermined his firm's ability to identify and comply with health and safety requirements in the highest-value export markets.

104. In the chemicals sector, the top four challenges include (i) lack of available in-house or proximate testing and quality assurance facilities; (ii) high costs of upgrading manufacturing technology to align with global best practices, which is an issue that highlights the importance of capital investments among lead firms in the chemicals value chain; (iii) lack of availability of training and skills development facilities; and (iv) the costs and availability of raw materials in domestic markets. The top four recommendations include improvements in (i) last mile connectivity up to the factory gate; (ii) the quality and availability of the power supply; (iii) accessibility to factories and industrial areas via road, rail, and water; and reduced congestion for cargo transport; (iv) last mile connectivity in terms of public transport for employees that need to commute.

105. In the electronics sector, the top four identified challenges include (i) raw materials prices fluctuations, (ii) uncompetitive quality and high costs of raw materials in the domestic market, (iii) lack of available research and development facilities to develop indigenous technology, and (iv) lack of available training and skill developments facilities. (This final challenge was listed as a key problem for firms across all three sectors.) The top four suggestions for improvement include (i) developing common effluent infrastructure—such as Chemically Enhanced Primary Treatment, Sewerage Treatment Plant, or Effluent Treatment Plant—via public–private partnerships or other modes for industrial clusters and industrial parks; (ii) improving power supply availability and quality; (iii) upgrading basic internal infrastructure of industrial parks (roads, sewage, drainage, and lighting); and (iv) improving the last mile connectivity of public transport for labor and employee commuting.

106. Labor housing and power supply were also indicated as priority areas for improvement, highlighting areas where investments in public goods are lacking. In line with this, a large majority of firms (80%) across all three sectors noted that a support facility that would help their business grow was the provision of labor housing.[12] Labor housing is not something that public policy makers and implementers often think about when constructing industrial parks, at least in the Indian context. By contrast, in the PRC, it is standard policy to plan industrial parks simultaneously with proximate industrial townships that offer key amenities (labor housing, schools, health facilities, and public transit as well as banks, training facilities, and key industrial public goods). The lack of coordination in India results in a deficit of services that not only leads to bottlenecks that lower productivity and raise production costs, but also creates negative externalities such as unplanned development and the proliferation of slums.

107. Having examined the current structure and global linkages of three core sectors of the Vizag–Chennai Industrial Corridor, the next section turns to examples of policies and strategies that other economies have used to successfully grow and upgrade through active participation in global production networks. From these insights, broad conclusions for Andhra Pradesh will be drawn in the final section of this paper.

[12] Only three firms responded to this question and all three identified labor housing as a factor in facilitating growth.

VI. COUNTRY CASE STUDIES: LESSONS ON UPGRADING AND GLOBAL INTEGRATION FROM OTHER EMERGING ECONOMIES

108. This section will look to other economies and regions for insights on upgrading within global production networks to draw relevant strategic lessons for policy makers and other industry stakeholders in Andhra Pradesh and at the national level, and for other economies with regions at the cusp of industrial transformation. The focus of the discussion is on upgrading strategies within the global electronics industry not only for the sake of clarity and conciseness, but also to elucidate strategies for growth in an emerging sector in Andhra Pradesh with a nascent base and the highest levels of value-addition and global linkages of all three sectors under review.

109. This section examines the policies of East Asian economic leaders in the 1980s and 1990s, including the Republic of Korea and Taipei,China, and how they succeeded in closing the gap with then-global leader, Japan. This section will also look at select Southeast Asian economies, who were later industrializers and part of the East Asian electronics production networks that benefited from the so-called "flying geese model" to link their growth to that of Japan; the Republic of Korea; and Taipei,China.[13] A discussion of Brazil's upgrading strategy in the electronics industry is also included in this section. Brazil's economy is large, like India's, and its earlier industrial policies were based on import substitution before evolving into a sophisticated mix of capability generation predicated on aggressive investment in the domestic market and strong engagement with global production chains.

A. The Republic of Korea and Taipei,China: Cultivating National Leaders in Electronics

110. Compared with other economies in the region (with the obvious exception of Japan), the Republic of Korea and Taipei,China represent early Asian entrants into electronics global production networks. Their respective governments provided substantial government support to national firms through the provision of subsidized credit, grants, and incentives, which were gradually pared back as beneficiaries acquired the technological capabilities and efficiencies necessary for international competition (Rasiah et al. 2014). For example, the Republic of Korea introduced tax incentives and duty-free imports for key capital goods and promoted education and research and development (R&D) through direct investments in the economy's public and private universities. It also invested directly in R&D in leading technologies, such as the Dynamic Random Access Memory research project in the 1980s and the Highly Advanced National Project in the 1990s. Likewise, Taipei,China's state-owned Industrial Technical Research Institute (now the Electronics Research Service Organization) oversaw early technology transfers to small and medium-sized enterprises (SMEs) by facilitating licensing agreements with United States-based semiconductor firms beginning in the 1970s and investing in process R&D, the outcomes of which it then disseminated among national firms.

[13] The flying geese model describes the catching-up process among late-developing economies in East and Southeast Asia, and the division of labor within Asia and the Pacific. The model suggests that as labor costs in the leading economy (originally understood to be Japan) increase over time, its dynamic comparative advantage shifts from labor-intensive to higher productivity, capital-intensive activities. Labor-intensive activities are then shed to peripheral economies with lower labor costs. As this process reproduces itself from the core to peripheral economies and then to a subsequent tier of less-developed economies, more complex activities are sequentially diffused throughout the region. This pattern resembles a group of geese flying in a "V" pattern, with the leading economy at the head of the flock and peripheral economies following behind. The fragmentation of global production into GVCs was not a part of the initial formulation of the flying geese model, but it allows for the shedding of finer-grained activities than were captured within the original model.

111. In 1980, Taipei,China established the Hsinchu Science Park, which was modeled on California's Silicon Valley, to link SMEs to the skills and knowledge generated by nearby universities and to provide infrastructure and other public goods to national firms. Around the same time, the Republic of Korea made strategic use of tariff policies to incubate domestic and vertically integrated lead firms as they developed branded product lines. Conversely, Taipei,China emphasized the manufacture of intermediate goods, particularly semiconductors, that were produced by fragmented firms for global markets. Therefore, the protection of the domestic market was of less relevance to this industry. Today, these two economies host the headquarters of leading globally competitive firms in the electronics and semiconductor industries, such as Samsung and LG in the Republic of Korea and TSMC, UMC, and Foxconn in Taipei,China. While the Republic of Korea's strategy has been to build out vertically integrated lead firms with extensive and diversified product lines, Taipei,China has specialized in fragmented (though highly scale-driven) activities, including both labor-intensive contract manufacturing and capital-intensive semiconductor wafer fabrication.

112. As labor costs rose in these economies, lead firms and contract manufacturers and semiconductor producers outsourced labor-intensive processes to the PRC and Southeast Asian economies including Malaysia and the Philippines (Andrew 2014). Compared to the other emerging Asian economies, the Republic of Korea and Taipei,China have the largest number of R&D centers, most of which are nationally owned, and also generated the largest number of patents, indicating that they are maintaining their position at the industry's technological frontier (Rasiah et al. 2014).

B. Southeast Asia: From the Flying Geese Model to Market-Driven Investment Strategy

113. In contrast to the incubation of domestic firms that was characteristic of the Republic of Korea and Taipei,China's early entry into semiconductor fabrication and electronics manufacturing, more recent Southeast Asian entrants such as Malaysia, the Philippines, and Thailand pursued an emphasis on investment promotion and foreign direct investment (FDI). Out of 43 semiconductor firms located in Malaysia in 2011, 35 were foreign-owned (Rasiah et al. 2014). Foreign firms accounted for 22 out of 29 semiconductor firms in the Philippines and 15 out of 21 firms in Thailand. In contrast, 61 out of 84 firms in Taipei,China and 23 out of 42 firms in the Republic of Korea were nationally owned in 2011, indicating less dependence on FDI for industry development. The foreign firms located in Southeast Asia primarily come from Japan, Republic of Korea, and the United States. These developing economies are an attractive production location given reduced labor costs in the context of rising wages in traditional production locales. Foreign firms can establish bases for low-value component production and/or contract manufacturing assembly in low-cost locations and export intermediate goods throughout the region. The low interregional tariffs guaranteed by the Association of Southeast Asian Nations enable multinational firms to shed segments from high-cost areas and fragment the value chain without facing additional costs tied to international production sharing. Thus, a necessary condition for the success of this market-driven approach is insertion into East Asia's well-known regional production networks. The governments of these economies facilitated this process through broad tax incentives and the establishment of industrial parks, such as the Penang export production hub in Malaysia. In contrast to the Republic of Korea and Taipei,China, there has been little emphasis on targeting specific product lines or investors (Athukorala 2015).

114. The tendency of these economies to focus on investment promotion rather than the indigenous development of skills and capabilities has important limitations, mainly in that the activities that are attracted to these economies are relatively low-value. While FDI has succeeded in creating jobs and absorbing labor, the multinational firms that have relocated to Southeast Asia have invested little in R&D and skills development. Furthermore, there has been little attention given to institutional

deepening in these economies such as the formation of tight linkages between firms, or the establishment of universities, public and quasi-public training institutes, and research and technology centers (Rasiah et al. 2014). Lacking the conditions for technological upgrading, these economies risk becoming trapped in low-value activities, which are liable to be outsourced to the next low-cost location as labor costs rise.

C. Brazil: Creating Capabilities and Structuring Markets

115. While international competition, spurred by aggressive tariff liberalization during the 1990s, created market-driven incentives for Brazilian electronics and semiconductor firms to become more efficient, this competition alone was not sufficient for the systematic upgrading of firm capabilities. Federal agencies—such as the Ministry of Science and Technology and the Ministry of Development, Industry, and Trade—introduced "incentives for progressive firm-level capability building coupled with continuous and constructive assessment exercises. Local development agencies could also provide firms with access to foresight exercises (technological and market), identification of sources of knowledge (local and non-local) for diverse technical and organizational activities, and also dissemination of successful experience, particularly those of local suppliers" (Figueiredo 2008, p. 30). Among the most relevant federal programs is the Informatics Law, which defines incentives for the electronics and related (e.g., medical devices) industries. This law was reformed wholesale in the early 1990s (Evans 1995), marking a shift from an earlier strategy of attracting national capital for import substitution in the hopes of creating a national champion to an emphasis on upgrading in a global context by authorizing the release of incentives to multinational corporations (MNCs), promoting more effective targeting through the introduction of product-specific incentives (conditioned on product-specific local content requirements), and requiring firms that receive incentives invest in R&D (Sturgeon et al. 2013b).[14] Lead firms may, and often do, outsource these research activities to contract manufacturers, such that the latter built economies of scale in R&D. As with manufacturing capacity, the R&D activities of contract manufacturers can serve multiple lead firms and end markets.

116. Meanwhile, federal ministries sought to attract investments from not only lead firms, which are interested in penetrating the large and growing domestic end markets, but also electronics contract manufacturers, such as Flextronics and Foxconn, with the goal of consolidating technological capabilities in manufacturing processes and ensuring that Brazilian technology firms engaged in product design would have easier access to electronic components as well as engineering know-how in the global contract manufacturers' national and global networks (Gereffi and Sturgeon 2013). Compared to lead firms, which typically specialize in product design and marketing activities, contract manufacturers focus on labor-intensive processes such as assembly and component production, generating more jobs. In another strategy emphasizing intermediate (rather than final) goods, the Ministry of Science and Technology created a small, state-owned semiconductor fabrication unit, CEITEC, which produces small batches of semiconductor chips for niche products designed by Brazilian firms, including a chip for tracing livestock that has been widely adopted by Brazil's large cattle industry. Rather than take head on the large, scale-driven semiconductor fabrication plants located in the United States and East Asia, the Brazilian approach is to focus on building design and manufacturing capabilities in high-value and nationally relevant niche segments of the industry.

117. Similarly, the Ministry of Science and Technology recently partnered with several investors—including IBM, the Brazilian National Economic and Social Development Bank, and a handful of diversified national firms—in the formation of SIX Semiconductors, a wafer fabrication and research

[14] A minimum of 4% of the value of Brazilian revenue from incentivized products must be invested in R&D.

facility specializing in chips used in commercial, energy-efficient lighting and appliances, and public health technologies. This policy emphasis on intermediate goods created jobs in assembly and component manufacturing activities and seeded opportunities for upgrading among Brazilian firms by promoting manufacturing capabilities that open up access to multiple end markets. It also underpinned innovation and improvements in labor productivity.

D. Lessons

118. While the state-driven strategies of the Republic of Korea and Taipei,China are difficult to replicate in the context of a mature industry and a liberalized global economy, India need not replicate the market-driven strategy pursued by Southeast Asian economies, which have inhibited the creation of national firms and the development of capabilities in higher-value segments of the value chain such as research, design, and project management. Like Brazil, India has a large domestic market to leverage, opening opportunities for both the attraction of market-seeking and employment-generating FDI as well as the development of high-value domestic capabilities aimed at serving a growing domestic market with eventual opportunities for export growth.

119. Generating employment will require the development of production capabilities in the middle of the value chain. This can be facilitated by FDI in labor-intensive activities such as assembly and contract manufacturing, which will not only create jobs but also help to alleviate supply constraints in the short-run. India's proximity to East Asian and Southeast Asian production networks (and therefore access to low-cost inputs) combined with rising labor costs in established production locations such as the PRC and Malaysia, make it an attractive production location for inward investments. In addition, India has sufficient human resources and a large domestic market that it can leverage to develop focused niches that will set the stage for upgrading.

VII. INDUSTRIAL POLICIES FOR GROWTH AND GLOBAL INTEGRATION

120. Industrial upgrading through engagement with global production networks requires a different kind of industrial policy than the traditional approaches of local content requirements, import substitution, and narrow export promotion. As several GVC scholars have pointed out (for example, Gereffi and Sturgeon 2013), new GVC-friendly industrial policies call for several departures from past practices to enable the harnessing of fresh avenues for growth and learning. What are some of the distilled findings about these new industrial policies? We conclude by listing a few specific policies that are applicable for the VCIC.

121. First, it is important to build on the segments that are already strong in Andhra Pradesh. Therefore, the study examined three important sectors that are already prominent in Andhra Pradesh's industrial mix: pharmaceuticals, chemicals, and electronics. Each of these sectors has the potential to anchor a vibrant and globally linked production network, though the sectors are currently at very different stages of development. Chemicals, for example, are much more domestically oriented in terms of end markets, while electronics and pharmaceuticals are export-oriented sectors. Furthermore, export growth in each sector is associated with different drivers.

A. Pharmaceuticals

122. Firms in Andhra Pradesh's pharmaceutical, medicinal, chemical, and botanical industry (NIC 21/210) produce a variety of therapeutic products, including pharmaceuticals, inputs to

pharmaceutical products, Ayurvedic preparations, veterinary preparations, and bandages and gauze. The majority of firms in the sector (83%, or 134 out of 161 exporters) and almost all output (99%) fall within the pharmaceuticals segment. Thus, pharmaceuticals (excluding homeopathics and veterinary preparations) will be the focus of this section. Firms in the pharmaceuticals industry contribute to the production of drugs and medicines, which consist of a therapeutic active ingredient (or several active ingredients) that is packaged in some way for internal or external application to the human body.

123. In addition to pharmaceuticals manufacturing, the pharmaceuticals value chain includes drug research, product development, clinical trials, distribution, and marketing. The protection and management of intellectual property is (in)famously central to pharmaceutical value chains, due to the massive costs and high levels of uncertainty surrounding the research, regulatory approval, and commercialization processes. Thus, there are three primary strands to GVCs in the pharmaceuticals industry—branded products, quality generics, and low-value generics. Given the importance of knowledge-based inputs into pharmaceutical products, universities, government research institutes, and other such elements of innovation systems play an important role in pharmaceutical value chains, particularly the upstream segments.

124. Among developing economies, upgrading usually entails moving from the packaging of active ingredients to the manufacture of active ingredients; movement into higher-value generics through R&D efforts or mastery of sophisticated chemical or bio-manufacturing techniques; or expanding market share through marketing or price competition. As upstream segments (R&D) in the value chain become increasingly fragmented, some developing economy firms have positioned themselves to carry out research tasks, ranging from clinical trials to new drug discovery, on an outsourcing basis without engaging in the manufacturing process.

125. Andhra Pradesh's pharmaceuticals sector is driven by the production of highly focused output in the final goods segment targeted toward export markets: antibiotics, vitamins, and biochemics (e.g., antiretrovirals). These segments use imported inputs, but are also linked in important ways to domestic input markets. GVC-linked growth opportunities in the pharmaceuticals sector cover six major areas.

(i) The pharmaceuticals sector can grow by scaling up exports to increase the scale of production among existing firms and formulations, or by inducting new players, to strategically target new global end markets and expand in the large domestic market.
(ii) There are relatively low levels of value-addition in the final goods sector. A second avenue for growth is through the upgrading of processes, technologies, and quality so that Andhra Pradesh's pharmaceuticals cluster comes to dominate the generics segment in these and other products. This can occur through strategic joint ventures, technical agreements, or other partnerships with global lead firms.
(iii) A third avenue of growth is via product upgrading and product diversification through global partnerships, domestic drug discovery, and R&D. Alternative herbal formulation, which already occurs in parts of Guntur district, is another avenue for diversification provided stringent quality standards can be developed.
(iv) The clinical trials market is often linked to the pharmaceuticals sector. The presence of a vibrant healthcare industry in Andhra Pradesh and the Indian economy can be a good anchor for this process, but this avenue is not without controversy. Very strong regulatory standards of quality, ethics, and oversight are necessary to safeguard the local populations on which the trials are carried out.

(v) The presence of a combination of the pharmaceuticals and chemicals sector in Andhra Pradesh suggests that conditions exist in the state for the successful development of the biotechnology industry.
(vi) Building out more robust backward and forward linkages can anchor the sector more deeply in the state, linking the domestic base with global networks.

B. Electronics

126. The electronics sector is an important but small sector in the state but the potential exists to link the sector with GVCs and build out its competitiveness. The sector's global linkages are driven by the export of intermediates—specifically, dry cell batteries. Indeed, Andhra Pradesh has a significant comparative advantage in this segment (electronics intermediates). The sector adds the highest share of gross value-added in output relative to other sectors and has a greater concentration of global linkages (exports and imports) than similar activities in India as a whole. How does Andhra Pradesh's electronics segment compare with the electronics GVC?

127. The global electronics industry, broadly defined, makes products that rely on semiconductor devices to control the flow of electrons on electrical circuits. These circuits define and often allow users to manipulate product features and functionality. The electronics industry is distinct from the electrical equipment industry, which is primarily involved in the generation, transmission, storage, and conversion of electrical energy. In practice, these two industries are somewhat intertwined, particularly as many electrical devices rely on advances in battery or wiring technologies.

128. The electronics industry is extremely complex and includes numerous product categories comprising both final goods as well as inputs to the automotive, aerospace, medical device, and communication equipment industries, as well as the services sector (Figure 6). Since the design and manufacture of electronic components and systems is highly codifiable, firms can display complex production information at a distance with relative ease. This has enabled the growth of large contract manufacturing service providers in the manufacture of semiconductors—semiconductors fabs, or fabrication facilities, are extremely capital-intensive propositions—and the assembly of final electronic products such as Hon Hai and Foxconn.

129. Thus, electronics value chains have a very modular character in which buyers can substitute suppliers with relative ease as all firms are expected to comply with industry-wide standards set by large lead firms like Intel in the semiconductors segment and Apple in the components and peripherals segment (Sturgeon and Memedovic 2011). With respect to semiconductors, given the large investments required and competitive global market environment (chips are light and easy to ship), many firms in the semiconductor space cannot afford their own fab. As a result, they focus on the design of semiconductors for particular applications and contract with fabs for the manufacture of these chips. Such firms are known as design houses. The majority of global semiconductor fabrication takes place in East Asia where electronics value chains are relatively consolidated, though there are several fabs in North America and Europe, and some capacity in Costa Rica thanks to the Intel plant, and in Brazil where both the Brazilian state and (more recently) IBM have set up small fabs.

130. In the case of Andhra Pradesh, the manufacture of batteries is the top subsector among exporting firms. Though it includes only three firms, exports of batteries (Rs30.1 billion) account for 21% of total output in the industry and 79% of exports. The primary product produced by Andhra Pradesh battery manufacturers is dry cell batteries, followed by scientific measurement equipment. Behind batteries, the other major subsector within electrical equipment is motors and electricity

generation, transmission, and distribution equipment. Electrical transformers account for about 8% of electrical equipment exports. Most output among non-exporters can be found within the electricity generation, transmission, and distribution equipment subsector. The top product manufactured by non-exporters is electricity transformers (Rs16.6 billion), followed by electrical switches (Rs5.9 billion). Batteries (Rs2.1 billion) and parts for batteries (Rs1.2 billion) are not major products among non-exporters in the same way that they are among exporters.

131. The import intensity of exports is the other side of global linkages. The top import among exporters of electrical equipment is solar collectors (Rs5.7 billion), followed by lead white (Rs2.5 billion). Both inputs go into activities carried out by firms in the battery-manufacturing subsector. The top domestic inputs for exporters within the electrical equipment industry can also be found among the three battery-manufacturing firms. These are lead white (Rs3.0 billion) and lead alloy (Rs2.9 billion). It is possible that this represents lead, which is imported by domestic firms, processed by local non-exporters, and then sold on to local exporting firms. In general, imports are less concentrated within the non-export segment of the industry. Here, the top import is steel sheets (Rs1.6 billion), followed by parts of electrical transformers (Rs1.0 billion). The top domestically sourced inputs for non-exporters are concentrated within the generation, transmission, and distribution equipment subsector. These are copper coils (Rs3.1 billion) and iron products (Rs2.0 billion).

132. In terms of policies in support of GVC-led growth, there are two main strategies: (i) build out and diversify electrical intermediates (beyond batteries), and (ii) encourage the growth of the final goods sector through joint ventures and partnerships. For example, video recording equipment and televisions are produced in large quantities locally but not shipped to export markets. There are extensive GVCs for such products that span East Asia and Southeast Asia. There may be opportunities to plug local producers into these chains. A second candidate is mobile telephony and handsets.

133. Perhaps surprisingly, batteries figure prominently as a major export. But clearly this can be an opportunity for upgrading, perhaps by identifying new export markets, developing new product lines, or working with major industrial buyers such as auto manufacturers or other large purchasers of batteries. Andhra Pradesh's production is entirely concentrated within dry cell batteries. Incorporating more sophisticated production technologies, such as lithium-ion or nickel-based battery manufacturing, could open more profitable global end markets and create opportunities for forward linkages with the emerging portable electronics industry.

134. Several non-exporters are active in producing semiconductors. This sector may also be developed by product and process upgrading through linkages with global players, particularly those in East Asia. This strategy of building a semiconductors industry through linkages with international lead firms was pursued by both Taipei,China (through technology licenses) and Malaysia (through FDI). Effective project management and policy development facilitated rapid industry growth in both economies.

C. Chemicals

135. The chemicals sector is well developed in Andhra Pradesh, but relative to the rest of the Indian economy, the sector is not very specialized in the state nor does it have a significant export presence. There is scope for further development of the sector, but it will depend on the direction in which the sector takes: Will it maintain its existing focus on fertilizers and paints and varnishes? Or will firms in the chemicals sector pursue linkages with pharmaceuticals, health care, and biotech companies? Or

perhaps enter the petrochemicals market? Interviews indicated that local firms are beginning to identify other routes available to them, including the military and defense market.

D. Conclusions

136. Beyond the sectoral strategies noted above, there are five broad strategies for integrating the VCIC into global markets. First, participation in GVCs that foster upgrading among domestic industrial clusters and push up the value chain will require domestic capacity building that goes beyond local content requirements. It requires building learning opportunities by harnessing the scale that comes from integrating domestic demand with diversified export demand. Domestic linkages need to come not from fiat or policy mandates, but from the efficiencies of building scale and deepening capabilities.

137. Second, building ties with first-tier global suppliers may be a faster way to get to original equipment manufacturer (OEM) status than waiting to build ties with lead firms directly. The importance of this point is illustrated by Brazil's success in getting Apple to focus on its economy as the second production hub for its products after the PRC. This was due in part to Brazil forging strategic ties with Foxconn that led to it having already established large capacities in Brazil. The path dependence of those prior relationships, investment-in-scale, and the learning processes that Brazilian firms and workers underwent through partnerships with Foxconn were critical to Apple choosing Brazil over India for its second OEM production hub. Beyond Apple, several other Brazilian and multinational OEMs have taken advantage of the capacity offered by Foxconn to develop efficient supply chains within Brazil.

138. Third, collaborating with global suppliers can occur through inward investments and partnerships, as well as through contract manufacturing that eventually deepens into full-package production. Both these strategies can help defray risks and lower barriers to entry into global markets. This calls for an array of strategic public goods that help lower the costs of production and turnaround time, thus improving the speed and flexibility of production. SEZs can provide some of these public goods, but others require a more strategic policy focus and sectorwide collective action in the areas of workforce housing, industry-specific public goods such as quality testing facilities, and other critical industrial infrastructure. Interviews and surveys indicate that improving speed and flexibility will also require better logistics and transportation capabilities, from logistical hubs to the development of last mile infrastructure outside of SEZs. This is an area where the industrial and economic corridor, as a strategy and planning process, is relevant. It can help reduce transportation costs between SEZs and ports as well as between production centers and the communities where workers live. These are places where targeted last-mile infrastructure can make a difference through the planning of logistics hubs.

139. Fourth, a strong mix of skills in the domestic workforce is essential for moving up the value chain. Task trade—which is skills and capabilities enhancing in terms of raising the quality of the mid-level and shop-floor production workforce as the volume of production that demands higher-quality capacities increases—will be an important motivator for growth. In addition to skills formation, developing strategies to facilitate labor absorption among all skill levels, such as coordinating the development of industrial and social infrastructure, will help domestic sectors take advantage of the opportunities presented by task trade.

140. Finally, everyday forms of innovation that enable firms to continuously absorb learning and technology will be essential. As one survey respondent said, the "shelf life of an engineer (in the electronics space) is less than 2 years today." The mix of learning and its application on the shop floor will require collaboration and strategic comparisons with the technology frontier, and the taking of

small steps through strategic augmentation of exposure to end markets that are progressively more quality conscious. Such an approach can help firms move up the value chain while also building market share at home.

APPENDIX

Table A.1: Top Four Products by Output, 2011—Arranged by Value Chain Position

Pharmaceuticals

Intermediate goods

Product	Value (Rs million)	Share of total	Number of Firms
Antibiotics & preparations thereof, n.e.c.	14,032	0.74%	32
Trimethoprim-sulfamethoxazole (co-trimoxazole)	2,538	0.13%	2
Biochemic mixed medicines	3,357	0.18%	15
Boric powder	773	0.04%	1

Final goods

Product	Value (Rs million)	Share of total	Number of Firms
Biochemic mixed medicines	13,633	0.72%	13
Antibiotics and preparations thereof, n.e.c.	12,797	0.67%	35
Other Vitamins in tablet or injectable form	5,514	0.29%	11
Amoxicillin / ampicillin with or without cloxacillin	4,926	0.26%	9

Chemicals

Intermediate goods

Product	Value	Share of total	Number of Firms
Urea	25,345	1.33%	2
Phosphate di ammon others	23,183	1.22%	1
Diammonium hydrogenorthophosphate (diammonium phosphate) n.e.c	10,551	0.56%	3
Polystyrene, PS, Thermocol	5,269	0.28%	1

Final goods

Product	Value	Share of total	Number of Firms
Catalyst, chemical	5,707	0.30%	1
Paints, enamels	5,494	0.29%	4
Paints epoxy, Epoxy powder and liquid	718	0.04%	2
Varnish (all types)	226	0.01%	1

Electronics

Intermediate goods

Product	Value	Share of total	Number of Firms
Battery dry cells	18,906	1.00%	3
Electronic Integrated Circuits	10,051	0.53%	1
Other surveying, hydrographic, oceanographic, hydrological, meteorological or geophysical equipment	8,904	0.47%	3
Electronic waste	1,081	0.06%	2

Final goods

Product	Value	Share of total	Number of Firms
Television cameras	7,962	0.42%	1
Electronic Integrated Circuits	5,745	0.30%	2
Solar collector and parts thereof of aluminum	1,171	0.06%	1
Point of sale terminals and ATMs	276	0.01%	1

n.e.c. = not elsewhere classified.

Source: Authors' calculations based on data from the Government of India, Central Statistics Office. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx

Table A.2: Top Four Imported Products by Value Chain Position, 2011

Pharmaceuticals							
Intermediate goods				Final goods			
Product	Value (Rs million)	Share of total	Number of Firms	Product	Value (Rs million)	Share of total	Number of Firms
Dexamethasone	410	0.10%	1	Heparin	1,584	0.38%	2
Beta naphthol	198	0.05%	1	Medicaments, for therapeutic or prophylactic uses n.e.c	1,507	0.36%	18
Chloromethanes	180	0.04%	1	Antibiotics and preparations thereof, n.e.c.	993	0.24%	6
Demm (diethylethoxy methylene malonate)	146	0.04%	1	Para octyl phenol	655	0.16%	1
Chemicals							
Intermediate goods				Final goods			
Product	Value (Rs million)	Share of total	Number of Firms	Product	Value (Rs million)	Share of total	Number of Firms
Phosphoric acid	18,808	4.52%	2	Oil, solvent	1,024	0.25%	1
Phosphorous compound (dnp, mop)	5,707	1.37%	1	Titanium dioxide	214	0.05%	2
Acid Phosphoric	5,262	1.26%	1	Butyl acrylate	103	0.02%	1
Ammonia liquid	4,376	1.05%	1	Chrome, yellow	81	0.02%	1
Electronics							
Intermediate goods				Final goods			
Product	Value (Rs million)	Share of total	Number of Firms	Product	Value (Rs million)	Share of total	Number of Firms
Solar collector and parts thereof of aluminum	6,293	1.51%	2	Solar collector and parts thereof of aluminum	1,737	0.42%	1
Lead white	2,592	0.62%	2	Liquid crystal devices n.e.c.	1,091	0.26%	2
Lead & lead alloy worked n.e.c	1,266	0.30%	1	Cabinet plastic	1,009	0.24%	1
Lead sulphide	736	0.18%	1	Modem	130	0.03%	1

dnp = dinitrophenol (fertilizer compound), mop = muriate of potash (fertilizer compound), n.e.c. = not elsewhere classified.
Source: Authors' calculations based on data from the Government of India, Central Statistics Office. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx

Table A.3: Top Four Domestic Inputs by Value Chain Position, 2011 (Rs million)

Pharmaceuticals

Intermediate goods				Final goods			
Product	Value (Rs million)	Share of total	Number of Firms	Product	Value (Rs million)	Share of total	Number of Firms
Antibiotics and preparations thereof, n.e.c.	521	0.07%	13	Other pharmaceutical products, n.e.c.	4,594	0.60%	69
Ethambutol, isoniazid, pyrazinamide, rifampicin (m.d.t. for t.b.) single or composition	450	0.06%	1	Nevirapine, zidovudine, stavudine, lamivudine, AZT, didanosin, indinavir, for HIV treatment antivirals	3,435	0.45%	5
Chrome lead	445	0.06%	1	Other Vitamins in tablet or injectable form	1,153	0.15%	11
Soda ash, washing soda	282	0.04%	1	Cefotaxime, cepodoxime, ceftriaxone	771	0.10%	2

Chemicals

Intermediate goods				Final goods			
Product	Value (Rs million)	Share of total	Number of Firms	Product	Value (Rs million)	Share of total	Number of Firms
Gas natural	5,099	0.66%	1	Oil, solvent	724	0.09%	2
Phosphoric acid	2,422	0.31%	2	Amonium nitrate	360	0.05%	3
Industrial monocarboxylic fatty acids; acid oils from refining n.e.c	1,702	0.22%	3	Varnish (all types)	359	0.05%	3
Palm oil, crude	946	0.12%	3	Titanium dioxide	196	0.03%	5

Electronics

Intermediate goods				Final goods			
Product	Value (Rs million)	Share of total	Number of Firms	Product	Value (Rs million)	Share of total	Number of Firms
Lead white	3,040	0.39%	1	Picture tube (color)	2,764	0.36%	1
Lead and lead alloy worked n.e.c.	2,940	0.38%	1	Cabinet iron, steel	2,096	0.27%	2
Lead oxide	736	0.10%	1	Electronic p c b /micro circuit	1,617	0.21%	1
Zinc and zinc alloys unwrought n.e.c.	434	0.06%	1	Solar collector and parts thereof of aluminum	307	0.04%	1

AZT = azidothymidine (anti-retroviral medication), m.d.t. for t.b. = multi-drug therapy for tuberculosis, n.e.c. = not elsewhere classified, p c b = printed circuit board.
Source: Authors' calculations based on data from the Government of India, Central Statistics Office. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx

Table A.4: Top Four Export Products by Value Chain, 2011

Chemicals				
Product	**Status**	**Value** (Rs million)	**Share of total manufacturing exports**	**Number of firms that export the product**
Chemical elements n.e.c.; inorganic acids except phosphoric, nitric and sulphonitric; inorganic oxygen	Intermediate	844	0.4%	3
Organo-sulfur compounds and other organo-inorganic compounds; heterocyclic compounds n.e.c.	Intermediate	704	0.3%	2
Yarn nylon twisted or not	Intermediate	267	0.1%	1
Disinfectants	Final	248	0.1%	1
Pharmaceuticals				
Product	**Status**	**Value** (Rs million)	**Share of total manufacturing exports**	**Number of firms that export the product**
Antibiotics and preparations thereof, n.e.c.	Intermediate, final	10,504	5.1%	14
Biochemic mixed medicines	Final	5,076	2.5%	5
Other Vitamins in tablet or injectable form	Intermediate, final	3,434	1.7%	1
Amoxicillin, ampicillin with and without cloxacillin	Intermediate	2,306	1.1%	6
Electronics				
Product	**Status**	**Value** (Rs million)	**Share of total manufacturing exports**	**Number of firms that export the product**
Other surveying, hydrographic, oceanographic, hydrological, meteorological or geophysical equipment	Final	7,265	3.5%	2
Battery dry cells	Intermediate	6,655	3.2%	1
Primary cells and primary batteries, n.e.c.	Intermediate	246	0.1%	2
Electronic valve, tube, components, n.e.c	Intermediate	129	0.1%	1

n.e.c. = not elsewhere classified.
Source: Authors' calculations based on data from the Government of India, Central Statistics Office. Annual Survey of Industries 2010–2011. http://www.csoisw.gov.in/CMS/cms/Home.aspx

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Leveraging Global Production Networks

Evidence from the Vizag–Chennai Industrial Corridor

This paper explores the conditions under which India's new economic corridors, particularly the Vizag–Chennai Industrial Corridor in Andhra Pradesh, can benefit from strategic participation in global value chains and integration with global production networks. It identifies how engagement in global value chains improve domestic capabilities and support industrial upgrading and job creation.

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