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Regional Pathways to Technological Upgrading: The Impact of Agglomeration Economies and its Regional Covariates on Upgrading in Post-reforms India's Manufacturing Sector

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A dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Philosophy
in Urban Planning

by

Bravishwar Mallavarapu

2013

ABSTRACT OF THE DISSERTATION

Regional Pathways to Technological Upgrading:

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Doctor of Philosophy in Urban Planning

University of California, Los Angeles, 2013

Professor Michael Storper, Chair

Globalization presents challenges to emerging economies, as exports from such countries typically consist of standardized outputs. In response, the new orthodoxy of market liberalization shows mixed technological upgrading results because it fails to account for cross-national, let alone, sub-national variations in institutional capacities. Literature highlights the central role of regional (subnational) economies in driving the global economy through productivity and innovation boosts from agglomerative forces. In emerging countries, the effectiveness of regional agglomerations is hampered by the negative impacts of over-urbanization. This problem is worsened in urban-primate settlement patterns involving very large primary cities and no comparable secondary urban areas. Thus, national reforms may have unequal subnational upgrading impacts because of the inter-regional heterogeneity in agglomerative, urbanization and institutional capacities.

In this dissertation consisting of three papers, I explore the above issues through the case of India's manufacturing sector in the post-1991 'delicensing' reforms era (1990 to 2005). In the first paper, I construct and employ a unique indicator of technological sophistication to track regional trends in technological upgrading. I find that technological levels for delicensed industries have converged at the state-level but to lower levels of sophistication. In the second paper, I find evidence that falling technological levels coincide with the dispersion of manufacturing activities from urban centers. Urbanization agglomeration economies (variety) are positively correlated with upgrading in conjunction with capital-intensity and imported inputs into production. However, localization agglomeration economies (own industry concentration) are found to have negative impacts on upgrading across the board, pointing to issues pertaining to limited supply of regional infrastructure. In the third paper, I examine the impact of urbanization on agglomeration economies. I find that urban size thresholds – larger to largest urban areas -- play a positive mediating role on the effectiveness of agglomeration economies on upgrading. Further, very large secondary urban areas influence upgrading by attracting skilled migration. In investigating regional political contexts, I find that the reasons why political majorities and lengthy tenures choose growth in secondary urban areas do not associate with upgrading. This may indicate competing policy priorities to the neglect of the manufacturing sector.

The dissertation of Bravishwar Mallavarapu is approved.

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2013

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This dissertation has been possible because of the guidance, help, support, and friendship of many remarkable individuals that I have come to know over the years. I came to UCLA for my masters studies in urban planning from primarily a built-environment background. However, very soon I found in me a keen student of the political economy of urban and regional development. Within this realm, the most fascinating topics constituted the examination of the spatial organization of the economy at the regional scale and its extensions out to the global economy. Economic geography, as I discovered the term-of-art, became my specialization of academic and research pursuit as I embarked upon my doctoral degree. This came together with an inherent longing for unpacking the developmental theatre called India, which I personally benefitted from growing up, and which has its ongoing challenges viz. economic growth, uneven development and disparity – a common undercurrent with similar post-colonial countries in contemporary globalization.

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Mallavarapu, Bravish. 2008. Multiple Dimensions of Regional Competences: The Whole, the Part and the Whole. Presented at the Association of American Geographers, Annual Meeting, Las Vegas.

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CHAPTER 1

Introduction

1.1. Technological Upgrading as Regional Upgrading

Understanding the connections between technological change and long-term economic growth is an important subject in the regional development literature. In this connection, technological change, as an ongoing process of upgrading techniques, skills and knowledge, defines evolving capabilities to deliver products and services of specific quality and at certain rates of efficiency. The uniqueness and complexity of these outputs typically determine net value-added, and thereby, the associated welfare outcomes.

This is especially relevant for developing countries, where technological catch-up enables participation in increasingly more complex stages of the global spatial divisions of labor (See Storper and Walker, 1989; Scott and Storper, 2003; and Dicken, 2007). Additionally, the process of technological upgrading in emerging countries occurs in a 'step-by-step' manner, where imitation of frontier technologies is potentially followed by adaptation and innovation (Aghion et al., 2001). Consequently, it becomes important to explain the set of factors that enable firms in developing regions to respond to emerging global opportunities. Such ongoing adjustments are outwardly observed in changes in traded products and services.

In recent times, policy interventions in developing countries aimed at promoting economic growth and competiveness have often been implemented under the new orthodoxy of national market liberalization reforms. Such policies aim at addressing market distortions by relaxing barriers related to trade, investment and product-market controls put in place originally to promote and protect domestic industry under the import-substitution era. Liberalization policies are implemented with the belief that greater competition automatically pushes domestic firms into higher productive efficiencies and innovation. However, the track record of such national interventions has at best been mixed, primarily because they follow ideologically motivated one-size fits all approaches (See Amsden, 2001 and 2004; and Rodrik, 2003 and 2006;). The criticism leveled on the new orthodoxy is that broad policy approaches need to be adopted to specific institutional contexts, which are increasingly thought of as being one of the most crucial determinants of long-term economic growth (See Djankov et al., 2002; Acemoglu, Johnson and Robinson, 2005; and Easterly, 2005)[1]. Further, even less understood is the fact that broad national policies may have uneven impacts within the same country due to regional variations in institutional contexts (Aghion et al. 2005 and 2008).

In this connection, research over the last three decades in economic geography has highlighted the importance of regions as the motors of national and global economies (See Scott, 1996 and Scott and Storper, 2003). The process of technological catch-up is essentially spatial in character, in that locational decisions of firms are driven by the supply of critical inputs that are more readily accessible within specific spatial industrial configurations – what is called 'matching, sharing and learning' (Duranton and Puga, 2004). Technological change is both the cause and outcome of agglomeration economies driven by the process of circular and cumulative causation (Cf. Martin and Sunley, 1998). Further, the literature characterizes two different agglomerative forces at work - 'Marshall-Arrow-Romer' (localization economies) and 'Jane Jacobs' externalities (urbanization economies) (See Glaeser et al., 1992). While localization economies refer to efficiencies from specialization-related external economies of scale, proximity and associated learning effects, urbanization economies refer to the generation of new activities from variety or external economies of scope within the larger regional economy. In

[1] These issues are also highlighted in the cross-disciplinary new institutionalism literature, including the 'national systems of innovation' (See Freeman, 1988; Lundvall, 1992; Nelson, 1993; and Edquist, 1997) and 'varieties of capitalism' (See Hall and Soskice, 2001). These approaches compare business and social systems of production as an outcome of social, political and economic institutions.

order to have meaningful upgrading impacts, policy interventions need to take into account the role of spatial processes underpinning specialization, knowledge generation and innovation.

The preceding discussion gains added significance given that institutions evolve in varying regional contexts in conjunction with the spatial organization of economic activities (See Storper, 1997). Institutions – formal and informal – serve specific industrial needs that resolve issues of coordination, transaction costs and opportunistic behavior [2]. The emphases of the formal and informal institutional traditions are different, and over the years have resulted in a vibrant debate on the respective primacy of society (formal anonymous rules) and community (group-based interdependencies) in determining economic transformation. Recent work in economic geography seeks to bridge the above dichotomy by instead situating at the center ongoing interactions between community and society in determining differential institutional configurations (See Storper, 2005). Levels of community-based 'bonding' and society-mediated 'bridging' of group-interests potentiate functional policy domains pertaining to micro-economic efficiency, social distributional arrangements, and effective problem solving (See Rodrik, 2003). Thus, regional institutional arrangements are crucial in facilitating adaptation and adjustments to newly emerging economic challenges and opportunities.

Given the self-reinforcing aspect of technological growth, which creates barriers for upstart countries in global trade, value-chain ascendency hinges upon the ability of such emerging countries to leverage regional agglomeration economies (industrial clusters) in conjunction with ongoing institutional adjustments (See Nadvi and Schmitz, 1994; Schmitz and Knorringa, 2000; and Humphrey and Schmitz, 2002). In the context of broad national policy

[2] While the formal institutions literature examines the impact of political systems, law and order, rules and regulation in facilitating economic outcomes (See Williamson, 1975 and 1985; North, 1990; and Acemoglu et al., 2004), the informal institutions literature examines the impact of community embeddedness (social capital, networks and structural holes) (See Granovetter, 1973 and 1985; Coleman, 1988; Putnam, 1993; and Burt, 1995).

initiatives, like market reforms, economic success or failure depends on successful adjustments to changing policy conditions. Further, as the actual agents of technological change, the ability of regional firms to imitate, adapt and innovate depends on the interaction of organizational characteristics with regional agglomeration economies and institutional contexts.

For developing countries, this additionally highlights the issue of promoting and sustaining regional agglomeration economies given pressures from over-urbanization and over-crowding (See Henderson, 2002; Fan and Scott, 2003; Scott and Storper, 2003; and Venables, 2005). In this regard, the literature points to the fact that urbanization in developing countries typically takes the form of urban primate systems, i.e. where the system of urban settlements is dominated by few but disproportionately large urban agglomerations (See Moomaw and Shatter, 1996; Ades and Glaeser, 1995; Henderson, 2002; and Davis and Henderson, 2003). The flipside of this dynamic is the systematic under-development of secondary urban areas and the disproportionate concentration of resources in primate cities, following a recursive pattern of growth and investment. To be sure, urban size matters, as positive external economies get activated at certain scales. However this relationship is not smooth, and beyond certain size thresholds negative externalities manifest, primarily as an issue of congestion and quality of life (See Duranton and Puga, 2001; and Henderson, 2003). In this regard, the structure of urbanization also influences the development of human capital, as it impacts migratory and industrial location patterns, with a real possibility of a mismatch between the two.

In the preceding overview, I have highlighted key challenges to technological upgrading in the developing world, which I examine further in this dissertation. At the center of this dynamic is the role of regional agglomeration economies in explaining technological change in concert with other regional factors that enhance or constrain its effectiveness. In response to the issue of uneven effects of national policy changes, important lessons could be gleaned by examining inter-regional variations in upgrading outcomes resulting from spatial heterogeneity in agglomeration economies and its interaction with regional covariates, such as organizational characteristics, urban systems and regional political contexts.

The 1991 market-liberalization reform in India provides one such policy context to illustrate the above dynamic. National economic reforms in India were implemented in three policy areas -- product markets, trade, and foreign direct investment (FDI). In this dissertation, I specifically take into account policy changes associated with product markets with the sequential undoing post-1991 of elaborate licensing controls on the manufacturing sector (License Raj) -- what is also called the 'delicensing reforms'. The impact of these reforms are taken into account as a policy signal impacting groups of manufacturing industries undergoing sequential delicensing over the study period of 1990 to 2005. The research approach involves measuring technological upgrading at the industry-region level over time as the outcome variable of interest, and then examining the impact of agglomeration economies and its regional covariates, namely organizational characteristics, urbanization patterns, and institutional contexts.

1.2. Research Background: India Political Economy Context

The 1991 market liberalization reforms in India were implemented at the behest of the International Monetary Fund (IMF). These reforms were triggered by a balance of payments crisis, which forced the Government of India to borrow structural adjustment loans from the IMF. The 1991 reforms sought to make domestic firms globally competitive by dismantling the license red-tape regime – the License Raj -- that opened to competition several protected industries and eased capital and technology flows by removing import and FDI restrictions (See Panagariya, 2004).

Conventional wisdom views the 1991 market reforms as a watershed for the scope and depth of structural changes undertaken by the federal government. However, there is debate on the actual timing and the ideological moorings of these reforms. While some scholars have attributed post-reforms growth to the success of the 'pro-market' nature of the main set of reforms in 1991 (See for example, Srinivasan and Tendulkar, 2003 and Panagariya, 2004), others attribute this to a statist 'pro-business' approach that selectively favored certain industry-groups in the period leading to and after the 1991 reforms (See, Rodrik and Subramanium, 2004). Thus, unlike some other countries, the Indian political economy never fully switched over to the neo-liberal policies of the Washington Consensus, but instead followed a unique blend of market reforms and statist policies (Rodrik and Subramanium, 2004; and Kohli, 2007). In favoring select groups, the emergent picture is one of a complex policy environment at the national level with necessarily regional implications that may have resulted in heterogeneous economic outcomes, the evidence and causes of which I further seek to examine in this research in upgrading arena. The above points gain significance given that several studies point to spatially uneven growth in the post-reforms era, with industrially advanced states diverging at an increasing pace from the laggards.

1.2.1. National Liberalization Market Reforms in India

The economic reforms included deregulation of product markets, international trade and foreign direct investment (FDI). In this paper, I specifically examine the impact of the product markets reforms (the Industrial Licensing Policy reform) on manufacturing growth after 1991. In the pre-reforms planned economic system, industrial licensing played a critical part in regulating industrial activity. Licenses basically controlled all private sector economic activity in terms of entry, plant location and expansions, import of inputs and production technology, and ownership structure, including FDI participation.

As stated before, industries in India were regulated through the License Raj in the command and control economy until the 80s. Starting mid-80s many of the industries were delicensed selectively with the deployment of a 'positive list' (i.e. a list of select deregulated industries). However, the major structural change in this policy occurred within the gamut of the 1991 reforms that switched from the positive list to a 'negative list' (i.e. a list that protected only a few select industries of strategic importance), with most industries being deregulated. To provide a magnitude of this shift, while 37 percent of industries were delicensed in 1985, by 1991 this number rose to about 85 percent. The detailed provisions of these measures are provided in Appendix A of this document.

1.2.2. Post-reforms Manufacturing Growth

The performance of manufacturing value-added itself has been mixed since 1991, with an initial spurt of 11 percent annual average growth rate from 1991 to 1996 followed by a drop to 3 percent growth from 1996 to 2001 and eventual an increase to 10 percent from 2001 to 2006 (Gupta, Hasan and Kumar, 2009). Additionally, research shows that post-reforms, capital-intensive and skill-intensive manufacturing industries have performed better compared to labor-intensive manufacturing (See Kocchar et al., 2006; and Gupta, Hasan and Kumar, 2009). This is contrary to conventional notions regarding growth potentials for labor rich economies (contrary to the early experience of China and Korea in a liberalizing market context) (ibid).

This opens to examination questions regarding the uneven impact of market reforms on inter-regional economic growth in interaction with the heterogeneity in regional factors. Several studies attempt to model these variations by examining the role of political economy and industry-level factors and its interaction with delicensing (See for example, Aghion et al., 2004; Bhaumick et al., 2006 and Gupta, Hasan and Kumar, 2009).

1.3. Main Questions: Agglomeration Economies and its Regional Covariates

In examining the set of issues highlighted in the preceding sections, I have structured my research into a series of questions under three stages of analysis. These questions first establish variations in technological upgrading by regions and industry-groupings, making the case for a need to further explore heterogeneity in regional and industry-level factors. In the next two stages, I situate regional agglomeration economies at the center of this upgrading dynamic, examining the impact of regional covariates on its efficacy in impacting upgrading. These covariates include organizational characteristics of each industry-state group over time, explored in Stage 2 of the analysis, followed by urban-systems growth and structure, migration, and political institutional variables in Stage 3 of the research. The main questions being examined are as follows:

a. Did the Indian market reforms enable technological upgrading at the national and regional levels in the post-reforms era?

b. What is the role of regional agglomeration economies in explaining upgrading at the industry-state level?

c. What are main and interaction effects of organizational characteristics on regional agglomeration economies in explaining technological upgrading?

d. How are regional agglomeration economies constrained by urban-systems and institutional conditions?

1.4. Methodology Overview

In this research, I primarily employ panel data methods to examine questions specific to different stages of my research. The study was concluded in three stages with relevant transformation and augmentation of the data panel for relevant analytical purposes. The panel data used in this study were constructed for the years 1990-91, 1995-96, 2000-01 and 2005-06. The geographical unit of observation of the upgrading outcome and the explanatory variables is the state-level. The terms regions, states and state-regions will be used synonymously in this study. The specific terms ‘urban agglomeration’ and ‘districts’, where employed, are used to denote geographical regions at the sub-state level.

In Stage-1 of this research, in order to observe upgrading outcomes, I construct a novel indicator of technological sophistication for 3-digit National Industrial Classification (NIC) codes controlling for changes in the classification over time. This technological indicator is based on price-based relative product quality information for Indian exports in US imports at the 6-digit Harmonized Systems (HS) code level obtained from Kemeny (2010). The methodological innovation in this stage of my study involves a mapping of these 6-digit HS codes on the trade side to the 3-digit NIC codes on the production side. The manufacturing production data comprises the core of the panel, and it is obtained as official 3-digit level tabulations by state over time from the Annual Survey of Industries (ASI) of the Ministry of Statistics and Programme Implementation (MOSPI). The various 3-digit industries are further grouped into 16 broad technological categories (techcat) of distinct manufactured outputs and techniques, as used in grouping strategies in similar studies. This product-based indicator then allows me to measure regional (state) technological changes as a function of the mix of regional output within each industry grouping over time (1990 to 2005).

Further in Stage-2, I limit my analysis to the delicensed group of manufacturing activities, as I am more interested in establishing explanatory relationships keeping policy constant. I construct a set of industry (techcat) indicators to measure agglomeration economies at the techcat-state level to examine ongoing impacts on technological upgrading. These agglomeration variables include measures of localization and urbanization economies, which are interacted with techact organizational characteristics of firms averaged at the techcat-state level. I employ two sets of microdata at this stage to construct the above measures. The Economic Census of India (EC) microdata provides information on the employment size of establishments with sub-state district location codes at the 4-digit NIC level, which are used to estimate the extent of concentration by techcat-state and economic variety at the state by calculating weighted averages of district-level measures aggregated to each techcat-state. Microdata from the ASI released by MOSPI, which are used for the official state-level tabulations, provide information on the organizational characteristics of firms, including age of establishment and import propensity. In order to test the strength and significance of the explanatory variables on the outcome measure, I run fixed-effects panel data regression models at the techcat-state level. This allows me to isolate the marginal impacts of the techcat variables (agglomeration economies and organizational characteristics) after controlling for other unobserved time-invariant effects for each techcat-sate category over time.

In the last stage of this research (Stage-3), I augment the techcat-state panel used in the previous stage of research with regional variables representing urban systems (primacy and urban agglomeration size), migration characteristics and regional political contexts. Regional political contexts are represented here in terms of state-level political majorities and their time consistencies. Each of these variables is entered as a 2-year lag variable to minimize issues pertaining to endogeneity with respect to the techcat characteristics (agglomeration economies and organizational characteristics). Here again, I employ fixed-effects panel regressions to model the marginal main and mediating impacts of the regional variables on the outcome variable and the techcat-state agglomeration variables, respectively. It should be noted that these are models of association and I do not claim causality in employing them.

On another note, the choice of studying the Indian manufacturing sector is informed keeping in mind that 'technological sophistication' is hard to observe and then measure, and that this challenge can potentially be addressed by assessing observed price-based global market value of produced goods. Secondly in the Indian case, long-term official data on production and organizational characteristics are more systematically available for the manufacturing sector, and virtually non-existent for the other sectors of the economy.

1.5. Significance of Research

In conducting this dissertation research I make several contributions in assessing theoretical issues pertaining to the role of regional agglomeration economies in technological upgrading in the Indian, and larger developing world contexts. Further, in addressing these issues, I employ unique methodological approaches and techniques relevant to different stages of my research. These unique contributions are as follows:

I provide a systematic assessment of upgrading in manufacturing output at the state-level in India in the post-reforms study period of 1990 to 2005. I have employed a novel approach in mapping price-based product quality scores of Indian exports on the trade side to the 3-digit manufacturing industries on the production side. In my assessment of the literature, I have not encountered any other study that examines on a systematic long-term basis the relative product qualities of Indian manufacturing as a measure of technological upgrading at the national and sub-national levels.

Further, I develop a framework to unpack the factors that enable and constrain the effective leveraging of agglomeration economies in technological upgrading in interaction with other regional covariates such as firm organizational characteristics, urban-systems structure and institutional contexts.

In this regard, I first provide a systematic evaluation of the levels of localization and urbanization economies assembled at the techcat-state level over the 1990 to 2005 study period. This is longer than other studies on India, which only account for one or two cross-sectional points in time.

On the theoretical side, I have explored two main issues that have been underexplored in the general literature on developing countries, and specifically in the Indian context, pertaining to the mediating impacts of urban-systems characteristics and political institutional contexts on the leveraging of agglomeration economies toward upgrading.

The mediating impacts of urban systems (urban size and structure) on agglomeration economies in aiding technological upgrading has not received much attention in the Indian context based on my assessment of the literature. In connecting with the larger theoretical literature, the assessment of constraints on the effective leveraging of agglomeration economies in developing countries is under-explored in current scholarship.

The examination of political institutional contexts from the bonding-bridging theoretical framework is an emergent empirical topic in itself. Additionally, the testing of this framework and its components in specific political-economy contexts is an ongoing research project. I have tested here one level of the dynamic interaction between bonding and bridging in exploring regional political contexts, as represented by political majorities and their time consistencies across Indian states.

In exploring the above topics, I provide a systematic unpacking of the development of regional capabilities in conjunction with the changing global demand landscape for competences into production in the Indian context, with potential lessons applicable to the larger developing world context.

1.6. Chapter Organization

Chapters presented in this dissertation were originally written as self-contained papers pertaining to different stages of my research (Stage-1 to Stage-3). The main tables and figures in each of these papers have been incorporated within the structure of the discussion. Any supporting material showing detailed trends and calculations are presented in the Appendix at the end of this dissertation delineated by chapter number, while the paper references are included at the end of each chapter. Chapters 2 through 4 comprise one paper each, while Chapter 5 presents a set of conclusions and recommendations emerging from the entire body of this dissertation. The references used in the introduction and conclusion chapters are included in the dissertation bibliography at the end of the document. I am the source on all tables and figures unless specified. The paper chapters are written as follows:

In Chapter 2 (Paper 1), I provide a systematic assessment of the heterogeneity in technological sophistication scores across regions (states) and industry groupings of India. These regional scores are based on the mapping of the price-based product quality measures of Indian exports on to the production side at the 3-digit industry level, as expounded in this paper. Further here, I make the case that a systematic understanding of the observed heterogeneity in output scores along the industry and state dimensions points in the direction of differential regional agglomeration and organizational factors.

I develop this point further in Chapter 3 (Paper 2), where I examine the role of agglomeration economies and organizational characteristics in explaining inter-regional heterogeneity in upgrading outcomes. Here, I construct measures of localization and urbanization agglomeration economies and organizational characteristics at the industry-state level. This paper concludes with the need to examine regional covariates that enhance or constrain the impact of agglomeration economies on technological upgrading.

In the final paper, Chapter 4 (Paper 3), I examine the role of the regional covariates of agglomeration economies that mediate the latter's impact on technological upgrading. These regional covariates include urbanization, migration, and regional political contexts. These interactions provide the reason for the observed heterogeneity in regional agglomeration economies. In Chapter 5, I present the main conclusions of this dissertation research with its policy implications. In this chapter I also discuss the current limitations and a set of recommendations for future study.

CHAPTER 2

PAPER 1: Inter-regional Heterogeneity in Manufacturing Technological Upgrading Outcomes in Post-Reforms India

2.1. Introduction

In this paper, I examine post-reforms technological upgrading trends in India in two successive steps. First, I construct a measure of technological sophistication for Indian manufacturing in the post-reforms era over the 1990 to 2005 time period. I then use this measure to assess the geographical components of technological upgrading in terms of variations within and across regions and industry-groupings. The backdrop for this research is the implementation of the national delicensing policy in 1991 in India, which I examine as a policy signal that interacts with an increasing set of manufacturing industries that get deregulated over time. Further here, I make the case that a systematic understanding of the observed heterogeneity in the upgrading outcome measures for deregulated industries points in the direction of variations in regional and organizational factors. In other words, the impact of the market reforms and deregulation are not automatic or uniform across the country and vary with heterogeneity in regional-and industry-level factors.

As data suggests, under the 'License Raj' policies India's economy grew at a per capita GDP growth rate of 1.7 percent per annum from 1950 to 1980 – what is called the 'Hindu rate of growth' – later increasing to 3.8 percent from 1980 to 2000 (Rodrik and Subramanium, 2004). Additionally, I estimate an average of around 7.2 percent per annum from 2003 to 2007, which has since fallen to an average of about 5.6 percent over the 2008 to 2011 time period, in the aftermath of the Great Recession (assembled from World Bank Data, 2013). However, the performance of manufacturing value-added itself has been mixed since 1991, with an initial spurt of 11 percent annual average growth rate from 1991 to 1996 followed by a drop to 3 percent growth from 1996 to 2001 and eventual an increase to 10 percent from 2001 to 2006 (Gupta, Hasan and Kumar, 2009). Additionally, research shows that post-reforms, capital-intensive and skill-intensive manufacturing industries have grown faster compared to labor-intensive manufacturing (Kocchar et al., 2006; Gupta, Hasan and Kumar, 2009). This has added significance given that several studies point to spatially uneven growth in the post-reforms era, with industrially advanced states diverging at an increasing pace from the laggards (Ahluwalia, 2002; Sachs, Bajpai and Ramiah, 2002; Rodrik and Subramanian, 2004; Kochhar et al., 2006 and Dougherty et al., 2008). This opens to examination questions regarding the uneven impact of market reforms on inter-regional economic growth and technological upgrading.

However, in order to even begin examining the policy-impact nexus, one must first measure and track technological change over time. In this paper I address this issue by, firstly, constructing an innovative measure for technological sophistication at the industry level, and then secondly, estimating technological upgrading (or downgrading) over time for state-regions within India. This effort draws upon previous work done in the international trade literature on revealed product values of traded goods (See for example, Lall, Weiz and Zhang, 2006; Hausmann, Hwang and Rodrik, 2007; Xu, 2007; and Kemeny, 2010).

The specific innovation in this paper involves the mapping of product values of Indian exports to the production side at the 3-digit industry level within the country. The scores for technological sophistication at the 3-digit industry level are estimated from Indian exports data. These are then converted to technology indexes for India and for each state-region in the country based on industry composition, allowing us to trace regional technological trajectories over time.

The above techniques assume that technological sophistication, as embodied in products, is reflected in commanded product price in the exports market.

Based on the calculated technological values for each 3-digit industry in India, technological indexes are then constructed for each state-region in the country over time as a function of industry output of the respective state-region. I then utilize the constructed technology indexes to examine questions regarding the magnitude and direction of inter-regional technological change within the country. This constitutes the first stage of my larger research that examines the regional causes for technological change in post-reforms India.

This paper is organized as follows. Sections 2.2 to 2.4 comprise the first part of this paper, where Section 2.2 reviews issues regarding the measurement of technological sophistication, followed in Section 2.3 by the methodology employed in this study to construct the Indian technological index and a comparison of this index to similar indexes in Section 2.4. The second part of this paper applies the constructed technological index measures to the national and state-level manufacturing structure over time to examine the regional trends in upgrading. Section 2.5 frames the questions for further evaluation, followed by empirical results in Section 2.6. A set of findings and conclusions are presented in Section 2.7.

2.2. Measuring Technological Upgrading: Literature Review

The study of upgrading and its relationship to policy reforms is limited by our ability to directly observe and measure technology, and then tracking these measures over time. In this connection, the definition of knowledge and its spillovers constitute a major challenge in understanding technological change. Empirical studies on technological change employ a wide variety of strategies for this purpose. Within neoclassical macroeconomics, technology has been studied indirectly as factor accumulation, productivity, and total factor productivity. With the emergence of endogenous growth theory, accounting now attributes virtuous cycles of growth to knowledge spillovers. However, the measurement and modeling of knowledge is complicated by its properties, as it is both codified and tacit, and it is also a public good, a proprietary good, and a collective activity (See Archibugi and Coco, 2004 and 2005; and Antonelli, 2005). Ongoing changes in the knowledge variables are then logically assumed to indicate the technological change in industries, sectors, regions and so on, over time and across geographies.

Strategies to proxy knowledge and innovation involve either capturing indicators of R&D efforts on the input side or product and production variables on the output side. Variables on the input side include R&D expenditures, the accumulation and composition of human capital, and technological infrastructure. Of these, Gross Domestic Expenditures on Research and Development (GERD) is one of the most prevalent indicators, conventionalized by the OECD in 1963 through the Frascati Manual (latest edition, 2002). GERD included all R&D expenditures in business, university, government and non-profit organizations (OECD, 1963).

However, widespread use of the GERD, and its GERD/GNP variation, has been criticized because R&D expenditures are not sufficient to understand innovation, as the process of technological change is not linear and involves several systemic and sociological dimensions (Archibugi and Coco, 2004). Further, using the GERD/GNP ratio tells us nothing about the relationship between these two variables, either in terms of direction of causality or the magnitude of change (Godin, 2002). Additionally, it does not also reflect the supplementing role of international R&D spillovers through trade on domestic total factor productivity growth (See for example, Grossman and Helpman, 1991a; and Coe and Helpman, 1995). A variation on GERD is Business Enterprise Research and Development (BERD) that seeks to capture R&D expenditures in the private sector, including any government grants. There is ongoing debate on the relative importance of the social and private returns to R&D expenditures (See for example, Griffith, Redding and Van Reenen, 2003).

Several studies have examined the role of human capital in cross-country comparisons of economic growth using both, augmented Solow models and endogenous growth models (see for example, Mankiw, Romer and Weil, 1992; Barro and Lee, 1994; and Benhabib and Spiegel, 1994). The works of Barro and Lee (1994, 2001, and 2010) periodically assess how output growth relates to growth in 'human capital stock'. Benhabib and Spiegel (1994) make the distinction between rate of human capital accumulation and levels of human capital in explaining growth in total factor productivity. The level of human capital is linked to the development of absorptive capacities (Cohen and Levinthal, 1990) for new technologies and knowledge (Lall, 1998; and Keller, 1996).

Some studies examine the direct impact of technical and scientific workforce on innovation. These measures are typically included as constituent components of indexes of innovation, including the UN Development Program (UNDP) Technology Achievement Index (TAI), the UN Industrial Development Organisation (UNIDO) Industrial Performance Scoreboard, the RAND Corporation's Science and Technology Capacity Index, the World Economic Forum (WEF) Competitiveness Index and the Archibugi-Coco (ArCo) index (for an overview of the above, see Archibugi and Coco, 2005). Besides including input side components like science and tertiary enrolment, R&D expenditures and technical infrastructure, these indexes also include output or outcome components like manufacturing value-added, patents and exports. However, the complex properties of knowledge, in its tendency to diffuse and spillover, could potentially result in incorrect estimations of upgrading at the country-level. In this context, diffusion and spillovers across different scales from the local to the global presents a parallel challenge for economic geographers.

In this connection, strategies employed at the regional level to measure the spatial nature of innovation include data on 'paper trails' and movement of human capital. Patenting activity and tracking patent citations constitutes one form of paper trail (See for example, Jaffe et al., 1993; Jaffe and Trajtenberg, 1996; Feldman and Audretsch, 1999). Another stream of literature has examined the movement of human-capital as a means of knowledge spillover. Zucker and Darby (1996) and Zucker, Darby and Armstrong (1998) trace the impacts of R&D spillovers from universities on local start-ups by tracing the movement of highly cited 'star scientists'. However, the efficacy of these techniques to analyses at the sub-national scale in the developing world is severely limited by availability of relevant data. In such situations, industry specific case studies could bridge this gap, as emerging from the global value chain/production networks literature [3]. Here upgrading describes the set of activities undertaken by firms to maintain or increase income in the face of global competition. These may include increasing the skill content of activities through process innovation or entering new product markets.

In the value chain/production networks literature, upgrading can be of four types; these include process upgrading, product upgrading, functional upgrading and inter-sectoral upgrading (Humphrey and Schmitz, 2002) Upgrading in these studies is explained as an outcome of the interactions between local capabilities and the type of value chain governance (Humphrey and Schmitz, 2002; and Gereffi, Humphrey and Sturgeon, 2005). The basic point being made in the value-chain/networks literature is the centrality of product qualities in understanding

[3] See for example, in garment and textiles (Gereffi, 1999; and Tewari, 1999 and 2006), footwear manufacturing (Knorringa, 1999; and Schmitz, 1999), surgical instruments (Nadvi, 1999), automotive parts (Humphrey, 2003) and electronics (Ernst and Kim, 2002).

technological change in manufacturing. At the same time, although the case-study approach provides insights into specific industrial contexts, it is relatively time-consuming and resource-intensive. Therefore, it may be limiting in its contribution to system-wide comparisons. In such cases methodologies are required for larger-scale implementation. Periodically collected output data through national economic censuses and industry surveys provide one possible way to combine larger scale analyses with regional variations. The challenge here is to be able to develop measures that indicate change in technological sophistication from one time period to another.

One such approach assigns industry output to levels of sophistication from low to high, developed a priori using various ‘index’ criteria, such as those discussed previously. The most prominent among these sophistication indexes is the OECD Science and Technology scoreboard (various years), which classifies industries as low, medium-low, medium-high and high based on the intensity of BERD expenditures, as shown in Table 1 (See for example, Kumar and Joseph, 2008). However, applying the scoreboard across countries, especially developing countries, is problematic for several reasons. The scoreboard is an average measure of R&D intensities across OECD countries, and therefore, not appropriate for non-OECD economies due to intra-industry heterogeneity in product qualities. In other words, the notion of sophistication is relative and not absolute. Even if one were to observe between-categories movement, there exists no basis to determine the actual distance between these categories. Thus, the OECD scoreboard is tailored for broad cross-country comparisons of upgrading relative to an average index, and it is not conducive to within-country industry-level analysis of upgrading. Though organizing industrial output by low to high categories is a helpful way to compare the relative structures of economies, it is not helpful in estimating within-industry upgrading over time.

In order to get around issues of subjectivity and 'lumpiness' from categorical assignment, I build on recent work in international development literature that examines technological upgrading at the country-level based on relative export structures (See Lall, Weiss, and Zhang, 2006; Hausmann, Hwang, and Rodrik, 2006; and Kemeny, 2010). The basic idea behind these studies is that 'rich' countries are more prosperous because of what they export. These exports are relatively more sophisticated technologically, and therefore command higher market prices.

In Lall, Weiss, and Zhang (2006) and Hausmann, Hwang, and Rodrik (2007) per product export shares of individual or group of countries are first calculated, and then these export shares are weighted by each contributing country's or group's per capita GDP. This results in an estimated weighted per capita value for each individual product. As one can see, the greater the share of richer countries in the exports of a particular product, higher is its relative weighted per capita GDP value, which is indicative of its technological sophistication. Finally, these products could be indexed relative to the maximum and minimum calculated values to estimate a sophistication ranking from 0 to 100. How these indexes end up being used is different in the two studies. Lall, Weiss and Zhang (2006) construct their product sophistication index at the 3-digit and 4-digit SITC Revision 2 levels using UN Comtrade exports data for 1990 and 2000. They utilize the constructed sophistication values to classify products into 9 technology categories. The main objective of their study is to study the dissimilarities between the export structures of the world total, developed countries and developing countries by technology categories.

On the other hand, Hausmann, Hwang, and Rodrik (2007) utilize their calculated sophistication index to examine the theoretical basis for comparative advantage. They also make use of the UN Comtrade exports data but they develop sophistication values at the 6-digit level over 1992-2003 following the same weighted per capita GDP approach for individual countries.

The question they ask is why do countries with similar endowments develop different export specializations. They propose that these differences are due to the process of 'cost discovery' that entrepreneurs undertake to produce novel products (that are obviously undertaken because of higher economic rents). In doing so, this process makes the cost of production information an externality for followers in the same countries to exploit. Localization of such knowledge externalities results in countries being able to develop distinct specialization patterns from the reallocation of resources from lower productivity activities to novel higher productivity activities. They conclude that countries that export goods associated with higher productivity levels grow more rapidly, even after controlling for initial income per capita, human capital levels, and time-invariant country characteristics, and they attribute this phenomenon to the entrepreneurial cost-discovery process.

Although the above two studies provide a step forward in creating smooth numerical indexes based on revealed product prices, they average out product variety within one product code over all countries. Therefore, their estimates do not reflect variations in technological sophistication within the same product categories. Thus, for example, watches manufactured in Hong Kong fall in the same product code as those manufactured in Switzerland. By calculating an average value for this code, the Hong Kong watches are effectively over-estimated for sophistication, while the Swiss watches are underestimated. This is significant as product variety is a key determinant in trade patterns in contemporary globalization, given the importance of intra-industry trade (Krugman, 1991). Therefore, a true depiction of cross-country comparisons of technological levels of traded products must capture variations in product variety.

Kemeny (2010) addresses the above issue using methodologies similar to Lall et al. and Hausmann et al. for calculating the weighted per capita average product scores but additionally incorporates a dimension for product variety in his calculation of technology sophistication scores. This methodology is similar to Xu (2007), who constructed a technology sophistication index for Chinese exports to examine the higher than predicted sophistication values of Chinese exports compared to its income level. This inconsistency is explained by correcting for the over-estimation of product quality values of Chinese exports inherent in using world average product values and the under-estimation of per capita incomes of exporting regions within China compared to the national average.

Kemeny constructs his index for a longer time span 1972 to 2001 based on data on US imports at the 10-digit HS code (other system codes are provided here as well, including SITC Revision 2), and utilizes this index to study patterns of technological upgrading as an interaction between FDI and social capabilities. His calculated relative 'quality ladder' position of each country for a particular good is estimated by incorporating variations in price per unit of a product for each country. The final score for a country-product pair is a function of its average score, its relative quality ladder position and its share of the country-product share in U.S. imports. For analysis in this paper, I have obtained from Kemeny (2010) product quality technology scores for Indian exports, which I map to the production side at the Indian 3-digit National Industrial Classification (NIC) system, as explained next.

2.3. Constructing the Indian Industry Technological Indexes

I analyze patterns of inter-regional technological upgrading based on changing sophistication levels of industries within India at the state-level over the 1990 to 2005 time period. For this purpose, I estimate technology scores for industries in a panel of manufacturing data at the state level over this time period. The industry technology scores are estimated by mapping the technology scores of Indian exports at the SITC Revision 2 5-digit level obtained from Kemeny (2010) to NIC 3-digit industries in the state-region manufacturing panel data. Additionally, a weighted technology score for each state-region is calculated based on weighting the calculated individual industry scores by the respective industry technology scores.

2.3.1 Datasets Used

Discussed below are details of the state-region manufacturing panel data and the product-based technology scores of Kemeny (2010). I assembled the manufacturing state-panel data for India from tabulations made available from the Annual Survey of Industries (ASI) program of the Ministry of Statistics and Programme Implementation (MOSPI).

a. The ASI manufacturing panel data was constructed for the years 1990-91, 1995-96, 2000-01 and 2005-06.

b. Over the study period, the national industrial codes changed twice; so, while the data for 1990-91 and 1995-96 were organized on the NIC 1987 basis, data for the years 2000-01 were organized on the NIC 1998 basis. Data from 2005-06 is based on NIC 04, which differs from the NIC 1998 only at the 4-digit level and upward. The detailed 3-digit codes for NIC 87 and NIC 98/04 classification are shown in Appendix Table A-1 and A-2.

c. Further, over the study period, state geographical definitions in India changed in two major waves. In order to maintain the longitudinal nature of the dataset, geographical units over time have been maintained as in the first year, 1990-91.

The product technology scores used to construct the Indian industry technological indexes prepared for this paper are from Kemeny (2010). These product scores were assembled from data on US Imports. Important aspects of these data are as follows:

a. For this study, I utilize product scores calculated by Kemeny for the years 1990, 1995 and 2000, which were an average of the current year, 1-year back and 3-years forward for the respective panel years in the manufacturing dataset.

b. Kemeny constructed 'revealed' product scores from US imports data collected by the U.S.Census, and compiled by Feenstra, Romalis and Schott (2002) for the National Bureau of Economic Research (NBER).

c. The US imports database contains complete records of merchandise imports into the U.S. from 1972 to 2001. This dataset includes pair-wise information on US and its export partners (i.e. sources of US imports) by product and it is coded on different classification basis, including the Standard International Trade Classification Revision-2 (SITC2) at the 5-digit level.

d. Kemeny's sophistication value is a function of the average product value for all exporters to the US, the country-specific quality ladder value for each product, and the share of that product in total imports to the U.S., adjusted to constant 2000 dollars.

2.3.2 Crosswalk between Product and Industry Codes

In order to estimate the technology sophistication values for manufacturing industries I have created a highly detailed crosswalk from all the 4-digit SITC Rev.2 codes to the 3-digit NIC-87 and NIC-98/04 Indian manufacturing codes, a fairly laborious and time consuming process. I utilize the constructed crosswalk to translate the Kemeny export product values at the 5-digit SITC Rev.2 codes to the Indian NIC production structure based on the following steps:

a. First reducing all the 5-digit SITC Rev.2 codes in the Kemeny 1990, 1995 and 2000 datasets to their respective 4-digit SITC Rev.2 codes. This results in a total of 1,060 5-digit codes being mapped to 596 4-digit codes.

b. Creating a crosswalk by coding the 596 4-digit SITC Rev.2 codes with the respective NIC 87 and NIC 98/04 3-digit codes for the respective years in the US imports dataset.

c. Calculating the weighted technological scores over the two NIC systems by weighting the technological scores of the exported products by the value of exports.

d. The NIC 98 classification of the Indian industrial production structure is based on the International Standard Industrial Classification (ISIC) Rev.2, which is the basis for the SITC Rev.2 international trade codes. Therefore, the mapping of products at the SITC Rev. 2 4-digit level is unique to a specific 3-digit code in NIC 98.

e. However, the above is not true 100 percent of the time for the mapping of the SITC Rev.2 to the NIC 87 codes, and several cases were encountered, as below in Table 2.1.

Table 2.1: Mapping of SITC Codes to NIC 87 Codes

Case	Mapping Type	Number of Cases
1.	Many SITC Codes to One NIC 87 Code	134
2.	Many SITC Codes to Many NIC 87 Codes	21

Source: Author

f. Case 2 essentially involves the creation of groups of 3-digit NIC codes, which could be correlated to one or several SITC 4-digit product codes, totaling 21 SITC codes. The member 3-digit codes of each group then receive the same score as the estimated parent group score.

g. The above steps result in the calculation of India-specific industry technological scores for 3-digit industries (Indval) based on the product quality scores of Indian exports at 4-digit level SITC Rev.2 from the Kemeny dataset, specified as:

$$Indval_i = {}_{p=1}\Sigma^n(\text{Product Income Value}_{pi} * \text{Export Value}_{pi}) / {}_{p=1}\Sigma^n \text{Export Value}_{pi} \quad \ldots\ldots\ldots 1.1$$

Where; p = exported product, i=industry group for 1 to n exported products; Product Income Value= technology scores for exported products; and Export Value = export value of product p in year 2000 dollars.

h. The export quality scores for 1990, 1995, and 2000 correspond to the 1990-91, 1995-96 and 2000-01 manufacturing panel years. I hold the year 2000 export product values for the 2005-06 manufacturing panel year.

i. A ranked sophistication index for the NIC industry values is constructed from the absolute values obtained from the previous steps by normalizing all values over the maximum value in the two series and then scaling up by 1000 units. This translates to a sophistication scale on the NIC 87 and NIC 98/04 3-digit basis, where 1000 is the maximum value and 0 is the smallest value.

2.3.3 Coding Manufacturing Panel Data with Tech Values

The final step in constructing a technological index for all the states in India over time involves translating the technology values (overall average and India-specific product quality values) at the NIC 87 and NIC 98/04 basis to the respective years in the panel dataset, i.e. coding the NIC 87 values to the 3-digit codes in the 1990-91 and 1995-96 panel years, and coding NIC 98/04 values to the 2000-01 and 2005-06 panel years. The technological sophistication index for each state is then constructed by weighting the tech values (average and product quality) for each NIC code by the state NIC 3-digit output to result in weighted technological index for each state over time.

The above steps allow me to construct industry-specific technology scores (Indval), which I aggregate to construct indexes at the national India-level (Natindex) and at the state-region level (Stateindex), as follows:

$Natindex=[_{i=1}\Sigma^{n}(Indval_i*Output_i)/_{i=1}\Sigma^{n}Output_i]/100$ ……………………1.2

Where; i = NIC 3-digit industry 1 to n, Indval= weighted technology value of industry i, and $Output_i$= Value-added of industry i.

$Stateindex_r=[_{i=1}\Sigma^{n}(Indval_{ir}*Output_{ir})/_{i=1}\Sigma^{n}Output_{ir}]/100$ ………………..1.3

Where; i = NIC 3-digit industry 1 to n, r= state region; and Indval= weighted technology value of industry i; and and $Output_i$= Value-added of industry i.

A third index (Catindex) is constructed from Indval to track changes in technological sophistication by industry groupings based on the 3-digit industry codes that represent distinct applied technologies and products. Creating broader groupings of industries allows us to isolate components of regional technological change over time on a more practical basis. As shown in Table 2.2, I develop 16 major categories of production (Techcat) similar to the analytical strategy used by Lall, Weiss and Zhang (2006). The developed Catindex is the primary outcome variable in the subsequent stages of research, in which I employ in the panel data organized at the techcat-state level over time.

The above grouping allows me to construct an index by major production categories (Catindex) as follows:

$Catindexr=[i =1\Sigma\ n(Indval_{ic}*Output_{ic})/i=1\ \Sigma nOutput_{ic}]/100$ …………1.3

Where; i = NIC 3-digit industry 1 to n, c= production category; and Indval= weighted technology value of industry i; and and Outputi= Value-added of industry i.

Table 2.2: Major Manufacturing Production Categories

Category	Description
C1	Animal and Plant Products
C2	Processed Food and Beverages
C3	Minerals, Fuels, and Lubricants
C4	Chemicals
C5	Pharmaceuticals and Perfumes
C6	Organic and Semi-Organic Intermediates
C7	Inorganic and Metallic Intermediates
C8	Processing and Power Machinery
C9	Electronic Equipment
C10	Electrical Equipment
C11	Automotive Equipment
C12	Home Improvement
C13	Clothing and Accessories
C14	Technical and Photographic Equipment
C15	Printed and Recorded Materials
C16	Miscellaneous

Source: Author

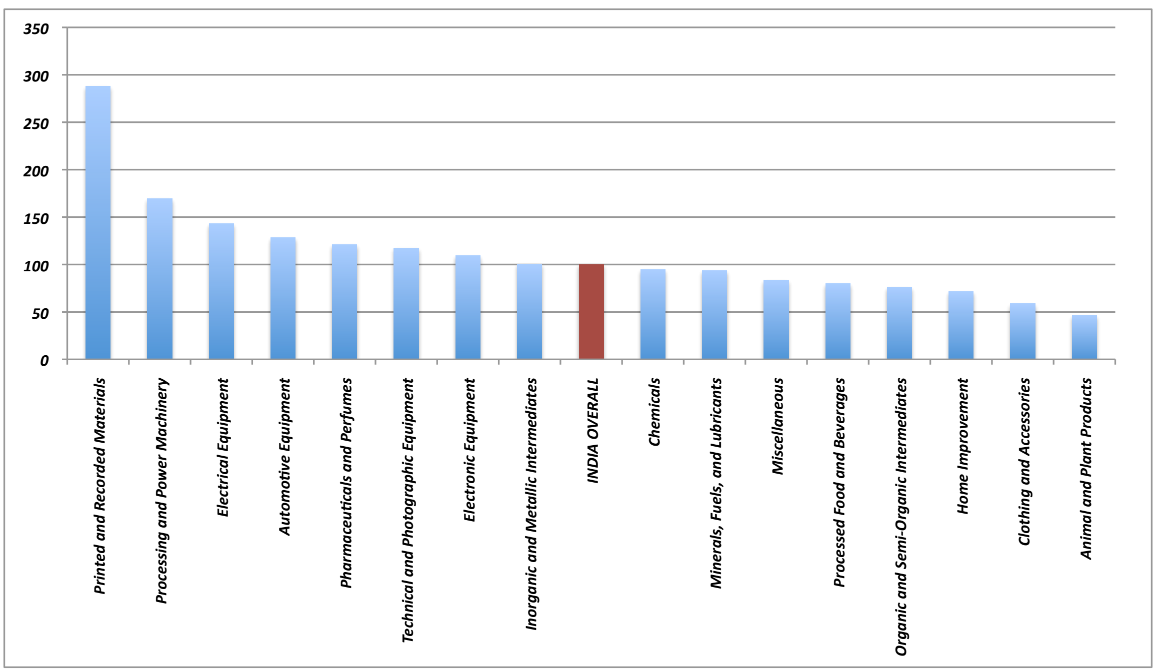
2.4. Properties of the Technological Category Index

In comparing the constructed technological category index (Catindex) to similar index scores from Lall, Weiss and Zhang (LWZ) (2006) and the OECD (2003) one finds similarities in sophistication trends. A general note of caution while making these comparisons is that though the broad groupings of the three indexes are similar or tractable, the sophistication results may differ due to the combination of industries selected for inclusion within one grouping, which, as LWZ point out, is based on judgment.

The calculated 3-digit industry technology scores (Indval) are aggregated into 16 larger production categories that represent similar technologies and products (Catindex). As shown in

Figure 2.1, based on Indian exports to the US, Printed and Recorded Materials is the most sophisticated production category followed by Processing and Power Machinery. The national weighted average technological index (Natindex) for the year 2005 was calculated at 100. Production Categories higher than the national overall score included Electrical Equipment (143), Automotive Equipment and Parts (128), Pharmaceuticals and Perfumes (121), Technical/Scientific and Photographic Equipment (118), Electronics (109), and Inorganic and Metallic Intermediates (101). Production categories that fell below the national average cut-off score of 100 in 2005 include Chemicals (remainder), Minerals, Fuels and Lubricants, Processed Food and Beverages, Organic Intermediates, Home Improvement, Clothing and Accessories, and Animal and Plant products.

Figure 2.1: National Catindex Scores, 2005



Source: Author.

The Catindex categories parallel the categories of Lall, Weiss and Zhang (LWZ), as shown in Table 2.3. The LWZ scores are calculated on the revealed sophistication strategy similar to that used in my estimations of the Catindex. Scores for the world average and developing countries in LWZ follow similar ranking order of technological sophistication. However, the scores for the latter set of countries start at relatively lower levels such that the second ranked group for the world average has comparable scores to those of the most sophisticated group for developing countries, and so on. Additionally, some categories further down the ladder switch ranks between the two geographies. For example, electronic products (HT1) in developing countries are ranked higher than process industry products (MT2) for the world average. In this respect, the Catindex scores are similar to the LWZ world averages for the higher sophistication categories, with the exception of the rank order for electronic products (HT1) and Process Industry Products (MT2), which is similar to other developing countries.

Table 2.3: Lall, Weiss and Zhang Technology Scores, 2006

	Description	World	Developing
HT2	Other High Technology: e.g. Pharmaceuticals, Aerospace, Optical/Measuring Instruments, Cameras.	84.27	78.80
MT1	Automotive Products: Passenger Vehicles and Parts, Commercial Vehicles, Motorcycles and Parts.	78.07	76.25
MT3	Engineering Products: e.g. Engines, Motors, Pumps, Ships and Watches	75.65	67.94
MT2	Process Industry Products: Synthetic Fibres, Chemicals and Paints, Fertilizers, Plastics, Pipes and Tubes	69.96	62.86
HT1	Electronics and Electrical: Computing, Telecommunications, Televisions, Turbines and Power Generation.	67.49	65.68
RB1	Agro-based Manufacturers: Prepared Meats/Fruits, Beverages, Wood Products, Vegetable Oils	67.00	54.93
LT2	Other Low Technology Products: Pottery, Metal Parts, Furniture, Toys, Plastic Products	65.83	62.06
RB2	Mineral-based Manufacturers: Ore Concetrates, Petroleum/Rubber Products, Cement, Cut Gems, Glass.	64.35	58.00
LT1	Fashion-Cluster: Textile, Clothing, Headgear, Footwear, Leather Manufacturing, Travel Goods	41.07	38.74

Source: Lall, Weiss and Zhang, 2006 and Lall, 2000.

Another comparison is presented here is with scores from the OECD Scientific and Technology Scoreboard (2003), as shown in Table 2.4. These scores are calculated based on relative R&D intensities for manufacturing within OECD countries. The OECD High Technology and Medium Technology industries parallel the Catindex groups that have scores higher than the India-wide average. Ostensibly, the exports-based revealed product sophistication scores of the Catindex and the LWZ appear to be correlated to the OECD R&D intensity scores. In other words, this suggests that export-sophistication is associated to research intensity.

Table 2.4: OECD Science and Technology Scoreboard Scores

Industries	R&D Intensities
High Technology Industries	
Aircraft and Spacecraft	10.3
Pharmaceuticals	10.5
Office, Accounting and Computing	7.2
Radio, TV and Communications	7.4
Medical, Precision and Optical Instruments	9.7
Medium-High Technology	
Electrical Machinery and Apparatus, n.e.c.	3.6
Motor Vehicles, Trailers and Semi-trailers	3.5
Chemicals excluding Pharmaceuticals	2.9
Railroad Equipment and Transport	3.1
Machinery and Equipment, n.e.c	2.2
Medium-low Technology	
Building and reparing of Ships and Boats	1.0
Rubber and Plastic Products	1.0
Coke, Refined Petroleum Products	0.4
Other non-metallic Mineral Products	0.8
Basic Metals and Fabricated Metal Product	0.6
Low-technology Industries	
Manufacturing, n.e.c.; Recycling	0.5
Wood, Pulp, Paper Products, Printing and Publishing	0.4
Food Products, Beverages and Tobacco	0.3
Textiles, Textile Products. Leather and Footwear	0.3

Source: OECD Science and Technology Scoreboard, 2003.

2.5. Questions: Framing Heterogeneity in Technological Upgrading

Based on the technological indexes discussed in the previous sections, I outline a set of questions that examine the geographical and industry-level upgrading trends in the Indian manufacturing sector. As explained earlier, the basic 3-digit NIC industry technology scores (Indval) are aggregated at various levels to result in the India technological index (Natindex), the state-region technological index (Stateindex) and the major technological categories (techcat) index (Catindex) for the years 1990, 1995, 2000 and 2005. I examine to two basic questions regarding the structure and change in technological upgrading in the post reforms era:

a. Does India's manufacturing sector experience technological upgrading in the post-reforms era?

b. What are the regional and industry-level dimensions of technological upgrading in the post reforms era?

I present a review of issues pertaining to the above questions, followed by a set of hypotheses to examine further in the empirical analysis.

2.5.1. Market Reforms and National Technological Upgrading

The study of technological change itself has been recast in terms of knowledge externalities, which are endogenized to the growth modeling process (Romer, 1986; and Lucas, 1988). The two leading approaches to endogenous technological change include the 'expanding variety' approach and 'quality ladders' approach (See Helpman, 1991). In the expanding variety approach, growth occurs through innovation in the aggregate due to horizontal product differentiation. In the neo-Schumpeterian quality-ladders approach, technological innovation is a deliberate act undertaken to improve existing product varieties (Grossman and Helpman, 1991b;

and Aghion and Howitt, 1992). Additionally, in later quality-ladder versions, imitation is equally important as innovation, and the two mechanisms are seen to operate in a 'step-by-step process' in enabling technological catch-up (Aghion, Harris and Vickers, 1997 and 2001). An endogenous change imitation-adaptation-innovation framework is useful in conceptualizing technological catch-up, as most developing countries, including India, have been laggards in the modern era. Policy reforms seek to spur this process by addressing issues related to competition and rents (See Griffith and Harrison, 2004).

Evidence on the relationship between competition and innovation is mixed. Aghion et al. (2005) model innovation (patents filing) to have an'inverted-U' relationship with competition, initially increasing with competition but then decreasing beyond a certain threshold. The inverted-U relationship is explained using the step-by-step innovation model (Aghion, Harris and Vickers, 1997), where laggards first catch-up with the technological leader, before being able to redefine the frontier technology. Assuming a step-by-step process, increased competition, especially within neck and neck industries (closely contested industries), has a net overall impact of inducing innovation to escape competition. However, increases in competition (a liberalizing economy) could have a deterring effect on innovation, as firms' research investments are influenced by the difference between pre- and post-innovation rents and not solely on the levels of post-innovation rents. Stated differently, the greater the competition the greater the likelihood of technological obsolescence, which in turn deters current investment decisions for research and development.

Other follow-up studies show that the predictions of the above model are qualified and depend upon the definition of competition (See for an overview, Tingvall and Poldhal, 2006; and Vives, 2008), and vary across countries (For the European Union, see, Griffith and Harrison, 2004; and Griffith, Harrison and Simpson, 2010). In Griffith and Harrison (2004) reforms are tested to impact innovation through the level of rents in the economy. They test the impact of product market reforms on competition (level of rents) and then the effect of competition on allocative, productive and dynamic efficiencies. They find that product market reforms that ease entry barriers, remove price controls, and reduce public involvement in production affect the average level of economic rents in the economy in many ways. Overall, levels of rent are found to be negatively associated with growth in employment and investment. However, they find that within countries, decreases in rents seem to be correlated with decreases in R&D investments and productivity. On the other hand, on average, countries with lower rents tend to have higher R&D investments and productivity growth. From these seemingly contradictory outcomes, they question if it is possible to draw valid conclusions on a cross-country basis due to the different estimators (within and between) used. Instead, they suggest examining industries within the same country that have different reform treatments over time.

In this regard, an extension of the step-by-step growth approach isolates the differential impacts of reforms on industrial innovation within the same country, actually using India as a case study. These models examine interaction of firm entry (due to lower barriers) with technological heterogeneity at the industry-level in explaining innovation behavior of incumbent firms aggregated at industry level (See Acemoglu, Aghion and Zilliboti, 2006; and Aghion et al., 2008). Aghion et al. (2008) find that response of incumbent firms to foreign firm entry varies by their distance to the technological frontier. Technologically advanced foreign firm entry might encourage innovation in incumbent firms close to the technological frontier. On the other hand, where incumbents are farther away from the frontier, aggregate innovation behavior is found to be associated negatively with entry. Thus, technological upgrading over time can be interpreted as an aggregate outcome of the interaction between starting (pre-reform) technological states and the sophistication levels of entering firms from reduction in barriers**.**

From the above, the following hypotheses are in order, which are further tested in the empirical analysis for this paper in Section 2.6.

a. Given the evidence on uneven impacts of reforms across countries, we are not certain about the expected direction of technological upgrading outcomes in the Indian case in the aggregate. The above research points to several factors that likely determine the aggregate upgrading outcome, including the pre-reform levels of technology (distance to frontier) and the industry composition of the manufacturing base. At the same time, it is likely that in a partially protected economy, where protected and delicensed industries coexist, upgrading levels and trends are likely to differ across these groups.

H1: *The direction of technological upgrading outcomes in the aggregate in post-reforms India are not known.*

H2: *The level and direction of technological change might be different between the protected and deregulated industries at any given time.*

b. Further, technological outcomes within the country are likely to differ by technological categories. Applying the distance to frontier model, upgrading outcomes are likely to be heterogeneous by the sophistication levels of industry in their respective technologies. As already discussed in Section 2.4, the order of technological categories by their scores for India closely matches other conventional scoreboards. However, in the absence of an actual distance measure from the frontier, we don't know enough about the relative sophistication of a given technological category. In this regard, observed changes by technological categories in response to reforms can shed light on the evolving technological capabilities of manufacturing in the country. While technological laggards are expected to fall back further, relatively more advanced industries within a given technological category might benefit from competition.

H3: *Upgrading outcomes are likely to be heterogeneous by technological categories.*

2.5.2. Regional Heterogeneity in Technological Upgrading

The above review describes the impact of competition at the national level but a key insight into the efficacy of reforms is that national policy changes are likely to induce unequal outcomes within the country due to sub-national heterogeneity in institutional conditions. In the Indian context, recent studies interact national reforms with state-level institutions like labor laws, democracy, law and order, and procedural efficiency to examine state-level economic impacts.

Amongst studies that specifically look at the impacts of delicensing, Aghion, Burgess, Redding and Zilibotti (ABRZ) (2008) interacted state-level heterogeneity in labor laws with delicensing and examined impacts on manufacturing performance by 3-digit industries at the state level. This study builds on a pioneering approach for modeling labor institutions in India by Besley and Burgess (2004), which examined changes in state labor laws being amended in the direction of being either being ‘pro-labor’ or ‘pro-employer’ over the 1958 to 1992 time period. The Besley-Burgess study indicates that states in India that had a more ‘pro-labor’ legislative environment over the study period attracted lesser investment and had lower output and productivity growth in manufacturing. ABRZ (2008) augment the above conclusions by observing growing intra-industry divergence across states over the 1980-1997 time period; the same 3-digit manufacturing industries grew at different rates after delicensing, with faster growth in states that had pro-employer labor markets.

In a companion study, ABRZ (2005) expand a generalized Schumpeterian model of firm behavior in the context of response to threat of entry in a deregulating economy controlling for institutional factors. This model predicts that firm behavior even within the same industry is heterogeneous with firms located closer to the technological frontier incentivized to invest more in technology upgradation and innovation, which further is influenced by the prevalent institutional context. Therefore, in the aggregate, the authors expect to observe within-industry divergence across states in India, which is supported by the 1980-1997 3-digit state panel data.

Similarly, Bhaumik et al. (2006) examine the association of entry rates with growth in total factor productivity and growth in manufacturing over the 1980 to 1997 time period at the 3-digit state-industry level. Their findings suggest that in the pre-1991 phase industry-level factors played a determining role in influencing entry, while in the post-1991 federal political economy, state-level factors became more important in determining rates of entry. Additionally, in the post-reforms era total factor productivity and growth in manufacturing was positively associated with entry rates and this was heterogeneous across states determined by the state-level institutional factors.

The sectoral characteristics of inter-state divergence in manufacturing growth are further explored in Gupta, Hasan and Kumar (2009), who employ a 3-digit state panel for the 1980 to 2004 time period. The study finds that labor-intensive manufacturing industries and infrastructure dependent industries fared worse relative to capital-intensive industries overall in the post-reforms period. Additionally, labor-intensive industries in states with less flexible labor market regulations fared worse than states that had flexible labor markets. States with better infrastructure and product market regulations benefited overall from delicensing. Other studies suggest similarly that regulatory and administrative bottlenecks at the state-level have eroded the efficacy of the national reforms (Veeramani and Goldar, 2005 and Dougherty et al., 2008).

Besides the formal institutional and business environment factors used in the above studies, other factors including path dependence have also been examined. In an OECD commissioned study, Dougherty et al. (2008) point to industry concentration due to legacy of licensing as a determinant of unequal growth in the manufacturing sector in the post-reforms era. Iarossi (2009) examines the World Bank 2006 Investment Climate Survey on 46 'investment climate' variables across states in India with variables grouped into three categories – 'institutions', 'infrastructure' and 'inputs'. The study finds that higher quality of investment climate is highly associated with higher rates of growth and investment. Infrastructure is particularly hampering to the growth prospects of states that have initial low levels of investment and growth, while institutions appear to affect low and high growth investment states uniformly.

From the above, the following propositions and hypotheses are in order:

a. There are two aspects to spatial heterogeneity in technological upgrading outcomes, as observed in inter-regional convergence or divergence dynamics. First, this is the spatial manifestation of industry-level differences in upgrading outcomes, as already discussed in Section 2.5.1, resulting from the variations in the mix of industries comprising the regional manufacturing base. Secondly, at a deeper level, the preceding review points to the role of the differences in regional contexts, which might have differential impacts by industry, and the varying overall levels of which might impact the regional economy on the whole. Therefore, regional contexts have both selection effects (in terms of the industries they support) and efficiency effects impacting the existing manufacturing base. Therefore, we are likely to observe inter-regional divergences in technological upgrading because of variations in industrial histories and accompanying regional contexts across states in India. Additionally, these trends might differ between the regulated and delicensed segments of the economy over time.

H4: *There may be inter-regional divergence in upgrading scores over time.*

b. In this connection, an important aspect of post-reforms development is its relationship with industrial history. The fundamental issue here is whether technological capabilities within the same industry get transferred from the protected to the deregulated time periods. Secondly, in a more spatial sense, do technological capabilities in location formed in the pre-reforms era have regional spillover effects in the post-reforms era? If there were any such inter-relations, then we would expect to see some parallels in the scores for the regulated and delicensed industries over time.

H5: *Upgrading outcomes are likely to be heterogeneous by technological categories.*

c. Lastly, I examine the compositional trends of technology change over time at the state-region level. Logically, technological upgrading can occur because of 3 ongoing dynamics. Firstly, it could be due to the redistribution of the manufacturing base into relatively more advanced industries. Secondly, it could be from increasing levels of technological sophistication within existing industries. Additionally, the above changes can happen simultaneously in various combinations.

H6: *Technological upgrading over time at the state level could occur because of changes internal to industries or changing compositions of the overall manufacturing base.*

2.6. Empirics and Discussion

I test the above propositions by applying the three constructed technological indexes at the national level (Natindex), state level (Stateindex) and technological category level (Catindex).

2.6.1. National Upgrading Trends

a. Does India's manufacturing sector display technological upgrading over the 1990 to 2005 time period? Is there a difference between licensed and delicensed industries in the rate of change in technological sophistication scores at the national level?

Overall technological scores have fallen consistently in the post-reforms period. As shown in Table 2.5, the overall Natindex value is shown to first increase slightly over the 1990 to 1995 time period followed by a period of decline over the 1995 to 2000 time period and then staying flat over the next 5 years. In the year 2005, licensed manufacturing is shown to be nearly 31 index points higher compared to delicensed industries. While licensed industries increases in technological sophistication over time, delicensed industries show overall decline. When compared to the starting points, the Natindex for licensed industries grew by nearly 15 percent over the study period, while delicensed industries show 2.5 percent decline over time. However, these trends were dramatic over the 1995 to 2005 period, with a 13 percent increase for protected industries and a 16 percent decline for delicensed industries.

Table 2.5: National Technology Scores (Natindex)

	1990	1995	2000	2005	Change in Tech Scores	Percent Change
Licensed	110	112	115	126	16	14.6%
Delicensed	125	109	102	100	-25	-20.3%
Overall	108	113	99	100	-8	-7.3%

Source: Author

Table 2.6: Share of Output by Licensed and Delicensed Industries
(In Millions constant 2005 Rupees)

	1990	1995	2000	2005	AAGR [1]
Licensed	5,891,477	3,386,073	1,960,764	3,158,661	-4.1%
Delicensed	1,159,340	6,946,341	9,032,019	15,388,747	18.8%
Overall	7,050,817	10,332,414	10,992,783	18,547,407	6.7%
Licensed	83.6%	32.8%	17.8%	17.0%	
Delicensed	16.4%	67.2%	82.2%	83.0%	
Overall	100.0%	100.0%	100.0%	100.0%	

1. Annual average growth rate
Source: Author

The above result appears to be counter-intuitive at the outset, as one would have expected delicensed industries to perform better compared to licensed industries. However, this is most likely the result of self-selection as the government has over time chosen to reserve strategic industries including aerospace and defense within the public-sector domain. These industries are also some of the most sophisticated industries. As shown in Table 2-6, the share of licensed manufacturing has declined over 1990-2005.

b. What is the technological ordering of different product categories? How do these categories upgrade or downgrade over time?

Technological upgrading scores differ by the sophistication ordering of industry categories, with lower groups tending to show negative change. As shown in Table 2.7 and Figure 2.2, examining the change in technology scores over time, one finds that most of the production categories that are above the national average score in 1990 also display positive changes over the long term 1990 to 2005. However, a prominent exception is Processing and Power Machinery that fell by 53 points over this period from 222 in 1990 to 170 in 2005, as shown in Figure 2.4.

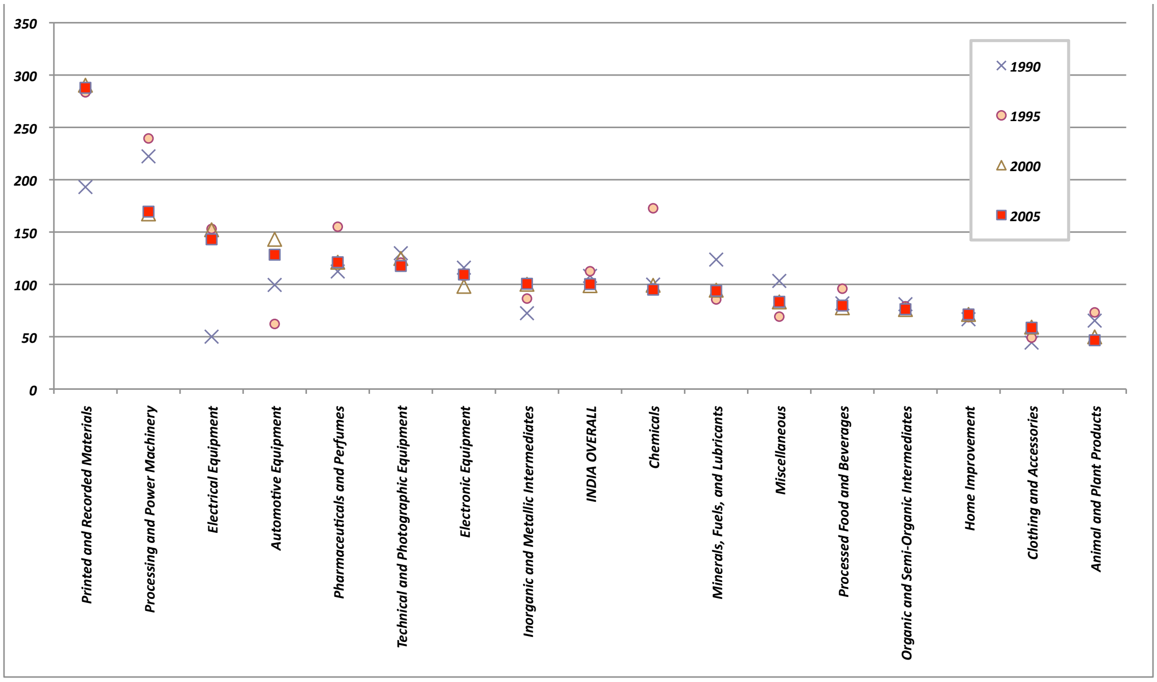
Table 2.7: Tech Scores by Major Production Categories (Catindex)

	PRODUCTION GROUP	1990	1995	2000	2005	1990-2005	1990-1995	1995-2000	2000-05
C1	Animal and Plant Products	65	73	50	47	(19)	8	(23)	(3)
C2	Processed Food and Beverages	82	96	78	80	(2)	14	(18)	2
C3	Minerals, Fuels, and Lubricants	124	86	94	94	(30)	(38)	9	(1)
C4	Chemicals	100	173	99	95	(5)	73	(74)	(4)
C5	Pharmaceuticals and Perfumes	112	155	121	121	9	43	(34)	0
C6	Organic and Semi-Organic Intermediates	81	79	76	76	(5)	(2)	(3)	0
C7	Inorganic and Metallic Intermediates	72	86	100	101	28	14	14	1
C8	Processing and Power Machinery	222	239	167	170	(53)	17	(72)	2
C9	Electronic Equipment	116	108	98	109	(7)	(8)	(10)	11
C10	Electrical Equipment	50	153	152	143	93	103	(1)	(9)
C11	Automotive Equipment	99	62	143	128	29	(37)	81	(15)
C12	Home Improvement	67	69	71	71	5	2	3	0
C13	Clothing and Accessories	44	49	59	59	14	5	10	(1)
C14	Technical and Photographic Equipment	130	121	125	118	(12)	(9)	4	(7)
C15	Printed and Recorded Materials	193	284	290	288	95	90	7	(2)
C16	Miscellaneous	103	69	83	83	(20)	(34)	14	0
	INDIA OVERALL	**108**	**113**	**99**	**100**	**(8)**	**4**	**(14)**	**1**

Source: Author.

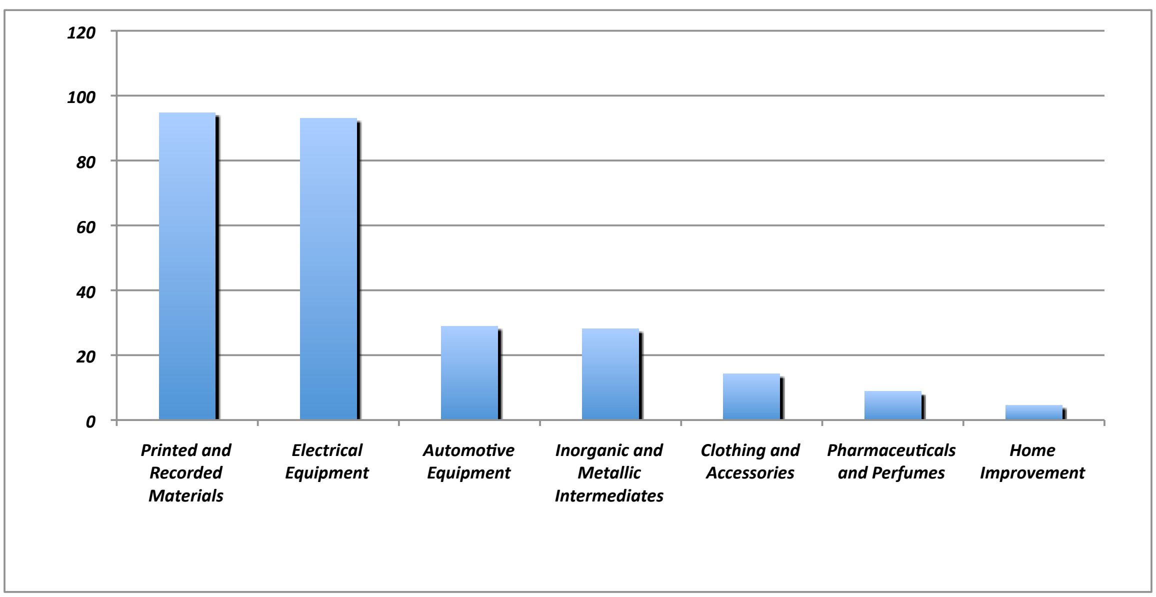
Figure 2.2: Catindex by Production Group

(Ordered by Descending Order of Technological Sophistication in 2005)



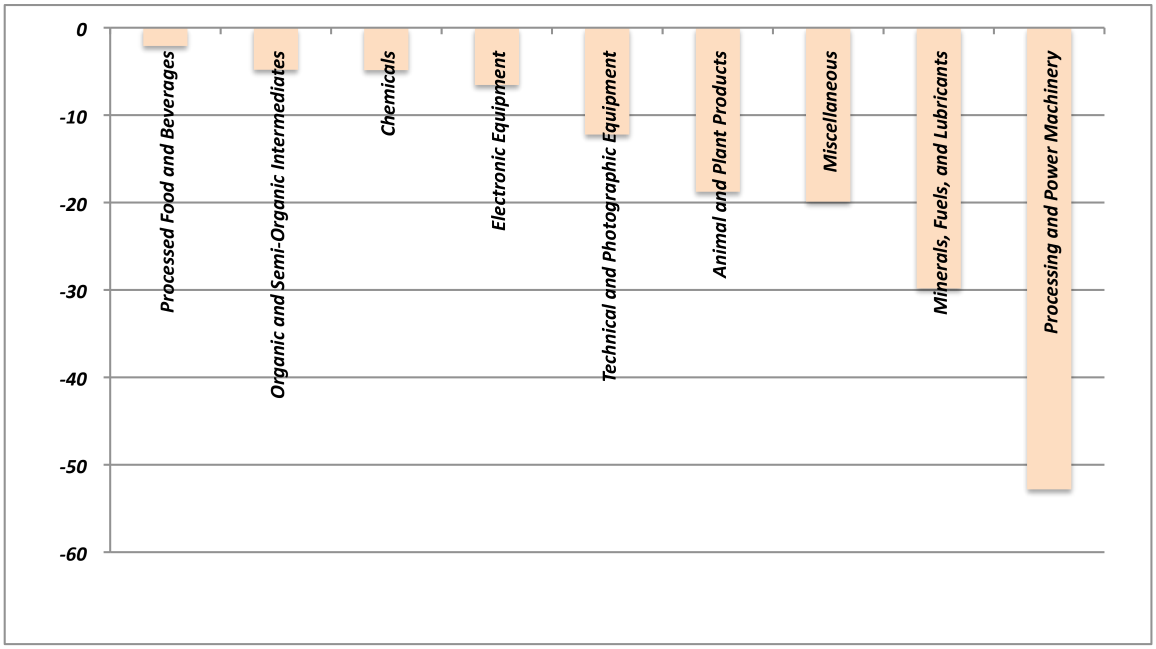
Source: Author.

Figure 2.3: Production Groups with Increases in Catindex, 1990 to 2005



Source: Author.

Figure 2.4: Production Groups with Decreases in Catindex,1990 to 2005



Source: Author.

Table 2.8: Score Change by Catindex Percentile Categories in 1990

Industries within	1990-2005	1990-95	1995-2000	2000-2005
75th Percentile and Over Score in 1990	-22.9%	-7.0%	-7.8%	-10.0%
Upto 75th Percentile Score in 1990	-6.1%	50.9%	-36.5%	-1.9%
Upto 50th Percentile Score in 1990	16.9%	-0.3%	13.5%	3.4%
Upto 25th Percentile Score in 1990	40.0%	39.3%	-4.8%	5.5%
INDIA OVERALL	-7.3%	4.1%	-12.2%	1.5%

Source: Author

Further, an evaluation of Catindex over 1990 to 2005 by the quartile profile in 1990 shows that industries located in the lowest two quartiles show overall positive change as a group over the 1990 to 2005 time period, as shown in Table 2.8. The top-two quartile groups show declines from their initial sophistication scores over the 1990 to 2005 time period.

This is explained by several of the production groups showing movements between quartile bands over the 1990 to 2005 time period. As shown previously in Figure 2.3, groups showing positive Catindex change over the 1990 to 2005 time period include Printed and Recorded Materials, Electrical Equipment, Automotive Equipments and Parts, Inorganic/Metallic Intermediates, Clothing and Accessories, Pharmaceuticals and Perfumes, and Home Improvement. Of these, Printed and Recorded Materials remained in the highest quartile over the 1990 to 2005 time period, Electrical Equipment showed a significant jump from the lowest quartile to the highest quartile, Automotive Equipments and Parts and Inorganic/Metallic Intermediates moved from the second to the third quartile, Pharmaceuticals and Perfumes remained in the third quartile, and Clothing and Accessories and Home Improvement production group remained in the lowest quartile.

2.6.2. Overall Regional Upgrading Trends

a. Are technological sophistication-levels of Indian states converging or diverging over time?

Overall technological scores at the state-level are observed to display declines with convergence over the study period. Technology scores at the state-region level (Stateindex) over the study period are calculated as an average of industry scores (Indval) weighted by the respective industry output at the state-region level. The state-regions shown in this table comprised about 99 percent of the total output in India over 1990 to 2005, as shown in Appendix Table B-1 and Appendix Figure B-2. A map of states in India is shown in Figure 2.5.

Figure 2.5: Map of States in India

Source: Census of India, 2001

As shown in Table 2.9, state-regions in India are ranked based on the Stateindex for 2005; the calculated scores have a range of 45 points from a high of 131 for Pondicherry to a low of 86 for Madhya Pradesh. As shown in the table, this range narrows over time, ostensibly suggesting that the state scores converge over time, with standard deviation of the scores decreasing over time. This suggests that on the whole states in India are converging to lower average technological levels in the post-liberalization era.

Table 2.9: Overall Stateindex Scores in Descending Scores for 2005

	1990	1995	2000	2005	Change in Tech Score
Pondicherry	78	101	116	131	53
Chandigarh	124	90	126	130	6
Haryana	149	120	114	114	(35)
Himachal Pradesh	110	109	95	109	(0)
Karnataka	115	128	108	108	(6)
Goa	143	103	104	106	(37)
Tamil Nadu	99	110	98	106	6
Delhi	98	115	105	104	5
Maharashtra	115	119	100	101	(15)
Gujarat	98	115	106	101	3
Orissa	125	107	101	100	(25)
Andhra Pradesh	87	113	95	99	12
West Bengal	92	95	100	99	6
Bihar	138	96	97	97	(41)
Kerala	97	103	96	97	0
Uttar Pradesh	112	126	94	96	(17)
Punjab	102	103	92	92	(9)
Jammu and Kashmir	73	78	78	92	19
Rajasthan	93	108	92	92	(1)
Dadra and Nagar Haveli	24	118	78	89	65
Daman and Diu	159	144	101	88	(70)
Assam	46	52	72	86	40
Madhya Pradesh	122	102	80	86	(36)
INDIA AVERAGE	**108**	**113**	**99**	**100**	**(8)**
SCORE RANGE	135	92	54	45	
MINIMUM	24	52	72	86	
MAXIMUM	159	144	126	130	
SERIES MEAN	104	107	98	101	
STD. DEV	31.2	18.2	12.7	12.0	

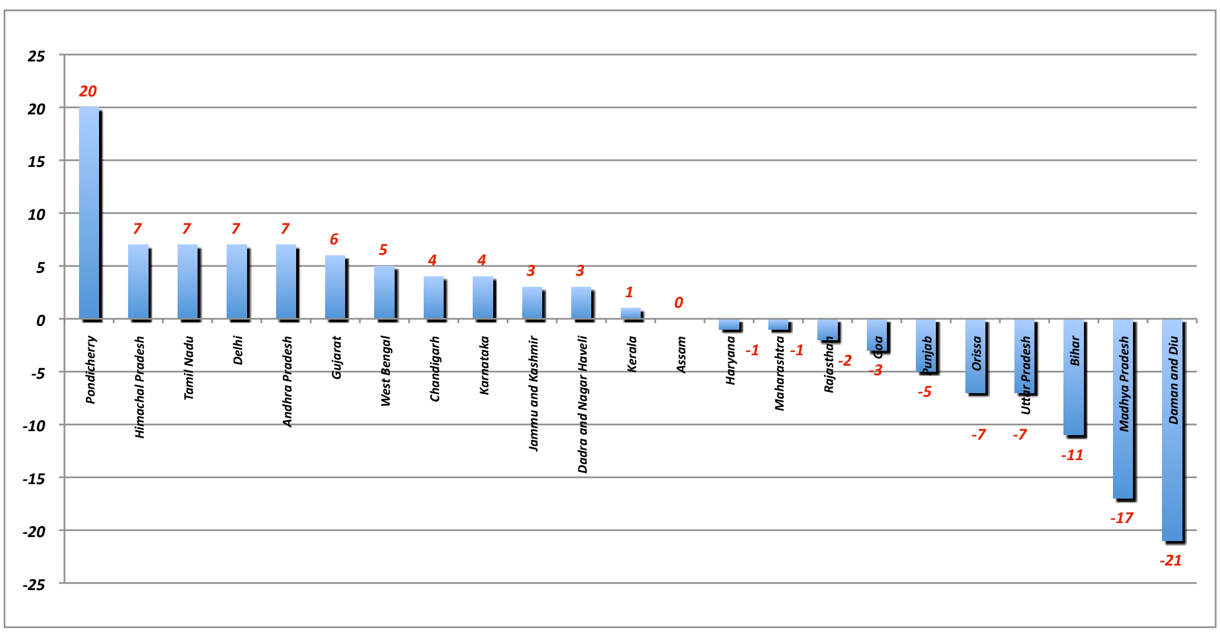
Source: Author

Table 2.10: Stateindex Scores Ranking in Ascending Ranks for 2005

	1990	1995	2000	2005	Change in Rank
Pondicherry	20	18	2	1	19
Chandigarh	6	21	1	2	4
Haryana	2	4	3	3	(1)
Himachal Pradesh	11	11	16	4	7
Karnataka	9	2	4	5	4
Goa	3	15	7	6	(3)
Tamil Nadu	13	10	12	7	6
Delhi	14	7	6	8	6
Maharashtra	8	5	10	9	(1)
Gujarat	15	8	5	10	5
Orissa	5	13	8	11	(6)
Andhra Pradesh	19	9	15	12	7
West Bengal	18	20	11	13	5
Bihar	4	19	13	14	(10)
Kerala	16	14	14	15	1
Uttar Pradesh	10	3	17	16	(6)
Punjab	12	16	18	17	(5)
Jammu and Kashmir	21	22	22	18	3
Rajasthan	17	12	19	19	(2)
Dadra and Nagar Haveli	23	6	21	20	3
Daman and Diu	1	1	9	21	(20)
Assam	22	23	23	22	0
Madhya Pradesh	7	17	20	23	(16)

Source: Author

Figure 2.6: Net Change in Ranks, 1990 to 2005



Source: Author

As shown in Table 2.10 and Figure 2.6, an analysis of the ranking of states by the Stateindex score reveals increases and decreases over time. Pondicherry, which was ranked 1 in 2005, made an improvement of 19 ranks over the study period, while Madhya Pradesh and Daman and Diu show big declines over this same time period to end up with the lowest ranks in 2005. These dramatic swings suggest that these states have relatively less diverse manufacturing bases, where the rise and fall of certain industries and their associated output influences changes in the rank scores over time.

The movement of the rest of the states ranges between increases of +7 ranks and decreases of -16 ranks. States that show improvement in overall manufacturing scores include Himachal Pradesh, Tamil Nadu, Delhi, Andhra Pradesh, Gujarat, West Bengal, Chandigarh, Karnataka, Jammu and Kashmir, and Dadra and Nagar Haveli. The states that show improvements in ranking include both large and small states. Of these, Tamil Nadu, Andhra Pradesh, Gujarat, Karnataka, and West Bengal are the larger and better-known state-regions that include several important urban agglomerations including Bangalore, Chennai, Hyderabad and Kolkata. Delhi and Chandigarh are both union territories, which have several federal government related research and production facilities. Himachal Pradesh is a smaller state in the north of the country that has recently emerged as a hub of pharmaceutical production.

The notable exception in the above list is Maharashtra (capital Mumbai), which is the largest state economy in the country by GDP. Maharashtra surprisingly was outside of the top 5 states by technological sophistication in each year of the study period. However, this could be more due to the diversity of the state's economic base with large portions of its production base engaged in lower sophistication activities.

2.6.3. Regional Upgrading in Protected versus Delicensed Manufacturing

a. Is there any overlap between technological sophistication scores in protected and deregulated manufacturing within each state over time?

Delicensed manufacturing scores are significantly lower than those for protected industries, with increasing convergence over time at the state level. I decompose the preceding overall state-level upgrading analysis further by protected and delicensed industries across state-regions over time. This comparison is made in order to examine whether there are any observable patterns in state technological sophistication scores between protected and delicensed industries. Effectively, we are asking the question whether there might be technological spillovers between strategic industries and deregulated manufacturing. The presence or lack of any such inter-connections might point to the role of regional settings in upgrading.

As shown in Table 2.11, the Stateindex score standard deviation for protected industries is comparable to the standard deviation for overall manufacturing at the beginning of the study period. However, over time, this standard deviation does not appear converge. By 2005, the standard deviation for protected industries is nearly 3 times that for all industries. This suggests that within protected industries, technological sophistication has persisted within a fewer pockets of the country relative to all industrial activities, as the liberalization process expanded over greater shares of industrial output over time.

For example, it comes as no surprise that Karnataka had the highest technological score of 170 points in 2005, across the board for overall, protected and delicensed industries. Karnataka is home to most of the high technology ventures undertaken by the Government of India in space, aeronautics, defense, and telecommunications technologies, mostly located in and around Bangalore. Karnataka also showed the highest overall technological increase over time of 56 points. Other states with higher than national average values for protected industries in 2005 include Haryana, Tamil Nadu, Chandigarh, Delhi, Bihar and Maharashtra.

Table 2.11: Stateindex for Licensed Industries

	1990	1995	2000	2005	Change in Tech Score
Karnataka	114	131	144	170	56
Haryana	156	141	150	162	5
Tamil Nadu	103	114	142	155	51
Chandigarh	126	74	109	147	21
Delhi	100	180	162	143	43
Bihar	149	147	128	139	-11
Maharashtra	120	134	116	130	10
Rajasthan	96	92	117	124	28
Himachal Pradesh	112	113	82	114	2
Orissa	125	84	92	111	-14
Punjab	103	113	112	110	7
Pondicherry	71	75	100	108	37
West Bengal	92	94	96	107	15
Uttar Pradesh	117	131	104	104	-13
Gujarat	96	80	101	102	6
Dadra and Nagar Haveli	22	84	81	96	73
Madhya Pradesh	123	85	74	95	-28
Andhra Pradesh	80	82	90	94	14
Assam	46	44	101	88	42
Kerala	99	64	83	81	-18
Daman and Diu	179	95	107	80	-99
Jammu and Kashmir	73	73	68	70	-3
Goa	169	97	63	68	-101
INDIA	**110**	**112**	**115**	**126**	**16**
SCORE RANGE	157	135	99	102	
MINIMUM	22	44	63	68	
MAXIMUM	179	180	162	170	
SERIES MEAN	107	101	105	113	
STD. DEV	36.5	31.6	26.2	28.9	

Source: Author

Table 2.12: Stateindex for Delicensed Industries

	1990	1995	2000	2005	Change in Tech Score
Pondicherry	129	109	121	135	5
Chandigarh	94	97	133	126	32
Andhra Pradesh	95	109	117	116	21
Himachal Pradesh	90	108	97	108	18
Jammu and Kashmir	108	131	107	101	-8
Maharashtra	118	125	97	100	-18
Uttar Pradesh	85	138	96	98	13
Rajasthan	77	81	78	98	21
Karnataka	93	95	100	98	4
Orissa	91	101	96	97	6
Delhi	97	113	95	95	-2
Tamil Nadu	97	123	92	94	-4
West Bengal	96	110	96	94	-2
Gujarat	119	127	96	93	-26
Kerala	80	107	91	92	12
Bihar	34	82	92	91	56
Assam	88	159	100	89	2
Punjab	92	99	89	89	-3
Dadra and Nagar Haveli	99	124	78	88	-11
Daman and Diu	75	113	88	88	13
Goa	108	100	91	87	-21
Haryana	79	72	71	86	7
Madhya Pradesh	117	108	81	85	-32
INDIA	**125**	**109**	**102**	**100**	**-25**
SCORE RANGE	95	88	62	50	
MINIMUM	34	72	71	85	
MAXIMUM	129	159	133	135	
SERIES MEAN	94	110	96	98	
STD. DEV	19.3	19.4	13.9	12.7	

Source: Author

In contrast, as shown in Table 2.12, the technology index value for delicensed industries at the national level is shown to decrease over time. The standard deviation of the score spread over time decreases from 19.3 points in 1990 to 12.7 points in 2005. Technological trends for delicensed industries are similar to the overall manufacturing index over time as greater shares of the industrial base are deregulated. As stated earlier, state-region scores in India converge, as evidenced in the lowering standard deviations in the technology scores over time, but this convergence is occurring towards lower levels of technological sophistication over time.

Further, by 2005, state-regions in delicensed manufacturing with higher than national average technological scores are all smaller states with the exception of Andhra Pradesh and Maharashtra. Comparing the top 6 states of the protected and delicensed list, there are almost no overlaps, with the exception of Chandigarh.

The evidence seems to suggest that there is very little translation of technological leadership in protected manufacturing to activities within deregulated industries. The usual caveats apply to this observation, in that industries are unique sets of activities. So for example, Karnataka's expertise in hi-tech space and defense technology may not necessarily translate to the growth in the electronics industry. The counter-point to this is that the presence and development of a skilled technical labor pool in a specific location with possible applications across several industries is a positive regional externality. The lack any cross-industry translation points to either blocked locational attributes or ineffective institutional and market frameworks to build on existing capabilities.

2.6.4. Regional Upgrading: Specialization versus Diversity

a. Do states that show increasing overall technological scores over time upgrade due to increasing specialization, entry or increasing diversification?

Next, I identify the components of technological change over time by industry and geography. As hypothesized earlier, changes in the overall state-level technological scores could potentially be due to various factors, including ongoing changes in the sophistication composition of the manufacturing base, as well as upgrading within the existing industries, and a combination of both. In order to keep the analysis at manageable levels, I have ranked production categories (C1 through C16) in 2005, discussed earlier in Section 2.3, to combine these into 4 rank-wise groupings (Top 4, Rank 5-8, Rank 9-11 and Bottom 4). The summary technological scores of the above grouping for India are shown in Table 2.13 for overall, delicensed and protected industries. Over time, the overall scores for the Top 4 grouping, which includes Printing and Publishing (C15), Processing and Power Machinery (C8), Electrical Equipment (C10) and Automotive Equipment (C11), are more heavily weighted toward the protected group. Conversely, deregulated industries have a relatively larger presence down the sophistication ladder over time.

Table 2.13: Change in Technology Scores by Production Categories Grouping

Production Categories Grouping	1990	1995	2000	2005	CHANGE 1990 to 2005
Overall Manufacturing					
Top 4	169	174	162	150	-18
Ranks 5-8	91	105	103	104	13
Ranks 9-12	108	109	90	90	-18
Bottom 4	75	75	68	67	-8
Delicensed Manufacturing					
Top 4	97	164	141	116	18
Ranks 5-8	93	112	109	108	15
Ranks 9-12	n/a	127	95	94	n/a
Bottom 4	99	74	67	66	-33
Protected Manufacturing					
Top 4	191	182	184	189	-2
Ranks 5-8	89	65	40	38	-51
Ranks 9-12	108	74	64	66	-42
Bottom 4	66	78	77	73	8

Source: Author

By analyzing the output trends of state-regions over time by the above groups one can identify the components of change in the overall state technology scores. I estimate location quotients at the state-level for each of the 4 groupings benchmarked to the respective national output shares, as shown in Table 2.14. I discuss the case of overall manufacturing to capture the post-1991 trends for both delicensed and protected industries. As shown in Table 2.14, the Top 15 state-regions by share in national output are arranged in descending order of Stateindex scores change. A common feature in almost all state-regions is that the second grouping of production categories (Ranks 5-8) displays increasing concentrations or relative share of output over time. This grouping includes Pharmaceuticals and Perfumes (C5), Technical and Photographic Equipment (C14), Electronics (C9) and Inorganic and Metallic Intermediates (C7). This means that on the whole Indian manufacturing is moving towards this band of industries (obviously, not all location quotients are greater than 1.00).

As observed in Table 2.14, manufacturing output in state-regions showing increases in the Stateindex Score tends to redistribute from the lower sophistication categories to the higher ones. For example, Dadra and Nagar Haveli, which comprised about 2 percent of the total national output in 2005, shows decreasing concentrations in Group 4 activities (Bottom 4) and increasing concentrations in Groups 2 and 3 over time. In fact, there was no manufacturing activity in Groups 1 and 2 in 1990. This indicates entry activity in industries with relatively higher sophistication scores. In general, state-regions showing positive change or stable technology scores do not show any decline in the scores for Groups 1 and 2.

Table 2.14: Location Quotients by Descending Order of Stateindex Change

	1990	1995	2000	2005	CHANGE 1990 to 2005
Dadra and Nagar Haveli (+65 Stateindex Change)					
Top 4	0.03	0.42	0.50	0.63	0.61
Ranks 5-8	0.00	0.85	1.02	1.74	1.74
Ranks 9-12	1.05	0.97	1.29	0.93	-0.12
Bottom 4	4.35	2.73	3.45	1.98	-2.37
Andhra Pradesh (+12 Stateindex Change)					
Top 4	0.79	0.65	0.64	0.58	-0.21
Ranks 5-8	0.71	0.59	1.44	1.38	0.67
Ranks 9-12	2.34	2.37	2.70	2.26	-0.08
Bottom 4	1.59	1.34	1.49	1.09	-0.50
West Bengal (+7 Stateindex Change)					
Top 4	1.05	1.03	0.84	0.43	-0.62
Ranks 5-8	0.70	0.78	1.82	1.65	0.96
Ranks 9-12	2.27	1.87	2.07	2.22	-0.05
Bottom 4	1.40	1.29	1.55	0.99	-0.41
Tamil Nadu (+7 Stateindex Change)					
Top 4	1.39	1.22	1.28	1.51	0.11
Ranks 5-8	0.30	0.30	0.94	0.78	0.48
Ranks 9-12	1.89	1.63	1.75	1.48	-0.41
Bottom 4	1.84	1.81	2.32	1.51	-0.33
Gujarat (+5 Stateindex Change)					
Top 4	0.62	0.58	0.49	0.36	-0.25
Ranks 5-8	0.55	0.53	0.90	0.84	0.29
Ranks 9-12	2.44	2.59	3.46	3.22	0.78
Bottom 4	1.82	1.26	1.39	0.85	-0.97
Kerala (+0 Stateindex Change)					
Top 4	0.45	0.35	0.35	0.25	-0.19
Ranks 5-8	0.33	0.35	0.60	0.50	0.18
Ranks 9-12	3.06	2.54	3.88	3.36	0.30
Bottom 4	1.60	1.71	1.43	1.17	-0.43
Rajasthan (+0 Stateindex Change)					
Top 4	0.56	0.55	0.45	0.61	0.04
Ranks 5-8	0.71	0.60	1.78	1.54	0.82
Ranks 9-12	1.36	1.47	1.78	1.30	-0.06
Bottom 4	2.80	2.33	2.26	1.85	-0.95
Karnataka (minus 5 Stateindex Change)					
Top 4	1.41	1.38	1.31	1.25	-0.16
Ranks 5-8	1.04	1.02	1.64	1.13	0.10
Ranks 9-12	1.67	1.33	1.78	2.10	0.43
Bottom 4	1.31	1.22	1.55	0.81	-0.50
Punjab (minus 9 Stateindex Change)					
Top 4	1.01	0.97	1.15	1.07	0.06
Ranks 5-8	0.49	0.55	1.20	1.29	0.80
Ranks 9-12	1.87	1.77	1.79	1.10	-0.77
Bottom 4	2.05	1.66	2.13	1.82	-0.23
Maharashtra (minus 14 Stateindex Change)					
Top 4	1.20	1.34	1.29	1.40	0.19
Ranks 5-8	0.78	0.88	1.12	1.15	0.37
Ranks 9-12	2.26	1.70	2.59	2.06	-0.21
Bottom 4	1.18	1.04	1.28	0.68	-0.50
Uttar Pradesh (minus 17 Stateindex Change)					
Top 4	0.75	0.78	0.92	0.86	0.11
Ranks 5-8	0.97	0.91	1.67	1.56	0.60
Ranks 9-12	2.34	2.12	2.30	1.69	-0.65
Bottom 4	1.37	1.15	1.37	1.16	-0.21
Orissa (minus 25 Stateindex Change)					
Top 4	0.28	0.14	0.19	0.20	-0.09
Ranks 5-8	1.00	1.30	3.47	3.62	2.62
Ranks 9-12	3.49	2.71	1.66	0.99	-2.51
Bottom 4	0.63	0.80	0.96	0.50	-0.13
Haryana (minus 35 Stateindex Change)					
Top 4	2.29	2.34	3.01	2.93	0.63
Ranks 5-8	0.63	0.61	1.16	0.93	0.30
Ranks 9-12	1.40	1.05	0.88	0.58	-0.83
Bottom 4	1.10	0.95	1.21	0.86	-0.25
Madhya Pradesh (minus 37 Stateindex Change)					
Top 4	0.71	0.55	0.59	0.60	-0.11
Ranks 5-8	0.67	1.13	2.23	2.60	1.94
Ranks 9-12	2.45	1.75	1.07	0.69	-1.75
Bottom 4	1.60	1.53	2.38	1.38	-0.22
Bihar (minus 45 Stateindex Change)					
Top 4	0.78	0.95	0.83	0.72	-0.06
Ranks 5-8	0.36	0.40	3.25	2.60	2.24
Ranks 9-12	4.10	3.44	1.99	1.84	-2.26
Bottom 4	0.18	0.17	0.20	0.13	-0.05

Source: Author

Table 2.15: Technology Scores by Descending Order of Stateindex Change

	1990	1995	2000	2005	CHANGE 1990 to 2005
Dadra and Nagar Haveli (+65 Stateindex Change)					
Top 4	184	75	153	135	-49
Ranks 5-8	n/a	223	116	112	n/a
Ranks 9-12	29	49	78	80	51
Bottom 4	22	116	56	57	36
Andhra Pradesh (+12 Stateindex Change)					
Top 4	118	210	190	187	69
Ranks 5-8	88	110	104	109	21
Ranks 9-12	88	111	82	86	-2
Bottom 4	71	71	72	67	-4
West Bengal (+6 Stateindex Change)					
Top 4	126	153	199	215	89
Ranks 5-8	70	83	98	95	25
Ranks 9-12	104	91	89	96	-9
Bottom 4	58	60	62	60	2
Tamil Nadu (+6 Stateindex Change)					
Top 4	152	154	142	151	0
Ranks 5-8	91	86	121	120	29
Ranks 9-12	92	117	86	86	-6
Bottom 4	69	77	74	72	3
Gujarat (+3 Stateindex Change)					
Top 4	131	189	231	197	66
Ranks 5-8	97	118	105	112	15
Ranks 9-12	112	120	106	98	-13
Bottom 4	67	68	63	59	-9
Kerala (No Change)					
Top 4	163	223	298	308	145
Ranks 5-8	78	116	103	106	28
Ranks 9-12	109	114	86	88	-21
Bottom 4	59	61	70	75	16
Rajasthan (minus 1 Stateindex Change)					
Top 4	147	144	188	165	18
Ranks 5-8	76	128	106	103	27
Ranks 9-12	116	150	104	102	-14
Bottom 4	75	68	52	52	-24
Karnataka (minus 6 Stateindex Change)					
Top 4	150	210	184	174	24
Ranks 5-8	113	116	106	105	-8
Ranks 9-12	111	107	82	86	-25
Bottom 4	82	68	75	71	-11
Punjab (minus 9 Stateindex Change)					
Top 4	90	119	127	123	33
Ranks 5-8	90	90	91	88	-2
Ranks 9-12	119	110	100	101	-18
Bottom 4	94	91	67	71	-23
Maharashtra (minus 15 Stateindex Change)					
Top 4	202	173	156	136	-66
Ranks 5-8	94	105	101	100	6
Ranks 9-12	95	105	87	87	-8
Bottom 4	81	82	71	72	-9
Uttar Pradesh (minus 17 Stateindex Change)					
Top 4	251	236	151	150	-101
Ranks 5-8	99	100	94	98	-1
Ranks 9-12	95	116	83	82	-14
Bottom 4	76	88	75	74	-2
Orissa (minus 25 Stateindex Change)					
Top 4	142	130	157	155	13
Ranks 5-8	49	85	102	99	50
Ranks 9-12	150	123	96	94	-56
Bottom 4	95	85	99	101	6
Haryana (minus 35 Stateindex Change)					
Top 4	228	154	148	144	-84
Ranks 5-8	88	110	101	90	2
Ranks 9-12	101	94	74	77	-24
Bottom 4	82	74	69	61	-21
Madhya Pradesh (minus 36 Stateindex Change)					
Top 4	176	239	116	115	-61
Ranks 5-8	86	97	97	97	11
Ranks 9-12	142	100	85	84	-57
Bottom 4	84	58	54	54	-30
Bihar (minus 41 Stateindex Change)					
Top 4	51	59	119	117	66
Ranks 5-8	76	103	92	92	16
Ranks 9-12	162	103	100	98	-64
Bottom 4	113	133	74	95	-18

Source: Author

Examining the cases of negative overall Stateindex scores for the largest 15 state-regions in India by output, one finds that these declines result from the decreasing technological sophistication of manufacturing activities that comprised relatively higher concentrations at the beginning of the study time period. These trends correspond with the history of industrialization in India, where state-regions that industrialized first after independence were relatively more concentrated in manufacturing activities with lower levels of sophistication (or basic industries). With time, as seen in the time period selected for this study (1990 to 2005), the manufacturing base has redistributed out of lower technology industries into newer industries at higher technological levels. It is possible that the early industrializers got locked into path dependence due to various factors including scale economies and found it harder to climb up the national technological ladder.

Of the three largest state-regions by output share in the country, Gujarat and Tamil Nadu show increasing Stateindex scores, while Maharashtra shows a decline over the 1990 to 2005 study period. It is important to note that in 2005 the location quotient for Maharashtra for Group 1 at 1.40 was nearly 4 times that for Gujarat. Of these states, Tamil Nadu had the highest location quotient at 1.51 in 2005. Additionally, while relative concentrations of the Top 4 group increased in Tamil Nadu and Maharashtra, the location quotient for Gujarat declined over time. The above trends indicate that Maharashtra and Tamil Nadu are more established as centers of high technology manufacturing. All states show stable or increasing scores for Group 2 (Ranks 5-8) activities with increasing locational concentrations.

Among the other prominent Top 15 state-regions, Karnataka and Haryana have both high concentrations of Group 1 activities with high technology scores. As mentioned earlier, Karnataka is the defense-aerospace, heavy electricals, telecommunications and electronics center of India with industries located in and around Bangalore. Haryana has high concentrations of Automotive Parts and Equipment and Power and Processing Machinery manufacturing located in and around Gurgaon and Faridabad (which are both suburbs within the National Capital Region of Delhi). Among the 15 largest states, high technology activities have sustained or grown in only a few pockets of the country. These states either contain or are contiguous with the largest urban agglomerations in India – Maharashtra (Mumbai), Tamil Nadu (Chennai), Haryana (Delhi) and Karnataka (Bangalore). However, the growth in Group 2 (ranks 5-8) activities appears to be more evenly dispersed in the country.

In this connection, a group of smaller state-regions that comprise another 5 percent of India's manufacturing output have gained prominence, as shown in Table 2.16 and Table 2.17. Of these Delhi and Chandigarh show location quotients greater than 1.00 and relatively high scores in Group 1 activities compared to the national average of 150. Further, all of the smaller state-regions shown have high location quotients for Group 2 activities alongside relatively high technology scores. Of these state-regions, Pondicherry and Chandigarh show nearly a six-fold increase in location quotients, while Himachal Pradesh shows an eight-fold increase over 1990-2005. As noted earlier the pharmaceutical industry has taken-off in Himachal, while Pondicherry has strong presence of electronics and automotive parts manufacturing.

Table 2.16: Location Quotients of Smaller States-regions

	1990	1995	2000	2005	CHANGE 1990 to 2005
Pondicherry (+53 Stateindex Change)					
Top 4	0.13	0.59	0.70	0.66	0.53
Ranks 5-8	0.42	0.88	2.41	2.79	2.37
Ranks 9-12	2.50	2.23	1.96	1.09	-1.40
Bottom 4	2.35	1.25	1.20	0.75	-1.60
Chandigarh (+6 Stateindex Change)					
Top 4	2.06	1.35	2.30	1.73	-0.33
Ranks 5-8	0.40	0.62	2.86	2.50	2.11
Ranks 9-12	2.35	2.57	0.93	0.62	-1.72
Bottom 4	0.60	0.41	0.19	0.43	-0.17
Delhi (+5 Stateindex Change)					
Top 4	1.14	1.20	1.26	1.10	-0.04
Ranks 5-8	0.90	0.68	0.90	0.85	-0.05
Ranks 9-12	1.61	0.86	1.58	1.40	-0.21
Bottom 4	1.75	2.22	2.51	1.93	0.18
Himachal Pradesh (0 Stateindex Change)					
Top 4	0.66	0.48	0.31	0.72	0.06
Ranks 5-8	0.39	1.01	3.14	2.99	2.59
Ranks 9-12	2.77	1.76	0.74	0.51	-2.26
Bottom 4	1.60	1.72	2.08	1.09	-0.52
Goa (minus 37 Stateindex Change)					
Top 4	0.50	0.54	0.44	0.57	0.08
Ranks 5-8	0.89	0.87	1.80	1.69	0.79
Ranks 9-12	2.96	2.51	3.14	2.41	-0.55
Bottom 4	1.08	1.03	0.89	0.60	-0.47

Source: Author

Table 2.17: Technology Scores of Smaller State-regions

	1990	1995	2000	2005	CHANGE 1990 to 2005
Pondicherry (+55 Stateindex Change)					
Top 4	155	264	168	132	-23
Ranks 5-8	69	104	150	165	96
Ranks 9-12	97	72	72	80	-17
Bottom 4	56	72	91	81	26
Chandigarh (+6 Stateindex Change)					
Top 4	103	125	196	198	95
Ranks 5-8	73	100	84	104	32
Ranks 9-12	169	73	91	91	-78
Bottom 4	59	69	77	60	1
Delhi (+5 Stateindex Change)					
Top 4	161	216	206	202	40
Ranks 5-8	83	130	100	94	11
Ranks 9-12	100	95	91	93	-7
Bottom 4	64	63	64	60	-4
Himachal Pradesh (0 Stateindex Change)					
Top 4	93	104	159	176	83
Ranks 5-8	121	129	110	116	-4
Ranks 9-12	117	108	93	71	-46
Bottom 4	102	101	62	63	-38
Goa (minus 37 Stateindex Change)					
Top 4	94	160	198	165	72
Ranks 5-8	107	144	120	119	12
Ranks 9-12	181	85	91	88	-92
Bottom 4	93	82	74	84	-9

Source: Author

2.7. Findings and Conclusions

In this paper I demonstrated the possibility of constructing a unique index of technological sophistication at the 3-digit industry level by utilizing exports-based revealed product quality values. These industries scores were weighted by output to calculate the national average (Natindex), the overall state-region scores and for a technological grouping of industries. I then provided analysis on the geographical trends in technological upgrading in manufacturing in the post-1991 era. Issues and significant trends identified in this paper will be further analyzed in the next two papers of this research on the geographical and institutional underpinnings of upgrading. On the whole the analysis of the technological scores indicates that responses to the set of new conditions introduced by the national reforms post-1991 have heterogeneous impacts by industry characteristics and regional contexts. The main conclusions from the preceding analyses are as follows.

National Convergence and Divergence Trends

The constructed technological measure suggests that on the whole technological sophistication levels of overall manufacturing in India have declined steadily in the post-reforms era. This process appears to be driven by falling technological levels in delicensed manufacturing, while regulated manufacturing (though shrinking over time) shows increasing scores. These dynamics indicate that the spread of industrialization across the country in the post-reforms era in deregulated industries is in areas of lower technological sophistication. This proposition is supported by evidence of convergence in scores for delicensed industries at the state-level but to lower levels of technological scores in the liberalization era. On the other hand, the shrinking regulated areas of manufacturing in the post-reforms era show high levels of sophistication accompanied by increasing divergence. Therefore, it appears that upon deregulation, Indian manufacturing adjusted to catering to global demands for products at lower levels of sophistication.

Industry-level Heterogeneity

In decomposing the above trends by industry characteristics, the analysis indicates that technological upgrading in post-reforms India differs by the sophistication level of industries, with lower groups tending to show negative change over time. Regulated industries comprise a larger share of the technologically more sophisticated industries, while also showing higher scores relative to the delicensed group. On the whole, Indian manufacturing appears to be moving towards the middle rung of technological sophistication (Group 2), including Pharmaceuticals and Perfumes, Technical and Photographic Equipment, Electronics and Inorganic and Metallic Intermediates, which show increasing relative concentrations. States with increasing overall technological scores show stable or increasing scores in the above group, and in most cases for the most sophisticated industry grouping (Group 1) -- Printing and Publishing, Processing and Power Machinery, Electrical Equipment and Automotive Equipment. Thus, the divergence and convergence dynamics are driven by differential industrial responses to the reforms.

Importance of Regional Contexts

Further, the above industry level variations coincide with certain geographical patterns of upgrading. Among the 15 largest states, high technology activities have sustained or grown in only a few pockets of the country. These states either contain or are contiguous with the largest urban agglomerations in India – Maharashtra (Mumbai), Tamil Nadu (Chennai), Haryana (Delhi) and Karnataka (Bangalore). At the same, evidence seems to suggest that there is very little translation of technological edge in protected manufacturing to activities within deregulated industries, which interpreted using a spatial framework indicates a lack of localized technological spillovers. The lack of cross-industry transfers points to either blocked locational attributes or ineffective institutional and market frameworks to build on existing capabilities. The growth of the medium technological grouping appears to be relatively more evenly dispersed in the country. A group of smaller state-regions, including Delhi, Chandigarh and Pondicherry have gained prominence in both Group 1 and Group 2 activities, accompanied by high scores and high relative concentrations. Additionally, examining the cases of negative overall Stateindex scores, one finds the effects of path-dependence, where such states were early industrializers in the lower rungs of technological activity and have found it harder to divest or ascend out of these manufacturing areas.

In the preceding analyses, evidence points to the possible role of heterogeneity in regional contexts and industry-level characteristics in explaining technological upgrading in post-reforms manufacturing in India, which I will examine in the next two papers of this dissertation.

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CHAPTER 3
PAPER 2: Impact of Industry-level Agglomeration Economies and Organizational Covariates on Technological Upgrading

3.1. Introduction

This is the second paper (Paper 2) of my 3-stage research that examines the issue of technological upgrading in Indian manufacturing in the post-liberalization era. The primary purpose of this paper is to place at the center of the upgrading process the role of agglomeration economies, which in conjunction with the industry organizational characteristics defines here one set of regional conditions for upgrading. These organizational characteristics include absorptive capacity (age and size), import propensity and firm formation rate. In the final paper of this dissertation (Paper 3), I augment these regional conditions with other covariates to agglomeration economies, including urban-systems structure, skilled migration and institutional contexts. Thus defined, regional conditions for catch-up are hypothesized to vary geographically within India, and in interaction with the national level delicensing, result in inter-regional variations in upgrading outcomes over time.

In situating agglomeration economies at the heart of the upgrading process, I relate to research in economic geography and regional development that has highlighted the importance of regions as the motors of the national and global economies (See for example, Scott, 1996 and Scott and Storper, 2003). Upgrading is driven by the ability of firms to access critical inputs in response to demand opportunities for products and services. This matching is more readily available within specific spatial industrial configurations, as observed externally in the concentration of economic activities. Clustering of economic activities enables the efficient matching and sharing of a diverse set of assets and facilitates learning along tacit and codified dimensions (Duranton and Puga, 2004). Further, the literature characterizes two different agglomerative forces at work – localization economies of specialization and urbanization economies of variety (See Glaeser et al., 1992). These two agglomerative forces provide different dimensions to upgrading and innovation, as I discuss later in this paper. Further, the micro-foundations of technological upgrading are built upon the actions of economic agents and their evolving capabilities. In this respect, I examine the main and joint impacts of absorptive capacity (age and size), import propensity and firm formation rate with agglomeration economies

In this paper, I construct a set of industry (techcat) indicators representing localization and urbanization economies, which are interacted with techact organizational characteristics of firms averaged at the techcat-state level. I construct variables for critical inputs into production -- capital-intensity and skill-intensity. I run fixed-effects panel data regression models allowing me to isolate the marginal impacts of the explanatory variables after controlling for other unobserved time-invariant effects at the techcat-sate level. In implementing the above analysis, I limit myself to only the delicensed portions of manufacturing, thus keeping the production conditions in response to the given national policy context constant over time.

The paper is organized as follows. Section 3.2 provides a summary of the technological trends as observed in Stage 1 of the research as context for analysis here. Research questions and hypotheses are presented in Section 3.3, followed by a discussion of the empirical approach and study measures in Section 3.4. This is followed by descriptive analysis of the study variables in Section 3.5 and regression analysis in Section 3.6. A set of conclusions is presented in Section 3.7.

3.2. Overview of Inter-regional Technological Change

In the previous stage (Paper 1) of this dissertation, I developed an indicator for technological change for India’s 3-digit National Industrial Classification (NIC) manufacturing codes in India utilizing information on the revealed sophistication of Indian exports in US imports with respect to all other world exports obtained from Kemeny (2010). I then grouped these 3-digit codes to develop indicators of technological change at the state-level and by 16 industry groupings of similar products for the 1990 to 2005 time period, which is used here as the outcome measure of upgrading in this paper.

The constructed technological measure suggests that on the whole technological sophistication levels of overall manufacturing in India have declined steadily in the post-reforms era. This process appears to be driven by falling technological levels in delicensed manufacturing. These dynamics indicate that the spread of industrialization across the country in the post-reforms era in deregulated industries is in areas of lower technological sophistication. This proposition is supported by evidence of convergence in scores for delicensed industries at the state-level but to lower levels of technological scores in the post-liberalization era.

Further, technological upgrading in post-reforms India differs by the sophistication level of industries, with lower groups tending to show negative change over time. The delicensed group shows lower scores relative to overall manufacturing in the top tiers of technological sophistication. Inter-state divergence and convergence dynamics are driven by differential industrial responses to the reforms. In this connection, high technology activities in overall manufacturing have sustained or grown in only a few pockets of the country. These states either contain or are contiguous with the largest urban agglomerations in India – Maharashtra (Mumbai), Tamil Nadu (Chennai), Haryana (Delhi) and Karnataka (Bangalore). At the same, evidence suggests a lack of localized technological spillovers, as high overall scores in overall manufacturing (driven by protected industries) do not transfer over to deregulated industries. This could possibly be due to blocked locational attributes or ineffective institutional arrangements to build on existing capabilities. The growth of the medium technological grouping appears to be relatively more evenly dispersed in the country. The preceding set of observations suggests that inter-regional variations in technological upgrading correlate with the heterogeneity in regional and industry level characteristics, which are further explored next.

3.3. Research Questions and Hypotheses

The direction and distribution of observed technological change by states for delicensed industries suggests that the manufacturing growth story in India has been one of dispersion of the relatively less-sophisticated industries to newer locations of the country, possibly as a process of industrialization mirroring the geographical supply of inputs and competences.

Further, I propose that the liberalization reforms have redefined the opportunities and constraints for this matching process giving rise to new regional technological pathways. I further explore this proposition through a series of questions examining the relationship between the observed technological change as the outcome and a set of explanatory variables including inputs for production, and spatial concentration and organizational characteristics of industry groups at the state-level. Three sets of questions and related hypotheses emerge for further analysis.

3.3.1. Capital and Skill Intensities

a. How have demand conditions for inputs into production transformed over time at the state- and industry-level and how are these correlated to technology?

If the industrialization process within India has indeed been one of dispersion and technological downgrading, it would be observed in ongoing changes in the intensity of inputs into production. Theoretically, technological upgrading would entail that more sophisticated processes be adopted for the manufacture of products. Following the standard growth model

(Solow, 1956), one would expect capital intensity to be positively correlated to technological growth. Additionally, following endogenous growth models (Romer, 1986; Lucas, 1988, Grossman and Helpman, 1991; and Aghion and Howitt, 1992) one would expect human capital to have a significant role in explaining technological growth.

At the same time, it is unclear whether in labor-surplus countries like India, decreasing capital-intensity or skill-intensity, necessarily also result in declining levels of technological sophistication or status-quo outcomes or vice versa. Additionally, levels of association between technological growth and capital- and skill-intensity may differ both by industries within a state and also within same industries across different states. Any modeling effort to explain these relationships would have to control for unobserved factors at both state- and industry-levels. Further, the impact of capital-intensity and skill-intensity on technological change is also likely influenced in interaction with locational decisions, in the context of agglomeration economies, and heterogeneity in industry-level organizational characteristics, which are discussed next.

H1*: Capital-intensity and skill-intensity are positively associated with observed technological change at the state-industry level.*

3.3.2. Agglomeration Economies

a. How is technological change associated with external economy factors in the Indian context?

Locational choice is driven by the need to access critical inputs for production and markets for products. On a continuum of mundane to complex tasks, industries have different sensitivity to location within specific spatial industrial configurations and external economies– what is called ‘matching, sharing and learning’ (Duranton and Puga, 2004). Literature characterizes two sets of external economies, namely localization economies (‘Marshall-Arrow-Romer’ externalities) and urbanization economies (‘Jane Jacobs’ externalities) (Glaeser et al., 1992). There is ongoing debate on the relative importance of these two aspects of externalities (cf. Storper, 2009).

Localization economies refer to spillover effects that emerge from the collocation of firms in the same industries or closely related technical divisions of labor These externalities include shared specialized infrastructure, specialized labor market, dense buyer-supplier and subcontracting networks, and technical and knowledge spillovers. These relationships allow firms to adapt to uncertain market conditions and short production runs, and have the overall effect of reducing transaction costs. Thus, manufacturing firms located in such clusters are likely to be comparatively more efficient and also likely to develop absorptive capacities to adopt new technologies. Several econometric studies have attempted to draw out the importance of localization economies on industrial location decisions and productivity (See for example, Ciccone and Hall 1996; Ellison and Glaeser, 1997; Maurel and Sedillot, 1999; Gordon and McCann, 2000; and Rosenthal and Strange, 2003).

Urbanization economies refer to the spillover benefits that emerge from other industries by locating within diverse economic settings (See for example, Sveikauskus, 1975 and Quigley, 1998). These spillovers include access to producer services, large variegated labor pool, inter-industry knowledge spillovers, and generalized infrastructure. Studies also suggest that urbanization economies benefit knowledge- and technology-intensive manufacturing more compared to standardized operations (See for example, Henderson, Shalizi and Venables, 2001). Stated differently, knowledge-intensive operations self-select into diverse urban settings as a trade-off between access to knowledge and ideas versus higher costs and negative externalities.

In the Indian context, a small but growing number of studies have begun to analyze the relative impacts of localization and urbanization economies on manufacturing growth. Yet, to the best of my knowledge, no studies directly examine the association between measures of technological sophistication in Indian manufacturing and external economies. The closest approximations include proxies such as rates of profit, productivity growth and total factor productivity. Further, evidence on the significance and direction of impacts from external economies is not clear for Indian manufacturing, possibly due to definitions of the 'local' and the 'regional' and the associated spatial units of observation.

For example, one of the pioneering studies on the impact of agglomeration economies on total factor productivity, Mitra (2000) analyzing a panel of Indian states from 1977-78 to 1992-93 finds the impact of urbanization economies (urban population and urban manufacturing) to be significant up to a certain size threshold after which diseconomies outweigh the external economy benefits. At the India-wide district-level, Lall, Shalizi and Deichmann (2004) find evidence for benefits to firm-level marginal rates of profits from localization economies to be positive and significant for only 2 out of 11 constructed industry groupings of their study. Further, they do not find evidence that locating in dense urban areas (as proxy for urbanization economies) have beneficial effects to offset costs associated with high rents and wages. Similarly, Lal and Chakravorty (2005) find no significant impacts of own-industry concentration on profitability at the district level. However, this study finds beneficial impacts to firm profitability from diversity or the 'local presence of mix of industries'. This study also finds that, in the post-reform context, industrialization led by private capital favors profit-maximization locations away from lagging regions in the country.

In a pioneering companion study of the city-regions of Mumbai, Kolkatta and Chennai, Chakravorty, Koo and Lall (2005) find industrial location decisions in the urban context are not so much driven by access to localization economies but from market imperfections, such as land market rigidities, exit policy and labor regulations. Though, they find industries to collocate in a few ZIP codes of these city-regions, they do not find strong collocation patterns between industries sharing similar labor profiles and strong input-output relationships. However, this study finds that access to

Kathuria and George (2007), utilizing the Ellison-Glaeser index of collocation, find that Indian manufacturing industries are agglomerated within a few states. Further, they find evidence for clustering to be positively correlated at the industry-level to research and development intensities and ratio of skilled labor force, and at the state-level to be negatively correlated to labor regulations and high electricity tariffs. Lall and Mengistae (2005) find large productivity gaps between states at the industry level, which they attribute partially to agglomeration economies, besides degree of labor regulation and the severity of power shortages.

From the above, it is unclear what associations one might find between technological change and external economy variables, i.e. localization and urbanization economies. In this study, measures of localization economies developed include measures of spatial concentration including the Gini coefficient (Gini) and the Herfindahl index (Herfindahl) . Measures of urbanization economies are represented by percent share of location of firms within urban areas (Urban) and the Shannon index of entropy (Diversity).

H2: *Measures for localization economies may be related to observed technological growth in the Indian context.*

H3: *Measures for urbanization economies are expected to have significant impact on technological change.*

3.3.2. Industry Organizational Characteristics

a. How is technological change associated with firm characteristics at the industry-level in the Indian context?

Further, I explore the organizational dimensions of technological pathways by examining the association of technological change with firm characteristics at the industry-level, including average age, average factory size, rate of entry, and the propensity to import production inputs. New growth theory has recast technological change by endogenizing knowledge externalities to the growth modeling process (Romer, 1986; and Lucas, 1988). Thus, firms, as nexus of workers and embodied knowledge, occupy a central role within this framework.

The two leading approaches to endogenous technological change include the 'expanding variety' approach and 'quality ladders' approach. In the expanding variety approach, growth occurs in the aggregate due to horizontal product differentiation. In the neo-Schumpeterian quality-ladders approach, technological innovation is a deliberate act undertaken by firms/entrepreneurs to improve existing product varieties (Grossman and Helpman, 1991; and Aghion and Howitt, 1992). Additionally, in later quality-ladder versions, imitation is equally important as innovation, and the two mechanisms are seen to operate in a 'step-by-step process' in enabling technological catch-up (Aghion, Harris and Vickers, 1998; and Aghion et al., 2001).

In the context of market reforms, evidence on the relationship between competition and innovation is qualified. Aghion et al. (2005) model innovation (patents filing) in the UK as having 'inverted-U' relationship with competition, initially increasing with competition but then decreasing beyond certain thresholds. Assuming a step-by-step process, increased competition, especially within neck and neck industries (closely contested industries), has a net overall impact of inducing innovation to escape competition. However, further increases in competition could have a deterring effect on innovation, as firms' research investments are influenced by the difference between pre- and post-innovation rents and not solely on the levels of post-innovation rents. Stated differently, the greater the competition the greater the likelihood of technological obsolescence, which in turn deters current investment decisions for research and development. Related studies show that the predictions of the above model depend upon the definition of competition (see for an overview, Tingvall and Poldhal, 2006; and Vives, 2008), and vary across countries (for the European Union, see, Griffith and Harrison, 2004; and Griffith, Harrison and Simpson, 2009).

Impact of Rate of Entry

Few studies have also applied the step-by-step growth approach to isolate the impacts of competition on industrial growth in the Indian context (See Acemoglu, Aghion and Zilliboti, 2003; and Aghion et al., 2004, 2005 and 2008). These studies analyze the interaction of firm entry (due to lower barriers) with technological heterogeneity at the industry-level in explaining aggregate innovation responses.

In their evaluation of Indian 3-digit state-level manufacturing panel data from 1980 to 1997, Aghion et al. (2004 and 2005) find evidence to support their theoretical model that shows incumbent firms closer to the technological frontier more likely to upgrade in response to increasing rates entry. In this study, the within-industry inequality in output and output per employee rises in response to increasing rates of entry from liberalization. The upshot of their analysis is that firm-level responses to liberalization reforms are heterogeneous and that the success of such broad policies is geographically varied due to firm and industry level characteristics. However, in this analysis, quantity of output rather than any measure of quality is used as a proxy of technological growth, and the two may not correspond well.

Similarly, Bhaumik, Gangopadhyay and Krishnan (2006) find positive association between rates of entry and growth in total factor productivity. They suggest that in the post-reforms era entry rates are associated with state-level institutional factors in contrast to being associated with industry-level factors in the License-Raj era. The importance of institutional factors in determining the rate of entry and aggregate innovation outcomes is also emphasized in Aghion et al. (2008), where the state labor laws are shown to impact industrial output.

H4: *Firm formation rate is expected to be positively associated with increases in technological scores.*

Impact of Age and Size

The above discussion also underscores the importance of industrial structure on aggregate technological outcomes. The step-by-step model also suggests a key role for domestic absorptive capacities (Cohen and Levinthal, 1990, Lall, 1998; and Keller, 1996) for imitation to precede innovation. A similar point is made in Acemoglu, Aghion and Zilibotti (2006), who suggest that developing economies that are typically farther away from the technological frontier are likely to pursue an investment-based strategy to adopt technologies based on stable relationships, high average size and age of firms. In this context, liberalizing developing economies with longer histories of industrialization and stocks of human capital are more likely to upgrade, initially by adopting new technologies. As a logical extension, one might also expect that sub-national regions with longer histories of industrialization have greater absorptive capacities to adopt, imitate and innovate, as eventually observed in regional convergence and divergence patterns.

From the empirical standpoint, one would expect average firm age to be indicative of levels of absorptive capacity and to be positively correlated with technological change at the industry level. For example, Katrak (1997) analyzing the Indian electrical and electronics industries found significant correlation between existing capabilities and the degree of adoption of new technologies. Similarly, Lal (1999), studying the adoption of information technologies in manufacturing processes, found evidence that the existing capabilities of entrepreneurs, in terms of their qualifications and information base, were significantly correlated to IT adoption. This study also found strong evidence that the extent of IT adoption was strongly correlated to market share and size of operations. Similalrly, in their study of the basic chemicals industry in India, Narayanan and Bhat (2009) find significant association of firm size and age with R&D intensities.

H5: *The impact of average age and size on technological change is expected to be positive on technological scores.*

<u>Impact of Import Propensity</u>

In the context of imitation and adoption, import of inputs into production is one possible channel for technological acquisition (See for example, Coe and Helpman, 1992 and Eaton and Khortum, 1995). Technology transfer through imports can take the shape of designs and blueprints and embodied in intermediate inputs and machinery. One set of views regarding technological acquisition and imports is that the latter fills gaps in domestic technological capabilities through substitutive relationship (Cf. Fu, Pietrobelli and Soete, 2011). However, on the other hand, it may well be the case that it is the more sophisticated firms that also display higher propensity to import complementary inputs and technologies into production. Further, it has been suggested that the successful deployment of imported technologies also hinges upon domestic absorptive capacities and needs to be coupled with in-house research and development efforts (Lall, 1992 and 1993; and Bell and Pavitt, 1993).

In the Indian context several studies have studied the association of technological imports and domestic R&D efforts (Cf. Sasidharan and Kathuria, 2011). Katrak (1994) finds in-house R&D intensity to be strongly correlated to innovative output among Indian firms that imported but not among those firms that were non-importers. This is suggested as providing support that indigenous R&D and import of technology are actually complementary in nature. In a separate study, Katrak (2002) reports that a liberalized imports regime did not hurt indigenous R&D efforts, as those firms that built indigenous capabilities in the pre-reforms era and continued in-house efforts in post-reforms era were also likely to import inputs. Aggarwal (2000) further makes the distinction between the role of imports in a regulated regime and liberalized regime, in that in the former, imports played more of the role of filling gaps while in the post-reforms era imports were actively sought for upgrading technological capabilities. However, Narayanan and Bhat (2009) find in-house R&D and imports to have complementary relationship only in those firms that actively sought multiple sources of technology.

H6: *The impact of import propensity on technological growth is unclear.*

3.4. Empirical Approach and Measures

I analyze the above questions using regression methods on a unique time-series panel dataset for delicensed manufacturing that I have constructed for Stage-2 of my research. This dataset includes the observed technological scores and explanatory variables, as summarized in Table 3.1.

Table 3.1: Summary of Study Variables

Variables	Definition	Data Source and Time Period	Pooled Observavtions: 1990, 1995, 2000, 2005				
			Obs	Mean	Std. Dev.	Min	Max
Dependent Variable: Tech Score [1]	Technology scores for 3-digit manufacturing industries grouped into **16 technological categories by state (state-tech)**, scores calculated from price-based revealed product quality value of exports at 5-digit HS Codes.	Author for industry groupings for 1990, 1995, 2000 and 2005; ; Kemeny (2011) for price-based revealed product quality value of exports at 5-digit HS Codes for 1990,1995 and 2000.	1146	110.8	66.6	12.6	507.9
Explanatory Variables:							
Capital-Labor Ratio [2]	Ratio of invested capital (inflation adjusted) to number of factory floor workers for state-tech.	Annual Survey of Industries (ASI), 1990-91, 1995-96, 2000-01, and 2005-06 at the 3-digit state level.	1146	1,675,010	4,906,291	19,077	98,700,000
Skill Ratio	Ratio of skilled employees to factory floor workers by state-tech, where the number of skilled employees is calculated as the difference between total employees and factory floor workers.	ASI 1990-91, 1995-96, 2000-01, and 2005-06 at the 3-digit state level.	1146	0.4413	0.2886	0.0594	4.6967
Gini Coefficient	Gini Coefficients for state-tech from district-level employment data.	Economic Census of India (EC) unit-level microdata for 1990, 1997 and 2005, interpolated for 1995 and 2000.	1147	0.2042	0.1670	0.0000	0.8390
Herfindahl Index	Plant-size based calculation of market competition by state-tech	ASI factory-level microdata fpr 1989-90, 1994-95, 2000-01, and 2005-06.	1143	0.1409	0.1513	0.0020	1.0000
Urban Location	Location of activity in urban areas by state-tech	Economic Census of India (EC) unit-level microdata for 1990, 1997 and 2005, interpolated for 1995 and 2000.	1147	0.5468	0.3381	0.0000	0.9995
Diversity Index	Shannon Entropy Index for state-tech developed from district-level employment data	Economic Census of India (EC) unit-level microdata for 1990, 1997 and 2005, interpolated for 1995 and 2000.	1135	1.6922	0.3349	0.3648	2.4948
Average Age	Average age of factories for state-tech, calculated from first-year of operation.	ASI factory-level microdata fpr 1989-90, 1994-95, 2000-01, and 2005-06.	1147	16.4	6.9	0.0	56.3
Factory Size	Average number of employees per factory for state-tech.	ASI factory-level microdata fpr 1989-90, 1994-95, 2000-01, and 2005-06.	1147	74.8	69.6	0.0	860.5
Firm Formation Rate	Percent of factories below age 5 years for state-tech, calculated from first-year of operation.	ASI factory-level microdata fpr 1989-90, 1994-95, 2000-01, and 2005-06.	1147	0.1790	0.1527	0.0000	1.0000
Import Input	Ratio of value of imported inputs to total inputs into production for state-tech.	ASI factory-level microdata fpr 1989-90, 1994-95, 2000-01, and 2005-06.	1142	0.1604	0.2071	0.0000	1.0000

1. $10 per Capita
2. Rs.100,000 Invested Capital per worker

Source: Author.

3.4.1. Panel Structure

The primary unit of observation in this time-series panel data is the technology-state category **(techcat-state)**, which is a grouping of 3-digit industries into 16 broader technological categories (similar products) at the state-level, as shown in Table 3.2. This techcat-state time series includes collapsed information on employment, inputs and outputs obtained from the published 3-digit Annual Survey of Industries (ASI) data for the accounting years 1990-91, 1995-96, 2000-01 and 2005-06, as used earlier in Paper 1.

Table 3.2: Panel Structure Delicensed Techcat-State Categories over Time

State	1990	1995	2000	2005
Andhra Pradesh	11	16	16	16
Assam	5	12	10	11
Bihar [1]	7	12	13	14
Chandigarh	5	11	10	12
Dadra and Nagar Haveli	2	5	13	14
Daman and Diu	3	9	14	15
Delhi	11	16	16	16
Goa	7	12	16	15
Gujarat	11	16	16	16
Haryana	11	16	16	16
Himachal Pradesh	6	14	13	13
Karnataka	11	16	16	16
Kerala	11	16	16	16
Madhya Pradesh [2]	10	16	16	16
Maharashtra	11	16	16	16
Orissa	9	14	10	10
Pondicherry	4	13	15	15
Punjab	11	16	16	16
Rajasthan	10	15	16	16
Tamil Nadu	11	16	16	16
Uttar Pradesh [3]	11	16	16	16
West Bengal	11	16	16	16
TOTAL ROWS	**189**	**309**	**322**	**327**

1. Includes the splinter state of Jharkhand in 2000 and 2005.
2. Includes the splinter state of Chatthisgarh in 2000 and 2005.
3. Includes the splinter state of Uttarakhand in 2000 and 2005.

Source: Author.

Technology scores (outcome measure) calculated originally at the 3-digit state level for Stage-1 are recalculated for techcat-state and coded into the techcat-state time series panel data. Explanatory spatial and organizational variables were developed by techcat-state over time from independent datasets that have additional information on location and firm characteristics, which are coded back into the constructed time series panel data. These additional datasets include

a. The Economic Census of India (EC) microdata for 1990, 1997 and 2005, which includes information on the location of manufacturing activities identified at the district-level and by urban-rural location.

b. ASI unit-level microdata for the fiscal years 1989-90, 1994-95, 2000-01 and 2005-6, which includes information on firm organizational-characteristics including age and import propensity.

c. Note: Although, several previous studies claim to have used the ASI microdata to identify location of units by districts, these codes are not publically available in the official ASI data release and are embedded in larger Unit ID codes. I have not been able to ascertain the veracity of these claims. Thus, I have instead used the Economic Census microdata, which have district codes clearly identified in their data structure.

3.4.2. Geographical Coverage

From the point of view of availability and consistency of long-term data across multiple data sources used, I have included in this study the 22 largest states and union territories of India, which constitute nearly 99 percent of the total output of the country. In the year 2000, the Indian Parliament subdivided three states into one additional state each. These original states included Bihar, Madhya Pradesh and Uttar Pradesh. For this study, in order to maintain the longitudinal character of the panel data, I have maintained the geographical units as of the initial year.

3.4.3. Modeling Strategy

I utilize fixed-effects time-series OLS methods to analyze the association between the technology outcomes and the explanatory variables. The choice of this modeling approach is informed by several criteria.

I seek to analyze the within-industry associations between technology scores and explanatory variables controlling for state-level unobserved effects. I examine within-industry effects because the production requirements by industry are likely heterogeneous, therefore the marginal impacts of the explanatory variables on technology scores are likely to be different.

A fixed-effects model by techcat-state informs us about the impact of the predictor variables on the technology outcome on an average for the panel data, which is markedly different from a pooled regression, which may not yield any meaningful or significant relationships.

Technology score outcomes by techcat-state are modeled as a function of production input variables, spatial variables and organizational variables.

Technology Score = f (Production Input Variables, Spatial Variables, Organizational Variables)

The variables used for the regression analysis have all been log-transformed in order to establish comparable scales. The percent change in the outcome variable is interpreted as the impact of percentage changes in the explanatory variables. Thus, log transformed variables also test elasticity relationships between the outcome and predictor variables.

<u>THE MODEL</u>

$$ln\ (TECH_{it}) = b\ \ ln(X_{it}) + u_i + v_{it}$$

Where; i = techcat-state panel id; t= year; u_i = fixed intercept for techcat-state; and v_{it}= error term

TECH = Technology Scores; X = vector of predictor variables; b = vector of coefficients.

Further, I test 5 log-linear fixed-effects models in total based on the above empirical framework.

- Models 1 through 3 load sequentially the log-transformed production input, agglomeration and organizational variables.
- Models 4 and 5 include interaction terms of mean-centered log-transformed variables.

3.4.4. Variables

As summarized previously in Table 3.1, presented below are technical notes on the construction of the variables used in this paper:

a. Capital-Labor Ratio: Calculated for techcat-state as the ratio of the invested capital to the factory floor workers from the 3-digit ASI tabulations for 1990, 1995, 2000 and 2005.

b. Skill Ratio: This is the ratio of skilled workers to factory floor for techcat-state calculated from the 3-digit ASI tabulations. Skilled workers are calculated as the difference between the total employment and factory floor workers.

c. Gini Coefficient: Used as a measure of localization economies that represents the spatial inequality of employment distribution within a state for each techcat-state category. The spatial distribution of employment for a given techcat-state category within each state was calculated from district-level employment estimated from the Economic Census of India microdata at the 4-digit NIC level. Further, the EC was carried out for the years 1990, 1998 and 2005, thus values for the years 1995-96 and 2000-01 were interpolated over time for the constructed techcat-state time series panel data.

   $\text{Gini} = \text{abs}\left[1 - {}^{n}\Sigma_{i=1} (\sigma y_{i-1} + \sigma y_{i}) (\sigma x_{i} - \sigma x_{i-1})\right]$

   Where i = district within state; σy_i = cumulative sum of percent shares of employment by district within a techcat-state category upto to the i^{th} distirct; x = cumulative sum of percent shares of equal distribution (or 1/n; where n = number of districts within a state) upto to the i^{th} district.

d. Herfindahl Index: Used as a measure of localization economies that represents the level of industry concentration or market competition within a state for each techcat-state category calculated from the unit-level data of the ASI.

$\text{Herfindahl} = {}^{n}\Sigma_{i=1} (S_i^{2})$

Where S_i = Employment Share of manufacturing unit i within techcat-state category.

e. Urban Location: Used as a measure of urbanization economies that represents the percentage of manufacturing activity by techcat-state within a state. This measure is developed from the Economic Census microdata.

f. Diversity Index: Used as a proxy measure of urbanization economies is an index of variety of manufacturing activity within urban areas of a state. This measure is calculated as weighted sum of district-level variety for each state, as given by an entropy index (see for example, Frenken, Hekkertb and Godfroijc, 2004).

$\text{Entropy}_d = - {}^{n}\Sigma_{d=1} p_d \ln (p_d)$

$\text{State Diversity Index} = \Sigma (\text{Entropy}_d * \text{Total Employment}_d) / \Sigma(\text{Total Employment}_d)$

Where p_d = Count variety by manufacturing category at the district-level; and Entropy_d = district-level entropy.

g. Average Age: Used as proxy for absorptive capacities, this variable measures the maturity of an industry (techcat-state) and it is calculated from the unit-level microdata of the ASI.

h. Average Firm Size: This is another proxy to test for absorptive capacities, calculated as the ratio of the number of factories by the total employees within a techcat-state category.

i. Rate of Entry: The percent share of firms under the age of 5 years in a given techcat-state category. The age cut-off was based on the time intervals of the panel data that establishes new entrants in a given time-period. This measure was calculated from the ASI unit-level microdata.

j. Import Propensity: Also established using the ASI unit-level microdata, this variable measures the share of imported inputs in the total inputs for production.

3.5. Descriptive Analysis

Summary statistics by each panel data year are shown in Table 3.3. Detailed trend tables over time for each study variable by state and techcat-state category are provided in Appendix C. The following trends are noted briefly.

As shown in Table 3.3, the mean values for the capital-labor ratio (inflation-adjusted) and the skill ratio display opposite trends for 1990, 1995 and 2000, with the skill ratio declining consistently at the national level. However, the capital-labor ratio shows a decline from 2000 to 2005, in inflation-adjusted rupees. The more sophisticated industry categories (techcat-state) display consistently higher skill ratios (Appendix Table C-2), like Electronics (0.7034), Pharmaceuticals (0.6330) and Technical and Photographic Equipment (0.5317).

For the agglomeration variables, the two localization measures – Gini and Herfindahl – show declining trends at the national level, as shown in Table 3.3. This lends support to the previously noted changes in technological scores in Stage-1 of the research, for deconcentration and spatial dispersion over time. The two urbanization variables – Urban Location and Diversity Index – also display declining trends at the national level. Share of manufacturing in urban locations shows considerable decline over the study period, while the Diversity Index (variety within urban areas) stays steady up to year 2000 and then declines sharply over the 2000 to 2005 study period. This suggests that the locational preference of manufacturing units for non-urban areas has increased consistently in the post-liberalization era. Further, the variety in types of industrial activity within urban areas is shown to decline over time, indicating a recent trend at the state-level toward specialization accompanied by dispersion of activities to rural areas.

Further, the overall manufacturing base displays increasing maturity as evidenced in the slight increase in the average age of firms over time. This is also accompanied with stable average factory size over time, as shown in Table 3.3. In this context, it is also interesting to note that at the national level the rate of firm entry, as measured by the percent of firms under age 5-years, has steadily declined over the study period.

At the outset, in combination with the observed status quo on unit-level economies of scale, the low rates of entry raise doubts over the effectiveness of the national liberalization reforms in encouraging employment growth, and larger welfare outcomes such as income distribution. However, firm formation rates display heterogeneity across states in the country (Appendix Table C-9). For example, in 2005, these rates range from a high of 42 percent in Himachal Pradesh to a low of 6 percent in West Bengal and 4 percent in Chandigarh.
Firm formation rates by techcat-state categories (Appendix Table C-9) are within a relatively narrow band of values (10 percent to 19 percent) in 2005, with the exception of Clothing and Accessories (30.2 percent), which is an important exports industry in India.

Additionally, as shown in Table 3.3, one also notices that the share of imported inputs into production have consistently increased over time. On the one hand, this increase is partly expected because of fewer restrictions on imports in the post-liberalization era, but on the other hand, this is cause for concern as falling domestic inputs might indicate the lack of domestic supplier capabilities and sourcing networks within the country. Imports are also important vehicles for embodied and codified technologies. Thus, sourcing imports is likely a necessity for firms' competiveness in the context of low levels of domestic and in-house capabilities.

Table 3.3: Descriptive Statistics by Techcat-state Panel Years

Variable	Obs	Mean	Std. Dev.	Min	Max
-> year2 = 1990					
Tech Score [1]	189	78.2	39.0	20.6	174.6
Capital-Labor Ratio [2]	189	764,884	890,133	23,523	9,166,599
Skill Ratio	189	0.4335	0.2594	0.1122	1.9327
Gini Coefficient	189	0.2431	0.2031	0.0000	0.8200
Herfindahl Index	189	0.1321	0.1557	0.0026	0.9870
Urban Location	189	0.6469	0.3104	0.0000	0.9989
Diversity Index	186	1.7753	0.2897	0.3648	2.4948
Average Age	189	14.5	5.5	0.0	35.5
Factory Size	189	75.5	78.8	4.8	860.5
Firm Formation Rate	189	0.2216	0.1452	0.0000	0.8000
Import Input	188	0.0685	0.0971	0.0000	0.4915
-> year2 = 1995					
Tech Score [1]	308	121.0	75.6	12.6	437.4
Capital-Labor Ratio [2]	308	1,124,334	1,160,969	19,077	9,299,533
Skill Ratio	308	0.4204	0.2212	0.0629	1.7907
Gini Coefficient	309	0.2142	0.1583	0.0000	0.6930
Herfindahl Index	309	0.1207	0.1377	0.0022	0.8200
Urban Location	309	0.5896	0.3391	0.0000	0.9995
Diversity Index	300	1.7725	0.3050	0.4966	2.3798
Average Age	309	16.4	6.6	0.0	56.3
Factory Size	309	79.4	57.6	0.0	357.2
Firm Formation Rate	309	0.1612	0.1396	0.0000	1.0000
Import Input	309	0.0935	0.1463	0.0000	0.9313
-> year2 = 2000					
Tech Score [1]	322	116.3	66.1	37.0	498.5
Capital-Labor Ratio [2]	322	2,283,380	7,632,824	21,696	98,700,000
Skill Ratio	322	0.4219	0.2104	0.0543	1.3512
Gini Coefficient	322	0.1958	0.1533	0.0000	0.7143
Herfindahl Index	318	0.1705	0.1705	0.0026	1.0000
Urban Location	322	0.4957	0.3446	0.0000	0.9993
Diversity Index	322	1.7473	0.3664	0.5757	2.4017
Average Age	322	15.9	7.3	0.0	51.1
Factory Size	322	69.6	74.0	5.8	804.9
Firm Formation Rate	322	0.1917	0.1757	0.0000	0.8333
Import Input	318	0.1613	0.1868	0.0000	0.9650
-> year2 = 2005					
Tech Score [1]	327	114.8	65.3	39.1	507.9
Capital-Labor Ratio [2]	327	2,120,659	4,911,426	68,919	57,500,000
Skill Ratio	327	0.4044	0.3207	0.0533	4.2653
Gini Coefficient	327	0.1807	0.1609	0.0000	0.8390
Herfindahl Index	327	0.1364	0.1366	0.0020	0.8651
Urban Location	327	0.4988	0.3289	0.0000	0.9987
Diversity Index	327	1.5169	0.2852	0.5512	1.9941
Average Age	327	17.8	7.2	4.3	54.4
Factory Size	327	75.3	69.7	5.4	591.8
Firm Formation Rate	327	0.1586	0.1383	0.0000	0.8571
Import Input	327	0.2755	0.2610	0.0000	1.0000

1. $10 per Capita
2. Rs.100,000 Invested Capital per worker

Source: Author.

3.6. Modeling Results

I ran a set of fixed effects models to explore the associations between the observed technology scores and a set predictor variables – production inputs, spatial and organizational. I report here results of two sets of fixed-effects models that were arrived at after running diagnostics and several preliminary regression models. The correlation matrices for the pooled study variables are presented as pure level variables and then also as log transformed variables in order to demonstrate the difference in the correlations before and after rescaling, as shown in Table 3.4 and Table 3.5.

In preliminary analysis, no significant associations were found using simple OLS regressions for pure level variables under either pooled or fixed-effects modeling, while using log-transformed variables showed significant associations under fixed-effects modeling. This confirmed the preliminary assumptions of the regression analysis that associations between technology scores and the predictor variables were likely to be one of marginal change or elasticities.

Further, Stata's Hausman Test provided validity that the fixed-effects approach would provide more efficient panel data estimators compared to a random-effects model. I also ran modified Wald statistics using the Stata 'xttest3' module (Baum, 2000), to check for group-wise heteroskedasticity for the fixed-effects model. The tests were significant to reject homoskedasticity for the standard error terms. As a result, I have used the robust standard errors specification for all the fixed-effects models used in this analysis

Table 3.4: Correlation Matrix for Variables – Levels (Pooled)

	Tech Score	Capital-Labor Ratio	Skill Ratio	Gini Coefficient	Herfindahl Index	Urban Location	Diversity Index	Average Age	Factory Size	Firm Formation Rate	Import Input
Tech Score	1.0000										
Capital-Labor Ratio	0.0012	1.0000									
Skill Ratio	0.2009	0.1181	1.0000								
Gini Coefficient	-0.0119	0.0187	0.0670	1.0000							
Herfindahl Index	0.0133	0.1436	0.1547	0.0151	1.0000						
Urban Location	0.0301	-0.0638	-0.0258	0.2237	-0.2160	1.0000					
Diversity Index	-0.0111	-0.0515	0.0865	-0.0410	0.0152	-0.0652	1.0000				
Average Age	0.1229	-0.0997	0.0461	-0.1038	-0.0666	0.1436	0.1738	1.0000			
Factory Size	0.0214	0.0725	0.0484	0.1514	0.1242	0.1613	-0.0086	-0.0240	1.0000		
Firm Formation Rate	-0.0297	0.0901	0.0529	0.1427	0.0371	-0.1613	-0.2333	-0.6180	-0.0313	1.0000	
Import Input	0.1553	0.3035	0.0232	0.0169	-0.0606	0.0307	-0.1470	-0.0346	0.1024	0.0436	1.0000

Source: Author.

Table 3.5: Correlation Matrix for Variables – Log Transformed (Pooled)

	Tech Score	Capital-Labor Ratio	Skill Ratio	Gini Coefficient	Herfindahl Index	Urban Location	Diversity Index	Average Age	Factory Size	Firm Formation Rate	Import Input
Tech Score	1.0000										
Capital-Labor Ratio	0.2159	1.0000									
Skill Ratio	0.3080	0.3945	1.0000								
Gini Coefficient	0.0295	0.0532	0.1094	1.0000							
Herfindahl Index	0.1100	0.1397	0.2503	0.1681	1.0000						
Urban Location	-0.0118	-0.1997	0.0798	0.0064	-0.0928	1.0000					
Diversity Index	-0.0058	-0.0899	0.0939	-0.0101	0.0547	0.0705	1.0000				
Average Age	0.0729	-0.1647	0.0481	-0.1910	-0.1385	0.3472	0.1162	1.0000			
Factory Size	-0.0053	0.1460	0.0203	0.0773	0.1461	0.0721	0.0260	-0.0416	1.0000		
Firm Formation Rate	-0.0922	0.1092	-0.0458	0.1576	0.0856	-0.2466	-0.0844	-0.7188	-0.0188	1.0000	
Import Input	0.2509	0.2374	0.0554	0.0459	0.1235	0.0392	-0.0627	0.0014	0.1086	-0.0168	1.0000

Source: Author.

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Fixed Effects with Log Variables

The results for three fixed-effects models using log-transformed variables are summarized in Table 3.6. I test for the impact of capital- and skill-intensity on the observed technology scores in Model 1. I find that capital-intensity shows significant positive association with technology. Though the coefficient on skill intensity is not significant, it shows a negative sign.

I load the set of spatial variables in Model 2. Significant negative associations are shown for measures of localization economies -- Gini and Herfindahl. The urbanization economy variables – Urban Location and Diversity -- are positive but not significant. Capital-intensity remains positive and significant.

In Model 3, I include the set of organizational variables. Among the organizational variables, Average Age and Import Input show significant positive associations with technology. Among spatial variables, the Herfindahl Index shows significant negative relationship, while the Diversity index becomes significantly positive over Model 2. Capital-intensity remains positive and significant.

Fixed Effects with Log Variables and Interactions

From the results in Table 3.6, we observe changing levels of significance and direction in some predictor variables. These results are further investigated with interaction terms in the next set of models, as shown in Table 3.7.

In order to run interactions under the fixed-effects approach, I first mean-centered the log-transformed predictor variables (See for example, Aiken and West, 1991 and Curran and Bauer, 2005). I use the Stata 'mcenter' module (Simon, 2004), which centers each variable at the grand mean for the panel data.

Table 3.6: Summary of Modeling Results, Models 1 to 3

Dependent Var = Tech Score	**Hypotheses**	**MODEL 1**	**MODEL 2**	**MODEL 3**
Constant		2.3107 *** (4.82)	1.6064 * (2.41)	0.2446 (0.28)
Capital-Labor Ratio	+	0.1639 *** (4.76)	0.1856 *** (4.43)	0.2224 *** (4.81)
Skill Ratio	+	-0.0562 (-1.38)	-0.0923 (-1.67)	-0.0974 (-1.56)
Gini Coefficient	?		-0.0441 * (-2.28)	-0.0351 (-1.79)
Herfindahl Index	-		-0.0598 ** (-2.89)	-0.0862 ** (-3.70)
Urban Location	+		0.0227 (0.64)	-0.0394 (0.90)
Diversity Index	?		0.1497 (0.95)	0.5726 * (2.43)
Average Age	+			0.1979 * (2.19)
Factory Size	?			0.0330 (0.77)
Firm Formation Rate (FFR)	+			0.0017 (0.05)
Import Input	+			0.0346 * (2.18)
R-Square: Within		0.0715	0.0991	0.1586
Between		0.0048	0.0003	0.0006
Overall		0.0167	0.0068	0.0227
No. of Observations		1,146	946	809
No. of Groups		339	296	276

1. t-statistic reported in parentheses.
   * p < 0.05 ; ** p<0.01 ; *** p <0.001

2. Models Used
   MODEL 1. Tech = f (Capital Intensity, Skill Intensity)
   MODEL 2. Tech = f (Cap Intensity, Skill Intensity, Spatial Vars)
   MODEL 3. Tech = f (Cap Intensity, Skill Intensity, Spatial Vars, Organizational Vars)

Source: Author.

Table 3.7: Summary of Modeling Results, Models 4 and 5

Dependent Variable = Tech Score	Hypotheses	MODEL 4	MODEL 5
Capital-Labor Ratio	+	0.1894 *** (4.37)	0.2217 *** (4.27)
Skill Ratio	+	-0.1258 ** (-2.13)	-0.1083 (-1.73)
Gini Coefficient	?	-0.0502 * (-2.46)	-0.0452 * (-2.20)
Urban Location	+	0.0194 (0.41)	0.0074 (0.17)
Diversity Index	?	0.2711 (1.53)	0.4576 (1.72)
Average Age	+		0.1961 * (2.14)
Factory Size	?		0.0296 (0.67)
Firm Formation Rate (FFR)	+		0.0071 (0.21)
Import Input	+		0.0289 (1.74)
INTERACTION TERMS			
Capital-Labor Ratio * Gini	?	-0.0008 (-0.03)	
Capital-Labor Ratio * Urban Location	?	0.0581 * (2.56)	
Capital-labor Ratio * Diversity	+	0.2984 * (1.99)	
Skill Ratio * Gini	+	0.0080 (0.18)	
Skill Ratio * Urban Location		0.0313 (0.47)	
Skill Ratio * Diversity	?	0.0322 (0.15)	
Average Age * Gini	?		0.0581 (0.68)
Average Age * Urban	?		-0.2023 (-1.55)
Average Age * Diversity	?		0.4047 (0.96)
Firm Formation * Gini	+		0.0417 (1.05)
Firm Formation * Urban	+		-0.1131 * (-1.98)
Firm Formation * Diversity	?		-0.0356 (-0.18)
Import Input * Gini	+		0.0046 (0.37)
Import Input * Urban	?		-0.0208 (-1.01)
Import Input * Diversity	?		0.1235 (-1.12)
R-Square: Within		0.1127	0.1618
Between		0.0001	0.0007
Overall		0.0181	0.0329
No. of Observations		897	809
No. of Groups		292	276

1. t-statistic reported in parentheses.
* $p < 0.05$; ** $p<0.01$; *** $p <0.001$

2. Models Used
MODEL 1. Tech = f (Capital Intensity, Skill Intensity, Locational Vars, Interactions)
MODEL 2. Tech = f (Cap Intensity, Skill Intensity, Locational Vars, Org Vars, Interactions)

Source: Author.

In Model 4, I test for the interactions of the production variables with the spatial variables. Of the interaction terms, urban location with capital-intensity and diversity with capital-intensity are positive and significant. Skill-ratio becomes negative and significant with the addition of the interactions with Gini, Urban Location and Diversity, which are all in the positive direction but not significant.

In Model 5, I interact the spatial variables with the organizational variables. The only interaction term that is significant is that of Firm Formation Rate with the Urban Location variable, which has a negative sign. Capital-intensity and average age are significant and positive, while the Gini Coeffcient is negative.

3.7. Findings and Conclusions

In this paper, I have attempted to explain India's post-reforms technological upgrading by examining how agglomeration economies in conjunction with industry-level organizational characteristics channel critical inputs into production, namely capital-intensity and skill-intensity. In doing so, I have uncovered several critical patterns.

It appears that manufacturing activities in India are dispersing out from urban centers into more rural areas in the post-reforms, as evidenced in the falling percentages in the urban location and localization Gini measures. However, for the most part, this dispersion is not driving technological upgrading.

The two main channels through which technological upgrading seems to have occurred in post-reforms India is through increases in capital intensity and through increases in imported inputs into production. Capital-intensity explains technology in interaction with location in urban areas and in diverse industrial settings. This suggests that even though the larger trend is one of dispersion out of urban areas, any upgrading that took place in the manufacturing sector in the post-reforms period was associated with urban areas.

At the same time, increasing localization economies (Gini measures) show significant negative but relatively small associations with changes in technology scores. This could be interpreted to mean that some share of the upgrading scores is associated with dispersion. However, this factor becomes non-significant in the presence of the imported inputs variable. From the policy imperative, it is important to understand the reasons behind this dispersive trend. Several studies point to institutional rigidity, for example regarding land markets, that deter location within urban areas.

One aspect of this institutional rigidity is evidenced in the negative association between technology scores and the interaction term of firm-formation rates with urban location, meaning that new firms that are able to locate in urban areas do not necessarily contribute to technological upgrading. Assuming that firms within more sophisticated industries are likely also those that are able to afford the costs of urban location in order to access skilled labor. How can low-tech industries afford urban locations? The above trend could potentially mean that land markets are imperfect and that political economy factors play a major role in property rights allocation, especially in the context of high land prices.

In this context, the inability to access a skilled urban labor force is likely deterring potential growth in the technologically more sophisticated industries. This is indicated by the fact that skill-intensity is not a significant factor in technological upgrading. Further, the sign for this variable is consistently negative, which indicates that manufacturing in India is extremely standardized, and the accumulation of human capital could be a remnant of the License-Raj era.

It is actually baffling that skill accumulation has not translated into technologically sophisticated products.

At the same time, skill-intensity shows non-significant but positive signs for interaction terms with the localization and urbanization economies variables. This underscores the larger trend of the declining importance of urban centers in manufacturing in being able to affect technological upgrading. In this connection, as also noted earlier, lowering firm formation rates and stable factory size indicate a status-quo situation in the manufacturing sector, raising doubts over the effectiveness of the national liberalization reforms in encouraging employment growth and the associated welfare outcomes.

The above analysis indicates institutional blockages in facilitating the matching of demand and supply of competences into production through locational choice. Some of these matching mechanisms could potentially relate to land markets and infrastructure, skill development, and the presence of a local supplier base. Development policy in India needs to recognize the important role played by agglomerated urban centers in facilitating economic change. Urban development policy in India seems to be obsessed with the call-center and software service economy, which arguably has lower infrastructure requirements, much to the neglect of the manufacturing sector, which has greater employment potential across the skills spectrum.

For Indian manufacturing to upgrade and compete internationally in the global economy, the importance of accessing skilled urban labor force can hardly be overemphasized. Additionally, the larger role of an urban-centered revitalized manufacturing sector in generating employment should become an urgent priority for industrial policy-makers in the country. Further, there appear to considerable blockages in the realization of efficiency and innovation boosts from localization and urbanization economies. These blockages could be due to state-level urban-system patterns, which influence skilled migration into urban areas and in the fundamental institutional conditions operating within states that determine urban and regional developmental priorities. These factors are further analyzed in the concluding paper of this dissertation (Paper 3).

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CHAPTER 4

PAPER 3: Mediating Impacts of Urban Systems and Regional Political Contexts on Agglomeration Economies in Upgrading

4.1. Introduction

The role of economic concentration in anchoring and sustaining industrial development is now well established in the regional literature, which highlights positive externalities from matching, sharing and learning (Duranton and Puga, 2004). Further, regional industrialization occurs in step with urbanization, as manifested in industrial and residential location patterns and their ongoing transactions over space. The effectiveness of urban agglomerations, in this regard, is impacted by the menu of locational choice given constraints internal to the urban region, including land rents, land availability and assembly, mobility, and to some extent, quality of life (Cf. Storper, van Marrewijk, and van Oort, 2012).

An external dimension impacting the effectiveness of urban agglomeration economies is the structure of the larger urban system within a state or a country, where the complementing role of primary and secondary cities supports industrial dynamism by expanding the menu of locational choice. Critically, the evolution of urban systems is steered by the allocation of resources for infrastructure and services, as a function of the relative importance attached to primary and secondary areas by political institutions, as represented by the type of local governments and political coalitions. This issue is of great significance to developing countries where urban systems tend to be dominated by very large primary cities besought with unique issues. In particular, these issues include negative externalities from over-crowding resulting in inadequate land assembly, and infrastructure and services provision for industrial and residential location (Henderson, 2002; Fan and Scott, 2003; Scott and Storper, 2003; and Venables, 2005). It follows that the innovation challenge for developing countries is one of sustaining scale-related urban agglomeration economies, while at the same time dissipating the adverse impacts of over-crowding over a more diversified urban-system [4]. The interplay of urban systems and regional politics has a direct bearing on the effectiveness of urban agglomeration economies in sustaining regional and national industrial development.

In this paper, I investigate across states of India the impacts of urban systems and regional politics on the effectiveness of urban agglomeration economies in sustaining innovative output. I examine the impact of this relationship on technological upgrading in the manufacturing sector at the industry-state level in the post-economic reforms era (1990-2005) [5]. Though several studies examine the role of external economies in the Indian context, especially over the last decade [6], there are practically no studies that systematically evaluate the impact of evolving urban-systems on innovation across states within the country.

This paper builds on the findings from preceding stages of my research show that any technological upgrading in the manufacturing sector was positively associated with urbanization economies but negatively with localization economies (Paper 2 of this dissertation). Upgrading was significantly associated with capital-intensity and imported inputs in interaction with urbanization economies. However, at the same time, aggregate technological upgrading outcomes were hampered by the inability of more firms to locate within urban areas, as observed in a dispersive trend out from urban to rural areas (See for example, Ghani, Goswami and Kerr, 2012). These findings point to negative externalities, as often attributed to inadequate and

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[4] For analytical purposes I use the terms 'diverse' and 'diversified' to contrast with 'primate' and 'primacy', respectively.

[5] This is the third paper of my 3-paper dissertation research, where the overall project makes the case that national policies do not have uniform technological upgrading effects across the country, as pre-existing regional industrial and institutional conditions influence pathways of upgrading over geography.

[6] Pioneering studies in the Indian context include studies by Arup Mitra and his collaborators, and several studies by Sanjoy Chakravorty, Uwe Deichmann, Soumik V. Lall and Anthony Venables, as individual and team contributions.

heterogeneous supply of land, services and infrastructure across Indian states (See for example, Doughtery et al., 2008; Gupta, Hasan and Kumar, 2010; and Lall, Wang and Deichmann, 2010). In this context, the emergence and development of secondary cities could alleviate problems associated with overcrowding given over-burdened land, infrastructure and services in primary cities.

Further, the growth of secondary cities could also facilitate the formation of a diverse human capital pool through in-migration, with lower barriers to residential relocation compared to purely urban primate systems. Even though the Constitution of India does not restrict mobility of persons within the country, this has blind-sided perceptions of the actual and practical hardships faced by internal migrants (UNESCO-UNICEF, 2012). The emergence of secondary urban locations with specific human capital endowments could act as a locational sorting mechanism for manufacturing by the degree of sophistication and product variety (See for example, Henderson, 2002). A diversified urban-system increases the probability of the match between the demand and supply of specific competences into production, thus sustaining industrial dynamism.

Finally, the emergence of secondary cities is influenced by the politics of development. Studies have suggested that rent seeking in developing countries favors urban concentration and primacy through the maintenance of status quo by power elites in capital and major cities (Ades and Glaeser, 1995; and Davis and Henderson, 2003). It follows that democracy and decentralization play a key role in the spatial distribution of infrastructure and services beyond existing large urban centers. Additionally in India, with the retreat of the federal government from local economic planning in the post-reforms era, state-level factors including politics have become increasingly important (Chakravorty, 2011). In this regard, given the corporatist and clientelist nature of the Indian political system, the composition of state political majorities and their time consistencies are crucial determinants of patterns of the politics of resource allocation across the country.

At a more fundamental level, policy priorities and their time consistencies are reflective of the underlying process of bridging disparate interests and political ideologies within governing majorities. On the other hand, society-wide compromises and coalitions (bridging) are offset by strong community-affinities (bonding) and associated group interests. The interplay of bonding and bridging potentiates fundamental dimensions of the regional institutional context for economic and technological transformation (Storper, 2005). So, while "bonding enhances the potential for autonomy and builds the capacities of actors to find a place in the economy, bridging tends to limit their potential opportunism and make them more responsible in the exercise of their autonomy" (pp. 43). Thus, levels and mix of bridging and bonding result in the balance between autonomy and responsibility/accountability, which in the context of democracy, at the most abstracted level is observed in the nature and type of regional (state) governments elected to office. The emerging possibilities along a continuum of high-low bonding-bridging dimensions result in a variety of government types. So at the extremes, while high levels of society-wide bridging results in greater accountability and transparency, excessive community-based bonding could result in a self-perpetuating cycle of electing governments characterized by political monopolization and high levels of rent seeking. Thus, development priorities and favors to specific groups are an outcome of the interplay between bridging and bonding institutions.

The above set of arguments suggests that urban systems that are less urban primate are more conducive to sustaining technological upgrading over the long-run by mediating favorably with locational opportunities and human capital formation to match the needs of an evolving manufacturing base. In this regard, the nature of regional politics– whether it results in political power distribution over time -- is likely to impact the shape of urban systems and migration, and thereby technological upgrading. A few major questions emerge in the Indian context regarding the effective leveraging of urban agglomeration economies in conjunction with its regional covariates highlighted in the preceding discussion.

a. Does urban-primacy hinder technological upgrading in manufacturing in Indian states?

b. Are more diverse state urban systems (less urban-primate) more conducive to skilled migration thus impacting manufacturing upgrading?

c. Do regional political contexts, as measured by political majorities and their time consistencies, impact upgrading by mediating urbanization and migration patterns?

The next section further elaborates on the above research questions and the empirical strategy employed for the analysis. Section 4.3 presents the results of the statistical analysis, followed by conclusions in Section 4.4.

4.2. Research Questions and Hypotheses

I propose that states that have structured urbanization away from large primary centers to secondary urban areas have presented favorable upgrading conditions by enhancing industrial location and labor pooling options. Secondly, diverse urban-systems are more favorable to skilled migration compared to congested mega urban centers. Lastly, regional political contexts, as represented by political majorities and their time consistencies, mediate urbanization and migration patterns. I explore the above propositions through a series of questions.

4.2.1. Urban Systems Structure

a. Does urban-primacy hinder technological upgrading in Indian manufacturing?

As stated earlier, the trade-off between the benefits of agglomeration and costs of over-concentration influences the locational choice of industries [7]. Cities that are of excessive size tend to draw resources away from productive and experimental activity to addressing quality of life issues (Henderson, 2003 and Duranton and Puga, 2001). Further, Henderson (2002) observes that city-size variety within a system of cities reflects product-variety, with innovative and emerging industries always invariably located in large urban areas where information is thick and easily accessible. While large urban areas have more diverse economies, smaller cities in mature urban systems (developed countries) tend to be specialized. Further, it has been noted that larger cities in developing countries play a crucial role in technology imports and adaptation (Henderson, 2010). In the Indian context, Deichmann et al. (2008) find evidence that skill-intensive industries show greater concentration in primary metropolitan areas and that the share of manufacturing increased fastest in secondary cities and areas adjacent to the primary cities [8]. This suggests that state urban systems with competitive secondary cities lend dynamism to the manufacturing-base by matching product cycle and variety with locational opportunities. However, it is unclear whether urban primacy in the aggregate has a net negative or positive impact on upgrading, in light of the various trade-offs involved.

H1*: Technological upgrading in India maybe inversely related to urban primacy.*

b. When do benefits of size/concentration start to be weighed down by primacy in impacting technological upgrading?

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[7] Scholars have compared levels of urbanization in developing countries at equivalent historical stages of development to their developed counterparts (Moomaw and Shatter, 1996). Based on this, several studies have concluded that levels of urbanization in developing countries far exceed those of developed countries at similar stages of development. In other words 'over-urbanization' in developing countries is not growth-related, but reflective of other structural push and pull factors including the decline of rural employment.

[8] Interestingly, Kundu and Sarangi (2005) have noted that smaller cities in India experienced a large decline in population over the decade of the 90s due to the lack of employment opportunities. This further underscores the critical role of the intermediate tiers of urban hierarchy in anchoring regional development.

From above, it is likely that the relationship between urban primacy and technological upgrading is not smooth but rather dependent on the interaction between levels of urban size/concentration and urban systems diversity. Henderson (2003) has suggested that there is a 'best degree' of urban concentration, in terms of maximizing productivity growth, and that this varies with the level of economic development and country size[9]. On the cost side, Henderson (2002) has estimated that an increase in city size from 250,000 to 2.5 million (a ten-fold increase) results in 80 percent increase in commuting costs and housing rental prices. Similarly, in the Indian context, Mitra (2000) finds that the productivity benefits of urbanization economies (measured as urban population and urban manufacturing) are only evident after crossing certain minimum size. Further, the impact of urbanization economies is found to be significant up to certain size thresholds after which diseconomies outweigh agglomeration benefits. Further, increasing same industry concentration (as a measure of localization economies) may not necessarily correlate with technological sophistication or upgrading in the Indian context because this might be a function of the supply-side constraints on infrastructure and services limiting locational opportunities. However, this relationship might also depend on other factors, including urban size, migration trends and institutional conditions.

H2: *Technological upgrading might be impacted by external economies conditional on the interaction between threshold limits of urban size and urban systems diversity.*

4.2.2. Skilled Migration

a. Are more diverse state urban systems (less urban-primate) more conducive to skilled migration thus impacting manufacturing upgrading?

[9] This best degree of urban primacy is characterized by higher degree of concentration in the initial phase of development followed by deconcentration (Williamson, 1965).

The matching of human competences with production needs determines regional technological trajectories (Rodriguez-Pose and Vilata-Bufi, 2005). Migration data capture this dynamic process by indicating the ongoing augmentation of existing human capital stock with new skills and ideas (Crescenzi, Rodriguez-Pose and Storper, 2007 and 2012). The question of whether urban primacy itself influences in-migration rates is not discernible from existing literature. It is suggested that in developing countries migrants experience a high premium on relocation to primary cities due to restrictions imposed by power elites to prevent overcrowding (Henderson and Wang, 2007).

In the Indian context, studies suggest that migration has shifted from agricultural rural to rural movements to an accelerated trend toward rural to urban movements (Dev and Evenson, 2003; and Srivastava and Bhattacharyya, 2003) [10]. The housing market in large Indian cities is highly segregated along income lines where only high wage earners can afford market-rate housing in concentrated job centers. Given that manufacturing typically employs a diverse workforce, a highly segmented housing market creates a spatial mismatch of housing and jobs. Further, low wage migrants in large urban areas in India face institutional hardships including procuring identity cards to access subsidized government services (UNESCO-UNICEF, 2012). These factors make migration to primary urban areas prohibitive. The emergence of secondary urban areas could potentially alleviate cost of living and quality of life issues thus sustaining a diverse workforce toward manufacturing growth and upgrading.

H3*: Technology upgrading could be impacted by in-migration rates in interaction with the development of secondary urban areas.*

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[10] By 2011, about 31 percent of the total population in India was urban, compared to 28 percent in 2001 and a large portion of this increase was explained by migration (Bhagat, 2011).

4.2.3. Regional Political Context

a. Do regional political contexts, as measured by political majorities and their time consistencies, impact upgrading by mediating urbanization and migration patterns?

Further, I examine the direct and mediating impacts of regional (state) political contexts on technological upgrading. As explained earlier, regional political contexts are reflective of the underlying interplay between community-based bonding and society-wide bridging, which are the first order institutional conditions of economic and technological growth (Storper, 2005)[11]. Observed regional power sharing arrangements result from trade-offs or the effective exertion of influence of group interests (bonding) and coalition formation (bridging), determining levels of accountability, transparency and rent-seeking behavior exhibited by local governments. Further, bonding and bridging conditions potentiate functional policy domains of economic development pertaining to micro-economic efficiency, social distributional arrangements, and effective problem solving (Rodrik, 2003, as adopted by Storper, 2005). Thus, political power arrangements carry regional development (distributional) consequences by shaping economic priorities and resource allocation decisions. Here, I proxy state political contexts with measures for political majorities and their time consistencies.

State political contexts may influence technological upgrading directly through the stability of the rules environment, including those concerning land use allocation, industrial promotion and labor deregulation, which have spatial selection effects in favoring specific activities and locations (See for example, Besley and Burgess, 2003; Chakravorty, Koo and Lall;

[11] This question relates to a larger issue in the development literature that examines the incentive structures of economic action and resulting outcomes, grouped broadly into formal and informal aspects of institutions. The emphasis of these two traditions is different and over the years has resulted in a vibrant debate on the mechanisms of economic growth. More recently, work in economic geography seeks to bridge this dichotomy advancing the framework of 'bonding and bridging' between economic actors giving shape to a diversity of institutional arrangements (Storper, 2005).

2005; and Bhattacharjee, 2006). Thus, we would expect to see the beneficial impacts of the rules environment through the net impact of economic activity on technological, say as captured by the association of firm-formation rates with upgrading.

Secondly, state political contexts may also indirectly influence upgrading through its mediating impacts on urbanization and migration patterns, and thereby the effective leveraging of urban agglomeration economies. It is observed that in developing countries, non-democratic forms of government with centralized and authoritarian rule encourage urban primate systems, as does political instability in a democracy (Ades and Glaeser, 1995; and Davis and Henderson, 2003). In the Indian context, recent work on the political economy of public expenditures indicates an orientation towards rent seeking and that electoral competition does not translate to public investments driven by productivity or efficiency concerns but rather to consolidate electoral vote banks (See for example, Chibber, 1995; Besley et al., 2004; and Khemani, 2010)[12].

In this connection, the formation of political majorities in state governments influences regional development priorities in reflection of intra-state spatial representation and the ensuing competition for rent extraction benefits. However, it is not known whether greater contestation or political stability mediates urbanization and the growth of secondary urban agglomerations in explaining technological upgrading. While competition can act as a strong check and balance against entrenchment of power, it can also stifle legislative action for a broader developmental

[12] Chibber (1995) observes that increasing political competition beginning in the mid-60s, challenging the ruling Indian National Congress, resulted in growth of government subsidies aimed at consolidating electoral support but at the expense of undercutting resources available for development projects. Similarly, Khemani (2010) presents evidence at the national and state levels of a mismatch arising from the low levels of capital spending and high levels of infrastructure demand from poor voters. This is interpreted to lend support to the phenomenon of infrastructure projects being used at the margin for political rent-seeking, while spending on social programs were used to generate jobs to secure votes for re-election. In a similar vein, analyzing village and household surveys from three states in South India, Besley et al. (2004) find that public goods with high spillover effects are usually located near elected representatives, while group affinity mattered most for the allocation of goods with low spillovers.

agenda (Aghion, Alessina and Trebbi, 2004). It is possible that the length of a regime, as represented by the Chief Minister's tenure, may be based on clientelist policies aimed at preserving political monopoly – a situation of high bonding but low bridging. Larger coalitions may represent strong regional factions that spatially redistribute development – a balance of bonding and bridging. Further, state politics can influence in-migration trends, as regional parties in India tend to be less tolerant to migrants, as embodied in 'sons of the soil' movements (UNESCO-UNICEF, 2012).

H4: *The mediating impacts of political contestation and stability on urbanization and migration patterns on technological upgrading are not known*

H5: *The direct impact of political contestation and stability on upgrading through the rules environment are not known*

4.3. Empirical Approach and Measures

In investigating the above questions, I have augmented the industry-state time series cross-sectional dataset from the previous stage of analysis (Paper 2 of this dissertation), which included the technology outcome measure and the industry-state explanatory variables (1990, 1995, 2000 and 2005), with state level variables lagged by two-years for each point in time (1988, 1993, 1998 and 2003). Among the explanatory variables, the industry-state variables analyzed in Paper 2 included measures for production inputs (capital and skill intensity), agglomeration characteristics (localization and urbanization economies) and industry characteristics (firm formation rate), while the lagged state-level characteristics being added in the current stage (Paper 3) include intra-state urbanization measures (size and primacy), migration characteristics, and regional political contexts.

4.3.1. Panel Structure

The panel structure consists of 16 possible industry categories or techcat (i) located in 13 major states of India (s), which have repeated measurements over 4 points in time (t). As shown in Table 4.1, the total units of observations (n = ist) in this unbalanced panel dataset are 727 distributed over a maximum of 204 techcat-state categories (is) over the study period. The selected 13 states, as shown in Figure 4.1, comprised nearly 80 percent of India's manufacturing output in 2005. These states form a reduced dataset from the larger panel dataset used in Paper 2, and were selected based on the following criteria:

a. In the descending order of manufacturing output in 2005, as found in the larger dataset constructed from the Annual Survey of Industries (ASI) tabulations;
b. Availability of data for industry-level variables of interest over the span of the study period 1990-2005 and for the estimated state-level lagged explanatory variables utilizing the official Census of India and National Sample Survey Data (NSSO) data over the 1983 to 2007 time period;
c. Continuity in the geographical units of analysis, which in this case meant maintaining the state political boundaries from the point of view of testing the state-level political variables.

4.3.2. Modeling Strategy

I have employed the fixed effects time-series panel data approach. The general form of the relationship conceived between the technology score and the industry- and state-level variables is presented as below:

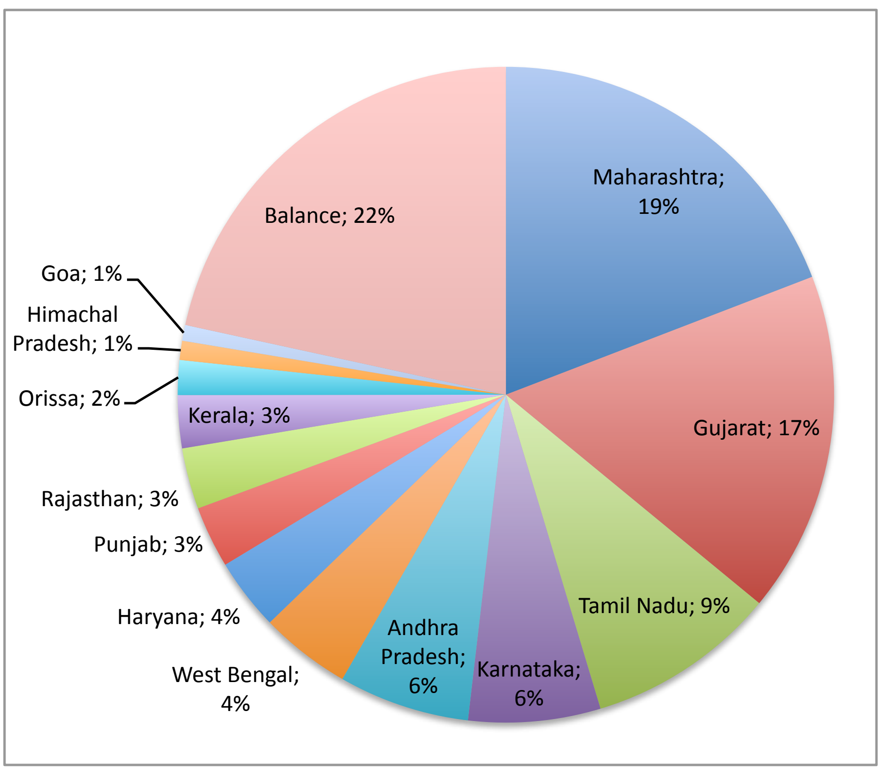
Tech Score = f (production inputs, agglomerations, urban systems, skilled migration, regional political context)

Table 4.1: Panel Structure Industry Observations (Techcat) by Year and State

State	1990	1995	2000	2005	Total	Maximum
Andhra Pradesh	11	16	16	16	59	16
Goa	7	12	16	15	50	16
Gujarat	11	16	16	16	59	16
Haryana	11	16	16	16	59	16
Himachal Pradesh	6	14	13	13	46	14
Karnataka	11	16	16	16	59	16
Kerala	11	16	16	16	59	16
Maharashtra	11	16	16	16	59	16
Orissa	9	14	10	10	43	14
Punjab	11	16	16	16	59	16
Rajasthan	10	15	16	16	57	16
Tamil Nadu	11	16	16	16	59	16
West Bengal	11	16	16	16	59	16
Total	131	199	199	198	727	204

Source: Author

Figure 4.1: Percentage of India Manufacturing Output for Sample States, 2005



Source: Author

In panel data analysis, the fixed-effects approach is employed to obtain consistent coefficient estimates for the explanatory variables by explicitly taking into account the effects of unobserved variables (See Wooldridge, 2012). It does so by decomposing the total error term into 2 parts, where one part is the time invariant individual fixed effect (v_i) and the other is the usual idiosyncratic error term (e_{it}) (Equation 1). The fixed-effects approach provides consistent beta coefficients by making the assumption that the unobserved time invariant individual effects (v_i) are correlated with the explanatory variables. The second assumption made is one of strict exogeneity, in that the idiosyncratic error term (e_{it}) is uncorrelated to the explanatory variables and the unobserved individual effects in the same time period.

I have implemented the fixed effects modeling approach using Stata's xtreg command, which utilizes the following series of equations that fit a range of models including the fixed-effects 'within-estimator', the group averaged 'between-estimator' and the random effects estimator, which is a weighted average of the within and between estimators (Stata Corp, 2012).

The general model fitted by xtreg to estimate the beta estimators is as follows:

$$y_{it} = a + x_{it} b + [v_i + e_{it}] \qquad (1)$$

Where; i = panel id; t= year; v_i = fixed techcat-state residual; and e_{it}= error term; y_{it} = technology score for group i in time t; x_{it} = predictor variables for group i in time t; b = vector of coefficient

The above equation when averaged over time results in the following group-meaned equation:

$$y_i = a + x_i b + v_i + e_i \qquad (2)$$

Where; i = panel id; v_i = fixed techcat-state residual; and e_i= error term; y_i = technology score averaged for group I; x_i = group averaged vector of predictor variables; b = vector of coefficient

In order to estimate the fixed-effects model, xtreg differences out the time invariant fixed-effects in the above models by subtracting (2) from (1):

$$(y_{it} - y_i) = (x_{it} - x_i) b + (e_{it} - e_i) \qquad (3)$$

Where; i = panel id; t= year; v_i = fixed techcat-state residual; and e_{it}= error term; Y = technology score vector; X = vector of predictor variables; B = vector of coefficient

Equation (3) forms the basis for the xtreg fixed-effects calculation of the within-group estimator. A final procedure in the above modeling process involves accounting for the problem of heteroskadasticity in the error terms, which might result in biased coefficient estimates. This problem is addressed by estimating Heteroskadasticity Consistent Standard Errors (HCE) by employing the robust standard errors specification with the Stata xtreg command.

4.3.3. Variables

The variables used in this analysis are described in detail in Table 4.2 along with their data source, while Table 4.3 provides summary measures. The detailed estimations at the state-level for each variable used in the regression analysis is presented in Appendix D. Presented below are technical notes on the construction of these variables:

Technology Score: This is the dependent variable at the *techcat-state* level as an indicator for technological change over 4 points in time, constructed for each state technology category as an output weighted grouping of technology scores calculated at the 3-digit National Industrial Classification (NIC) codes. These scores were calculated by utilizing information on revealed sophistication of Indian exports in US imports with respect to all other world exports, as obtained from Kemeny (2010).

Capital-Labor Ratio: Calculated for *techcat-state* as the ratio of the invested capital to the factory floor workers from the 3-digit ASI tabulations grouped to *techcat-state*.

Skill Ratio: This is the ratio of skilled workers to factory floor for *techcat-state* calculated from the 3-digit ASI tabulations grouped to the 16 possible *techcats*. Skilled workers are calculated as the difference between the total employment and factory floor workers.

Table 4.2: Description of variables

Variable Category	Coding Level	Years	Variable name	Details	Source
Outcome Variable					
Technology Score	Industry-state	1990, 1995, 2000 and 2005	**Tech Score**	Constructed from price-based scores of Indian exports for Indian 3-digit manufacturing National Industrial Classification (NIC) codes and aggregated to 16 larger technology categories (techcat).	Author, based on revealed price-based export sophistication data for India obtained from Kemeny (2010).
Explanatory Variables					
Production Inputs	Industry-state	1990, 1995, 2000 and 2005	**Capital Intensity**	Invested Capital per Worker (constant 2005 Rupees)	Author, based on Annual Survey of Industries, 1990-2005.
			Skill Intensity	Ratio of skilled workers, defined as the balance of total employees less factory workers, divided by factory workers.	See Above
Industry Agglomeration Measures	Industry-state	1990, 1995, 2000 and 2005	**Localization Economies**	Gini Coefficients for state-tech from district-level employment data.	Economic Census of India (EC) unit-level microdata for 1990, 1997 and 2005, interpolated for 1995 and 2000.
	Industry-state	1990, 1995, 2000 and 2005	**Urbanization Economies**	Shannon Entropy Index for state-tech developed from district-level employment data	See Above
Urbanization (Urban Agglomeration Population)	State	1988, 1993, 1998 and 2003.	**Urban Agglomeration Gini**	Gini Coefficient of population distribution of urban agglomerations within a state	Author, based on Census of India, 1981-2011 urban agglomeration data, obtained from Thomas Brinkhoff: City Population, http://www.citypopulation.de
			Urban Primacy Ratio	Ratio of population share of state's primary agglomeration (UA1) and popualtion share of sum of next two agglomerations (UA2+3).	See Above
			Population Level Dummies	Dummy variables for centiles of population for UA1 and UA2+3 based on the pooled national distribution of agglomeration population	See Above
			Urban Primacy Ratio Dummies	Dummy variables for centiles of Urban Primacy Ratio based on pooled national distribution.	See Above
Migration (Urban)	State	1988, 1993, 1998 and 2003.	**Interstate Migration**	Percent of total urban population reported to have migrated to present place of residence from another state in India.	Author, based on the India National Sample Survey Organization (NSSO) employment survey micro-data obtained from IPUMS-International Minnesota Population Center.
			Migrant Higher Ed Attainment	University educational attainment of migrant urban population within state.	See Above
Regional Political Context	State	1988, 1993, 1998 and 2003.	Rule Vote Percent	Percentage of electoral votes secured by ruling coalition of the current government in the state-assembly elections.	Author, based on Election Commission of India reports on state elections for each year by state during the study period.
			Seat Percent in Assembly	Percentage of seats secured by ruling coalition of the current government in the state-assembly.	See above
			Seats to Rule Vote Ratio	Ratio of the percent seats in state assembly to the percent of electoral votes secured by the ruling coalition, as defined above.	See above
			Chief Minister's Length of Tenure	Number of days in office of the current chief minister of the state.	Author based on various interent sources, including news archives and Wikipedia ®
			In Federal Government Dummy	Dummy variable for ruling state party support to national federal government in the Indian Parliament in the current year.	See above
			Political Ideology Dummies	Dummy Variables for orientation of the leading party of the ruling coalition for left-leaning, regional interests, centerist (Indian National Congress), and right-leaning (Hindu nationalists).	See above

Source: Author

Table 4.3: Summary Description of Study Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
STATE-TECHCAT LEVEL					
Technology Score (Outcome Variable)	727	111.10	69.36	12.61	507.88
Capital Intensity (Constant Rupees per factory workers)	727	1,775,119	5,176,808	21,696	98,700,000
Skill Intensity (Ratio of Skilled Employees to Factory Workers)	727	0.44	0.28	0.06	4.70
Localization Economies (Specialization Gini Index)	727	0.22	0.16	0.00	0.82
Urbanization Economies (Diversity Index)	727	1.71	0.26	1.05	2.40
Firm Formation Rate over 5-years (Percent)	727	16.2%	12.0%	0.0%	80.0%
STATE-LEVEL					
Population of Primary Agglomeration in State (UA1)	727	4,257,888	4,510,941	83,028	16,800,000
Population of Rank 2 plus Rank 3 Agglomerations in State (UA2+3)	727	1,794,205	1,387,650	0	6,221,658
Urban Primacy Ratio (UA1/UA2+3)	681	2.29	2.26	0.54	10.30
Urban Inter-state Migration Rate (Percent of Total State Urban Population)	727	9.3%	6.3%	2.4%	22.7%
Total Higher Education Rate (Urban Population)	727	7.5%	3.3%	1.2%	17.4%
Migrant Higher Education Rate (Urban Population)	727	10.8%	2.6%	6.3%	17.2%
Seat to Vote Ratio	727	1.45	0.34	0.00	1.93
Chief Minister's Tenure (Days)	727	2057.84	1845.38	0.00	8540.00

Source: Author

Localization External Economies: This concept is represented by a measure of spatial inequality of employment distribution within a state for each *techcat-state* category. The spatial distribution of employment for a given *techcat-state* category within each state was calculated from district-level employment estimated from the Economic Census of India (ECI) microdata at the 4-digit NIC level. Further, the ECI was carried out for the years 1990, 1998 and 2005, thus values for the years 1995-96 and 2000-01 were interpolated over time for the constructed techcat-state time series panel data.

$$\text{Gini} = \text{abs}\left[1 - {}^{n}\Sigma_{i=1} (\sigma y_{i-1} + \sigma y_i)(\sigma x_i - \sigma x_{i-1})\right]$$

Where i = district within state; σy_i = cumulative sum of percent shares of employment by district within a techcat-state category upto to the i^{th} distirct; x = cumulative sum of percent shares of equal distribution (or 1/n; where n = number of districts within a state) upto to the i^{th} district.

Urbanization External Economies: This concept is represented by an index of variety in manufacturing activity within urban areas of a state. This measure is calculated as weighted sum of district-level variety for each state, as given by an entropy index (see for example, Frenken, Hekkertb and Godfroijc, 2004).

$$\text{Entropy}_d = - {}^{n}\Sigma_{d=1} \, p_d \ln(p_d)$$

State Diversity Index = Σ (Entropy$_d$ * Total Employment$_d$)/ Σ(Total Employment $_d$)
Where p $_d$ = Count variety by manufacturing category at the district-level; and Entropy $_d$ = district-level entropy.

Firm Formation Rate (FFR): The percent share of firms under the age of 5 years in a given techcat-state category. The age cut-off was based on the time intervals of the panel data to estimate the number of 'new' entrants in a given time-period. This measure was calculated from the ASI unit-level microdata. Although, the ASI survey is not a census, the choice of using this source was informed by the availability of the age characteristic variable, which cannot be ascertained using in the ECI. Further, the relatively shorter intervals for the ASI microdata compared to the ECI, avoids to the extent possible having to interpolate intermediate data points. I employ the FFR variable to provide a proxy measure for the effectiveness of the rules environment in the state in fostering industrial location.

Intra-State Urbanization Patterns: I have employed two sets of variables representing different concepts pertaining to intra-state urbanization patterns in examining their main and mediating impacts on technological upgrading. These variables are developed from data on the distribution of within-state urban agglomeration (UA) population over UAs of size 100,000 or more in 2011. The data are from four decadal India censuses – 1981, 1991, 2001 and 2011 -- obtained as compiled by City Population (2012).

a) The first set of urban agglomeration variables consists of two continuous measures, an intra-state UA Gini index measure and a measure of urban primacy (Urban Primacy ratio). The intra-state UA Gini variable represents the concept of urbanization spread within a state, and it is a constructed *index* of the continuous distribution of UA population with the state, depicted as follows:

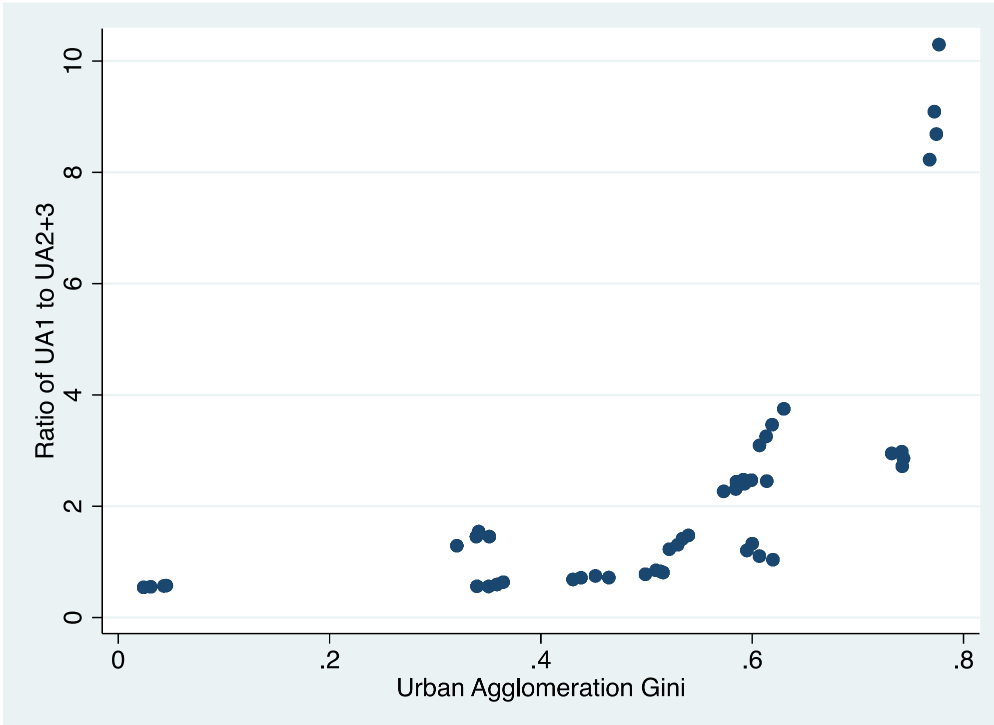
$$\text{UA Gini} = \text{abs}\left[1 - {}^{n}\Sigma_{i=1} (\sigma y_{i-1} + \sigma y_{i}) (\sigma x_{i} - \sigma x_{i-1})\right]$$

Where i = urban agglomeration within state; σy_i = cumulative sum of percent shares of population by urban agglomeration upto to the i^{th} agglomeration; x = cumulative sum of percent shares of equal distribution (or 1/n; where n = number of agglomerations within a state) upto to the i^{th} agglomeration.

The Urban Primacy Ratio variable represents the concept of urban-systems structure and it is calculated as the ratio between the population of the primary agglomeration (UA1) in the state and the sum of next two (UA2+3). Figure 4.2 shows the relationship between the above ratio (urban systems structure) and the urban agglomeration gini (urbanization spread).

b) The second set of variables includes threshold measures that examine the relative impact of UA size on external economies. These include percentile distribution of UA1 and UA2+3 on their respective pooled national distributions over the entire study period, as shown in Table 4.5. In other words, the range of the respective UA1 and UA2+3 percentile scale is determined by the minimum and maximum value of the UA1 and UA2+3 population over the entire study period. In the context of modeling, there is movement of each UA1 and UA2+3 observation along this national population percentile scale over the entire study period, and therefore threshold effects are captured appropriately in the fixed-effects panel regression context.

Figure 4.2: Relationship between Urban Primacy Ratio and Urbanization Spread



NOTE: 1. UA1 = Primary Urban Agglomeration (UA); UA2+3 = Sum of Second and Third UA
2. Urban Primacy Ratio = Population UA1/Population U2+3.
3. Urbanization Spread denoted by Urban Agglomeration Gini measure.
Source: Author

Table 4.4: Percentile Distribution of State UA1 and UA2+3 in National Pooling

Percentile	Primary Urban Agglomeration (UA1)	Second and Third Urban Agglomeration (UA2+3)
10	134,591	183,217
20	702,974	729,831
30	1,113,885	1,107,136
40	1,367,313	1,358,399
50	2,472,730	1,568,099
60	4,161,174	1,676,003
70	5,230,099	2,079,088
80	6,261,037	2,520,962

Source: Author

Skilled Migration: Two migrant population related variables at the state-level include the percent of urban population that moved into the state from another state or Inter-state Migration*,* and the Higher Education Attainment levels of total urban migrant population within the state.

a) Inter-state migration rates were calculated from the NSSO National Employment and Unemployment surveys microdata for 1987-88 (NSS 43d Round) and 1999-2000 (NSS 57th Round), as obtained from the IPUMS-international program of the Minnesota Population Center, and the published NSSO 'Migration in India' report for 2007-08 (NSS 64th Round). Data for the panel years were calculated by interpolating within the available data points. The question asked in the survey is whether the person moved to her/his current residence from another location where she/he lived previously continuously for more than 6 months.

b) Migrant Higher Education Attainment levels were developed from available data using a combination of the NSSO National Employment and Unemployment surveys microdata and published reports, as cited above. This variable measures the percent of urban migrant population with college degrees and above in a state for the given panel year.

Regional Political Context: The idea that regional political contexts emerge from the interplay of bonding and bridging forces, which in turn shape distributional policies, would have ideally required the measurements representing these two individual institutional dimensions. Using these measures, one would then have constructed indexes representing the type and nature of local government. However, I have been limited by the availability of data in employing such a strategy. Instead, I have used a parallel construct by measuring the end outcome of these unobserved underlying dynamics, as embodied in the character of the state government, as represented by measures for state political majorities and their time consistencies. The impacts of these observed measures then enable us to make qualified deductions regarding the impacts of the latent institutional processes. Two variables developed for this purpose include a ratio of the ruling coalition's percent seats in the state assembly to the percent share of popular votes (Seat to Vote Ratio), and the length of the state Chief Minister's tenure.

a) The variable 'Seat to Vote Ratio' is constructed from data obtained from state assembly reports published by the Election Commission of India (EC) for the study time period. This variable provides a measure of the level of contestation for political power, as a higher ratio is indicative of greater contestation in a winner-take-all situation. Extending this logic further, a higher ratio would also mean that intra-state regional interests and issues find greater accommodation within the elected ruling coalition ensuing from increased competition for popular votes.

b) The second variable developed here is the length of tenure of the Chief Minister in power for coalitions formed over the study period. This variable is a measure of time continuity in the policy and rules environment of the state. Additionally, this variable tells us about the possible impacts of political monopoly over lengthy tenures. This information is compiled from a variety of web resources including Indian newspapers and Wikipedia ®.

c) Also included are dummy variables for the co-presence of the state ruling party in the ruling coalition at the Federal level and for political ideology – centrist (Congress and allies), left (communist and socialist), right (Hindu nationalists) and regional (state-level) parties over the study period.

4.4. Modeling Results

As explained previously, I apply the fixed-effects panel data modeling approach to examine the main and mediating impacts of state-level urbanization patterns, skilled migration and institutional predictor variables on technological. These variables augment models from the preceding stage of research (Paper 2) that included variables on production inputs, agglomeration economies (localization and urbanization economies) and firm formation rate. These regression models explored the relationships between the outcome and predictor measures as log-transformed variables, as tests of level variables did not show significant impacts. Thus, it was concluded that the associations between technology scores and the predictor variables were likely to be one of marginal change or elasticities. The correlation matrix of the modeled variables is shown in Table 4.4.

Further, Stata's Hausman Test provided validity that the fixed-effects approach would provide more panel data estimators compared to random-effects. I also ran a modified Wald statistics using the Stata 'xttest3' module (Baum, 2000), to check for group-wise heteroskedasticity for the fixed-effects model. The tests were significant to reject homoskedasticity for the standard error terms. As a result, I have used the robust standard errors specification for all the fixed-effects models used in this analysis.

Three groups of fixed-effects models are presented, each with varying combinations and types of explanatory variables. A common set of explanatory variables used in these models includes four *techcat-state* level variables, namely capital-labor ratio, skill-ratio, localization economies and urbanization economies.

Table 4.5: Correlation Matrix of Log-transformed Variables

	Technological Score	Capital Intensity	Skill Intensity	Localization Economies	Urbanization Economies	Firm Formation Rate	Urban Population Agglomeration Gini	Urban Primacy Measure	Interstate Migration Rates	Migrant Higher Education	Chief Minister's Tenure	Ruling Seats to Popular Vote Ratio
Technological Score (ST)	1.000											
Capital Intensity (ST)	0.248	1.000										
Skill Intensity (ST)	0.304	0.356	1.000									
Localization Economies (ST)	0.004	0.018	0.133	1.000								
Urbanization Economies (ST)	0.026	-0.029	0.134	-0.003	1.000							
Firm Formation Rate (ST)	-0.095	0.076	-0.035	0.073	0.028	1.000						
Urban Population Agglomeration Gini (S)	-0.071	-0.089	0.026	0.017	-0.383	-0.169	1.000					
Urban Primacy Measure (S)	-0.038	0.002	0.089	0.022	0.037	-0.119	0.578	1.000				
Interstate Migration Rates (S)	0.000	0.130	0.116	-0.011	0.317	-0.066	-0.371	-0.122	1.000			
Migrant Higher Education (S)	0.202	0.195	-0.115	-0.119	-0.094	-0.247	-0.053	0.168	0.002	1.000		
Chief Minister's Tenure (S)	-0.061	-0.120	-0.081	-0.034	-0.031	-0.111	0.101	0.346	-0.212	0.207	1.000	
Ruling Seats to Popular Vote Ratio (S)	-0.033	-0.102	-0.077	0.034	-0.238	-0.141	0.122	0.109	-0.087	-0.054	0.140	1.000

NOTE: 'ST' denotes that the variable is defined at the technology category and state level.
'S' denotes that the variable is defined at the state level.

Source: Author

As shown in Table 4.6, in the first group of models (1 through 7), I examine the main impacts of urban size and structure on technological scores and mediation of these urbanization patterns on the impact of external economy variables on technological scores. In the second group of models (8 through 14), as shown in Table 4.7, I examine the mediating impacts of urban size and structure on the impact of skilled migration on technological scores. In the final group of models (15 through 20), I examine the main impacts of the regional political context variables on the technological scores and the mediating impacts of regional political context on urban structure and skilled migration, as shown in Table 4.8. The last of these models introduces the measure of firm formation rate as a proxy for checking the impact of the rules environment.

4.4.1 Urban Primacy and Structure

In the first set of models explored, as shown in Table 4.6, controlling for continuous measures of urbanization spread (Urban Agglomeration Gini) and structure (Urban Primacy Ratio), I find that the main effects of localization economies have a consistently negative effect on technological upgrading, while urbanization economies have a positive impact but non-significant impact (Models 1 to 3).

Table 4.6: Fixed Effects Models -- Agglomerations and Urban Systems

Dependent Variable = Tech Score	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7
STATE-TECHCAT LEVEL							
Capital Intensity	0.219 *** (4.09)	0.231 *** (4.01)	0.224 *** (3.86)	0.211 *** (3.86)	0.212 *** (4.31)	0.214 *** (4.04)	0.204 *** (3.75)
Skill Intensity	-0.158 *** (-2.71)	-0.161 *** (-2.62)	-0.152 *** (-2.52)	-0.149 *** (-2.52)	-0.148 *** (-2.58)	-0.146 *** (-2.51)	-0.133 *** (-2.31)
Localization Economies (Specialization)	-0.048 ** (-2.05)	-0.048 ** (-1.98)	-0.052 ** (-2.35)	-0.111 (-1.02)	-0.132 ** (-2.47)	-0.098 ** (-2.40)	-0.114 *** (-3.34)
Urbanization Economies (Variety)	0.360 * (1.72)	0.350 (1.55)	0.318 (1.36)	0.244 (0.90)	0.226 (0.85)	0.54** (2.13)	0.334 (1.36)
STATE-LEVEL							
Urban Agglomeration Gini		0.001 (0.00)					
Urban Primacy Ratio		0.067 (0.18)	0.152 (0.38)				
STATE-LEVEL DUMMY VARIABLES							
UA1 Population-level Dummies							
20th percetile				0.204* (1.76)			
30th percetile					0.207** (2.29)		
40th percetile						0.128** (1.97)	
60th percetile							0.176** (2.04)
INTERACTION TERMS							
Urban Primacy Ratio * Localization Economies			0.036 (0.91)				
Urban Primacy Ratio * Urbanization Economies			-0.121 (1.36)				
UA1 Level Dummy * Localization Economies				0.067 (0.60)	0.105 * (1.86)	0.730 (1.54)	0.135 *** (3.30)
UA1 Level Dummy * Urbanization Economies				0.182 (0.50)	0.354 (0.95)	-0.366 (-1.03)	-0.022 (0.07)
R-Squared							
Within	0.1153	0.1207	0.1235	0.1220	0.1432	0.1265	0.1451
Between	0.0024	0.0033	0.0034	0.0019	0.0045	0.0034	0.0036
Overall	0.0234	0.0222	0.0201	0.0202	0.0285	0.0283	0.0297
Number of Observations	667	628	628	667	667	667	667
Groups	204	190	190	204	204	204	204

1. t-statistic reported in parentheses.
* p < 0.10 ; ** p<0.05 ; *** p <0.01

Source: Author.

However, in testing the impact of population percentile thresholds for UA1, I find specific levels at which the above impacts gain significance (Models 4 to 7). Both localization and urbanization economies are non-significant at the 20th percentile level of UA1. The negative impacts of localization economies become significant at the 30th percentile, while the positive impacts of urbanization economies become significant at the 40th percentile, and later, non-significant at the 60th percentile. Interestingly, at the margins, the interaction between the UA1 60th percentile threshold and localization economies is positive and significant, suggesting that industrial clustering occurring within the larger urban agglomerations in India does have a positive impact on technological upgrading.

In models not shown here, the impact of UA 2+3 percentile thresholds follow similar signs as in the UA1 case, where the two external economy variables gain significance beyond the 50th percentile. Additionally, the mediating interaction effect of UA2+3 threshold at the 70th percentile with localization economies is significant and positive. The marginal effects of the interactions between external economies and size thresholds on technological upgrading are further explored next controlling for migration and the regional political variables.

4.4.2. Skilled Migration

As shown in Table 4.7, I further test the impact of urbanization on technological upgrading outcome scores in mediation with inter-state immigration and its educational attributes (Models 8 to 14).

Table 4.7: Fixed Effects Models -- Agglomerations, Migration and Urban Systems

Dependent Variable = Tech Score	MODEL 8	MODEL 9	MODEL 10	MODEL 11	MODEL 12	MODEL 13	MODEL 14
STATE-TECHCAT LEVEL VARIABLES							
Capital Intensity	0.200 *** (3.34)	0.187 *** (3.02)	0.184 *** (2.90)	0.1741 *** (3.01)	0.1800 *** (3.22)	0.174 *** (3.11)	0.179 *** (3.15)
Skill Intensity	-0.092 (-1.50)	-0.071 (-1.15)	-0.064 (-1.05)	-0.074 (-1.23)	-0.072 (-1.31)	-0.062 (-1.08)	-0.079 (-1.33)
Localization Economies (Specialization)	-0.037 (-1.57)	-0.0331 (-1.44)	-0.040 * (-1.66)	-0.115 (-1.03)	-0.115 *** (-2.86)	-0.080 (-1.18)	-0.065 * (-1.89)
Urbanization Economies (Variety)	0.739 *** (3.12)	0.981 *** (3.32)	0.924*** (3.18)	0.79 *** (2.62)	0.830 ** (2.51)	0.793*** (2.64)	1.031 *** (3.85)
STATE-LEVEL VARIABLES							
Urban Primacy Ratio	0.167 (0.43)	0.128 (0.33)	0.212 (0.52)				
Inter-state Migration	-0.059 (-0.58)	-0.110 (-1.06)	-0.094 (-0.70)	-0.265 (-1.51)	0.021 (0.13)	-0.183 (-1.15)	-0.178 (-1.63)
Total Higher Education Rate	0.322 *** (3.51)	-0.023 (-0.15)					
Migrant Higher Education Rate		0.516 ** (2.09)	0.478 *** (3.26)	0.482 *** (3.33)	0.373 ** (2.41)	0.427 *** (2.95)	0.481 *** (3.38)
STATE-LEVEL DUMMY VARIABLES							
UA1 Population-level Dummies							
20th percetile				-0.176 (-0.68)			
60th percetile					-0.014 (-0.19)		
UA 2+3 Population-level Dummies							
30th percetile						0.278* (1.91)	
70th percetile							0.363 ** (2.06)
INTERACTION TERMS							
Urban Primacy Ratio * Localization Economies			0.026 (0.62)				
Urban Primacy Ratio * Urbanization Economies			-0.125 (-0.53)				
Urban Primacy Ratio * Inter-state Migration			-0.035 (-0.32)				
UA Level Dummy * Localization Economies				0.085 (0.75)	0.134 *** (2.94)	0.048 (0.70)	0.085 * (2.13)
UA Level Dummy * Urbanization Economies				0.291 (0.85)	-0.186 (-0.61)	0.193 (0.58)	-0.399 (-1.06)
UA Level Dummy * Inter-state Migration				0.242 (1.16)	-0.190 (-0.98)	0.281 (1.38)	0.398 * (2.05)
R-Squared							
Within	0.1584	0.1708	0.1836	0.1705	0.1839	0.1791	0.1775
Between	0.0072	0.0138	0.0222	0.0113	0.0173	0.0091	0.0105
Overall	0.0324	0.0382	0.0550	0.0458	0.0598	0.0365	0.0376
Number of Observations	602	602	641	641	641	641	641
Groups	190	190	204	204	204	204	204

1. t-statistic reported in parentheses.
* p < 0.10 ; ** p<0.05 ; *** p <0.01

Source: Author.

In these models, while the main effects of inter-state immigration do not show up as significant, the interaction between inter-state migration and the UA 2+3 dummy at the 70th percentile shows up as having a positive and significant impact on upgrading. After controlling for immigration and education, the interaction of UA1 and UA 2+3 dummies with localization economies have a positive and significant impact on technological upgrading at higher percentile thresholds.

Most significantly in these models, the main effect of immigrant higher education on technological upgrading rates is consistently positive and highly significant. The main effects on an average of urbanization economies on upgrading remain positive and significant after accounting for urban size and structure, and migration characteristics.

4.4.3. Regional Political Context

In the next set of models (Models 15 to 20), shown in Table 4.8, I examine the impacts of state political majorities and their time consistencies. These variables include a measure of state political contestation - the number of popular votes per state assembly seat won by the winning coalition (Seat to Vote Ratio) - with higher ratios indicating greater competition in a winner-take-all situation. The second variable utilized is the state Chief Minister's tenure length representing policy continuity and time consistency, the adverse extreme of which also represents political monopoly. These variables are interacted with variables capturing urban-systems characteristics and inter-state migration to estimate the impacts of localization and urbanization economies on upgrading. Other variables used are dummies for political ideology and the ruling coalition's presence in the federal government.

Table 4.8: Fixed Effects Models – Agglomerations and Regional Political Context

Dependent Variable = Tech Score	MODEL 15	MODEL 16	MODEL 17	MODEL 18	MODEL 19	MODEL 20
STATE-TECHCAT LEVEL VARIABLES						
Capital Intensity	0.186 *** (3.00)	0.187 *** (3.18)	0.183 *** (3.13)	0.184 *** (3.24)	0.182 *** (3.22)	0.236 *** (4.19)
Skill Intensity	-0.081 (-1.29)	-0.081 (-1.32)	-0.079 (-1.28)	-0.075 (-0.239)	-0.072 (-1.14)	-0.172 *** (-2.69)
Localization Economies (Specialization)	-0.035 (-1.52)	-0.034 (-1.43)	-0.031 (-1.30)	-0.034 (-1.42)	-0.034 (-1.38)	
Urbanization Economies (Variety)	0.930 *** (3.27)	0.998 *** (3.36)	1.246 *** (3.26)	1.199 *** (2.93)	1.244 *** (2.87)	
Firm Formation Rate						-0.063 * (-1.69)
STATE-LEVEL VARIABLES						
Urban Primacy Ratio	0.273 (0.73)	0.382 (0.97)	0.586 (1.44)	0.726 * (1.64)	1.19 ** (2.18)	0.188 (0.49)
UA 2+3 Population					0.355 (0.55)	
Inter-state Migration	-0.109 (-1.01)	-0.165 (-1.44)	-0.160 (-1.40)	-0.158 (-1.20)	-0.204 (-1.55)	
Migrant Higher Education Rate	0.485 ** (3.40)	0.477 ** (3.33)	0.16 *** (3.22)	0.554 *** (2.95)	0.540 *** (2.78)	
Seat to Vote Ratio	-0.060 (-0.52)	-0.105 (-0.80)	-0.094 (-0.74)	-0.150 (-1.02)	-0.038 (-0.28)	-0.140 (0.99)
Chief Minister's Tenure Length	-0.054 * (-1.91)	-0.054 (-1.64)	-0.071* (-1.86)	-0.094 ** (-2.18)	-0.115 ** (-2.54)	0.070 *** (2.36)
STATE-LEVEL DUMMY VARIABLES						
Political Ideology						
Left		-0.227 *** (-2.69)	-0.340 *** (-3.02)	-0.374 *** (-2.90)	-0.393 *** (-2.90)	
Right		0.040 (0.76)	-0.057 (-0.76)	-0.022 (-0.25)	-0.044 (-0.47)	
Regional		-0.059 (-1.14)	-0.119 ** (-2.11)	-0.108 (-1.41)	-0.094 ** (-1.17)	
In Federal Government			-0.112 (-1.55)	-0.118 (-1.59)	-0.122 (-1.54)	
INTERACTION TERMS						
Chief Minister's Tenure * Urban Primacy Ratio				-0.095 * (-1.66)	-0.024 (0.11)	-0.047 (-0.88)
Chief Minister's Tenure * UA 2+3 Population					-0.085 (-0.62)	
Chief Minister's Tenure * Immigration				-0.049 (-0.477)	-0.052 (0.72)	
Chief Minister's Tenure * Firm Formation Rate						-0.015 (-0.33)
Seat to Voter Ratio * Urban Primacy Ratio				0.119 (0.42)	-2.007 ** (-2.01)	0.486 ** (1.93)
Seat to Voter Ratio * UA 2+3 Population					-0.832 * (-1.74)	
Seat to Voter Ratio * Immigration				-0.189 (-0.66)	0.1131 (0.41)	
Seat to Voter Ratio * Firm Formation Rate						0.210 (1.04)
R-Squared						
Within	0.1766	0.1900	0.1964	0.2047	0.2103	0.1371
Between	0.0074	0.0053	0.0030	0.0024	0.0013	0.0031
Overall	0.0242	0.0195	0.0101	0.0079	0.0036	0.0195
Number of Observations	602	602	602	602	602	602
Groups	190	190	190	190	190	190

1. t-statistic reported in parentheses.
* p < 0.10 ; ** p<0.05 ; *** p <0.01

Source: Author.

As shown in Table 4.8, the main effect of the length of Chief Minister's Tenure on technological upgrading is consistently and significantly negative, while the main effects of political contestation (Seat to Vote Ratio) are not significant. However, the interaction of political contestation with the Urban Primacy Ratio and UA2+3 population growth has a significant negative impact on technological upgrading. The impact of the interaction term between Chief Minister's tenure and urban primacy ratio is also found to have significant and negative impact of technological upgrading. Inter-state migration interacted with the political context variables do not show up as significant. After accounting for the regional political context variables and their interaction with urban systems and migration, the main impacts of localization and urbanization economies on technological upgrading do not display any marked changes from the previous groups of model runs.

Among the political ideology dummies, with the Indian National Congress as the reference political category at the center, left and regional ideology governments do not seem to associate positively with upgrading. Additionally, whether or not a state ruling political party is part of the ruling coalition at the national level seems not to have any significant bearing on upgrading outcomes at the state-level in its main effects.

The main effects of urbanization economies and urban primacy ratio on technological upgrading are positive and significant in a maximum model after accounting for secondary urban growth, migration and political ideology. Further, as a simple test of the rules environment in a model restricted to urban systems and regional political context, I find no significant main or interaction results of firm formation rates with either of the two regional political variables in explaining technological upgrading.

4.5. Conclusions

In this paper, I examined the role of regional factors in mediating the effectiveness of urban agglomeration economies -- localization and urbanization economies -- in explaining India's post-reforms technological in delicensed manufacturing. These regional covariates included urban-systems structure and growth, skilled migration and the regional political context, as represented by political majorities and their time consistencies. The following conclusions are made based on the preceding analyses that have addressed the questions presented at the beginning of the paper.

Urban Primacy and Structure

Infrastructure and services deficiencies are often cited as major bottlenecks constraining economic growth in India, and that of the Indian manufacturing sector, in particular (See Doughtery et al., 2008; Gupta, Hasan and Kumar, 2010; and Lall, Wang and Deichmann, 2010). Studies also cite periodic swings in investment priorities at the federal and state levels between urban and rural areas, and consequently that infrastructure and public services in India's urban areas have fallen significantly, not keeping pace with urban growth (See Becker, Mills and Williamson, 1986; and Rao and Bird, 2010).

From the preceding quantitative analyses, it emerges that in the Indian context, the significant negative association of industrial concentration with technological upgrading on an average are indicative of across-the-board infrastructure and services deficiencies, which severely constrain locational choice, regardless of urban size distinctions and industrial sophistication. In other words, on the whole, industries appear to cluster around available limited infrastructure and not because of positive externalities associated with 'matching, sharing and learning'.

At the same time, results also indicate that in the larger to largest agglomerations in the country, industrial clustering is shown to positively impact technological upgrading at the margins, aligning with more classical ideas regarding agglomeration economies. It follows that, subject to data availability on infrastructure and services at the urban agglomeration level, the concept of negative externalities and over-crowding are more appropriately represented by density measures rather than absolute size measures in the Indian context. For example, it is possible that infrastructure and services provision are much higher on an area or per capita basis in primary agglomerations compared to other urban areas.

The positive impacts of urbanization economies are found to be more in line with the association of positive externalities with absolute size measures, subject to certain size thresholds, and then, as shown in the results, controlling for migration at the higher thresholds.

Skilled Migration

Higher education attainment rates of immigrant population are consistently among the most significant and positive variables influencing technological upgrading in the Indian context, in line with conventional conceptions of the role of human capital in economic change. Further, results show that increases in inter-state migration in interaction with secondary urban areas (UA2+3) at higher size thresholds positively impact technological upgrading suggesting that larger secondary urban agglomerations offer conducive residential options to high-skilled immigrants.

Regional Political Context

In this paper, I have theoretically framed regional political contexts as interplay between the first-order institutional dimensions of bonding and bridging. From the empirical standpoint, I capture inter-state heterogeneity in regional political contexts using measures for political majorities (seat to vote ratio) and time consistency/monopoly (Chief Minister's tenure length). Using these measures, the results of the foregoing empirical analyses in this paper allow us to make some qualified deductions regarding the impacts of the unobserved first-order institutional dimensions on urbanization and technological trends in India.

It appears that the mediating impact of the two regional political variables on urbanization structure and growth does not associate positively with the needs of manufacturing upgrading; in fact the relationship goes in the other direction. Political majorities and their time consistencies, emerge in their main and mediating effects to be correlated with other unobserved time variant factors that positively explain urban primacy and growth in secondary cities but are inversely associated with upgrading in the manufacturing sector. These unobserved time variant factors could include changing competition for resources from other sectors of the economy and possibly associated with greater rent extraction opportunities.

After accounting for these interactions, urban primacy ratio in its main effect emerges with positive impacts on upgrading and this association gets stronger with inclusion of growth in secondary urban areas. I conclude that what we are observing here is a strong indication that, at the margins, the largest primary urban agglomerations in India indeed contribute positively to technological upgrading.

The apparent lack of attention to the needs of the manufacturing sector suggests ongoing issues with problem-solving and social distribution policy at the state level. These conditions are typically associated with institutional conditions emerging out of low levels of bridging and high levels of group interests influencing resource allocation and policy priorities. Ironically, the above conditions of low bridging and high bonding self-select political systems that favor limited political contestation, resulting in a vicious cycle of political entrenchment and continued assertion of group interests (Cf. Aghion, Alesina, and Trebbi 2004).

In this connection, the negative main effect of the length of Chief Minister's tenure on upgrading possibly suggests that the lack of competition or increased political monopoly removes the urgency and pressure to deliver on developmental promises [13]. This corresponds to political autonomy with little transparency and accountability, characterizing low bridging and high bonding (See Storper, 2005). A complementing explanation of the actual mechanics of clientelism could be that during a lengthy tenure different interest groups are favored periodically but not consistently due to political compulsions and resource limitations[14]. I extend this to imply that lag structures get created on the effective realization of public resource investment in a particular target venture, in this case the effective development of infrastructure and services in secondary urban areas for manufacturing. Further, it could very well be that manufacturing was not a favored group during the study period relative to other industries with higher returns on investment like information technology or real estate development.

The suggested nexus in the preceding discussion between state-level politics and regional development finds grounding in the complexities surrounding limited revenue-raising capabilities of urban local governments in India, which makes state government transfers to local

[13] Though high levels of political insulation could actually also alleviate hold up problems related to the implementation of development policies involving technical elites, the above observed adverse impacts in the Indian case suggest a strong connection between the use of power in conjunction with interest group politics.

[14] Prof. Sudipta Kaviraj, Columbia University, suggested this possibility to me in a personal meeting on August 13, 2012.

urban bodies critical for regional development (See Rao and Bird, 2010). However, intra-state transfers further suffer from upstream complexities in federal-state relations, marked by a lack of clear and predictable demarcation of expenditure allocations (See Cashin and Sahay, 1996; and Martinez-Vazquez and Rider, 2006). With federal fiscal policies targeting social development indicators through the 5-year planning process, one finds significant divergence in infrastructure capital expenditures across states in India (Kalirajan and Otsuka, 2012). Given these constraints, it is not surprising state political majorities use available resources at the margin for political mileage and rent extraction purposes.

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CHAPTER 5

Conclusions

5.1. Overview

Contemporary economic globalization presents developing countries with both opportunities and challenges in realizing economic development. On the one hand, due to technological improvements, there is greater international movement of goods, services, people, and to some degree, knowledge and ideas. On the other hand, trade and development is not homogenously distributed. North-north movement of goods driven by product quality and variety dominates international trade. Secondly, patterns of north-south exchanges evolve as a matching process within global value chains between the demand for and supply of specific competences into production, with the latter being strongly grounded in locational characteristics. Thus, thinking about the global economy as a mosaic of transacting nation states is limiting, as the actual sites of economic activity are regional (sub-national) economies with specific capabilities. Here in lies the development challenge for emerging countries -- the fostering of regional technological capabilities so as to capture increasing and more sophisticated portions of global economic exchange.

In this connection, regional technological capabilities evolve over time due to the confluence of several factors. The role of spatial concentration of economic activities, as embodied in regional economies, is often framed in terms of the impacts of agglomeration economies on efficiency and innovation, and as repositories of tacit knowledge, skills and ideas that cannot be codified and disseminated. In developing countries, this issue is further complicated by the process of urbanization, which exerts pressure on existing land, infrastructure and services through overcrowding that prevents firms' ability to locate and access agglomeration economies. Secondly, in conjunction with the larger development literature, institutions are increasingly thought of as the fundamental cause of long-term economic growth. Thus, regional industrial capabilities evolve in concurrence with regional institutions that facilitate micro-economic efficiency and demonstrate problem-solving capabilities to adapt to new demand circumstances. For emerging countries, the development task remains one of fostering regional agglomeration capabilities given the deleterious impacts of over-urbanization, and ascertaining the capacities of existing institutional arrangements in facilitating desired economic outcomes. Interestingly, it is precisely this lack of understanding of existing institutional capacities and its inter-regional heterogeneity within the same country, that often undermines the efficacy and intended consequences of national policy initiatives like market liberalization reforms – these are not silver bullets.

Through this dissertation, I have attempted to shed light on the above set of issues by employing the case of the manufacturing sector of India in the post-1991 market reforms era that involved policy initiatives to delicence (liberalize) industrial activity, and which were implemented with the purpose of opening India to global economic opportunities. Here, I capture regional capabilities in terms of the observed technological sophistication of industrial output at the state-level. In tracing the trajectory and influences on evolving regional technological upgrading over time, the analytical core of this dissertation comprises regional agglomeration economies and its interactions with other regional covariates. The major regional covariates examined in this study are organizational characteristics, urbanization and migration patterns, and regional political contexts. Further here, I summarize the main findings of the study and the accompanying policy implications. Additionally, I discuss the limitations of the current study in terms of scope and methodology, and identify future areas of research.

5.2. Major Findings

This research indicates that the national delicensing reforms did not result in significant technological upgrading outcomes in India's manufacturing sector, coinciding with the declining importance of manufacturing in urban areas. This decline is ostensibly due to locational blockages and pressures of urbanization on the limited supply of land and regional infrastructure, which undermine the effective leveraging of agglomeration economies toward upgrading. An examination of regional political contexts suggests competing priorities for urban development to the neglect of the upgrading needs of the manufacturing sector. The above points are discussed here further.

Regional Heterogeneity in Upgrading Outcomes

This study demonstrates that inter-regional variations in technological upgrading correlate with the heterogeneity in regional and industry level characteristics in the post-reforms era India. At the outset, technological sophistication at the national level for overall manufacturing in India has declined steadily in the post-reforms era, driven primarily by the lessening sophistication of delicensed manufacturing. Lower groups tend to display technological declines over time indicating that technological upgrading outcomes differ by the sophistication level of industries. Further, the delicensed group shows lower scores for industries at higher tiers of technological sophistication compared to overall manufacturing This seems to indicate that increased competition – the policy intention of market reforms - has not encouraged technological output in either the higher technological areas or in increasing technological sophistication across delicensed activity. This might possibly be due to distance-to-frontier selection effects, whereby domestic capabilities do not take advantage of liberalized imports and trade regime, and from the presence of multi-national entry. These connections are speculative for now and beyond the current scope of study, requiring measures for distance-to-frontier by industry of domestic firms and data on multi-national location by regions.

The geographical spread of industrialization across the country in the post-reforms era in deregulated industries is in areas of lower technological sophistication. This proposition is supported by evidence of convergence in scores for delicensed industries at the state-level but to lower levels of technological scores in the post-liberalization era. Inter-state divergence and convergence dynamics are driven by differential industrial responses to the reforms. In this connection, high technology activities in overall manufacturing have sustained or grown in only a few pockets of the country. These states either contain or are contiguous with the largest urban agglomerations in India – Mumbai, Delhi, Chennai and Bangalore (Kolkata shows up as an exception). The growth of medium to lower technological industries appears to be relatively more evenly dispersed in the country.

Urban Location and Agglomeration Economies

In examining the regional factors impacting technological upgrading, I have positioned the role of agglomeration economies at the analytical core of this research. Evidence from the analysis suggests that the existing advanced technological capabilities found in large urban agglomerations in protected industries do not translate to comparable sophistication levels in the growing deregulated segments of manufacturing over time. This points to lack of localized knowledge transfers possibly due to blocked locational attributes or ineffective regional institutional arrangements that fail to recognize and build on existing capabilities.

This coincides with trends that show that manufacturing activities in India are dispersing out from urban centers into more rural areas in the post-reforms era. The two main channels through which technological upgrading seems to have occurred in post-reforms India is through increases in capital intensity and through increases in imported inputs into production. Both these factors explain technological upgrading in interaction with location in urban areas and in diverse industrial settings (urbanization economies). This suggests that even though the larger trend is one of dispersion out of urban areas, any upgrading that took place in the manufacturing sector in the post-reforms period was associated with the ability to draw on urban location and its associated advantages.

At the same time, increasing localization economies (spatial concentration) within a given industry show significant negative but relatively small associations with changes in technology scores in their main effects. Interestingly, this offers further clues on locational difficulties and the effects of over-urbanization. I interpret this to mean that the observed levels of same-industry concentration, which theoretically should be a sign of positive externalities (efficiency and innovation spillovers), in fact, occur due to a lack of more widely available regional supply of infrastructure and services forcing over-crowding at few locations, and selects firms across the technological spectrum.

This study also indicates that skill-intensity is not a significant factor in technological upgrading, which is further cause for concern. In fact, the sign for this variable is consistently negative in its main effects, which indicates that manufacturing in India is extremely standardized, and the accumulation of human capital could be within previously regulated industries - an artifact of a bygone era. However, in its interaction effects, skill-intensity shows non-significant but positive signs with the localization and urbanization economies variables. This further underscores lost opportunities in the context of the larger trend of declining importance of manufacturing in urban centers, which is afflicting technological upgrading at the aggregate level.

Regional Covariates mediating Agglomeration Economies

From the policy imperative, it is important to understand the reasons behind the above-mentioned blockages in urban location and agglomeration economies. As examined in this research, I find evidence for the mediating impacts urbanization patterns (urban systems and migration), and regional political contexts on the effectiveness of agglomeration economies in aiding technological upgrading.

For example, my research demonstrates a negative association between technological upgrading and the interaction of firm-formation rates with urban location. In other words, new firms locating in urban areas do not contribute to technological upgrading. This is counterintuitive and suggests a mismatch between ability for urban location and the sophistication levels of firms. Typically, more skill-intensive high technology operations are able to afford increased costs associated with higher wages in urban areas. This points to imperfect land markets from institutional rigidity and to the role of political economy factors in assigning property rights.

As suggested earlier, infrastructure and services deficiencies are often cited as major bottlenecks constraining economic growth in India, and that of the Indian manufacturing sector, in particular. This is further exacerbated by fluctuating investment priorities at the federal and state levels between urban and rural areas, as a consequence that infrastructure and public services in India's urban areas have fallen significantly, not keeping pace with urban growth.

However, the above general trends are more nuanced in the Indian context based on urban size thresholds. In this study, I have also demonstrated that in the larger to largest agglomerations in the country, industrial clustering is shown to positively impact technological upgrading at the margins, aligning with more conventional concepts regarding agglomeration economies. The positive impacts of urbanization economies are found to associate with absolute size measures, beyond certain size thresholds, and then, at the highest thresholds, controlling for the effects of migration (over-crowding). These trends are similarly mirrored in the impact of the threshold limits of secondary urban areas on upgrading. Notwithstanding the above positive associations, these impacts drop-off at lower size thresholds of both primary and secondary areas.

Evidence for the importance of secondary urban areas is provided in this study in the role of skilled migration. Higher education attainment rates of immigrant population are consistently among the most significant and positive variables influencing technological upgrading in the Indian context, in line with standard thinking on the role of human capital. In particular, the results show that increases in inter-state migration in interaction with secondary urban areas at higher size thresholds of the latter positively impact technological upgrading, which suggests that larger secondary urban agglomerations are appealing destinations for high-skilled immigrants.

I further analyzed in this study the impacts of regional political contexts as explanation for the development of urban systems in India. I have theoretically framed regional political contexts as interplay between the first-order institutional conditions of bonding (group-life or community) and bridging (society). Empirically, I capture inter-state heterogeneity in institutional contexts using measures for state political majorities (seat to vote ratio) and time consistency/monopoly (Chief Minister's tenure length). The types of political contexts observed help us deduce the impacts of the deep seated institutional processes of bonding and bridging.

The mediating impact of the two regional political variables on urbanization structure and growth does not associate positively with technological upgrading. These variables appear to be correlated with other unobserved time variant factors that positively explain urban primacy and growth in secondary cities but are inversely associated with the needs of upgrading in the manufacturing sector. These unobserved time variant factors might include competition for limited resources from other sectors of the economy that possibly might also provide greater rents to power elites.

The above broad trends seem to indicate the adverse effects typically associated with institutional conditions emerging out of low levels of bridging and high levels of group interests influencing resource allocation and policy priorities. These conditions, as in the ostensible lack of attention to the manufacturing sector, suggest ongoing issues with problem-solving capabilities and social distribution policy at the state level. Further, conditions of low bridging and high bonding self-select political systems that favor limited political contestation, resulting in vicious cycles of political entrenchment and continued assertion of group interests. This effect is strongly picked up in this study in the negative association of the length of the Chief Minister's tenure with technological upgrading, which suggests political autonomy/monopoly with little transparency or accountability.

However, after accounting for the above institutional effects, the urban primacy ratio in its main effect emerges with positive impacts on upgrading and this association gets stronger with inclusion of growth in secondary urban areas. I conclude that what we are observing here is a strong indication that, at the margins, the largest primary urban agglomerations in India indeed contribute positively to technological upgrading.

5.3. Policy Implications

Two main issues emerge from analysis in this dissertation research regarding manufacturing technological upgrading trends in post market reforms India. First, technological upgrading outcomes are heterogeneous by industry and region. Secondly, this observed heterogeneity, from one specific perspective, could be explained as an outcome of the interactions between agglomeration economies and its mediating regional covariates. These observations support the notion that national market reforms cannot automatically be assumed to have uniform productivity and innovation impacts across the board within even the same country, but rather these outcomes depend on the regional variations in existing industrial capabilities and the concomitant institutions that support regional economic activity.

In this study, I have demonstrated locational blockages in the supply-demand matching of competences and in the realization of efficiency and innovation advantages from urban concentration. Some of these factors are deduced to include imperfect land markets, infrastructure and services deficiencies, and the absence of local firm networks to take advantage of pre-existing local capabilities from the pre-reforms era and from entering multi-national activity. It is imperative that Indian policy makers realize the crucial role of urban manufacturing in potentially enabling global competiveness through technological upgrading. Further, manufacturing with its broad spectrum of professional and technical skill requirements has enormous employment generation potential to address the existing high rates of unemployment in the country, which is in effect a national economic security issue. A few important policy implications are highlighted next.

Winners and Losers in Globalization

Globalization, in the context of the market reforms, is likely to have had strong selection effects on domestic Indian manufacturing. Global trade impacts both exporters and non-exporters, but in different ways, with specific policy implications for each group. The upshot here is that the opening up process results in cases of success and failure depending on the presence or absence of a supporting policy environment.

Exporters may fall under two broad categories, as defined by the type of market demand they meet. In the first instance, Indian manufacturers might be part of a larger global sourcing for parts and finished products that are standardized or labor intensive; for example, finished apparel products and automotive parts. These market segments are contested globally based not only on price points but by also meeting quality standards set by buyers -- this is the case of value chain insertion based on local capabilities. The policy challenge here is to identify and to enable a match of local capabilities to global buyer demands. The subsequent policy imperative here is one of value-chain ascendency through increasing skills and standard enforcement capabilities.

The second type of exporting activity is driven by access to larger markets from trade liberalization for products catering initially to domestic markets (tastes and preferences). This is the world of north-north trade driven by product qualities and niches, also likely more skill-intensive. This is an emerging area, especially aided by the consistent growth in recent years of south-south trade and possibly changing preferences in the north: examples include generic pharmaceuticals, compact cars, buses and trucks, and electrical machinery. Growth in the exports market for such finished products has greater regional development potential, as it involves an array of associated upstream activities. Building on domestic success, policy implications here involve support for marketing and outreach to potential importers.

Finally, trade presents new challenges to domestic manufacturers from increased competition from competitive imports in parts and finished goods. The challenge here is two-fold, one of lowering prices but concomitantly increasing product quality. This might have filtering effects on the manufacturing base, as the more productive value-added operations survive the influx of cheap foreign goods. For example, this is the case of the often publicized flooding of the Indian domestic market by Chinese goods in the lower end and budget consumer segments. Policy implications here might be that some industries might become obsolete over time. Therefore, domestic efforts are needed to monitor and develop institutions that reallocate resources to the more technologically developed sectors, where the chances of technological upgrading, and subsequent growth impacts are greater in response to global competition.

National and Regional Innovation System

As highlighted in previous discussions, there appears to be a lack of technological transfer between existing local capabilities in nationally protected industries and the deregulated portions of the manufacturing base. Such transfers logically imply the role skill circulation in the regional labor market and transactional relationships between key national strategic industries and research establishments and a local supplier base. These inter-connections are highlighted in the national systems of innovation approach. Further, the central functions of a system of innovation -- innovation and research – are supported by activities that promote and sustain entrepreneurial activity, networking between public and private organizations, calibration of regulatory and incentive structures, the provision of information to articulate product and process qualities and specifications, and enabling access to finance and infrastructure. Recently, there has been growing attention to regional innovation systems and human capital endowments in the developing world. There is an urgent need for India to not only approach innovation as a R&D function of research labs but also as a spatially anchored process involving regional economies and institutions. Some of these themes are reflected in the Science, Technology and Innovation Policy 2013 (Government of India, 2013).

Urban Governance and Decentralization

Lastly, the issue of the development of urban systems composed of functionally effective primary and secondary urban areas is contingent upon the levels of expenditures on infrastructure and services provision. In this connection, the issue of decentralization acquires significance in the context of the federal structure of Indian democracy. In the post-market reforms era, the federal government has played a diminishing role in economic planning at the state and local levels. This retreat has coincided with governance reforms toward decentralization with the passage of the 73rd and 74th constitutional amendments (CAS) in 1992, which sought to provide more planning and fiscal powers to sub-state urban and rural institutions. However, the implementation of these reforms is at various stages across the country primarily due to the considerable autonomy provided to states in interpreting and implementing the CAS. In particular, the extent of devolution in India has been abysmal with the combined finances controlled by the sub-state bodies at a mere 5 percent of total public expenditures in 2006 compared to between 20 percent to 35 percent in OECD countries, 51 percent in China and 15 percent in Brazil (Oomen, 2010). Thus, state level politics appear to play a major role in the implementation of these amendments. There is an urgent need to institute a nationally mandated oversight on the implementation of the decentralization reforms.

5.4. Limitations of Current Research

In this study, I examined the relationship between technological upgrading and agglomeration economies and its regional covariates employing quantitative methods. However, in doing so, my study was bound in its scope and depth by the availability of appropriate data in examining the posed research questions.

In terms of geographical scope, the most reliable source of data on manufacturing inputs and outputs was available only at the state-level, as obtained from the Annual Survey of Industries (ASI). This critically determined the spatial unit of observation in the panel data for the outcome technology measures, and then the requisite regional and organizational explanatory variables used in the regression analysis. Ideally, I would have liked to have better explored the spatial relationships in this study at the sub-state level, which in the Indian case would mean the district-level. A finer grained geographical basis of observation might possibly have better enunciated within-state heterogeneity in the upgrading measure and the regional contexts. But even within the available framework adopted in this study, I have tried my best to represent state level aggregate measures as weighted outcomes of district-level variations, as in the case of localization and urbanization economies, where the data were available.

Further, in the interest of balancing the panel data to the extent possible over the 1990 to 2005 time period, I restricted my sample of states in stages of this research so as to obtain longer time-series measures. This was necessary for the implementation of the panel data time-series methods employed in this study. However, even the smallest sub-sample in this study comprised states that contributed on an average 80 percent of the total manufacturing output in the country over the study period. In some cases, however, states could not be included because of discontinuity due to political reorganization, rendering institutional variables irrelevant. These states included the erstwhile Uttar Pradesh, Bihar and Madhya Pradesh.

Some of the concepts implied in the causal framework, including negative externalities and infrastructure development, tying the mediating effects of regional institutions on urban systems development and the efficacy of agglomeration economies in technological upgrading, could not be directly observed or measured due to the non-availability of relevant data. For example, these observations might have provided greater insights on intra-state variations in infrastructure and services by primary and secondary areas on absolute and per capita basis. Additionally, analysis of intra-state allocation of public expenditures by different cost categories to primary and secondary urban areas as in concurrence with the regional political context was not possible due to the non-availability of consistent data at the sub-state level.

5.5. Future Research

In concluding this dissertation, I would like to list four areas in which I would like to extend this work further.

a. Following from the review of the limitations listed in the previous section, I plan to extend the geographical depth of this analysis to the district-level. This is likely to be an extensive data assembly exercise, which however might be possible for the more recent years of the ASI data releases provided on a microdata basis. The availability of district-level infrastructure, services and public expenditures data are an ongoing topic of investigation.
b. In this connection, a relevant strategy to examine intra-state variations in capital expenditures seems to involve tracking the efficacy of the implementation of the 73^{rd} and 74^{th} amendments mandated decentralization of local governance. The emerging evidence from the unfolding of these sweeping institutional changes is not systematic over time and across states.
c. Another area of future research work involves a thorough analysis of the technological capabilities of Indian manufacturing at the industry level. This could take the shape of measurements on the distance to technological frontier to better analyze the heterogeneous responses to technological upgrading from competition and interactions with multinational entry. The latter aspect involves being able to identify entry activity by ownership type for

which one might have to resort to data sources other than the ASI. Another aspect of these technological spillovers is to scrutinize the role of nationally regulated industries (which are primarily in advanced technological areas) to the local manufacturing base.

d. Finally, I would like to expand the regional institutional framework to include actual measures of bonding and bridging and to quantify unobserved time variant policy domain factors, including the rules environment and social policy at the state level, and the impacts of these institutional dimensions on sub-state level urbanization and manufacturing growth.

Appendix A
National Licensing Policy, 1991

The economic reforms of 1991 were implemented toward deregulation of product markets, international trade and foreign direct investment (FDI). Licenses basically controlled all private sector economic activity in terms of entry, plant location and expansions, import of inputs and production technology, and ownership structure, including FDI participation. The following reform measures were included under the Industrial Licensing Policy [15]:

a) Change from a Positive to Negative List (Entry Restrictions): Private sector participation in the pre-1991 era was governed by a positive list, i.e. a list of industries where licenses were not required by the private sector to operate. After 1991, licenses were not required for any industry except those identified in a 'negative list', which included industries of strategic national and environmental importance (see Table A-1). Further, the list of industries reserved exclusively for the public sector was drastically reduced from 18 to 3 by the early 2000s (defense aircrafts and warships, atomic energy generation and railway transport) (Ahluwalia, 2001).

   In effect, the number of 3-digit industries, as percent of the total industrial base not requiring a license for private capital, rose from 12.8 percent in 1990 to 64.1 percent in 1995, and reaching a peak of 71.9 percent over 2000 and 2005. Though 12.8 percent of the manufacturing base was already deregulated prior to 1991 (mostly over the 1985 to 1990 time period), it is the effect of the increment in deregulation over the study period that I seek to examine in this research. However notwithstanding deregulation, private firms were required to file an information memorandum on new projects and substantial expansions with the Central Government.

b) Expanding Plant Size: Private sector firms (whether having entered before or after 1991) were not required to have licenses for expansion of existing operations. However, if these firms grew larger than Rs.1.0 billion, they would fall within the Monopolies and Restrictive Trade Practices (MRTP) Act designed to prevent industry monopolies and concentration (anti-trust regulation). The MRTP Act itself, as described later, was amended.

c) Expanding Product Variety: The New Industrial Policy, 1991 lay emphasis on promoting flexibility in production and abolished the requirement for licenses for adding new product lines within existing operations. This is often referred to as 'broad banding', i.e. allowing operations to switch between product lines.

d) Restrictions on MRTP Firms: Further, MRTP (Monopoly) firms were not required to get pre-approval for expansion, new undertakings or entry into new industries, merger, amalgamation and takeover and appointment of certain directors. Rules related to merger, amalgamation and takeover were repealed, while trading stocks and shares was brought under the Companies Act. The overall emphasis was to curb anti-trust practices of monopoly firms rather than controlling size of establishments as an indirect way to curb

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[15] Details on the various reform measures undertaken have been obtained primarily from the Government of India's Statement of Industrial Policy, 1991. http://siadipp.nic.in/publicat/nip0791.htm, Ahluwalia (2002) and Panagariya (2004).

monopoly behavior. The MRTP Act later transformed into the Competition Act in 2002, with radically different regulatory criteria.

e) Locational Restrictions: All locational restrictions on non-polluting industries, such as electronics, printing, and services, were removed. Although no Central Government approvals were required for such activities, these would still need local and state government clearances related to environmental and land-use zoning requirements. However, industries on the negative list would still require Central Government licenses and approvals. Further, polluting industries could not locate within 25 Kms of cities of population 1.0 million plus.

f) Import of Capital and Intermediate Inputs: Import restrictions on inputs required for production were removed completely, subject to two conditions. First, where foreign exchange was guaranteed through FDI, 100 percent of such imports were allowed. Second, for domestically owned operations (not accessing FDI), the cost, insurance and freight (CIF) value of the imports were restricted to 25 percent of the total after tax value of output.

g) Foreign Ownership: The threshold for foreign equity investment was raised from 40 percent to 51 percent. Foreign investment at the 51 percent level would receive automatic approvals from the Reserve Bank of India (the country's Central Bank) empowered to approve equity investment in 34 industries, listed in Appendix B. In subsequent years, the policy of automatic approval was expanded to almost all industries, except those subject to public sector monopoly and industrial licensing.

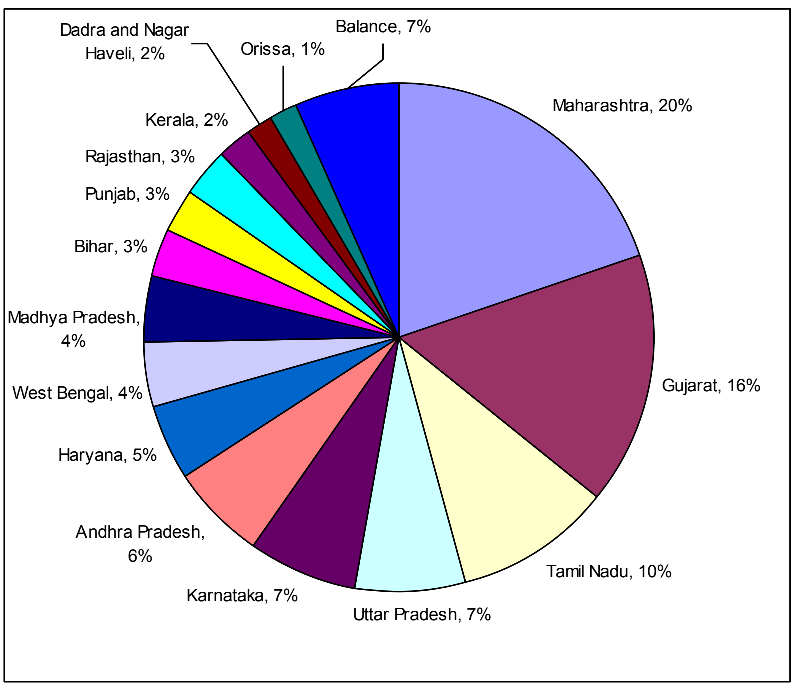
Appendix B
Additional Tables and Figures for Chapter 2

Table B-1. Output Shares of State-regions by Licensed and Delicensed Industries

	LICENSED				DELICENSED				TOTAL			
	1990	1995	2000	2005	1990	1995	2000	2005	1990	1995	2000	2005
Andaman and Nicobar Islands	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Andhra Pradesh	5.9%	5.3%	6.3%	5.4%	7.0%	7.1%	6.8%	6.5%	6.1%	6.6%	6.7%	6.3%
Assam	1.4%	2.0%	0.2%	0.4%	0.1%	0.4%	1.1%	1.6%	1.2%	0.9%	1.0%	1.4%
Bihar	5.3%	2.1%	2.5%	2.5%	2.9%	3.9%	2.9%	3.2%	4.9%	3.3%	2.9%	3.0%
Chandigarh	0.2%	0.1%	0.2%	0.1%	0.1%	0.2%	0.1%	0.1%	0.2%	0.2%	0.1%	0.1%
Dadra and Nagar Haveli	0.4%	0.2%	1.5%	1.2%	0.0%	0.5%	1.5%	1.9%	0.4%	0.4%	1.5%	1.8%
Daman and Diu	0.0%	0.3%	0.8%	0.7%	0.1%	0.4%	0.8%	1.6%	0.0%	0.4%	0.8%	1.4%
Delhi	1.9%	0.9%	1.1%	0.9%	2.8%	2.2%	1.6%	1.1%	2.0%	1.7%	1.5%	1.1%
Goa	0.3%	0.6%	1.1%	1.0%	0.7%	0.3%	0.8%	0.8%	0.3%	0.4%	0.9%	0.8%
Gujarat	10.7%	11.8%	11.2%	12.4%	8.6%	11.9%	14.6%	16.8%	10.3%	11.9%	14.0%	16.1%
Haryana	3.9%	6.4%	10.6%	9.8%	3.3%	3.2%	3.7%	3.5%	3.8%	4.3%	4.9%	4.6%
Himachal Pradesh	0.3%	0.3%	0.6%	0.9%	0.2%	0.5%	0.7%	0.9%	0.3%	0.4%	0.7%	0.9%
Jammu and Kashmir	0.2%	0.2%	0.1%	0.5%	0.1%	0.2%	0.2%	0.3%	0.2%	0.2%	0.1%	0.4%
Karnataka	4.3%	3.7%	6.5%	8.2%	6.0%	5.1%	4.6%	6.5%	4.6%	4.6%	4.9%	6.8%
Kerala	2.4%	3.5%	0.8%	0.7%	2.2%	2.0%	3.4%	2.6%	2.3%	2.5%	2.9%	2.3%
Madhya Pradesh	5.4%	4.9%	4.2%	2.7%	4.7%	6.9%	5.3%	4.4%	5.2%	6.3%	5.1%	4.1%
Maharashtra	21.8%	25.4%	25.1%	22.6%	27.2%	21.5%	18.8%	19.1%	22.7%	22.8%	19.9%	19.7%
Manipur	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Meghalaya	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Nagaland	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Orissa	1.9%	0.5%	0.3%	0.4%	0.9%	2.3%	1.7%	1.7%	1.8%	1.7%	1.4%	1.5%
Pondicherry	0.2%	0.2%	0.8%	0.5%	0.2%	0.3%	0.6%	0.7%	0.2%	0.3%	0.6%	0.7%
Punjab	5.0%	3.4%	3.2%	2.8%	3.2%	4.5%	3.9%	3.0%	4.7%	4.2%	3.8%	3.0%
Rajasthan	3.1%	2.2%	2.0%	1.9%	2.8%	3.6%	3.5%	3.0%	3.1%	3.2%	3.2%	2.8%
Tamil Nadu	10.3%	12.4%	9.0%	13.1%	9.9%	10.1%	11.5%	9.4%	10.3%	10.8%	11.1%	10.0%
Tripura	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Uttar Pradesh	8.8%	8.9%	8.3%	8.9%	12.3%	8.2%	7.4%	6.7%	9.4%	8.4%	7.5%	7.0%
West Bengal	6.1%	4.7%	3.7%	2.5%	5.0%	4.4%	4.4%	4.5%	5.9%	4.5%	4.3%	4.1%
INDIA	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source: Author based on the Annual Survey of Industries, Ministry of Statistics and Programme Implementation, India.

Figure B-1: Overall Manufacturing Output by Top 15 State-regions, 2005



Source: Author

Appendix C
Additional Tables and Figures for Chapter 3

Table C-1: Invested Capital per Worker

(in Rs. 100,000 constant 2005 Rupees)

a. By State

State	1990	1995	2000	2005
Andhra Pradesh	772,004	1,092,752	2,910,466	2,426,907
Assam	267,274	328,476	1,624,862	2,227,085
Bihar	456,758	898,694	1,452,454	2,326,813
Chandigarh	329,701	724,193	827,907	740,617
Dadra and Nagar Haveli	681,403	3,264,124	2,259,681	2,252,339
Daman and Diu	552,764	1,660,373	998,853	1,322,186
Delhi	414,603	663,777	916,910	1,060,006
Goa	1,538,774	1,504,088	2,613,863	2,346,478
Gujarat	640,902	1,528,285	3,125,812	3,601,349
Haryana	676,433	860,586	1,333,321	1,119,597
Himachal Pradesh	476,272	1,220,693	1,851,612	1,587,658
Karnataka	827,993	1,047,284	7,397,017	5,228,519
Kerala	608,746	684,561	1,360,098	1,717,200
Madhya Pradesh	870,843	1,209,783	1,530,095	1,571,480
Maharashtra	846,094	1,474,941	2,104,750	2,516,456
Orissa	652,256	1,139,596	1,870,939	2,100,295
Pondicherry	1,268,013	1,134,242	1,796,433	1,364,009
Punjab	931,500	1,167,571	1,086,859	1,135,173
Rajasthan	1,051,973	1,407,203	1,499,069	1,616,115
Tamil Nadu	584,508	1,041,056	1,879,597	3,553,324
Uttar Pradesh	1,534,934	1,399,200	6,716,963	1,528,810
West Bengal	485,938	738,127	1,697,187	2,851,900
INDIA	**764,884**	**1,124,334**	**2,283,380**	**2,120,659**

b. By Technology Categories (Industry Groupings)

Techcat	Description	1990	1995	2000	2005
C01	Animal and Plant Products	433,254	950,041	1,129,318	1,337,982
C02	Processed Food and Beverages		925,229	953,891	898,710
C03	Minerals, Fuels, and Lubricants		1,791,489	18,700,000	13,900,000
C04	Chemicals		3,259,923	3,914,767	4,938,725
C05	Pharmaceuticals and Perfumes	867,340	1,319,465	1,250,288	1,245,358
C06	Organic and Semi-Organic Intermediates	741,200	830,011	944,025	913,584
C07	Inorganic and Metallic Intermediates	399,519	1,422,135	1,632,478	1,860,220
C08	Processing and Power Machinery	752,252	868,716	939,395	931,374
C09	Electronic Equipment	1,663,406	1,492,092	2,153,098	1,834,017
C10	Electrical Equipment	984,188	1,437,548	1,446,694	1,244,275
C11	Automotive Equipment	624,030	746,303	1,328,373	1,336,260
C12	Home Improvement	480,230	563,949	871,783	988,717
C13	Clothing and Accessories	997,089	422,585	371,782	464,694
C14	Technical and Photographic Equipment	619,476	804,686	995,244	886,994
C15	Printed and Recorded Materials		347,734	701,921	905,740
C16	Miscellaneous		452,276	921,517	955,533
	TOTAL	**764,884**	**1,124,334**	**2,283,380**	**2,120,659**

Table C-2: Skill Ratio

a. By State

State	1990	1995	2000	2005
Andhra Pradesh	0.4360	0.3583	0.3938	0.3087
Assam	0.4161	0.4282	0.3249	0.6497
Bihar [1]	0.4036	0.3859	0.3584	0.3491
Chandigarh	0.3369	0.4712	0.6391	0.5386
Dadra and Nagar Haveli	0.3020	0.4885	0.4399	0.4402
Daman and Diu	0.1999	0.4303	0.3716	0.3459
Delhi	0.4160	0.4724	0.5229	0.6142
Goa	0.5122	0.6387	0.4160	0.3390
Gujarat	0.4656	0.3845	0.3922	0.3497
Haryana	0.4184	0.4346	0.4714	0.4611
Himachal Pradesh	0.4249	0.3821	0.3998	0.3421
Karnataka	0.4822	0.4681	0.4425	0.4613
Kerala	0.4112	0.3890	0.4056	0.3943
Madhya Pradesh [2]	0.4715	0.4009	0.4016	0.3696
Maharashtra	0.4637	0.5132	0.4908	0.4942
Orissa	0.4254	0.3436	0.3950	0.3639
Pondicherry	0.3799	0.3385	0.3611	0.3575
Punjab	0.3195	0.3217	0.3792	0.3696
Rajasthan	0.5388	0.4457	0.3958	0.3544
Tamil Nadu	0.4211	0.3750	0.3984	0.3232
Uttar Pradesh [3]	0.4108	0.4057	0.4364	0.3314
West Bengal	0.5328	0.4535	0.4577	0.4097
INDIA	0.4335	0.4204	0.4219	0.4044

b. By Technology Categories (Industry Groupings)

Techcat	Description	1990	1995	2000	2005
C01	Animal and Plant Products	0.3328	0.4226	0.3754	0.3733
C02	Processed Food and Beverages		0.4221	0.3757	0.2923
C03	Minerals, Fuels, and Lubricants		0.3135	0.5560	0.3996
C04	Chemicals		0.5965	0.5036	0.5007
C05	Pharmaceuticals and Perfumes	0.5648	0.5637	0.6339	0.6217
C06	Organic and Semi-Organic Intermediates	0.3090	0.2417	0.2507	0.2350
C07	Inorganic and Metallic Intermediates	0.2845	0.3658	0.3095	0.2837
C08	Processing and Power Machinery	0.5057	0.4405	0.3866	0.3272
C09	Electronic Equipment	0.7878	0.5126	0.5350	0.6990
C10	Electrical Equipment	0.6409	0.4959	0.4222	0.3544
C11	Automotive Equipment	0.3640	0.4048	0.3544	0.3185
C12	Home Improvement	0.3232	0.3120	0.3785	0.3856
C13	Clothing and Accessories	0.2542	0.2364	0.2370	0.2368
C14	Technical and Photographic Equipment	0.4709	0.5193	0.5157	0.5268
C15	Printed and Recorded Materials		0.5351	0.5672	0.6085
C16	Miscellaneous		0.3805	0.3387	0.2724
	TOTAL	**0.4335**	**0.4204**	**0.4219**	**0.4044**

Table C-3: Spatial Gini Coefficients

a. By State

State	1990	1995	2000	2005
Andhra Pradesh	0.321	0.229	0.184	0.182
Assam	0.100	0.198	0.225	0.233
Bihar	0.214	0.228	0.178	0.117
Chandigarh	0.000	0.000	0.000	0.000
Dadra and Nagar Haveli	0.000	0.000	0.037	0.140
Daman and Diu	0.150	0.289	0.172	0.000
Delhi	0.125	0.043	0.044	0.155
Goa	0.187	0.157	0.141	0.167
Gujarat	0.204	0.215	0.185	0.123
Haryana	0.270	0.271	0.248	0.170
Himachal Pradesh	0.313	0.314	0.346	0.421
Karnataka	0.401	0.287	0.238	0.178
Kerala	0.186	0.185	0.161	0.136
Madhya Pradesh	0.259	0.161	0.142	0.148
Maharashtra	0.233	0.219	0.217	0.218
Orissa	0.265	0.222	0.201	0.218
Pondicherry	0.521	0.357	0.397	0.399
Punjab	0.237	0.240	0.224	0.157
Rajasthan	0.344	0.262	0.239	0.209
Tamil Nadu	0.245	0.259	0.244	0.163
Uttar Pradesh	0.334	0.230	0.202	0.189
West Bengal	0.155	0.193	0.226	0.271
Total	**0.243**	**0.214**	**0.196**	**0.181**

b. By Technology Categories (Industry Groupings)

Techcat	Description	1990	1995	2000	2005
C01	Animal and Plant Products	0.170	0.168	0.138	0.143
C02	Processed Food and Beverages		0.117	0.123	0.119
C03	Minerals, Fuels, and Lubricants		0.173	0.203	0.223
C04	Chemicals		0.224	0.208	0.209
C05	Pharmaceuticals and Perfumes	0.306	0.255	0.241	0.240
C06	Organic and Semi-Organic Intermediates	0.170	0.166	0.170	0.184
C07	Inorganic and Metallic Intermediates	0.147	0.172	0.171	0.170
C08	Processing and Power Machinery	0.173	0.223	0.243	0.193
C09	Electronic Equipment	0.422	0.343	0.266	0.201
C10	Electrical Equipment	0.289	0.227	0.182	0.148
C11	Automotive Equipment	0.325	0.220	0.180	0.163
C12	Home Improvement	0.179	0.183	0.159	0.129
C13	Clothing and Accessories	0.235	0.263	0.226	0.133
C14	Technical and Photographic Equipment	0.317	0.290	0.221	0.254
C15	Printed and Recorded Materials		0.167	0.176	0.220
C16	Miscellaneous		0.305	0.262	0.166
	TOTAL	**0.243**	**0.214**	**0.196**	**0.181**

Table C-4: Herfindahl Index

a. By State

State	1990	1995	2000	2005
Andhra Pradesh	0.129	0.093	0.185	0.097
Assam	0.087	0.255	0.296	0.213
Bihar	0.250	0.158	0.233	0.203
Chandigarh	0.293	0.223	0.330	0.265
Dadra and Nagar Haveli	0.323	0.312	0.204	0.189
Daman and Diu	0.259	0.257	0.205	0.170
Delhi	0.056	0.059	0.128	0.141
Goa	0.175	0.187	0.240	0.175
Gujarat	0.038	0.039	0.102	0.085
Haryana	0.101	0.094	0.107	0.146
Himachal Pradesh	0.359	0.258	0.186	0.120
Karnataka	0.101	0.062	0.114	0.070
Kerala	0.160	0.108	0.192	0.163
Madhya Pradesh	0.120	0.095	0.149	0.169
Maharashtra	0.094	0.028	0.096	0.074
Orissa	0.140	0.130	0.221	0.181
Pondicherry	0.203	0.205	0.222	0.182
Punjab	0.174	0.095	0.139	0.115
Rajasthan	0.149	0.098	0.188	0.106
Tamil Nadu	0.050	0.036	0.092	0.058
Uttar Pradesh	0.059	0.047	0.118	0.053
West Bengal	0.107	0.130	0.153	0.119
Total	**0.132**	**0.121**	**0.170**	**0.136**

b. By Technology Categories (Industry Groupings)

Techcat	Description	1990	1995	2000	2005
C01	Animal and Plant Products	0.062	0.060	0.186	0.115
C02	Processed Food and Beverages		0.050	0.058	0.050
C03	Minerals, Fuels, and Lubricants		0.092	0.328	0.225
C04	Chemicals		0.126	0.129	0.072
C05	Pharmaceuticals and Perfumes	0.152	0.137	0.194	0.162
C06	Organic and Semi-Organic Intermediates	0.066	0.043	0.059	0.047
C07	Inorganic and Metallic Intermediates	0.115	0.071	0.067	0.046
C08	Processing and Power Machinery	0.089	0.077	0.097	0.080
C09	Electronic Equipment	0.206	0.209	0.179	0.212
C10	Electrical Equipment	0.125	0.147	0.134	0.105
C11	Automotive Equipment	0.155	0.182	0.173	0.131
C12	Home Improvement	0.116	0.109	0.416	0.307
C13	Clothing and Accessories	0.126	0.187	0.243	0.164
C14	Technical and Photographic Equipment	0.277	0.165	0.173	0.156
C15	Printed and Recorded Materials		0.143	0.174	0.154
C16	Miscellaneous		0.190	0.198	0.181
	TOTAL	**0.132**	**0.121**	**0.170**	**0.136**

Table C-5: Percent of Urban Manufacturing

a. By State

State	1990	1995	2000	2005
Andhra Pradesh	69.6%	59.1%	59.5%	49.0%
Assam	52.2%	39.2%	43.8%	67.6%
Bihar	95.7%	59.8%	78.2%	59.3%
Chandigarh	0.0%	4.3%	1.7%	67.4%
Dadra and Nagar Haveli	9.1%	14.1%	3.9%	7.3%
Daman and Diu	55.8%	88.9%	2.2%	1.1%
Delhi	1.5%	46.0%	26.2%	56.9%
Goa	16.0%	15.8%	11.8%	12.7%
Gujarat	82.9%	63.8%	52.8%	43.5%
Haryana	81.6%	72.4%	71.0%	66.7%
Himachal Pradesh	36.7%	20.7%	34.7%	30.4%
Karnataka	78.2%	72.9%	60.8%	59.6%
Kerala	30.7%	41.2%	26.9%	31.8%
Madhya Pradesh	86.4%	75.0%	67.2%	66.9%
Maharashtra	85.9%	73.7%	64.4%	58.1%
Orissa	60.8%	59.1%	68.1%	56.6%
Pondicherry	72.0%	41.9%	35.9%	36.4%
Punjab	91.1%	77.8%	66.1%	60.8%
Rajasthan	75.6%	74.8%	55.9%	61.9%
Tamil Nadu	63.1%	52.1%	51.4%	47.9%
Uttar Pradesh	67.3%	59.1%	60.5%	60.9%
West Bengal	86.0%	90.5%	81.6%	78.0%
INDIA	**75.0%**	**65.9%**	**57.4%**	**53.0%**

b. By Technology Categories (Industry Groupings)

Techcat	Category	1990	1995	2000	2005
C01	Animal and Plant Products	52.6%	53.7%	72.6%	62.0%
C02	Processed Food and Beverages		43.8%	34.9%	32.1%
C03	Minerals, Fuels, and Lubricants		62.5%	61.2%	48.3%
C04	Chemicals		62.5%	54.6%	56.4%
C05	Pharmaceuticals and Perfumes	78.5%	74.4%	54.3%	44.9%
C06	Organic and Semi-Organic Intermediates	70.5%	66.5%	53.7%	51.0%
C07	Inorganic and Metallic Intermediates	78.9%	73.7%	63.5%	54.7%
C08	Processing and Power Machinery	82.8%	81.8%	71.2%	65.1%
C09	Electronic Equipment	61.2%	70.0%	66.3%	66.5%
C10	Electrical Equipment	68.7%	72.0%	72.9%	46.7%
C11	Automotive Equipment	91.4%	71.1%	68.3%	61.3%
C12	Home Improvement	75.1%	79.7%	45.5%	70.3%
C13	Clothing and Accessories	66.8%	93.0%	67.0%	82.7%
C14	Technical and Photographic Equipment	60.2%	67.0%	71.4%	64.0%
C15	Printed and Recorded Materials		80.5%	80.5%	79.0%
C16	Miscellaneous		60.6%	80.7%	81.4%
ALL INDUSTRIES		**75.0%**	**65.9%**	**57.4%**	**53.0%**

Table C-6: Index of Diversity

a. By State

State	1990	1995	2000	2005
Andhra Pradesh	1.75	1.84	1.90	1.60
Assam	1.58	1.64	1.68	1.39
Bihar	1.61	1.55	1.52	1.30
Chandigarh	2.49	2.38	2.31	1.80
Dadra and Nagar Haveli	0.36	0.50	0.58	0.55
Daman and Diu			1.61	1.62
Delhi	2.16	2.25	2.31	1.99
Goa	2.22	2.33	2.40	1.93
Gujarat	1.29	1.43	1.51	1.40
Haryana	1.69	1.74	1.77	1.60
Himachal Pradesh	1.99	1.87	1.79	1.47
Karnataka	1.79	1.80	1.81	1.58
Kerala	1.81	1.93	2.01	1.70
Madhya Pradesh	1.77	1.75	1.74	1.52
Maharashtra	2.01	1.96	1.94	1.67
Orissa	1.94	1.48	1.20	1.05
Pondicherry	1.64	1.73	1.78	1.50
Punjab	1.81	1.81	1.81	1.62
Rajasthan	1.46	1.50	1.53	1.39
Tamil Nadu	1.56	1.47	1.41	1.30
Uttar Pradesh	1.71	1.67	1.64	1.45
West Bengal	1.89	1.90	1.90	1.67
Total	**1.78**	**1.77**	**1.75**	**1.52**

b. By Technology Categories (Industry Groupings)

Techcat	Description	1990	1995	2000	2005
C01	Animal and Plant Products	1.80	1.77	1.80	1.55
C02	Processed Food and Beverages		1.80	1.73	1.50
C03	Minerals, Fuels, and Lubricants		1.74	1.70	1.49
C04	Chemicals		1.77	1.71	1.49
C05	Pharmaceuticals and Perfumes	1.77	1.74	1.73	1.50
C06	Organic and Semi-Organic Intermediates	1.74	1.74	1.73	1.50
C07	Inorganic and Metallic Intermediates	1.77	1.74	1.73	1.50
C08	Processing and Power Machinery	1.78	1.80	1.75	1.53
C09	Electronic Equipment	1.80	1.68	1.75	1.54
C10	Electrical Equipment	1.81	1.77	1.73	1.50
C11	Automotive Equipment	1.78	1.80	1.83	1.59
C12	Home Improvement	1.74	1.80	1.73	1.50
C13	Clothing and Accessories	1.79	1.78	1.80	1.50
C14	Technical and Photographic Equipment	1.79	1.85	1.78	1.55
C15	Printed and Recorded Materials		1.80	1.73	1.50
C16	Miscellaneous		1.77	1.73	1.52
	TOTAL	1.78	1.77	1.75	1.52

Table C-7: Average Age of Firms

a. By State

State	1990	1995	2000	2005
Andhra Pradesh	11.936	14.594	14.150	15.810
Assam	19.940	21.817	22.180	19.578
Bihar	17.314	19.192	20.838	24.003
Chandigarh	11.480	15.118	21.150	22.856
Dadra and Nagar Haveli	1.800	6.020	4.762	7.928
Daman and Diu	7.367	4.456	5.593	7.975
Delhi	15.982	18.456	21.856	24.096
Goa	11.200	12.075	11.844	12.801
Gujarat	13.291	14.969	15.556	17.703
Haryana	14.355	15.869	15.463	18.883
Himachal Pradesh	12.533	15.993	10.523	11.327
Karnataka	14.436	17.200	15.825	15.727
Kerala	16.491	20.463	19.500	22.553
Madhya Pradesh	15.150	16.875	15.156	18.520
Maharashtra	17.600	18.400	18.856	19.454
Orissa	13.878	17.021	18.540	21.901
Pondicherry	9.675	12.908	11.753	12.974
Punjab	13.627	17.456	18.306	20.658
Rajasthan	13.580	14.880	14.931	15.876
Tamil Nadu	14.036	14.781	15.631	17.992
Uttar Pradesh	11.055	14.469	14.894	16.086
West Bengal	23.664	26.194	24.631	27.392
Total	**14.496**	**16.448**	**15.927**	**17.802**

b. By Technology Categories (Industry Groupings)

Techcat	Description	1990	1995	2000	2005
C01	Animal and Plant Products	15.793	17.087	18.405	19.070
C02	Processed Food and Beverages		21.386	19.459	20.339
C03	Minerals, Fuels, and Lubricants		14.405	13.122	15.050
C04	Chemicals		15.225	14.900	17.221
C05	Pharmaceuticals and Perfumes	15.475	15.686	16.350	18.733
C06	Organic and Semi-Organic Intermediates	14.105	14.968	14.859	16.140
C07	Inorganic and Metallic Intermediates	14.212	13.686	14.505	15.694
C08	Processing and Power Machinery	15.072	16.386	16.022	19.879
C09	Electronic Equipment	8.320	11.353	12.194	14.727
C10	Electrical Equipment	21.793	23.600	14.641	17.003
C11	Automotive Equipment	12.688	13.870	17.228	19.440
C12	Home Improvement	16.209	18.480	13.691	18.341
C13	Clothing and Accessories	15.160	17.589	11.844	12.536
C14	Technical and Photographic Equipment	9.813	9.750	16.726	18.677
C15	Printed and Recorded Materials		15.575	23.377	25.399
C16	Miscellaneous		26.600	16.161	15.205
	TOTAL	**14.496**	**16.448**	**15.927**	**17.802**

Table C-8: Average Size (Workers per Factory)

a. By State

State	1990	1995	2000	2005
Andhra Pradesh	88.7	91.5	68.7	96.5
Assam	35.5	46.6	129.1	99.7
Bihar	87.3	88.2	135.7	82.2
Chandigarh	34.6	41.3	43.4	48.8
Dadra and Nagar Haveli	30.6	42.2	44.9	55.2
Daman and Diu	30.6	55.4	39.9	64.0
Delhi	40.7	54.6	33.8	42.4
Goa	61.1	63.4	64.5	82.5
Gujarat	66.3	71.4	61.5	91.5
Haryana	83.2	90.2	81.7	101.0
Himachal Pradesh	69.7	111.4	55.7	58.4
Karnataka	69.3	80.7	68.2	86.5
Kerala	87.2	88.7	99.3	90.7
Madhya Pradesh	102.0	84.8	77.0	105.9
Maharashtra	85.7	92.7	74.4	76.2
Orissa	76.0	85.8	62.4	57.0
Pondicherry	32.6	68.7	53.1	62.5
Punjab	71.6	91.7	62.0	49.6
Rajasthan	159.3	68.6	69.0	72.3
Tamil Nadu	66.7	67.6	63.1	77.9
Uttar Pradesh	76.3	76.0	67.6	69.6
West Bengal	72.1	129.6	85.5	73.8
Total	**75.5**	**79.4**	**69.6**	**75.3**

b. By Technology Categories (Industry Groupings)

Techcat	Description	1990	1995	2000	2005
C01	Animal and Plant Products	71.3	77.0	38.3	43.9
C02	Processed Food and Beverages		59.7	63.3	59.8
C03	Minerals, Fuels, and Lubricants		78.8	108.7	101.2
C04	Chemicals		90.9	91.6	69.9
C05	Pharmaceuticals and Perfumes	61.5	69.4	57.2	63.7
C06	Organic and Semi-Organic Intermediates	59.0	79.9	67.9	65.2
C07	Inorganic and Metallic Intermediates	68.8	62.1	52.9	56.5
C08	Processing and Power Machinery	84.9	58.4	43.7	55.8
C09	Electronic Equipment	86.9	113.9	99.7	134.5
C10	Electrical Equipment	127.6	89.4	59.6	64.9
C11	Automotive Equipment	129.7	124.6	173.0	182.7
C12	Home Improvement	38.1	36.9	29.2	33.6
C13	Clothing and Accessories	44.6	81.0	90.2	110.6
C14	Technical and Photographic Equipment	83.0	103.0	65.5	72.5
C15	Printed and Recorded Materials		99.4	45.5	45.9
C16	Miscellaneous		50.6	51.6	80.7
	TOTAL	**75.5**	**79.4**	**69.6**	**75.3**

Table C-9: Rate of Entry (Firm Age below 5 years)

a. By State

State	1990	1995	2000	2005
Andhra Pradesh	27.3%	17.7%	19.6%	17.2%
Assam	11.9%	8.1%	17.6%	25.2%
Bihar [1]	16.6%	8.2%	12.1%	10.6%
Chandigarh	6.4%	6.4%	0.5%	3.8%
Dadra and Nagar Haveli	38.8%	45.1%	56.6%	32.7%
Daman and Diu	21.1%	57.3%	59.6%	31.9%
Delhi	18.5%	13.6%	5.9%	9.2%
Goa	33.3%	29.1%	26.0%	13.0%
Gujarat	22.3%	16.6%	11.1%	14.7%
Haryana	11.3%	16.8%	15.8%	8.9%
Himachal Pradesh	30.3%	12.6%	26.9%	42.7%
Karnataka	22.4%	16.7%	18.2%	22.1%
Kerala	16.3%	12.8%	12.2%	10.0%
Madhya Pradesh [2]	22.6%	14.1%	14.5%	10.7%
Maharashtra	18.6%	11.9%	12.9%	15.3%
Orissa	17.5%	12.1%	15.3%	11.8%
Pondicherry	44.4%	13.9%	34.2%	11.5%
Punjab	20.7%	9.5%	13.2%	7.3%
Rajasthan	22.7%	19.2%	16.3%	12.2%
Tamil Nadu	25.8%	19.6%	13.0%	12.7%
Uttar Pradesh [3]	45.3%	20.6%	17.1%	24.7%
West Bengal	11.3%	5.7%	7.3%	6.1%
INDIA	**22.2%**	**16.1%**	**19.2%**	**15.9%**

b. By Technology Categories (Industry Groupings)

Techcat	Description	1990	1995	2000	2005
C01	Animal and Plant Products	19.9%	15.6%	13.9%	12.1%
C02	Processed Food and Beverages		11.6%	18.0%	13.7%
C03	Minerals, Fuels, and Lubricants		17.8%	21.9%	17.9%
C04	Chemicals		17.8%	24.3%	15.7%
C05	Pharmaceuticals and Perfumes	23.2%	17.8%	16.9%	16.3%
C06	Organic and Semi-Organic Intermediates	25.2%	17.9%	19.5%	15.0%
C07	Inorganic and Metallic Intermediates	19.9%	20.3%	20.8%	19.2%
C08	Processing and Power Machinery	16.8%	14.5%	19.7%	12.9%
C09	Electronic Equipment	42.0%	20.7%	20.7%	17.5%
C10	Electrical Equipment	12.7%	6.8%	21.1%	16.8%
C11	Automotive Equipment	19.7%	18.8%	15.1%	10.1%
C12	Home Improvement	14.7%	9.2%	14.8%	11.6%
C13	Clothing and Accessories	22.0%	15.3%	24.8%	30.2%
C14	Technical and Photographic Equipment	30.6%	32.5%	16.7%	13.2%
C15	Printed and Recorded Materials		12.0%	17.0%	16.1%
C16	Miscellaneous		9.6%	22.6%	16.1%
	TOTAL	**22.2%**	**16.1%**	**19.2%**	**15.9%**

Table C-10: Imported Inputs Percent

a. By State

State	1990	1995	2000	2005
Andhra Pradesh	6.0%	12.7%	23.7%	42.1%
Assam	0.1%	1.1%	1.2%	2.8%
Bihar	6.2%	3.7%	11.1%	15.9%
Chandigarh	0.7%	3.9%	2.4%	6.8%
Dadra and Nagar Haveli	0.6%	16.3%	12.7%	30.4%
Daman and Diu	16.4%	7.9%	16.9%	34.8%
Delhi	1.7%	1.2%	8.1%	14.8%
Goa	15.6%	11.9%	18.3%	32.1%
Gujarat	10.4%	18.4%	28.2%	46.2%
Haryana	5.8%	5.0%	14.7%	16.2%
Himachal Pradesh	5.4%	12.9%	9.9%	25.2%
Karnataka	6.7%	12.0%	29.9%	44.0%
Kerala	7.0%	21.9%	21.7%	27.8%
Madhya Pradesh	8.5%	6.3%	13.0%	15.3%
Maharashtra	11.7%	13.7%	21.5%	41.4%
Orissa	3.9%	9.3%	12.4%	25.7%
Pondicherry	10.4%	6.7%	17.1%	25.8%
Punjab	8.3%	5.3%	7.8%	8.7%
Rajasthan	4.3%	4.5%	9.8%	17.5%
Tamil Nadu	5.3%	12.2%	21.1%	46.0%
Uttar Pradesh	5.5%	8.6%	15.4%	34.3%
West Bengal	8.5%	9.1%	22.8%	37.8%
Total	**6.9%**	**9.3%**	**16.1%**	**27.5%**

b. By Technology Categories (Industry Groupings)

Techcat	Description	1990	1995	2000	2005
C01	Animal and Plant Products	2.3%	1.0%	7.9%	21.4%
C02	Processed Food and Beverages		0.3%	2.6%	4.9%
C03	Minerals, Fuels, and Lubricants		21.1%	37.5%	48.6%
C04	Chemicals		16.3%	18.8%	31.7%
C05	Pharmaceuticals and Perfumes	12.7%	11.6%	13.5%	22.3%
C06	Organic and Semi-Organic Intermediates	8.4%	6.8%	9.7%	16.2%
C07	Inorganic and Metallic Intermediates	8.8%	13.3%	16.2%	36.3%
C08	Processing and Power Machinery	4.0%	6.2%	14.7%	31.3%
C09	Electronic Equipment	3.3%	8.8%	34.1%	42.7%
C10	Electrical Equipment	19.0%	18.3%	16.1%	33.1%
C11	Automotive Equipment	3.7%	7.9%	21.8%	34.4%
C12	Home Improvement	4.1%	7.8%	3.5%	17.9%
C13	Clothing and Accessories	4.7%	6.2%	10.3%	11.0%
C14	Technical and Photographic Equipment	4.2%	5.0%	21.1%	36.8%
C15	Printed and Recorded Materials		8.7%	11.5%	22.4%
C16	Miscellaneous		5.3%	24.9%	35.6%
	TOTAL	**6.9%**	**9.3%**	**16.1%**	**27.5%**

Appendix D
Additional Tables and Figures for Chapter 4

Table D-1: Technological Score in Delicensed Manufacturing

State	1990	1995	2000	2005	Change
Andhra Pradesh	118	125	97	100	-18
Goa	95	109	117	116	21
Gujarat	108	131	107	101	-8
Haryana	108	100	91	87	-21
Himachal Pradesh	90	108	97	108	18
Karnataka	119	127	96	93	-26
Kerala	85	138	96	98	13
Maharashtra	96	110	96	94	-2
Orissa	125	109	102	100	-25
Punjab	92	99	89	89	-3
Rajasthan	75	113	88	88	13
Tamil Nadu	80	107	91	92	12
West Bengal	93	95	100	98	4
Sample Average	**98**	**114**	**97**	**96**	**-3**

Source: Author

Table D-2 Distribution of Urban Population by Urban Agglomeration Size

	1988	1993	1998	2003	Change 1988-2003
Tier 1					
Pop >= 4million					
Andhra Pradesh	23.5%	33.9%	34.7%	35.5%	12.1%
Goa	0.0%	0.0%	0.0%	0.0%	0.0%
Gujarat	0.0%	6.2%	21.6%	35.7%	35.7%
Haryana	0.0%	0.0%	0.0%	0.0%	0.0%
Himachal Pradesh	0.0%	0.0%	0.0%	0.0%	0.0%
Karnataka	31.4%	45.2%	46.0%	47.6%	16.2%
Kerala	0.0%	0.0%	0.0%	0.0%	0.0%
Maharashtra	50.3%	51.1%	50.4%	51.7%	1.5%
Orissa	0.0%	0.0%	0.0%	0.0%	0.0%
Punjab	0.0%	0.0%	0.0%	0.0%	0.0%
Rajasthan	0.0%	0.0%	0.0%	0.0%	0.0%
Tamil Nadu	40.8%	41.4%	41.6%	41.5%	0.8%
West Bengal	73.1%	71.8%	71.6%	70.2%	-2.9%
Tier 2					
Pop >= 1million					
Andhra Pradesh	15.0%	9.5%	12.7%	14.8%	-0.2%
Goa	0.0%	0.0%	0.0%	0.0%	0.0%
Gujarat	51.1%	53.5%	42.6%	32.1%	-18.9%
Haryana	0.0%	4.8%	16.7%	23.5%	23.5%
Himachal Pradesh	0.0%	0.0%	0.0%	0.0%	0.0%
Karnataka	13.1%	0.0%	0.0%	0.0%	-13.1%
Kerala	16.1%	23.1%	23.4%	35.1%	19.0%
Maharashtra	17.1%	17.8%	20.1%	20.4%	3.3%
Orissa	0.0%	0.0%	0.0%	0.0%	0.0%
Punjab	18.9%	30.9%	40.6%	46.1%	27.2%
Rajasthan	24.7%	25.4%	26.9%	31.9%	7.1%
Tamil Nadu	11.7%	16.7%	16.9%	17.9%	6.3%
West Bengal	0.0%	1.2%	4.0%	5.8%	5.8%
Tier 3					
Pop >= 500,000					
Andhra Pradesh	8.7%	6.6%	6.7%	7.3%	-1.5%
Goa	0.0%	0.0%	0.0%	0.0%	0.0%
Gujarat	11.4%	6.5%	7.0%	7.1%	-4.3%
Haryana	15.0%	17.2%	6.4%	2.9%	-12.2%
Himachal Pradesh	0.0%	0.0%	0.0%	0.0%	0.0%
Karnataka	12.2%	15.6%	19.3%	21.7%	9.5%
Kerala	44.1%	32.4%	31.3%	24.6%	-19.5%
Maharashtra	7.6%	8.4%	9.7%	10.6%	3.1%
Orissa	0.0%	9.0%	31.4%	48.5%	48.5%
Punjab	35.4%	28.0%	19.1%	13.8%	-21.6%
Rajasthan	17.4%	20.7%	23.4%	22.2%	4.8%
Tamil Nadu	15.1%	10.6%	12.6%	13.3%	-1.8%
West Bengal	3.5%	4.0%	1.5%	1.2%	-2.3%
Tier 4					
Pop < 500,000					
Andhra Pradesh	52.8%	50.1%	45.9%	42.5%	-10.3%
Goa	100.0%	100.0%	100.0%	100.0%	0.0%
Gujarat	37.6%	33.8%	28.8%	25.1%	-12.4%
Haryana	85.0%	78.1%	76.9%	73.7%	-11.3%
Himachal Pradesh	100.0%	100.0%	100.0%	100.0%	0.0%
Karnataka	43.3%	39.2%	34.7%	30.7%	-12.6%
Kerala	39.8%	44.5%	45.3%	40.4%	0.5%
Maharashtra	25.1%	22.7%	19.9%	17.2%	-7.9%
Orissa	100.0%	91.0%	68.6%	51.5%	-48.5%
Punjab	45.7%	41.1%	40.3%	40.0%	-5.6%
Rajasthan	57.8%	53.8%	49.7%	45.9%	-11.9%
Tamil Nadu	32.5%	31.3%	29.0%	27.2%	-5.2%
West Bengal	23.4%	23.1%	22.9%	22.9%	-0.5%

Note: Urban agglomerations included in the above calculations meet the criteria of 100,000 or more in the 2011 Census of India.

Source: Author, calculations based on the Census of India, 1981-2011 urban agglomeration data obtained from Thomas Brinkhoff: City Population, http://www.citypopulation.de

Table D-3: Gini Coefficient of State Urban Agglomerations Population

	1988	1993	1998	2003	Change
Andhra Pradesh	0.57	0.58	0.59	0.59	0.02
Goa	0.05	0.04	0.03	0.02	-0.02
Gujarat	0.60	0.59	0.61	0.62	0.02
Haryana	0.32	0.34	0.34	0.35	0.03
Himachal Pradesh	0.00	0.00	0.00	0.00	0.00
Karnataka	0.61	0.61	0.62	0.63	0.02
Kerala	0.43	0.44	0.45	0.46	0.03
Maharashtra	0.73	0.74	0.74	0.74	0.01
Orissa	0.34	0.35	0.36	0.36	0.02
Punjab	0.50	0.51	0.51	0.52	0.02
Rajasthan	0.52	0.53	0.53	0.54	0.02
Tamil Nadu	0.59	0.59	0.60	0.61	0.03
West Bengal	0.78	0.77	0.77	0.77	-0.01

Source: Author, calculations based on the Census of India, 1981-2011 urban agglomeration data obtained from Thomas Brinkhoff: City Population, http://www.citypopulation.de

Table D-4: Levels of Urban Migrant Population

	1988	1993	1998	2003	Change 1988-2003
INTRA-STATE MIGRATION					
Andhra Pradesh	34.3%	30.7%	32.2%	34.7%	0.4%
Goa	25.4%	17.5%	20.7%	19.7%	-5.7%
Gujarat	22.0%	32.2%	28.0%	28.0%	6.0%
Haryana	26.3%	23.2%	24.5%	22.6%	-3.8%
Himachal Pradesh	29.5%	44.7%	38.4%	39.7%	10.2%
Karnataka	26.7%	26.0%	26.3%	24.9%	-1.8%
Kerala	26.8%	35.7%	32.1%	32.0%	5.2%
Maharashtra	25.8%	28.1%	27.2%	28.5%	2.7%
Orissa	34.6%	30.9%	32.5%	35.3%	0.7%
Punjab	28.0%	23.1%	25.1%	24.2%	-3.8%
Rajasthan	27.1%	31.6%	29.8%	30.3%	3.1%
Tamil Nadu	30.4%	29.8%	30.0%	26.2%	-4.2%
West Bengal	29.8%	31.9%	31.1%	29.8%	0.0%
INTER-STATE MIGRATION					
Andhra Pradesh	3.0%	2.6%	2.8%	2.7%	-0.4%
Goa	17.9%	17.2%	17.5%	18.0%	0.1%
Gujarat	6.8%	8.1%	7.6%	8.4%	1.5%
Haryana	20.0%	22.3%	21.3%	21.2%	1.2%
Himachal Pradesh	9.1%	22.7%	17.1%	15.6%	6.5%
Karnataka	4.6%	6.8%	5.9%	7.4%	2.8%
Kerala	2.8%	3.3%	3.1%	3.2%	0.4%
Maharashtra	8.4%	15.8%	12.7%	12.7%	4.4%
Orissa	5.2%	2.5%	3.6%	4.6%	-0.6%
Punjab	13.0%	14.8%	14.1%	14.2%	1.2%
Rajasthan	5.2%	5.9%	5.6%	5.7%	0.5%
Tamil Nadu	3.8%	2.4%	3.0%	2.6%	-1.2%
West Bengal	10.4%	3.9%	6.6%	6.5%	-3.9%
TOTAL MIGRATION					
Andhra Pradesh	37.3%	33.3%	34.9%	37.3%	0.0%
Goa	43.3%	34.7%	38.2%	37.7%	-5.6%
Gujarat	28.8%	40.4%	35.6%	36.4%	7.5%
Haryana	46.3%	45.5%	45.8%	43.7%	-2.6%
Himachal Pradesh	38.6%	67.4%	55.5%	55.2%	16.7%
Karnataka	31.3%	32.8%	32.2%	32.3%	1.0%
Kerala	29.7%	39.0%	35.1%	35.3%	5.6%
Maharashtra	34.2%	43.9%	39.9%	41.3%	7.1%
Orissa	39.9%	33.4%	36.1%	40.0%	0.1%
Punjab	41.0%	37.9%	39.2%	38.4%	-2.6%
Rajasthan	32.3%	37.5%	35.3%	35.9%	3.7%
Tamil Nadu	34.2%	32.2%	33.0%	28.8%	-5.4%
West Bengal	40.2%	35.9%	37.7%	36.4%	-3.8%

Source: Author, calculations based on the National Sample Survey Organization (NSSO) employment survey micro-data for the years 1983, 1987 and 1999 conducted by the India Ministry of Statistics and Programme Implementation (MOSPI) made available by IPUMS International, Minnesota Population Center and the report on 'Migration in India' for 2007-08 published by MOSPI for the National Sample Survey 64th round.

Table D-5: Educational Attainment at the University Level

	1988	1993	1998	2003	Change 1988-2003
TOTAL URBAN POPULATION					
Andhra Pradesh	4.1%	5.5%	8.0%	9.1%	5.0%
Goa	6.0%	4.7%	7.3%	10.8%	4.8%
Gujarat	5.4%	6.9%	7.8%	8.8%	3.4%
Haryana	12.8%	13.0%	15.8%	17.4%	4.6%
Himachal Pradesh	8.0%	11.0%	13.9%	11.1%	3.1%
Karnataka	4.2%	6.5%	8.7%	9.5%	5.3%
Kerala	5.7%	5.5%	5.6%	7.9%	2.2%
Maharashtra	5.9%	7.6%	8.3%	9.5%	3.6%
Orissa	5.0%	7.4%	6.9%	8.9%	3.9%
Punjab	4.2%	5.8%	5.8%	7.2%	3.0%
Rajasthan	5.5%	6.7%	9.7%	5.5%	0.0%
Tamil Nadu	3.9%	4.8%	7.7%	9.3%	5.4%
West Bengal	1.2%	2.0%	2.4%	2.4%	1.1%
MIGRANT URBAN POPULATION					
Andhra Pradesh	6.3%	9.2%	12.1%	12.8%	6.5%
Goa	7.5%	8.8%	10.0%	17.2%	9.7%
Gujarat	7.0%	8.8%	10.5%	10.8%	3.9%
Haryana	7.8%	8.9%	10.1%	12.5%	4.7%
Himachal Pradesh	12.1%	14.3%	16.6%	17.0%	4.9%
Karnataka	6.8%	9.9%	12.9%	14.1%	7.3%
Kerala	10.8%	10.4%	9.9%	13.0%	2.2%
Maharashtra	7.4%	8.6%	9.8%	12.1%	4.6%
Orissa	6.9%	8.1%	9.2%	14.0%	7.0%
Punjab	7.4%	8.4%	9.4%	12.5%	5.1%
Rajasthan	9.2%	10.4%	11.6%	11.4%	2.2%
Tamil Nadu	6.4%	8.7%	11.0%	12.3%	5.9%
West Bengal	9.8%	12.1%	14.4%	14.7%	4.9%

Source: Author, calculations based on the National Sample Survey Organization employment survey micro-data for the years 1987, 1993, 1999 and 2004 conducted by the India Ministry of Statistics and Programme Implementation (MOSPI) made available by IPUMS International, Minnesota Population Center.

Table D-6: Measure of Political Contestation

	1988	1993	1998	2003	Change 1988-2003
POLL PERCENTAGE OF RULING PARTY					
Andhra Pradesh	46.2%	47.1%	44.1%	43.9%	-2.3%
Goa	39.5%	40.5%	37.5%	35.6%	-3.9%
Gujarat	55.6%	29.4%	16.0%	49.9%	-5.7%
Haryana	38.6%	33.7%	22.7%	29.6%	-9.0%
Himachal Pradesh	55.5%	41.8%	48.8%	39.0%	-16.4%
Karnataka	43.6%	43.8%	33.5%	40.8%	-2.8%
Kerala	30.9%	32.1%	29.2%	28.6%	-2.3%
Maharashtra	43.4%	38.2%	29.2%	49.8%	6.4%
Orissa	51.1%	53.7%	39.1%	29.4%	-21.7%
Punjab	0.0%	43.8%	37.6%	35.8%	35.8%
Rajasthan	46.6%	0.0%	38.6%	45.0%	-1.6%
Tamil Nadu	37.0%	33.2%	42.1%	31.4%	-5.6%
West Bengal	39.3%	36.9%	37.9%	36.6%	-2.7%
SEAT PERCENTAGE OF RULING PARTY					
Andhra Pradesh	68.7%	61.6%	73.5%	61.2%	-7.5%
Goa	60.0%	50.0%	45.0%	52.5%	-7.5%
Gujarat	81.9%	38.5%	24.7%	69.8%	-12.1%
Haryana	66.7%	56.7%	36.7%	52.2%	-14.4%
Himachal Pradesh	85.3%	67.6%	76.5%	45.6%	-39.7%
Karnataka	62.1%	79.5%	51.3%	58.9%	-3.1%
Kerala	38.6%	39.3%	41.4%	44.3%	5.7%
Maharashtra	55.9%	49.0%	47.9%	46.2%	-9.7%
Orissa	79.6%	83.7%	54.4%	46.3%	-33.3%
Punjab	0.0%	74.4%	64.1%	53.0%	53.0%
Rajasthan	56.5%	0.0%	47.7%	76.5%	20.0%
Tamil Nadu	56.4%	64.1%	73.9%	56.4%	0.0%
West Bengal	63.6%	64.3%	53.4%	48.6%	-15.0%
RATIO OF SEAT TO POLL PERCENTAGE					
Andhra Pradesh	1.49	1.31	1.66	1.40	(0.09)
Goa	1.52	1.23	1.20	1.48	(0.04)
Gujarat	1.47	1.31	1.54	1.40	(0.07)
Haryana	1.73	1.68	1.62	1.76	0.04
Himachal Pradesh	1.54	1.62	1.57	1.17	(0.37)
Karnataka	1.42	1.82	1.53	1.44	0.02
Kerala	1.25	1.22	1.42	1.55	0.30
Maharashtra	1.29	1.28	1.64	0.93	(0.36)
Orissa	1.56	1.56	1.39	1.57	0.02
Punjab	N/A	1.70	1.70	1.48	N/A
Rajasthan	1.21	N/A	1.24	1.70	0.49
Tamil Nadu	1.52	1.93	1.76	1.79	0.27
West Bengal	1.62	1.74	1.41	1.33	(0.29)

Source: Author, calculations based on state election reports obtained from the Election Commission of India (EC).

Table D-7: Length of Chief Miniter's Tenure in Days [1]

State	1988	1993	1998	2003
Andhra Pradesh	1,903	794	3,378	3,378
Goa	3,724	633	1,323	1,563
Gujarat	1,681	1,447	128	1,827
Haryana	870	1,753	1,160	2,051
Himachal Pradesh	1,824	1,370	1,572	1,808
Karnataka	2,294	560	1,225	1,692
Kerala	1,545	1,369	1,820	1,201
Maharashtra	838	609	1,420	1,187
Orissa	3,469	1,837	1,436	4,561
Punjab	-	1,284	1,841	1,830
Rajasthan	1,047	-	1,822	1,834
Tamil Nadu	2,769	1,785	1,827	1,825
West Bengal	8,540	8,540	8,540	3,841
Total	2,317	1,722	2,143	2,137

1. The length of the Chief Minister's tenure in days for the ruling government in the year of data collection.

Source: Author

Table D-8: Political Ideology of State Government

	1988	1993	1998	2003	STUDY PERIOD TOTAL
CENTRIST	6	7	3	5	21
LEFT	2	1	2	1	6
REGIONAL	4	3	5	4	16
RIGHT	0	1	3	3	7
CENTRAL RULE	1	1	0	0	2
ALL STATE GOVTS	**13**	**13**	**13**	**13**	**52**

Source: Author, based on the Election Commission of India, and various internet sources including news archives and Wikipedia ® .

Table D-9: State Ruling Party presence in Federal Government

	1988	1993	1998	2003	STUDY PERIOD TOTAL
Andhra Pradesh	0	1	1	0	2
Goa	1	1	0	0	2
Gujarat	1	0	1	0	2
Haryana	0	1	1	0	2
Himachal Pradesh	1	0	0	0	1
Karnataka	0	1	1	1	3
Kerala	0	1	0	1	2
Maharashtra	1	1	0	1	3
Orissa	1	0	0	0	1
Punjab	0	1	0	1	2
Rajasthan	0	0	0	1	1
Tamil Nadu	0	0	1	0	1
West Bengal	0	0	0	0	0

Source: Author, based on various interner sources, including news archives and Wikipedia ®

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