Industrial Agglomeration and Its Impact on the Environment: A Study of the Indian Manufacturing Sector

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DECLARATION

I declare that the thesis entitled "**Industrial Agglomeration and Its Impact on the Environment: A Study of the Indian Manufacturing Sector**", submitted by me for the award of the degree of **Doctor of Philosophy** of Jawaharlal Nehru University is my own work. The thesis has not been submitted for any other degree of this University or any other university.

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CERTIFICATE

We recommend that this thesis be placed before the examiners for evaluation.

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List of Abbreviations

CEPI	Comprehensive Environmental Pollution Index
CPCB	Central Pollution Control Board
EG	Ellison Glaeser Index
GSDP	Gross State Domestic Product
GSDP	Gross State Domestic Product
IIRS	Indian Institute of Remote Sensing
ISO	International Organisation of Standardization
LQ	Location Quotient
MOEF	Ministry of Forest and Environment
MS	Maurel Sedillot
NAMP	National Air Quality Monitoring Programme
NEG	New Economic Geography
NIC	National Industrial Classification
SAR	Spatial Auto regressive Model
SEZ	Special Economic Zone
WHO	World Health Organisation

Chapter 1

Introduction

1.1 Background

Spatial disparity in the distribution of economic activities is a widespread phenomenon all over the world (Thunen 1826, Alonso 1964 as quoted in Fujita and et al 1999). The tendency of industries to co-locate near each other within few regions is driven by several distinct factors. While some industries may be concentrated in a region due to the availability of specific resources or proximity to consumer markets; sometimes concentration may be even triggered by some historical events. The uneven distribution of manufacturing activities across space accounts for greater regional income inequality compared to agricultural activities (Awasthi 1991). This gives rise to a *core-periphery* pattern of regional development i.e. advanced and less developed or backward regions (Krugman 1991). Analysing the nature and extent of spatial distribution of manufacturing activities, in particular, has been an important area of research in the literature of economic geography.

In India too, manufacturing activities show a highly skewed distribution across different levels of spatial aggregation (Lall and et al. 2004). While analysing the nature of this regional unevenness, Awasthi (1991) indicated that the colonial legacy under British rule inculcated a *core-periphery* dichotomy pattern in industrial development in India. Britishers guided by their own economic incentives, channelized investment only for the development of the port towns of Calcutta, Bombay and Madras in terms of the availability of infrastructure, and other amenities Awasthi (1991). In the post-independence era these cities emerged as the hub of industrial activities at the expense of the other cities in states like Assam, Bihar and Orissa which remained industrially backward.

The liberalization policies of India in 1991 marked the end of industrial licensing regime and industries were free to locate according to their profitability. High-tech industries like manufacturing of machinery equipment and manufacturing of electronics and computer equipment were found to concentrate near urban areas in order to reap the benefits from urbanisation economies i.e. availability of large pool of labour with multiple specializations, easy accessibility to consumer markets, public goods and other amenities (Lall and et al. 2004). For low-end manufacturing industries like food and beverages, leather processing and tobacco industries, agglomeration seemed to be driven mostly by intra-industry association benefits like access to industry-specific knowledge and a possibility of subcontracting of intermediate inputs between firms within the same industry (Mukim 2014). Studies on agglomeration in Indian manufacturing sector have distinguished between high-tech versus low-tech industries (based on capital intensities of the production process). But, while analysing the nature of agglomeration across industries, no attention has been paid to the polluting nature of industries. It is true that the traditional capital-intensive industries like manufacturing of iron and steel, chemical and related products are polluting. However all capital-intensive industries are not polluting *viz*; manufacturing of electronics and electrical goods, medical and surgical instruments etc. There are also certain labour-intensive industries like manufacturing of leather, plastic etc. which are highly polluting. Moreover, existing studies on agglomeration across industries have been done at an aggregated level of (two-digit level) industrial classification. It is likely that an analysis of industrial agglomeration at a disaggregated level would be able to reflect the polluting[1] nature of industries. This would facilitate policy formulation to mitigate the environmental problems arising from the concentration of these industries. For example industries like leather tanneries and manufacturing of leather products which differ in their polluting nature can be distinguished at a four-digit level of industrial classification whereas at the two-digit level they are clubbed together under manufacturing of leather. The present study, analyses the nature of industrial agglomeration in Indian manufacturing sector at a disaggregated level (four-digit level of national industrial classification).

The urban amenities and industry-specific benefits act as *centripetal/agglomerating forces* that drive concentration of industries. These forces are also found to have a significant impact on raising the productivity of the industries (Lall and et al 2004, Lall and Chakraborty 2005) which further attracts new manufacturers towards the existing cluster. This indicates that the *agglomerating forces* also affect the incidence of entry of new firms (Mukim 2014, Ghani and et al 2015, Fernandes and Sharma 2012). Birth of new firm implies new business formation or formation of new capacities (new job creation) which directly affects the development or growth of a region (Fritsch 2008). Analysing the entry decision of new firms has been an important area of research. Agglomerating forces are also found to have a significant impact on the export decision of firms in European and US manufacturing sector

[1] While categorising an industry as polluting or not polluting, we follow the Red list, Orange list and Green list of industries as defined by Ministry of Environment and Forest.

(Aitken and et al. 1997, Greenaway and Knellar 2008, Koenig 2009). In Indian context, analysing the role of agglomeration in driving export decision of firms is an emerging literature (Mukim 2013). The second objective of this study is to analyse the significance of agglomeration on the export decision of polluting vs. non-polluting firms in the Indian manufacturing sector

Increased concentration of industries or over-crowding of firms limits the availability of physical space and other resources of a region- resulting in negative effects which are known as agglomeration diseconomies (Henderson 1974 as quoted in Fujita and et al. 1999). In the presence of these diseconomies, producers may find it profitable to establish production in the periphery (Brakman and et al 1996, Kyriakopoulou and Xepapadeas 2014). There can be various forms of these diseconomies like increased rent of land, overuse of roads, sewerage and waste disposal problems. Moreover, some of the industrial activities are the significant emitter of toxic gases like sulphur dioxides, nitrous oxides etc. which adversely affect the quality of air. Agglomeration of these industries within a region may further aggravate the problem of air pollution in that region (Zheng and Kahn 2013). Little attention has been paid to empirically examine the impact of diseconomies associated with agglomeration of industries especially examining its impact on the environmental quality. The third objective of this study is to analyse the impact of industrial agglomeration on the air quality across Indian states.

1.2 Rationale and Scope of the Study

In this study, we will analyse the (i) nature of industrial agglomeration in the organised manufacturing sector across different Indian states and its environmental quality impacts. The underlying framework of the study is based on Krugman’s (1991) new economic geography model. The study uses dynamic probit model to (ii) analyse the role of agglomeration economies in determining the export behaviour of manufacturing plants-distinguishing between polluting vs. non-polluting industries over the period 2008-09 to 2013-14. Thirdly, the study analyses the extent of diseconomies arising from industrial agglomeration by observing its impact on the air quality across India states for the year 2013-14.

In this analysis industries are defined according to the National Industrial Classification. The degree of industrial agglomeration of industries has been estimated at the 4-digit level of industrial disaggregation.

The study will address the following questions:

a. What is the degree of agglomeration in polluting vs. non-polluting industries in Indian organised manufacturing sector

b. How has the spatial pattern of industrial agglomeration evolved over time?

c. What is the impact of industrial agglomeration in driving the export behaviour of plants ? -distinguishing between polluting industries and non- polluting industries

d. What has been the impact of industrial agglomeration on air quality across India states?

1.3 Chapter Scheme

The thesis is organised as follows. Chapter 2 presents a review of the existing theoretical as well as empirical literature on the agglomeration of industries in the context of developed vs. developing countries under the new economic geography framework. In **Chapter 3** of the thesis analyzes the nature of industrial agglomeration across Indian states in terms of the technology intensity and pollution intensity of the industries. **Chapter 4** of the dissertation analyses the impact of industrial agglomeration economies on the export behaviour of the Indian organised manufacturing plants. While analysing the impact of agglomeration economies on export behaviour of plants, the study also distinguishes between polluting vs. non polluting industries. **Chapter 5** of the thesis estimates the diseconomies associated with the concentration of the overall manufacturing sector in terms of the degrading the air quality across Indian states using a spatial modelling frame work.

Chapter 2

Industrial Agglomeration in Developed vs. Developing Countries-*a* review

Introduction

The regional duality in the development process across countries, popularly termed as-*North-South* issue (also known as developed vs. developing country) has been an important area of discussion both in the theoretical as well as in the empirical literature of economics. Cross-country comparative studies have analysed different issues of economics under this dualistic framework. These studies have indicated that the underlying factors driving the process of development largely differ between the two groups.

The process of industrial development has been considered to be the key to achieve economic growth, both in the developed as well as developing countries. The inception of the industrial revolution in UK (1770) followed by its gradual spread in other parts of Europe and United States of America, have made these countries industrially advanced as opposed to the newly industrialised countries (NIC) of Latin America and Asia. However, over time, some of the Asian countries like China, Japan, Korea and India have registered a significant growth in their industrial output with China capturing the bulk of the global manufacturing market (UNIDO 2018). The process of structural transformation and the industrial policies to achieve growth within these economies has been highly dissimilar. This in turn has drawn the attention of the researchers across the globe to analyse inherent dynamism within these economies. This chapter of the study briefly reviews the existing literature on the presence of agglomeration economies (or diseconomies) and its impact on the industrial development process of a country. The chapter also elaborates how the underlying agglomerative forces and their impact may vary across developed vs. developing counties.

The disparity in the distribution of geographical factors (*first nature and second nature geography*) creates cross-regional comparative advantages in terms of availability of factors of production, infrastructural facilities and other amenities within a country. This in turn drives the concentration of manufacturing activities in certain regions of the country as opposed to the others. The new economic geography literature emphasized the role of *second* *nature geography*, something beyond the natural advantages[2] of a region (*first nature geography*) in driving the concentration of manufacturing activities within a country (Krugman 1991). The *second nature geography* is defined as the external economies arising from the interaction among economic agents (both producers and consumers) in a localised environment. The economies in terms of availability of labor pool, availability of intermediate inputs, knowledge and information spillovers among the economic agents, in turn drive the agglomeration of manufacturing activities within a region. These economies are self-reinforcing or tautological i.e. concentration of manufacturing activities within a region attracts other industries in that region. This in turn reinforces further concentration of industries, leading to the formation of central business districts within a country. Other economies considered under the scope of *second nature geography* are proximity to consumer markets, availability of infrastructural facilities including the transport network system, institutional facilities and governance structure of a region.

It is true that these are some of the common factors behind driving the process of industrial agglomeration both in the context of developed as well as developing countries. However, the relative relevance and strength of each factor vary across countries. It has been observed empirically that the nature of industrial agglomeration differs between developed vs. developing countries (Fan, C. et al 2003, Deichmann et al 2008, Desmet et al 2015, Lu and Tao 2009). For example low-tech industries, driven by within–industry economies have been observed to be highly agglomerated in developing countries whereas high-tech industries are found to have high degree of concentration in developed nations.

The economies arising from the locational interdependency among economic agents have been observed to play a significant role in driving the overall productivity of a region within the country (Ciccone and Hall 1993). Moreover, empirical studies at a much disaggregated level have later confirmed that the spillover among economic agents in a localised environment have a positive and significant impact on the productivity of manufacturing plants (Henderson 2003, Rosenthal and Strange 2004, Cingano and Schivardi 2004, Lall et al 2004, Baldwin et al. 2008, Martin et al. 2011). This in turn acts as an impetus for the manufacturing plant to enter the export market. Analysing the role of within country geographical factors in shaping the internationalisation process of manufacturing plants has been well-established in the context of developed countries as well as developing countries.

[2] The natural availability of coastline or availability of mineral resources is defined as natural advantage or first nature geography of a region.

(Clerides et al 1998, Aitken and et al. 1997, Greenaway and Knellar 2008, Koenig 2009 Farole and Winkler 2013 and Pose et al 2013, Ito et al 2015, Mukim 2013, Pradhan and Das 2014).

The concentration of industries within a region, over time, may lead to scarcity of land, thereby escalating the rents of land and other immobile factors of production. Moreover, overcrowding of manufacturing activities (a potential source of harmful emission/effluents) within a region may significantly degrade the environmental quality of that region. The diseconomies associated with the agglomeration process catalyses the dispersion process of industrial activities across space. Theoretically it has been shown that the sustainability of an industrial cluster is largely dependent on the relative magnitude of the economies and diseconomies associated with it (Krugman 1991, Brakman et al 1996, Zheng 2001, Verhoef and Nijkamp 2002, Lange and Quass 2007, Kyriakopoulou and Xepapadeas 2013, Zheng and Kahn 2013). Empirically analysing the diseconomies has been a major challenge in the context of both developed as well as developing countries (Zhu et al 2014, Sun and Yuan 2015, Cheng 2016).

The *first section* of the chapter compares the existing literature on the spatial development of industries between developed and developing countries. The *second section* analyses the existing studies on the economies of industrial agglomeration under a comparative framework; especially emphasizing its role in driving the internationalisation of manufacturing plants in developed vs. developing countries. The *third section* presents a review on the role of agglomeration diseconomies, in the context of developed vs. developing countries. The *fourth* section concludes the chapter by highlighting the different gaps in the existing literature and scope for future research.

2.1 Nature of Industrial Agglomeration Economies

The degree of industrial agglomeration in developing countries differs from that of the developed nations. The overall concentration of the manufacturing industries is observed to be less in developing countries as compared to the developed nations (Lu and Tao 2009). It has been empirically observed that the technology spillovers, buyer-supplier linkages (among vertically linked industries), infrastructural facilities in urban areas are some of the common factors, driving the geographic concentration of industries in both developed as well as developing countries. Government policies and inflow of foreign direct investments have been found to be more relevant in inducing the industrial clustering process, especially in developing countries compared to that of the developed nations (Fan, C. et al 2003, Deichmann et al 2008).

The high-tech large scale industries are highly agglomerated in case of developed nations whereas in developing countries the traditional small scale enterprises are observed to form clusters example the gems and jewellery industry of Bangkok, the furniture industry of the Philippines, the pottery and silk industries in China and the leather product cluster of Agra in India (Fan, C. et al 2003). While analysing the nature of industrial agglomeration both in the context of developed as well as developing countries, existing studies have distinguished between high tech vs. low tech industries. But, while analysing the nature of agglomeration across industries, no attention has been paid to the polluting nature of industries. It is true that the traditional capital-intensive industries like manufacturing of iron and steel, chemical and related products are polluting. However all capital-intensive industries are not polluting *viz*; manufacturing of electronics and electrical goods, medical and surgical instruments etc. There are also certain labour-intensive industries like manufacturing of leather, plastic etc. which are highly polluting.

Moreover, existing studies on agglomeration across industries have been done at an aggregated level of (two-digit level) industrial classification. It is likely that an analysis of industrial agglomeration at a disaggregated level would be able to reflect the polluting[3] nature of industries. This would facilitate policy formulation to mitigate the environmental problems associated with the concentration of these industries. For example industries like leather tanneries and manufacturing of leather products which differ in their polluting nature can be distinguished at a four-digit level of industrial classification whereas at the two-digit level they are clubbed together under manufacturing of leather.

While comparing the spatial evolution process of manufacturing industries over time in developed vs. developing countries, studies have found that there lies a stark difference in the pattern of evolution, between the two groups (Desmet et al 2015). It has been observed that the manufacturing industries in the developed nations have been shifting from high population density areas to medium- density areas. In contrast to this, the medium-density (or

[3] While categorising an industry as polluting or not polluting, we follow the Red list, Orange list and Green list of industries as defined by Ministry of Environment and Forest.

the secondary cities) areas in the developing nations, especially in India registered a sluggish industrial growth owing to its infrastructural bottlenecks like lack of consumer markets, input-supplier's network, adequate power supply etc. It has been observed empirically that over the last decade, the large scale manufacturing industries in India has been shifting out from urban to rural areas, characterised by lower population density. This has been accompanied by an increased concentration of small scale industries like manufacturing of electronics components, parts and accessories of motor vehicles etc (Ghani 2012, Colmer 2014). However, among the developing nations, experience of China has been similar to that of many developed countries− medium density cities like Shanghai has become the industrial hub of the country.

While analysing the factors behind the dispersion of industries across regions, Desmet et al (2015) argued that the stage of development or the age of the sector plays an important role behind the dispersion forces originating from the concentration of industries. For example the manufacturing in US has now reached a stage of maturation and dispersion forces owing to the rising cost of congestion within the high density areas are now evident. It is true that in India also, the process of dispersion in manufacturing sector has started but the concentration of industries in the urban areas is higher relative to the developed nations. This may indicate that the cost of overcrowding in urban areas in India is lower as opposed to the developed countries.

Among the other developing countries like South Korea, Brazil, Indonesia and India, economic liberalisation policies significantly affected the spatial pattern of industrial development and initiated the process of industrial de- concentration. However the pattern of de concentration varied across countries. Indonesia and Brazil experienced inter-regional de concentration i.e. industries were found to be moving across regions. In contrast to this manufacturing industries in India over time remained concentrated in the already industrialised states. However, there has been de concentration of industries within a state; from urban to rural regions. Among the developing countries, India's experience in spatial evolution of manufacturing industries has been unique and it needs deeper analysis. Studies analysing the pattern of industrial agglomeration and their spatial evolution is emerging in the Indian context (Lall et al. 2004, Lall and Chakraborty 2005, Chakraborty 2003, Colmer 2014, Ghani 2012). **Chapter 3** of the thesis estimates the degree of industrial agglomeration and analyses the spatial distribution pattern of organised manufacturing industries across Indian states over the period 2000-01 to 2013-14. While analysing the nature of industrial agglomeration, the present study, has categorized industries in terms of both pollution intensity as well as technology intensity.

2.2 Industrial Agglomeration Economies and Export Behaviour of Manufacturing Firms

The existing studies in the international trade theory literature have primarily focussed on analysing the role of firm-level characteristics in driving their export participations (Roberts and Tybout 1997, Clerides et al. 1998, Bernard and Jensen 1999, Metlitz and Trefler 2012, Wagner 2007). However, these studied paid little attention on the role of within-country geographical factors, in shaping the export decision of firms. The economies arising from the locational interdependencies among economic agents or the agglomeration economies give firm/plant an impetus to enter the foreign market. The effect of agglomeration economies on the export market participation of plants is well documented both in the context of developed, countries (Greenaway et al 2004, Greenaway and Knellar 2008, Koenig 2009) as well as developing countries (Aitken and et al. 1997, Farole and Winkler 2013 and Pose et al 2013, ITO et al 2015), baring India. This is an emerging literature in the Indian context (Mukim 2013, Pradhan and Das 2014).

Most of the studies have examined the impact of concentration of incumbent exporters in affecting the decision of a firm to enter the export market; this is termed as export spillover. The export spillover has been observed to be positive and significant in driving the export decision of firms across developed as well as developing countries. The concentration of multinational exporting plants and inflow of foreign investment have been observed to be highly significant in affecting the export behaviour of manufacturing plants (Aitken and et al. 1997, Greenaway et al 2004, Farole and Winkler 2013[4]) across both the groups. However, the studies on developed countries went a step ahead and explained that the magnitude of the export-spillover is also dependent on the destination of the export i.e. the market where a firm starts to export. Koenig (2009) observed that that the exporter's spillover effect in the French manufacturing industries was higher for firms exporting to the remote markets. This indicates that the spillover effect significantly reduces the transaction costs of gathering information

[4] This was comprehensive study on the export behaviour of manufacturing as well as service sector firms across 126 emerging and developing economies over the period 2002 to 2010.

about the foreign markets and the effect becomes more relevant when the destination market is remote.

While analysing the role of geographical factors in shaping the export behaviour of Indonesian manufacturing plants, Pose et al (2013) observed that the export spillover effect is not limited to a specific region. There exists a spillover effect of the exporting activity of the adjacent regions within a country. While analysing the export behaviour of Chinese manufacturing plants, ITO et al (2015), emphasized the role of overall industrial agglomeration economies in shaping the export decision of manufacturing plants, apart from the exporter's agglomeration. This factor was earlier discussed by Koenig (2009) in the context of French manufacturer. However, analysing the effect of industry-specific agglomeration economies on the export behaviour of manufacturing firms is an emerging literature in the context of developing countries, especially in Indian context.

Chapter 4 of the thesis analyses the impact of both industry-specific agglomeration economies as well as exporters' spillover in driving the export behaviour of the Indian manufacturing plants. Unlike earlier studies the present study has also analysed, how the effect of agglomeration economies may vary across the nature of industries- distinguishing between polluting vs. non-polluting industries.

2.3 Industrial Agglomeration Diseconomies

It is true that industrial agglomeration significantly enhances the productivity thereby giving the plant an impetus to enter the exporting market. However, concentration of industries also gives rise to diseconomies in terms of increased price of factors of production, overcrowding at the use of infrastructural facilities leading to traffic congestion, degradation of environmental quality and scarcity of natural resources. These diseconomies in turn create repulsive forces within the industrial clusters thereby leading to the dispersion of industries across space (Krugman 1999, Brakman et al 1996). While analysing the sustainability of the industrial clusters, most of the studies have examined the trade off between the agglomerative forces vs. dispersion forces in a theoretical framework (Krugman 1999, Verhoef and Nijkamp 2002, and Kyriakopoulou and Xepapadeas 2013, Lange and Quass 2007). The empirical literature, analysing the impact of industrial diseconomies in terms of degradation in the environmental quality is sparse in the context of both developed as well as developing countries (Zhu et al 2014, Cheng 2016).

Chapter 5 of the thesis empirically analyses the impact of diseconomies associated with the agglomeration of manufacturing industries on the quality of air across Indian states.

2.4 Conclusion

The pattern and nature of industrial development have been different across developed vs. developing countries. The high-tech industries are mostly observed to be agglomerated in developed countries whereas most of low-tech industrial clusters are observed in developing countries. Eventually industries in developed countries have dispersed from high- population density areas to the medium-density areas. However, the medium-density areas in developing countries, like India have registered a sluggish industrial growth owing to the infrastructural bottlenecks. This indicates that developing countries still has some scope to unleash the potential of the medium density (or secondary cities) areas by increasing the infrastructural investment, especially in these areas. The agglomeration of exporters as well as overall industry-specific agglomeration economies positively and significantly affects the export behaviour of manufacturing firms/plants both in the context of developed as well as developing countries. Theoretical literature has established that along with the economies, concentration of industries also generates diseconomies and the sustainability of these clusters is dependent on the relative strength of the two opposing forces; agglomeration economies and diseconomies. The empirical evidences of the presence of agglomeration diseconomies associated with the industrial clustering process are sparse in the context of both developed as well as developing countries, indicating a potential area of research.

Chapter 3

Nature of Industrial Agglomeration across Indian States

Introduction

The disparity in the distribution of economic activities, especially manufacturing activities has been observed across the world. Silicon Valley of California, Diamond District of Manhattan, automobile manufacturing clusters of Detroit, IT-hub of Bangalore, small carpet-making clusters of Agra, Drugs and pharmaceuticals clusters of Ahmadabad are examples of some of the famous manufacturing clusters across the world. Why firms prefer to locate in certain regions? How the clusters are formed and how they evolve over time? What has been the impact of the economies, embodied in the clusters, on the overall development of the country? These are some of the questions that entail deeper economic analysis and have received substantive attention, both from the academic researchers as well as the policy-makers.

The tendency of plants to co locate near each other within few regions is driven by several distinct factors. While some firms may be concentrated in a region due to the availability of specific natural resources or proximity to consumer markets; sometimes concentration may be even triggered by some historical events. It has been observed that plant have a tendency to concentrate near the already existing clusters thereby further reinforcing the industrial agglomeration. The location-specific benefits arising from the co-location of plant and interdependences of economic agents within a same industry is termed as *localisation economies*. In contrast to this, any other locational benefits external to the industry is termed as *urbanisation economies*. Marshall (1890) broadly identified three types of benefits that a plant may get by locating near other plants; *viz;* availability of specialised pool of labour; buyer-supplier linkages and spillover of technological know-how (Krugman 1991). There exists an extensive literature that has examined the scope of *localisation economies* and *urbanisation economies* in the context of developed nations (Henderson et al 1995, Rosenthal, S. S., & Strange, W. C. 2004, Hanson 2001, Fujita and et al 1999).

While analyzing the scope of agglomeration economies, it is also pertinent to examine the nature of the agglomeration i.e. which type of industry is concentrated across space? Studies in the context of developed countries have empirically shown that the degree of agglomeration and the underlying forces driving the concentration largely differs across industries (Henderson et al 1995, Rosenthal, S. S., & Strange, W. C. 2004, Devereux et al. 2004). However, analysing the nature of industrial agglomeration and estimating the degree of concentration of industries across space is an emerging literature in the Indian context (Awasthi 1999, Lall and et al 2004, Mukim 2014, Fernandes and Sharma 2012, Lall and Chakraborty 2005, Ghani and et al. 2012, Colmer et al. 2014). The present chapter attempts to estimate the degree of industrial agglomeration in Indian organised manufacturing sector at a disaggregated level of industrial classification (at the four-digit level of NIC2008 classification) for the year 2013-14 using the information on plant level employment[5] across Indian states. While analysing the nature of this agglomeration, the present study distinguishes between polluting vs. non-polluting industries. Moreover, the chapter also analyses the evolution pattern of industrial agglomeration over the period 2000-01 to 2013-14.

In this analysis, four different indices are used to estimate the degree of industrial agglomeration in Indian organised manufacturing sector. It has been observed that states with a large industrial base are also the hub of some of the highly polluting industries. Irrespective of the nature of the industry, industrial agglomeration economies has been observed in the Indian manufacturing sector. The degree of industrial agglomeration has been observed to be higher in case of polluting industries as opposed to non-polluting industries in the year 2013-14. The extent of agglomeration economies of an industry has been observed to be affected by the spillover effect from adjacent regions. While examining the pattern of spatial concentration of industries over time, the chapter concludes that during the period of the analysis 2000-01 to 2013-14, the polluting industries have shown some dispersion both across states(captured by the LQ index) as well as in terms of within-in industry concentration(captured by the EG index). Compared to the scenario in 2000-01, it is true that the polluting industries show a trend of dispersion, but the environmental concern associated with the concentration of polluting industries, remains as they still appear to be among the highly agglomerated industries(EG>0.05) in the Indian manufacturing sector in the year 2013-14. Moreover, they also constitute a bulk of the share of total manufacturing output in some of the peripheral states of India.

[5] Alternatively, the entire analysis presented in this chapter has been done using the plant-level output data. The results were qualitatively same. However, the interpretation of the agglomeration index differs according to the variable used for the calculation of the industrial agglomeration index. The use of output data indicates the concentration of the overall production of the industry across space whereas the use of employment data indicates the concentration of a single factor of production across space.

The *first section* of the chapter gives a brief review of the theories explaining the mechanism behind industrial agglomeration and their evolution over time. It also discusses several indices that have been constructed to the measure the degree of industrial agglomeration. The *second section* of the chapter elaborates the nature and different features of industrial agglomeration in Indian organised manufacturing sector. The *third section* explains the pattern of evolution of industrial agglomeration over time across Indian states and industries. The *fourth section* concludes the chapter with a discussion on the observed features of agglomeration and its implication in Indian organised manufacturing sector.

3.1 Literature Review

3.1.1 Evolution Theories of Industrial Agglomeration

The study of unevenness in the spatial distribution of economic activities can be traced back into the early works of Von Thunen's (1826) monocentric city model, Christaller (1933) and Losch's (1940) central place theory and Alonso (1964) and Henderson's (1974) urban system theory (Fujita and et al 1999). Henderson (1974), urban system theory assumed that there exists a Central Business District (CBD) within a country where economic activities and consumers tend to concentrate. The availability of infrastructural amenities, presence of large consumer markets, port facilities; and other urban amenities create some externalities which further draws in new investors, thereby reinforcing the clustering process within the CBD. These theories were criticised later, as they did not analyzed the underlying mechanism behind the formation of CBD (Brakman et al 2001). Moreover these theories were primarily focused on analyzing the efficient allocation of space for production activities within the CBD and neglected the relevance of periphery (or non-urban space) within a country.

The locational theories of firm, explained the relevance of transport costs in determining the location of manufacturing activities in urban areas as opposed to non-urban space (Fujita and et al 1999). These theories analysed the location decision of a producer in presence of a trade-off between transport costs and market demand, under a perfectly competitive market structure. However, as indicated in the urban system theories, clustering of economic activities entails presence of some form of increasing return to scale or economies of scale. Modelling of increasing return to scale implies presence of imperfectly competitive market structure. Under the perfect competition assumption, these theories have also failed to model the underlying economies of scale, arising from the interaction between economic agents and other location-specific attributes that may influence the location decision of a producer.

Modelling of imperfect competition at the firm level can be traced back into the trade theory literature. Krugman (1991) in a general equilibrium framework showed that how in presence of economies of scale, transport costs and differential market size endogenously determines firm's decision to concentrate its production activity in a particular region of a country; giving rise to *core-periphery* dichotomy pattern of development. Using simulation techniques, he showed that the producer's propensity to agglomerate or disperse is dependent on some critical threshold values of economies of scale, transport costs and market demand for the manufactured goods. The relevance of geographical attributes in shaping the development of economic activities across space, re-gained its importance with this modelling strategy; also marked as the *new-economic geography* (NEG) *era*. While internal economies of scale, as modelled by Krugman (1991), is an important factor in driving agglomeration of industries, external economies of scale also reinforces the concentration of industries.

Firms within the same industry or related industries may co-locate near each other to enjoy a cost advantage in terms of easy availability of industry-specific factors of production (labour market pooling advantage) or diffusion of technology/knowledge or availability of specialised intermediate inputs across firms. In contrast to this, economies arising from the co-location of related or unrelated industries, availability of transport amenities, accessibility to large consumer markets or any other location-specific benefit outside own-industry is termed as *urbanisation economies.* Both *urbanisation economies* and *localisation economie*s have been observed to drive the concentration of manufacturing activities. These economies act as *centripetal forces* to reinforce the concentration process further.

3.1.2 Indices for empirical estimation of Industrial Agglomeration Economies

With the evolution of theories of industrial agglomeration, several indices have been developed to estimate the degree of industrial agglomeration across spatial units (Ellison and Glaeser 1997, Maurel and Sedillot 1999, Rosenthal, S. S., & Strange, W. C. 2004, Devereux et al. 2004, Alonso and et al. 2004, Guimaraes et al 2011, Amirapu et al 2019). It has been observed that the degree of agglomeration varies both across different levels of spatial aggregation (the degree of agglomeration the same industry may vary when measures at the district-level/county level vs. at the state-level), as well as different levels of industrial aggregation (agglomeration of industry, measured at the two-digit level differs from the agglomeration measured at the four-digit level) (Maurel and Sedillot 1999, Devereux et al.

2004). The existing indices can be broadly categorized into two categories- the discrete indices of industrial agglomeration where spatial units are considered to be discrete (Hoover's 1936, Krugman 1991, Ellison and Glaeser 1997, Maurel and Sedillot 1999,) and continuous indices where spatial units are considered to be continuous (Duranton & Overman 2002). The continuous indices are distance-based measures where kernel density function is estimated using the distance between pair of plants. This requires accurate location of a plant, which is often unavailable. Moreover, the theoretical foundation of these indices is emerging and beyond the scope of the present study.

The discrete indices can be further grouped into two broad categories *viz;* the raw measures of geographical concentration and the plant-based measures of industrial agglomeration. The raw measures of geographic concentration of an industry *viz;* Hoover's Location quotient (1936) and Krugman's spatial Gini coefficient (1991) captures the disparity in the distribution of regional employment (or output) in an industry relative to the regional-distribution of overall employment (or employment) in the country (Hoover's 1936, Krugman 1991). One of the major criticisms of raw measure of industrial agglomeration, these indices did not consider the within-industry plant structure which may have driven the degree of concentration of an industry. Suppose we have two industries; industry 1 and industry 2. Industry 1 is characterized by many plants all concentrated in one specific region whereas industry 2 is characterized by a single plant. Despite having dissimilar within-industry structures both the industries will show similar Gini coefficient. In industry 1 concentration may be driven by the region–specific external economies; however in industry 2, concentration is solely driven by the plant structure within the industry i.e. the entire production is concentrated within a plant. This feature makes these indices irrelevant for cross-industry comparisons of the degree of agglomeration.

While constructing an index to measure the degree of spatial concentration of an industry, the main challenge has been to incorporate the randomness involved in the agglomeration process i.e. some industries may be agglomerated spatially just by chance. Ellison and Glaeser (1997) proposed a location choice model for an industry where the probability of choosing a location by an industry is dependent on the natural advantages of that geographic area (availability of raw materials, water and electricity supply, large consumer markets, network of inter-industry linkages) and externalities arising from the co-location of plants within the industry. They defined agglomeration as the geographic concentration of an industry in excess of the plant-level concentration within the industry. This is also known as industrial localisation index.

Similar to Ellison and Glaeser Index (EG), Maurel and Sedillot (MS) formulated another index to measure the degree of industrial agglomeration. Both the indices measure geographic concentration of an industry after controlling the effect of within industry concentration. However, while calculating the degree of agglomeration of an industry, the two indices differ in the way they give weightage to the concentration of overall economic activity in a region. For example if an industry is located in a highly industrialised area then MS index takes on high value whereas if an industry is located in a less industrialized area, then the value of the index is lower. In case of EG index there is no such distinction made and the value is same in both the cases.

The Gini, Location Quotient, EG or MS indices captures the concentration of an industry as they quantify the variability in employment (or output) of an industry across spatial units relative to the national average. Arbia (2001) argued that these indices did not capture the actual geographical location of a production unit with respect to the other adjacent regions i.e. the spatial correlation between the economic activities of region *i* and the economic activities of neighbouring regions. Moreover, using the spatial unit data defined by boundaries, the degree of industrial concentration is calculated within a pre-defined spatial unit. In the spatial econometrics literature this is also termed as modified area unit problem (MAUP) (Anselin 1988, Arbia 2001, Guimaraes et al 2011). To account for both the neighbourhood effect as well as to correct the MAUP, indices of industrial concentration i.e. Gini, Location Quotient, EG or MS are weighed by using the row-standardized[6] spatial weight matrix. The spatial weights matrix captures the spatial dependence between the units of observations. The weights can be generated using the number of neighbours (*contiguity-based*) or the distance between the adjacent observations (*distance-based*) (Anselin 1988). The spatially weighted indices capture the degree of '*spatial*' agglomeration of an industry in true sense.

Most of the studies analysing the pattern of industrial agglomeration[7] across different levels of spatial aggregation has been a focus for many researchers since past few decades in both the developed (Maurel and Sedillot 1999, Rosenthal, S. S., & Strange, W. C. 2004, Ellison

[6] Each element in the row of the spatial weight matrix is standardized by the row-total. This is a standard exercise in spatial econometrics literature to assign equal weightage to all the neighbours of a particular spatial unit.

[7] While analysing the pattern of spatial development of industries, we specially focus on the manufacturing industries. Henceforth industry mentioned in this study, strictly imply manufacturing industries.

and Glaeser 1997, Combes, P. P., & Overman, H. G. 2004**,** Devereux and et al. 2004, Alonso et al. 2004) as well as developing countries (Fan, C. et al 2003, Venables, A. J. 2005, Deichmann et al 2008, Lu and Tao 2009, Chakraborty 2003, Fernandes, A. M., & Sharma, G. 2012, Desmet et al. 2015, Amirapu et al 2019). The literature has been emerging in the context of developing countries especially in India.

3.1.3 Spatial development of manufacturing industries - experience of India

While analysing the pattern of regional unevenness across Indian states, Awasthi (1991) indicated that the colonial legacy of India under British rule inculcated a *core-periphery* dichotomy pattern in the development process of manufacturing industries. Britishers guided by their own economic incentives, channelized investment only for the development of the port towns of Calcutta, Bombay and Madras in terms of the availability of infrastructure, and other amenities (Awasthi 1991). However, in the post independence era, liberalization policies of India in 1991 marked the end of industrial licensing regime and industries were free to locate according to their profitability.

Industries usually tend to locate to places characterised by availability of raw materials required in the production process and easy accessibility to consumer markets where it can cater its products. Over time freight policies have been revised to negate the locational advantages of proximity with raw materials i.e. industries located at any place of the country will get some of the critical inputs like coal, cement, iron ore, aluminium etc required for the development of industries at the same prices as that of the industries located in mineral-rich states. However, these policies facilitated agglomeration of industries in states characterised by large consumer markets as opposed to industrially backward but resource-rich states such as Bihar, Madhya Pradesh and Orissa, thereby aggravating the regional imbalance further (Aggarwal and Archa 2013).

Other locational policies like provision of adequate infrastructural amenities[8] across states play a significant role in shaping the spatial development process of industries. Infrastructural facilities include availability of power and water supply, telecommunication, banking services, transport-related infrastructures like roads and railway connectivity etc. Transport cost is a significant factor in determining the location of an industrial unit. To ensure better

[8] Several infrastructural development schemes have been initiated by the Government of India over time. The Industrial Infrastructure Up gradation Scheme (IIUS) was launched in 2003 with an aim to ensure water supply, road network, and facilities for management of waste within the industrial clusters. This policy was revamped in 2008 with special fund allotment for the north-eastern states and Jammu and Kashmir and Uttarakhand.

connectivity, across states over the period, Government of India has recommended the establishment of industrial corridors, improvement of connectivity of national highways (Golden Quadrilateral), development of rural roads under the Pradhan Mantri Gram Sadak Yojana (PMGSY 2000) scheme (Aggarwal and Archa 2013, Amirapu et al 2019) .

The development of small-scale traditional artisan industrial clusters significantly minimised the rural-urban divergence in the industrial development (Ghani and et al. 2012 Aggarwal and Archa 2013) process within Indian states. However, inter-state disparity in the development of the manufacturing industries has remained an important area of concern in the Indian economy. Presently, states like Gujarat, Andhra Pradesh, Maharashtra, Tamil Nadu and Punjab have emerged as the hub of diversified industrial activities in India at the expense of the states like Assam, Manipur, Nagaland and Jammu and Kashmir, Himachal Pradesh which remained industrially backward (Chakraborty 2003, Lall and et al. 2004, Ghani and et al. 2012).

It has been empirically observed that the presence of intra-industry spillovers, inter-industry linkages, availability of infrastructural facilities (urban amenities) like availability of proper transport infrastructure ensuring easy accessibility to input and output markets, electricity, water etc. and government policies are some of the driving forces (*centripetal forces*) behind reinforcing agglomeration of industries in Indian organised manufacturing sector (Lall et al 2004, Ghani et al 2012, Mukim 2014, Amirapu et al 2019) . The high-tech industries like manufacturing of machinery equipments and manufacturing of electronics and computer equipments are found to be concentrated mostly in urban areas as opposed to the low-end manufacturing industries like food and beverages, leather processing and tobacco industries. The high-tech innovative industries have greater ability to pay high wages and land rents prevailing in densely populated urban areas compared to the low-end manufacturing industries (Lall et al 2004, Ghani et al 2012, Colmer 2014).The externalities arising from the availability of infrastructural facilities, large consumer markets, presence of diversified industrial base or cross-industry economies, were found to have a positive and significant impact on the productivity of these high-tech industries (Lall et al 2004).

Low-end manufacturing industries like food and beverages, leather processing and tobacco industries were mostly found to benefit from within-industry economies i.e. industry-specific labour pool, technical know-how and are located in rural areas of the country (Lall et al 2004, Ghani et al 2012). While analysing the intra-industry agglomeration pattern of manufacturing sector in detail Mukim (2014) found that within an industry there is a close association between formal and informal sector firms. She observed that informal firms are sellers of material inputs and labor to the formal firms within an industry. Industries like tobacco, coke and non-metallic mineral products were found to subcontract labor more than material inputs. Sub contraction of material input was found to be higher in industries like textiles, wearing apparel and basic metals. In her analysis this buyer-supplier linkage was found to be one of the significant factors behind co-location of formal and informal firms within an industry.

While analysing the evolution of industrial agglomeration over time it has been observed that the organised firms, located in urban areas are moving towards rural or peri-urban areas i.e. the share of employment of organised firms in urban areas show a declining trend whereas their share has been rising in the rural areas/peri-urban areas (Chakraborty 2003, Ghani and et al 2012, Mukim 2014, Deichmann and et al. 2008, Colmer 2014). In contrast, unorganised manufacturing firms registered a high employment growth in the urban areas. Ghani and et al (2012) concluded that scale economies available in urban areas are more important for the small firms under unorganised sectors compare to the larger firms under organised sector. The manufacturing of non-metallic mineral products, Tobacco products and Food products and beverages are some of the least urbanised industry with less than 30% employment in urban areas. However industries like manufacturing of machinery and equipment, office, accounting and computing machinery experienced an increase in their urban employment share in the year 2000 compared to the employment share in 1994 (Ghani et al 2012). The observed pattern of evolution of manufacturing industries has been termed as *ruralisation of the organised manufacturing sector* (Ghani et al 2012 Colmer 2014).

The overall expansion of manufacturing activities in India has raised serious concern about the environmental problems associated with it. Industrial emissions have significantly led to the deterioration of the environmental quality. It has significantly aggravated the concentration of pollutants like NO_2 and SO_2 in the air (Jain 2017). While estimating the pollution-load of the Indian organised manufacturing sector using the Industrial pollution projection system (IPPS) by World Bank, it has been observed that with the increase in industrial output, industrial pollution load also shows an increasing trend (Jain 2017). Based on the pollution load of industries the study identified top ten polluting industries of India *viz* manufacturing of vegetable and animal oils, sugar, drugs and pharmaceuticals, cement, fabricated metal products, fertilizer and nitrogen compounds, basic and other non-ferrous metals, coke and refined petroleum, rubber and tyres. However, there is no study on analysing the pattern and degree of agglomeration of polluting industries in India. A study analysing the pattern and degree of spatial concentration of polluting industries would assist to identify the polluted regions across the country. This in turn will facilitate formulation of policies (especially area-based environmental management policies by regulating the location of these industries in already polluted areas) to mitigate the environment problems arising from the geographic concentration of manufacturing activities; especially that of the polluting industries.

Several attempts have been taken by the CPCB and the SPCBs to prepare a comprehensive environmental mapping for the location of industries (‘Zoning Atlas for siting industries’) across all districts. This mapping scheme engrafts both economic factors such as availability of raw materials, water and power supply, factor inputs like labor as well as the environmental factors (i.e. air, water quality of a location) that are required to be considered before a new industry is allowed to set up (CPCB 2010). This helps the entrepreneurs to find a suitable location which is economically and environmentally viable for the sustenance of their production process. Moreover, CPCB has also initiated the Environmental Impact Assessment Programme, under which entrepreneurs are issued environmental clearance certificates after assessing the potential environmental risk associated with their projects. However, the compliance with the industry-specific emission standards is monitored by the State Pollution Control Board (SPCBs) and the degree of enforcement of environmental laws varies across states.

The present chapter of the study attempts to fill the gap in the literature by examining the degree of agglomeration of organised manufacturing industries across Indian states, especially featuring out the concentration of polluting industries and their evolution pattern over time. Unlike the previous studies in Indian context, the present chapter analyses the degree of industrial agglomeration at a finer level of industrial classification (four-digit industries), thereby reflecting the polluting nature of industries. For example industries like leather tanneries and manufacturing of leather products which differ in their polluting nature can be distinguished at a four-digit level of industrial classification whereas at the two-digit level they are clubbed together under manufacturing of leather.

3.2 Nature of Industrial Agglomeration in Indian Organised Manufacturing Sector

3.2.1 Data

The spatial concentration of the organised Indian manufacturing industries has been estimated based on the Annual Survey of Industries (ASI) factory-level database, one of the primary sources of industrial statistics in India. It covers all manufacturing factories registered under the sections 2(m) (i) and 2(m) (ii) of Factories Act of 1948. A factory[9] is the primary unit of enumeration in the survey process. It is defined as any manufacturing unit with an employment of 10 or more workers using power and those with 20 or workers not using power. Other than solely manufacturing units, all electricity undertakings, engaged in transmission, generation and distribution of electricity. Moreover, some of the units engaged in services like repairing of motor vehicles, water supply, and cold storage also comes under the purview of the ASI survey. However, in this study our entire analysis is strictly restricted to units solely engaged in the manufacturing process[10].

The sampling frame of the ASI data has undergone several revisions over the year in order to expand its coverage in each state as well as across states. The survey frame of ASI can be broadly divided into two categories *viz*, census sector and sample sector. The census sector consists of large plants, based on the number of workers employed. The threshold to define the census sector plants has varied between 50 and 200 workers over the year, so that plants with 200 workers are always surveyed annually. However, no threshold is followed while sampling plants located in six industrially less developed states viz, Manipur, Meghalaya, Tripura and Andaman and Nicobar Island. All the small manufacturing units, not classified under census sector, are included under the sample sector. The plants defined under the sample sector are randomly surveyed over the period.

The sampling stratum of a manufacturing unit is defined by its geographical location, viz, state and district, industry group (at the 4-digit level of NIC) and sector. The multiplier weights are used to generate estimates at these four sub-sample level i.e. state, district, industry group and sector. The availability of geographical location of a factory along with the other characteristics like output, raw materials (including types of fuel consumed), types of fixed assets[11] used in the production process, workers employed in each unit, ownership structure and export share, makes this database ideal for analysing the pattern and the

[9] The owner of each factory identified under some industry group has to file a return annually to the statistical officer of the regional offices of NSSO. However, owners with more than two factories identified under same industry group and located in same state are allowed to file consolidated or joint returns.
[10] According to the NIC2008 classification, all units categorised under division 10 to 32 are included in the study. The detail list is given in **Table A.3.1** of the appendix of the chapter.
[11] Book value of fixed assets is reported in Annual Survey of Industries data.

underlying agglomerating/dispersing forces in driving the spatial development process of the organised manufacturing industries in India.

The survey covers all manufacturing units, registered under the Factories Act of 1948 across 29 states and 7 union territories except Arunachal Pradesh and Union territory of Lakshadweep[12]. The spatial coverage of ASI has been updated along with the change in the state boundaries in India for example ASI 2012-13 rounds started reporting data on Telengana. However, in the present study while analyzing the time series data, to maintain parity, the data of Telengana and Andhra Pradesh has been clubbed together.

In the present chapter of the study the spatial pattern of development of manufacturing industries across Indian states has been analyzed, based on the latest year published data i.e. ASI 2013-14 round. While analyzing the evolution of industrial concentration over time in **Section 3.3**, comparison has been done between the patterns of industrial concentration in 2013-14 vs. the pattern observed in the year 2000-01. In the year 2013-14, the industrial concentration has been estimated for all the 125 manufacturing industries as defined at the four digit level of National Industrial Classification 2008 (NIC2008). These industries together represent 77% of the total output produced by all factories[13] surveyed under ASI 2013-14 round. However, while assessing the evolution of industrial concentration, the degree of concentration of only 111 industries (defined at the four digit level of NIC2008) could be compared between 2000-01 and 2013-14. The coverage of plants across industries[14] over time has been reported in **Table A.3.2** in the appendix of this chapter.

In this study, the estimation of industrial concentration of manufacturing industries defined at the four digit level of NIC-2008 is based on the plant-level employment data. It can be observed from **Table 3.1** below, that there has been 26% growth in the number of plants over these 13 years. In the year 2013-14 there has been a substantive rise in the number plants employing more than 200 workers. This is driven by the revision of sampling coverage of

[12] Earlier Mizoram and Sikkim was also out of the coverage of the survey. However, in the latest frame adopted in 2011-12, these two states are added under the sampling framework of ASI. The plant coverage across states has been reported in **Table A.3.1** in the appendix of this chapter.

[13] This also includes factories belonging to repairing, water supply services and power generation and distribution services. However, coverage of factories classified under these sectors is beyond the scope of the present study. The present study considers only the factories engaged in the manufacturing process.

[14] The two-digit industrial classification has been reported just to avoid the clumsiness. However, the concordance of industries has done at the four-digit level of industrial classification.

'census sector plants'. The share of census sector plants in the year 2013-14 is 22% of the total plants covered under the survey as opposed to 10% in the year 2000-01.

Table 3.1 Distribution of Plant-level Employment

Year	Plants<= 50workers	50 <Plants<=200workers	Plants>200workers	Total Plants
2000-01	148985	15972	6744	171701
2013-14	143915	25984	48158	218056

Source: Author's calculation based on ASI unit level database

While analysing the nature of industrial agglomeration in Indian manufacturing sector, the study have categorised the industries in terms of their technology and polluting nature. The OECD definition of technology intensity[15] of industries has been followed (OECD 2011). The industries are classified into four major groups: Low-tech, Medium low-tech, Medium-High tech and High tech.

The CPCB of Government of India has classified industries into four different categories viz, Red, Orange, Green and White based on the pollution index score of each industry[16]. The pollution index score is dependent on the four criteria i.e. the i) emission from the industries (air pollutants), the ii) effluents from industries (water pollutants), iii) hazardous wastes generated by industries, and iv) consumption of resources by industries (CPCB 2016). In this study the red and orange category together has been defined as *polluting industry*. The Green and White category industries have been defined as *non-polluting industries* in the study. This categorization was initiated by CPCB to regulate the location decision of some of the highly polluting industries in ecologically sensitive areas across Indian states[17] and curb operations of certain pollution-intensive industrial processes.

3.2.2 Measures of Industrial Agglomeration

While empirically analysing the distribution of manufacturing activity across Indian states, the present chapter addressed four different measures: A) *specialisation* of industries within a state using the Hoover Balassa Index (1936) (popularly known as Location Quotient) B) *concentration* of industries has been estimated using the Krugman's index of Spatial Gini

[15] The definition of technology intensity of industries is based on the expenditure on research and development.
[16] The Red category is defined as industries with the pollution index score >60; the Orange category is defined as industries with pollution index score greater than equal to 41 but less than 60; the Green category is defined as industries with pollution index score greater than equal to 21 but less than 41; the White category is defined as industries with pollution index score less than equal to 20.
[17] The ecologically sensitive areas are protected areas for conservation of Biodiversity; example Doon Valley in Uttarakhand, Sultanpur in Uttar Pradesh.

(1991) C) the Ellison Glaeser's Index (1999) has been used to estimate the degree of *agglomeration or localisation* of industries D) degree of *spatial agglomeration* of industries has been estimates using the spatially weighted Ellison Glaeser's Index (Arbia 2001, Guimaraes et al 2011).

A. *Locational -specialisation of industries*

The concept of specialisation measures whether the share of a location in a particular manufacturing industry is relatively higher than the other locations of its production. Suppose there are M regions and I industries within a country. The Location Quotient (LQ) of industry i in region m is defined as the ratio of employment share of industry *i* in region[18] m (s_{im}) to the share of employment (or output) of region *m* in aggregate manufacturing employment (x_m); represented in equation (1) below;

$$LQ_{im} = \frac{s_{im}}{x_m} \qquad (1)$$

If the value of this ratio is greater than 1 then it indicates that region *m* is specialised in industry *i*. A value between zero and 1 indicates no specialisation. A value of the ration equal to 1 indicates that the share of industry *i* in region *m* is equal to the national average.

B. *Concentration of industries*

In contrast to this, the concept of industrial concentration within a country measures the overall concentration of an industry *i* across all M regions. In other words it captures the degree to which the percentage distribution of industry *i* employment across M regions corresponds to the percentage distribution of employment across M regions. It is defined by equation (2) below,

$$G_i = \sum_{m=1}^{M} (s_{im} - x_m)^2 \qquad (2)$$

Both these measures estimate the degree of industrial concentration without controlling for the within-industry distribution of plant. Ellison and Glaeser (1999) estimated the degree of

[18] Here region implies states of India.

concentration of industries across regions in excess of the plant-level concentration. They termed this index as index of industrial localisation or industrial agglomeration index.

C. *Agglomeration of Industries*

While estimating the degree of agglomeration of an industry, Ellison and Glaeser (1999), constructed a discrete probability model following Bernoulli distribution to analyze the correlation between the location choices of two plants belonging to the same industry. The two plants within the same industry may locate near each other due to the presence of externalities or spillovers. In this chapter, spillovers have been defined in terms of benefits[19] from exchange of labour pool within the same industry. A plant may choose to locate in a region where it can gain maximum profit.

The profit function of a plant belonging to industry *i* located in region *m* is affected by two factors- a) employment share of region *m* in aggregate employment and the b) location of other plants within the same industry owing to the presence of spillovers.

Let there be N number of plants in industry *i* and $z_1, ..., z_j, ..., z_N$, are the share of these plants in the total employment (or output) of the industry. The Herfindahl index of industry *i* as $H_i = \sum_{j=1}^{N} z_j^{\,2}$, captures the plant size distribution within industry *i*.

The model assumes that the location choice of plant j to set up its operations is an independent identically distributed random variable $v_1, v_2, ..., v_M$ each taking values from $1, 2, ..., M$ with probabilities $p_1, p_2, ..., p_M$. The re-write regional share of industry i as,

$s_i = \sum_{j=1}^{N} z_j u_m$, where u_m is the Bernoulli random variable which takes a value 1 if a plant j locates in region m, i.e. v_m= m and 0 otherwise.

[19] Other benefits as defined in the original model that may drive two plants within the same industry are technological know-how, inter-plant trade in intermediate inputs.

Ellison and Glaeser modelled the interaction between the location decision of two plants j and k within the same industry *i* owing to the presence of spillover. The interaction between the location decisions of two plants within the same industry in region *m* is defined as,

$$Corr(u_{mj}u_{mk}) = \gamma_0 \text{ for } j \neq k \tag{4}$$

The γ_0 captures the degree or the strength of spillover between two plants belonging to the same industry, located in the same region. The probability that plant *j* and *k* will locate in the same area *m* is given by,

$$p(j_m k_m) = E[u_{jm}u_{km}]$$
$$E[u_{jm}u_{km}] = Cov(u_{jm}, u_{km}) + E[u_{jm}]E[u_{km}]$$
$$= \gamma_o x_m(1 - x_m) + x_m{}^2$$

The probability P that plant *j* and *k* locates in any of the M locations is given by,

$$P = \sum_{m=1}^{M} p(j_m, k_m) = \gamma_0(1 - \sum_{m=1}^{M} x^2{}_m) + \sum_{m=1}^{M} x_m{}^2$$

Ellison and Glaeser explained (using the example of throwing dart in space) that the location choice of a plant is a two stage process. In the first stage natural advantages of a region drives a fraction of the plant to locate in the same region. In the second stage, some plants randomly choose to co locate in the same region owing to the presence of spillover among them. The strength of the spillover is captured by parameter γ_0.

$$\gamma_0 = \frac{G_i - (1 - \sum_{m=1}^{M} x_m^2) * H_i}{(1 - \sum_{m=1}^{M} x_m^2) * (1 - H_i)} \tag{5}$$

where, G_i is the measure of raw concentration of the industry as defined by equation (2)

D. *Spatially-Weighted Index of Industrial Agglomeration*

Ellison Glaeser (1999) index has been criticised, later for capturing the degree of concentration irrespective of its geographical position relative to other areas within the country i.e. spillover from adjacent regions was not considered in the estimation process. This can be elaborated with an example, Suppose there are 12 plants within an industry located across 16 regions. Three hypothetical spatial distribution patterns of these 12 plants across 16 regions has been represented by the grids in fig 3.1a), b) and c) below,

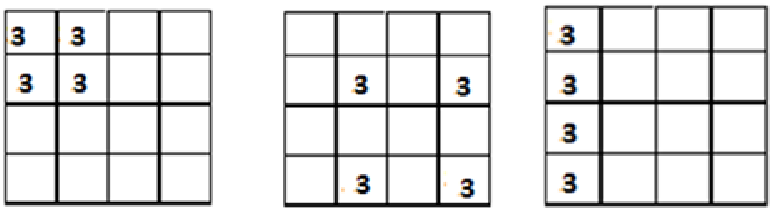

Figure 3.1a) Figure 3.1b) Figure 3.1 c)

From the above distributional pattern and given the position of each region, it can be interpreted that the concentration is highest in fig 3.1a) based on the distance between any two pair of plants. The concentration is higher in 3.1c) compared to 3.1b). However, the Gini and Ellison Glaeser indices both are observed to have same value in all the above three cases as these indices captures concentration within a defined spatial unit, irrespective of its geographical position with the neighbouring regions.

Guimareas et al. (2010) the index of industrial agglomeration has been modified to incorporate the spillover effect of the neighbouring regions. The spillover effect of economic activity of adjacent regions has been captured by weighing the regional share in equation (5) by using the spatial weights matrix; W. The modified Ellison Glaeser Index of agglomeration can be re-written as,

$$\gamma^{SW}{}_i = \frac{G_s - (1 - W\sum_{m=1}^{M} x_m^2) * H_i}{(1 - W\sum_{m=1}^{M} x_m^2) * (1 - H_i)} \qquad (5)'$$

Since, W is a spatial-weight matrix so the equation (2)’ can be re-written in the vector form as,

$$\gamma^{SW}{}_i = \frac{G_s - (1 - x_m{}'Wx_m)H_i}{(1 - x_m{}'Wx_m)\sum_{m=1}^{M}(1 - H_i)} \qquad (5)''$$

where, $G_s = (s_{im} - x_m)'W(s_{im} - x_m)$ is the Spatially weighted Gini Index of equation (1)

3.2.3 Features of Industrial Agglomeration

I. *States with highly developed industrial base are also hub of some of the highly polluting industries*

While analyzing the spatial development process of the organised manufacturing sector, it has been observed that there is an inequality in the distribution of the manufacturing output across states. In the year 2013-14, states like Tamil Nadu, Maharashtra, Uttar Pradesh, Gujarat and Haryana together accounts for 60% of the total manufacturing output produced in the economy. While analysing the nature of industrial development, it has been observed that industries (defined at the 4-digit level NIC2008) like manufacturing of sugar, tanning and dressing of leather, paper and pulp, pharmaceutical, basic iron and steel, basic chemicals show a high degree of specialisation (LQ>1; as defined by equation 1 in the previous section) in these states, baring Haryana. According to the definition of CPCB, these are the highly polluting industries and are defined under the Red Category (CPCB 2016).

As opposed to this, the nature of industrial development in Haryana, Karnataka and Chandigarh has been less polluting. Industries like manufacturing of parts and accessories of motor vehicles, fabricated metal products, electronic components, transport equipments; categorized under the Green category by CPCB, show a high degree of specialisation in these states

II. *44% of the total manufacturing industries (defined at the four-4digit level of NIC2008) are found to be highly agglomerated in the year 2013-14.*

The degree of agglomeration of Indian manufacturing sector has been estimated by using the EG Index (γ_0) as defined by equation (5) in the previous section. If the value of γ_0 is below 0.02 but positive then the industry is not very agglomerated. If the value of γ_0 varies between 0.02 and 0.05 then the industry is moderately agglomerated and if value of γ_0 is above 0.05 then the industry can be categorized as highly agglomerated. The negative value of γ_0 indicates that the industry is dispersed.

Using this definition, it can be observed from **Figure 3.2** below, that 44% of the total four-digit industries included in the study are highly agglomerated, 30% are moderately agglomerated and 26% of the industries are either dispersed or have lower degree of agglomeration.

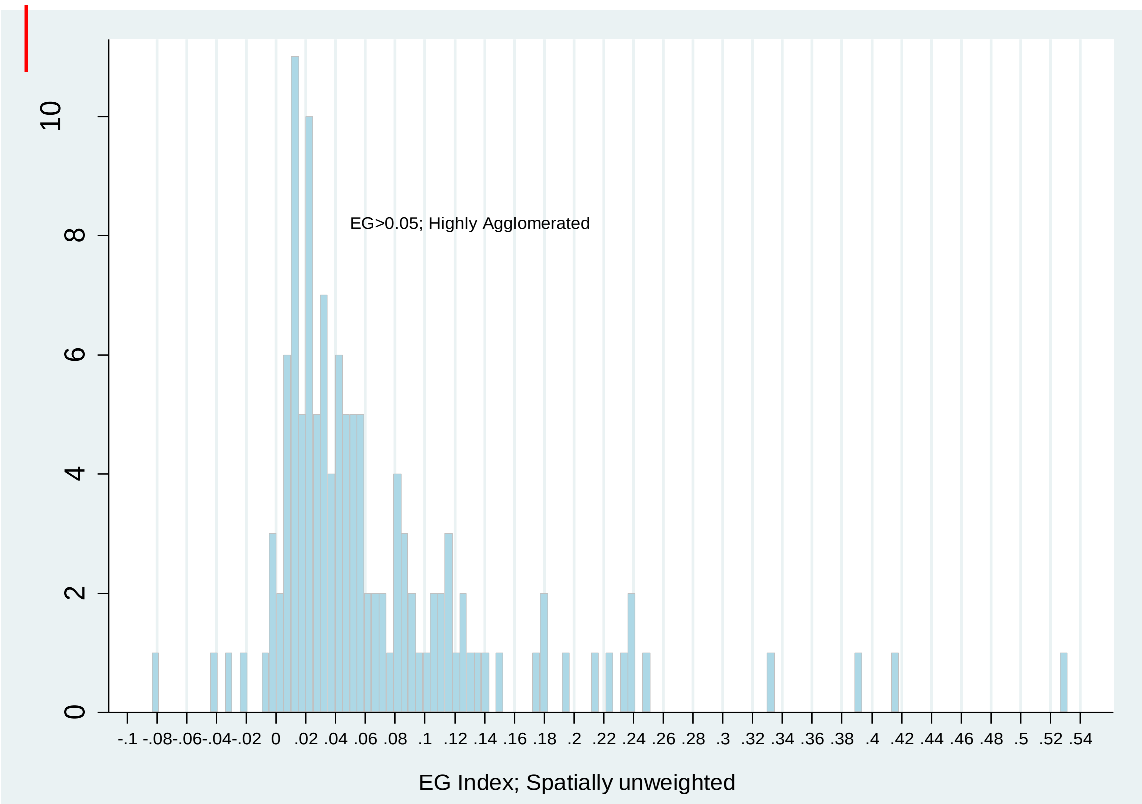

Figure 3.2 Distribution of the Degree of industrial agglomeration in the year 2013-14

Some of the top agglomerated industries, identified at the 4-digit level of industrial classifications are listed in the **Table 3.2** below. It can be observed that the agglomerated industries also have a high Gini Index (G^{UNW}) which captures the geographic concentration of the industry. However, it is not true that the all agglomerated industries have high degree of plant-level concentration within an industry, captured by the Herfindahl Index (H) in the second column of the above table. For example, tanning and dressing of leather have a high degree of geographic concentration (G^{UNW}) with a value of 0.22 but the within-industry plant structure (H) seems to be dispersed with a value of 0.004. This indicates that overall agglomeration; captured by EG^{UNW} of tanning and dressing of leather industry is primarily driven by the geographic concentration and not by the underlying plant-structure. Some of the least agglomerated industries in the manufacturing sector in the year 2013-14 are manufacturing of dairy products, manufacturing of structural metal products, manufacturing of pulp and paper etc. It has been observed that manufacturing of machinery for metallurgy, computer and computer peripherals, man-made fibres are some of the dispersed industries (EG^{UNW} <0) in the year 2013-14.

Table 3.2 Top 15 Highly Agglomerated industries in the year 2013-14

Industry	EG^{UNW}	Herfindahl	$Gini^{UNW}$
Manufacture of bicycles and invalid carriages	0.531	0.023	0.543
Manufacture of tobacco products	0.418	0.027	0.451
Manufacture of knitted and crocheted apparel	0.392	0.004	0.395
Manufacture of other porcelain and ceramic products	0.332	0.009	0.337
Processing and preserving of meat	0.248	0.032	0.264
Manufacture of carpets and rugs	0.240	0.012	0.252
Manufacture of leather luggage, handbags etc.	0.238	0.011	0.246
Manufacture of jewellery and related articles	0.231	0.033	0.238
Manufacture of sports good	0.224	0.045	0.265
Tanning and dressing of leather	0.216	0.004	0.222
Manufacture of railway locomotives and rolling stock	0.194	0.026	0.227
Finishing of textiles	0.182	0.003	0.183
Manufacture of coke oven products	0.181	0.028	0.196
Manufacture of other chemical products n.e.c.	0.176	0.005	0.177
Manufacture of other transport equipment n.e.c	0.149	0.119	0.202

Source: Author's calculation based on ASI-factory level database

UNW: Spatially unweighted Index

III. *Most of the low-tech polluting industries show a high degree of industrial agglomeration*

While analysing the nature of industrial agglomeration, it has been observed that the average degree of agglomeration of polluting industries[20] is greater than the average degree of agglomeration of non-polluting industries[21]. **Table 3.3** below lists some of the highly agglomerated (EG>0.05) polluting and non-polluting industries in the Indian organised manufacturing sector in the year 2013-14. It is apparent from the table that most of the low-tech[22] polluting industries are highly agglomerated.

[20] In this analysis all the industries classified under the Red and Orange category has been clubbed under the polluting industry category.

[21] In this analysis all the industries classified under the Green and White category has been clubbed under the non-polluting category.

[22] While categorizing the industries in terms of their technology, the study has followed OECD definition of technology intensity ISIC REV 3(based on R&D expenditure).

Table 3.3 Nature of Highly Agglomerated Industries

Industry	EG^{UNW}	Technology Category	Pollution Category
Manufacture of tobacco products	0.418	Low tech	Red
Manufacture of knitted and crocheted apparel	0.392	Low tech	Green
Manufacture of other porcelain and ceramic products	0.332	Low tech	Red
Processing and preserving of meat	0.248	Low tech	Red
Manufacture of carpets and rugs	0.240	Low tech	Green
Manufacture of leather luggage, handbags	0.238	Low tech	Green
Tanning and dressing of leather	0.216	Low tech	Red
Finishing of textiles	0.182	Low tech	Red
Manufacture of coke oven products	0.181	Medium-low tech	Red
Manufacture of other chemical products n.e.c.	0.176	Medium-high tech	Red
Manufacture of other food products n.e.c.	0.141	Low tech	Red
Manufacture of office machinery and equipment	0.131	High tech	Green
Manufacture of other textiles n.e.c.	0.128	Low tech	Red
Manufacture of Basic chemicals	0.125	Medium-high tech	Red
Manufacture of footwear	0.117	Low-tech	Green

Source: Author's Calculation based on ASI-factory level database

IV. '*Neighbourhood effect' is in the degree of industrial agglomeration*

The degree of industrial agglomeration has been estimated by using the EG Index as represented by equation (5) as described in the previous section. However, the formulation of the index does not capture the degree of *spatial* concentration of an industry i.e. concentration relative to other adjacent regions within the country. Moreover, it has been calculated based on the employment data of each industry across states, where states are pre-defined by boundaries. The degree of industrial concentration calculated in this manner, may suffer from a downward bias as this cannot capture the effect of adjacent regions. The bias has been corrected by estimating the spatially weighted agglomeration index as indicated by equation (5)" for all the 125 four digit industries included in our sample. The spatially weighted (EG^{SW}) and spatially unweighted EG (EG^{UNW}) are positively and highly correlated (the coefficient of correlation is 0.88 significant at 5% level of significance), as depicted by the scatter diagram in Figure **A.3.1** in the appendix of the chapter.

It has been observed that 26% of 125 four-digit industries considered in the analysis, appeared to be dispersed or least agglomerated according to the estimates of EG^{UNW}. However, after incorporating the effect of adjacent regions i.e. re-estimating EG by adjusting for the position of the industry in a state relative to other adjacent regions, some of the industries appeared to be highly agglomerated which were earlier dispersed i.e. $EG^{UNW}<0$[23]. The **Figure 3.3a) and 3.3b)**[24] depicts the example of two such industries *viz;* manufacturing of man-made fibres and manufacturing of machine for metallurgy respectively. It is apparent that these industries are spatially agglomerated and show some degree of clustering when the index was adjusted for the neighbouring regions. In these figures, the excess concentration ($s_{im} - x_m$) of both the industries are plotted.

The manufacturing of man-made fibres (NIC[25]-2030) seems to be clustered in the northern, north-eastern and eastern region of India. The manufacturing of machinery for metallurgy (NIC-2823) appears to be clustered in the north-western region. It also appears to be clustered in a small pocket in the eastern region.

This analysis indicates that EG index cannot capture the degree of spatial agglomeration and may lead to misleading conclusion about the degree of industrial agglomeration. While analysing the impact of industrial agglomeration it is pertinent to modify the index by weighing it with the spatial matrix.

[23] The converse is not true i.e. any industry which appeared to be highly agglomerated according to EG^{UNW} is actually spatially dispersed according to EG^{SW}. It is important to be mentioned here, that while comparing the EG^{SW} vs. unweighted EG^{UNW} for the highly agglomerated industries, it is true that the ranking of industries differed but they were agglomerated according to both the indices.

[24] In the figures below, the darker shade depicts higher degree of clustering whereas the lighter shade indicates lower degree of clustering.

[25] National Industrial Classification 2008 has been followed for the analysis.

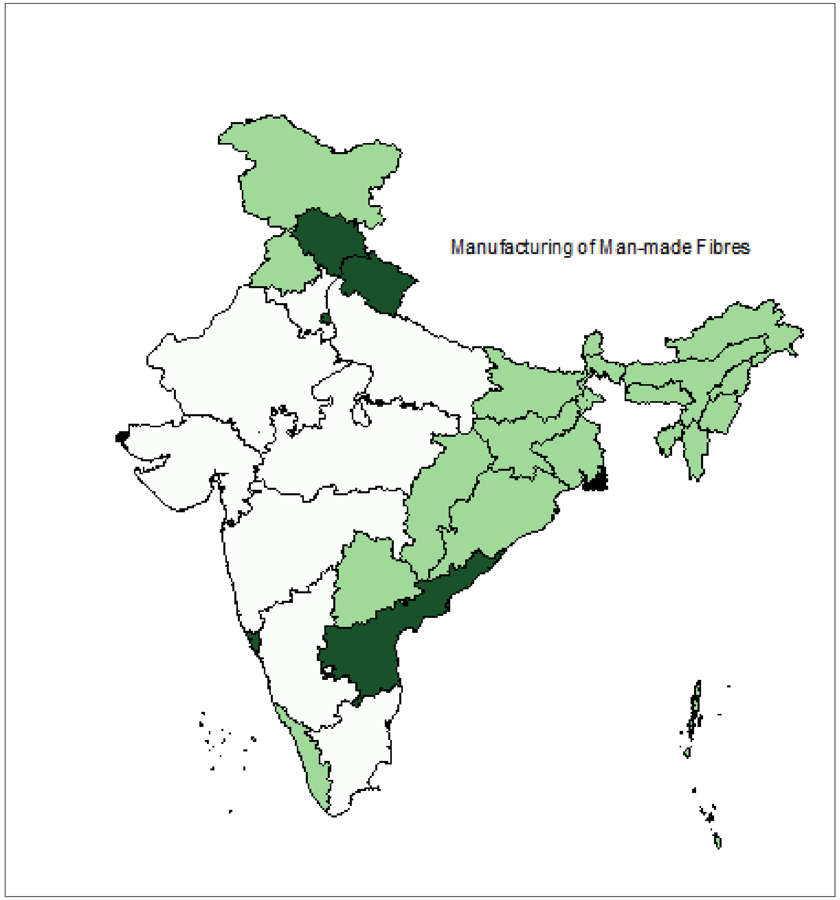

Fig 3.3a) Excess concentration in Manufacturing of Man-made Fibres

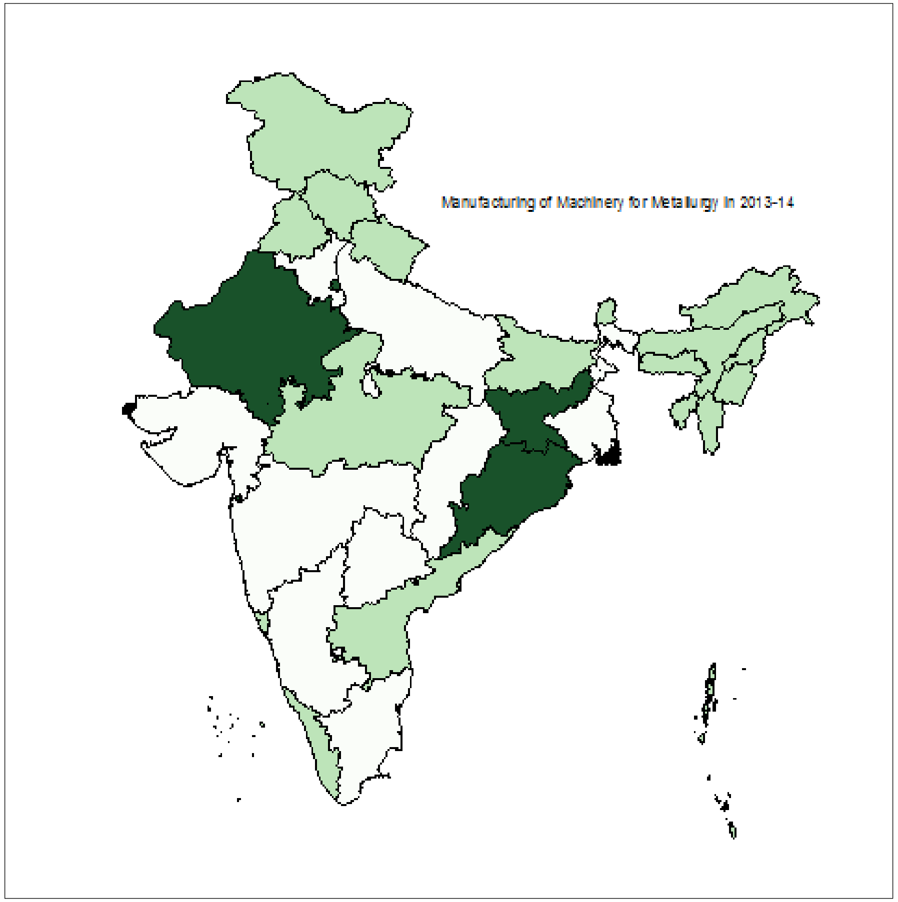

Fig 3.3b) Excess concentration in Manufacturing of Machinery for Metallurgy

3.3 Spatial Evolution of Industrial Agglomeration- 2000-01 vs. 2013-14

3.3.1 Evolution of Manufacturing Activity across states

During the period of analysis (2000-01 to 2013-14), the total output of the organised manufacturing sector has registered a growth of 0.151%[26] accompanied by a moderate employment growth (0.039%) in the sector. While analysing the distribution of manufacturing activity across Indian states, it is true that the share of the already industrialised states like Gujarat, Maharashtra, Andhra Pradesh and Uttar Pradesh constitute the bulk of the total manufacturing output. However, during this period it is noteworthy to observe that some of the industrially laggard states like Jammu and Kashmir, Meghalaya, Uttarakhand, and Himachal Pradesh, have registered a high growth rate in terms of both the manufacturing output as well as employment. This is reflective of the fact that over time organised manufacturing activities has been spreading across states.

While analysing the nature of this spread, it has been observed that some of these states like Jammu and Kashmir and Meghalaya have experienced an increase in the share of polluting industries in their total manufacturing output. **Figure 3.4 a) and b)** below compares the degree of specialisation of polluting industries between 2000-01 and 2013-14 across Indian states. It appears that states like Maharashtra and Rajasthan were specialised in polluting industries in the year 2000-01 but over the period they show a declining trend in the degree of specialisation in polluting industries. States in the north-eastern and eastern region of India over both the period specialises in polluting industries. It seems like the industrial core regions (baring, Gujarat and West Bengal) have been shifting towards production of cleaner output at the expenses of the peripheral regions of the country, generally characterised by lax environmental regulations. However, it is not possible to comment anything on the possibility of pollution haven effect across Indian states from this analysis and it is beyond the scope of the present study but this could be a possible hypothesis for future scope of research.

[26] The compounded annual growth rate has been calculated in this analysis.

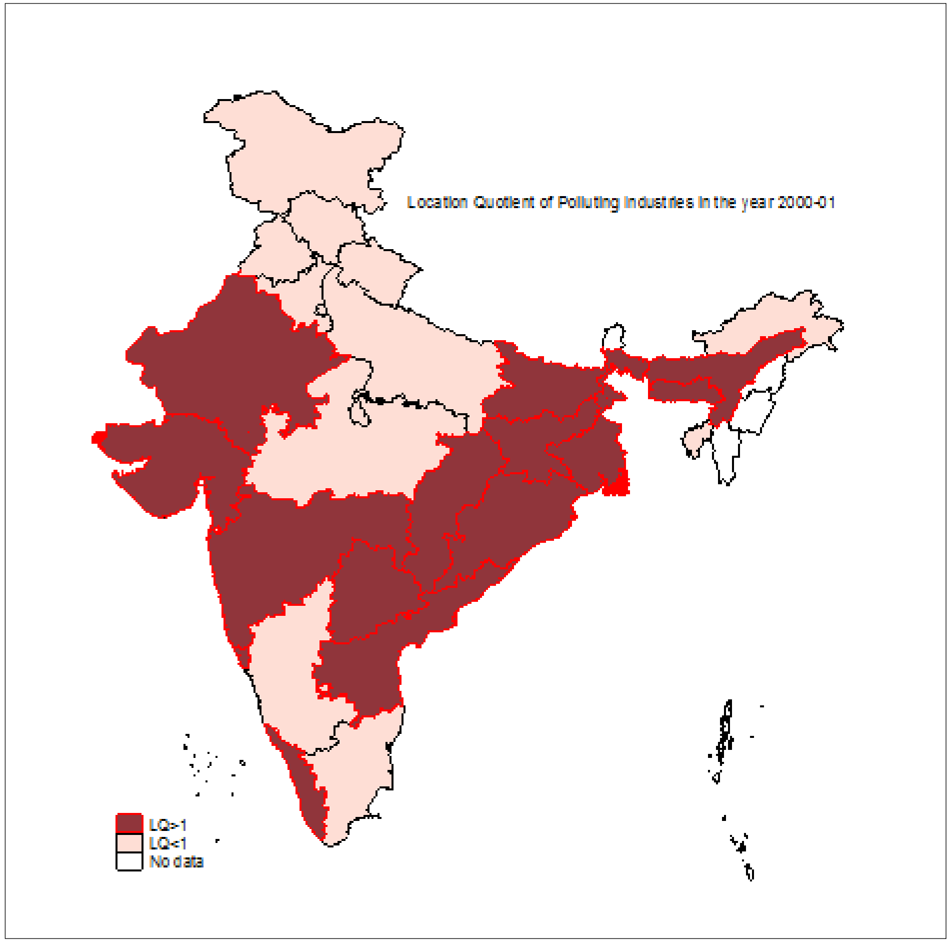

Figure 3.4 a) Location Quotient of Polluting Industries in 2000-01

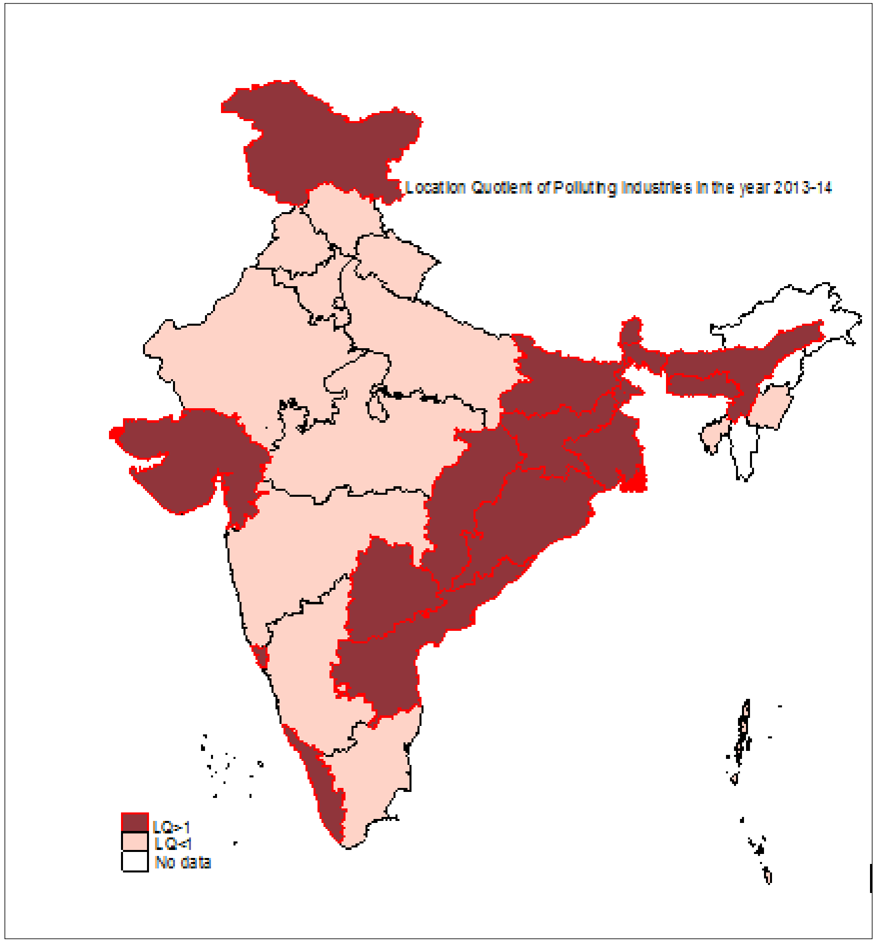

Figure 3.4 b) Location Quotient of Polluting Industries in 2013-14

3.3.2 Evolution of Manufacturing Activity across industries

The average degree of industrial agglomeration in both the time period 2000-01 and 2013-14 indicates that manufacturing industries in India are highly agglomerated; with $EG^{UNW}_{avg\ (2000-01)}$ as 0.111 and $EG^{UNW}_{avg\ (2013-14)}$ being 0.071 respectively. However, over time, the degree of concentration has declined, indicating the dispersion of industries across space. While distinguishing between polluting and non-polluting industries, it has been observed that during 2000-01 to 2013-14, the dispersion of polluting industries has been higher as opposed to the non-polluting industries[27]. **Table 3.4** below lists some of the polluting industries for which the degree of agglomeration has declined in the year 2013-14 compared to its degree of agglomeration in the year 2000-01.

Table 3.4 Change in the degree of Industrial Agglomeration of Polluting Industries

Industry	EG^{UNW} (2013-14)	EG^{UNW} (2000-01)	ΔEG^{UNW}	ΔEG^{SW}
Manufacture of coke and oven products	0.181	0.472	-0.29	-0.285
Processing and Preserving of Meat	0.248	0.474	-0.227	-0.421
Forging, pressing, stamping	0.047	0.222	-0.175	-0.203
Manufacture of plastics and synthetic rubber in primary forms	0.083	0.229	-0.146	-0.172
Manufacture of other chemical products n.e.c	0.176	0.304	-0.128	-0.1
Manufacture of Basic Chemicals	0.125	0.198	-0.073	-0.055

Source: Author's calculation based on ASI factory-level data

ΔEG^{SW}: [EG^{SW} (2000-01) - EG^{SW} (2013-14)]

It is true that polluting industries show a declining trend in their degree of agglomeration over time, but these are some of the highly agglomerated industries (EG>0.05) in the year 2013-14, also reported in **Table 3.3**. The decline in the EG index over time especially in case of polluting industries indicates the presence of diseconomies or negative spillover among the plants−initiating dispersion forces. The last column of the table indicates that over time spatial agglomeration (EG^{SW}) has also declined for these industries.

The analysis in this chapter confirms the fact that there are agglomeration economies (or diseconomies) in terms of sharing of labour across plants among the organised manufacturing industries. The impact of these economies and diseconomies has been empirically examined further in the following two chapters of the thesis.

[27] Dispersion is also visible in case of non-polluting industries. However, there are some non-polluting industries that have become agglomerated over time.

3.4 Conclusion

The distribution of the organised manufacturing sector has been uneven across Indian states indicating a core-periphery dichotomy pattern of industrial development within the country. States like Tamil Nadu, Maharashtra, Uttar Pradesh, Gujarat and Haryana together constitutes the bulk of the total manufacturing output produced in the organised sector. During the period of the analysis i.e. between 2000-01 and 2013-14, the bulk of the output has remained confined within the already industrialised states. However, it is noteworthy to observe that during this period, some of the industrially laggard states like Uttarakhand, Jammu and Kashmir, Himachal Pradesh have registered a high growth in terms of both manufacturing output as well as employment. This indicates that manufacturing activities has been spreading over time across states. While analysing the nature of industries it has been observed that these laggard states over time has actually gained in terms of the share of polluting industries in their total manufacturing output. In contrast to this, some of the industrial core regions like Maharashtra and Rajasthan have registered a declined in the share of polluting industries in their total manufacturing output. Is it true that over time the industrially advanced states characterised by stringent environmental regulations are becoming cleaner at the expense of the environmental degradation of the peripheral states in India?- indicating a pollution haven effect across Indian states. However, this needs further analysis and can be a potential area for future scope of research.

The chapter uses the annual survey of industries factory-level data to estimate the degree of industrial agglomeration in the Indian manufacturing sector based on the plant-level employment data. It has been observed that irrespective of the nature of industries there exists a high degree of agglomeration economies among manufacturing industries. The underlying economies arsing from the sharing of labour across manufacturing plants indicate that clustering of industries may accentuate the employment growth of the sector. However, the evidence of high agglomeration among the low-tech polluting industries raises concern about the environmental impacts associated with the clustering process. The presence of this trade-off associated with the clustering process entails some kind of cost-benefit analysis during the formulation of the industrial clustering policies. Moreover, it seems imperative to have information on industry-specific degree of concentration within a state as well as in the adjacent states (as indicated by the '*neighbourhood effect'* in the analysis. This in turn will facilitate formulation of industry and region specific policies to mitigate the environmental problems associated with the industrial clustering process.

Appendix

Table A.3.1 Spatial Distribution of Organised Manufacturing Plants

State	Number of Plants(2000-01)	Number of Plants(2013-14)
Tamil Nadu	23937	33645
Andhra Pradesh*	16487	28168
Maharashtra	23243	26652
Gujarat	21145	21551
Uttar Pradesh	12642	12846
Punjab	8424	11951
Karnataka	8328	10549
Rajasthan	5672	8365
West Bengal	7827	7943
Kerala	4914	6006
Haryana	5766	5857
Madhya Pradesh	3493	3636
Delhi	4242	3359
Assam	2085	3354
Bihar	1997	3142
Uttaranchal	933	2848
Himachal Pradesh	685	2686
Orissa	2029	2555
Jharkhand	1784	2412
Chattisgarh	1645	2333
Daman & Diu	1548	1841
Dadra & Nagar Haveli	1143	1366
Jammu & Kashmir	391	911
Pondicherry	559	803
Goa	537	558
Tripura	244	522
Chandigarh(U.T.)	305	238
Manipur	65	138
Nagaland	156	126
Meghalaya	27	101
Sikkim	Not Covered	60
Andaman & N. Island	23	13
Lakshadweep	Not Covered	Not Covered
Arunachal Pradesh	Not Covered	Not Covered
Mizoram	Not Covered	Not Covered

Source: Author's calculation based on ASI data
**In the year 2013-14 data for Telengana and Andhra Pradesh were also clubbed together*

Table A.3.2 Distribution of Plants across Industries

Industry*	Number of Plants (2000-01)	Number of Plants (2013-14)
Food and Beverages	29513	36585
Rubber and Plastic Products	15726	25434
Textiles	18461	18215
Fabricated Metal Products	11250	16362
Chemical Products (including Pharmaceuticals)	13912	16013
Machinery and Equipments N.E.C	12304	13781
Other Non-metallic Mineral Products	9677	11455
Basic Metals	9677	11455
Saw Milling & Planing of wood	4462	8634
Wearing Apparel	5256	8482
Electrical Equipments	5066	7093
Paper and Paper Products	4523	6742
Motor vehicles, trailers, semi-trailers	3227	5251
Printing and related services	4065	4360
Leather and Related Products	3017	3879
Tobacco Products	3117	3105
Other Manufacturing N.E.C	2587	3007
Other Transport Equipments	2416	2226
Coke and refined products	1115	1546
Manufacture of Furniture	679	1422

*Industries are reported after concording NIC-98 and NIC-2008 at the 4-digit level

Table A.3.3 Nature of Least and moderately Agglomerated Industries

Industry	EG	Technology Category	Pollution Category
Manufacture of pulp, paper and paperboard	0.0004	Low tech	Red
Manufacture of structural metal products	0.0066	Medium-low tech	Green
Manufacture of rubber tyres and tubes	0.007	Medium-low tech	Red
Manufacture of motor vehicles	0.0076	Medium-high tech	Green
Manufacture of optical instruments and equipment	0.0084	High-tech	Green
Manufacture of machinery for mining	0.01	Medium-high tech	Green
Manufacture of electric motors, generators	0.0102	Medium-high tech	White
Manufacture of batteries and accumulators	0.0116	Medium-high tech	Red
Manufacture of soft drinks	0.0137	Low tech	Orange
Manufacture of furniture	0.0142	Low tech	White
Manufacture of fertilizers and nitrogen compounds	0.015	Medium-high tech	Red
Manufacture of plastics products	0.0229	Medium-low tech	Green
Manufacture of electronic components	0.0242	High-tech	Green
Manufacture of communication equipment	0.0253	High-tech	Green
Manufacture of made-up textile article	0.0315	Low tech	Green

Source: Author's Calculation based on ASI-factory level database

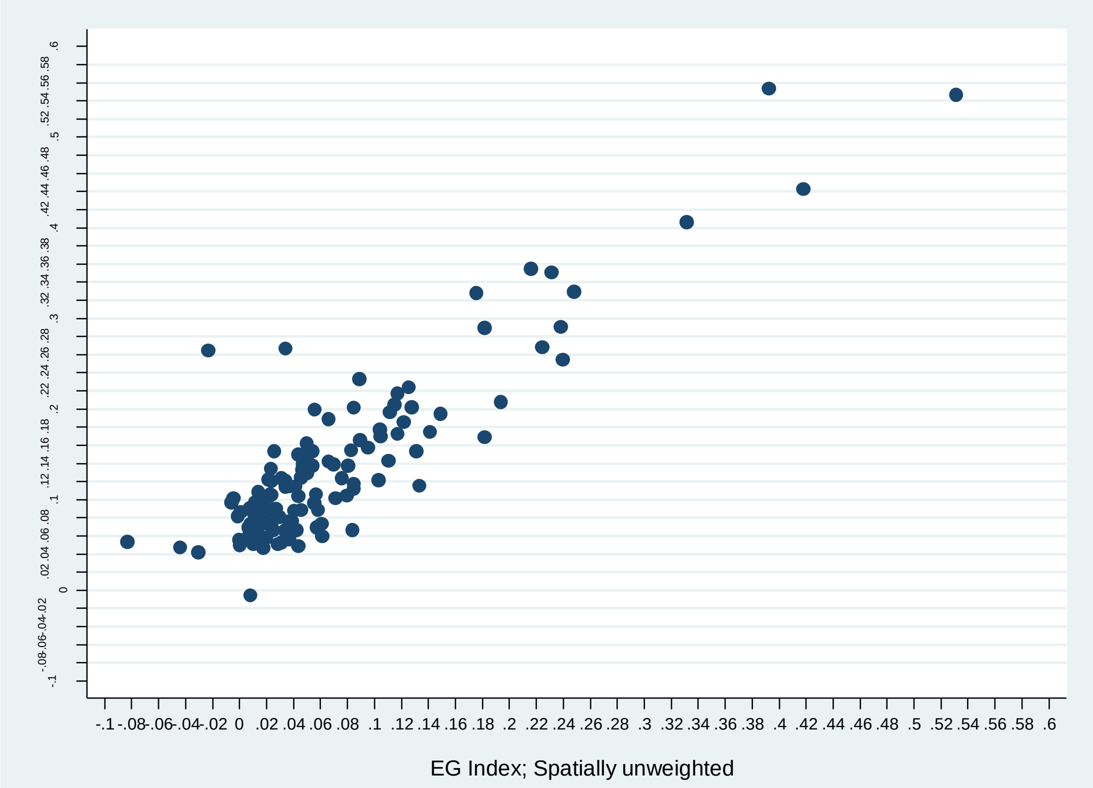

Figure A.3.1. Scatter Plot between EG^{UNW} and EG^{SW}

Table A.3.4 Ratio Estimation

	Ratio a: EG^{UNW}/EG^{SW}		Number of observations:125	
	Ratio	**Linearized Std. Err.**	**[95% Confidence Interval]**	
a	0.50767***	0.0329764	0.4424049	0.5729439

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Chapter 4

Impact of Industrial Agglomeration Economies on Internationalisation of Manufacturing Plants

Introduction

The heightened competitive pressure from global markets following the liberalisation policies of 1991, led to the greater internationalisation of the Indian manufacturing. However, even after two decades since the liberalisation era, the share of export of Indian manufacturing sector remained insignificant; fluctuating around 1.2-2% of the global share of manufacturing export. The rising import dependency, concerns about non-tariff barriers, lack of adequate export infrastructure and logistics have plagued the export performance of the Indian manufacturing sector. There exists an extensive literature on analysing several micro and macro-economic factors like plant level productivity, import-intensity, tariff rate, existing tax regimes (Goods and service tax), trade agreements (FTAs), and exchange rate as determinants of export performance of the Indian manufacturing plants. However, little attention has been paid to the geographical factors in shaping the export behaviour of the Indian manufacturing plants. The present study aims to analyze the importance of geographical factors *viz*; the economies emerging from the locational interdependencies among exporters, industry-specific agglomeration economies, and provision of other export-related infrastructural amenities of a region, in driving the export behaviour of Indian organised manufacturing plants over the period 2008-09 to 2013-14.

It has been observed that states well endowed with infrastructure, transport network, electricity/power generation facilities have a comparative advantage in terms of attracting exporting activity, over the poorly endowed counter parts. Beyond these advantages, several initiatives have been taken by the Government of India to support the process of internationalisation of the manufacturing sector *viz*; creating special economic zones (SEZ) model[28], setting up of industrial parks, special financial assistance to states for the development of export-related infrastructure etc. The states of Maharashtra, Gujarat, Karnataka, Tamil Nadu, Telengana, and Haryana together account for more than 70% of the total merchandise export of India (Economic survey 2017-18). This reflects an underlying

[28] Special Economic Zones are policy induced industrial clustering of export oriented units. It embodies several infrastructural facilities coupled with incentives like tax cut, capital subsidy etc. These regions are created to promote the exporting activities of firms belonging to both manufacturing as well as servicing sector.

spatial inequality in the exporting activity within the country, highlighting the need of examining the role of the distribution of geographical factors across spatial units within the country, in shaping the internationalisation of the organised manufacturing plants.

The process of internationalisation affects the pattern and production structure (also known as compositional effect of trade) of an economy. Consequently, this has an impact on the quality of the environment *via;* scale effect, composition effect and technique effect (Grossman and Krueger 1991, Copeland and Taylor 1994, Antweiler 2001, Cole and Elliot 2003). There is an emerging strand of literature that have argued that the presence of agglomeration economies within a country may have a distortion effect on the pattern of trade driven by either factor endowment hypothesis or pollution haven hypothesis(Zeng and Zhao 2009, Cole et al. 2010). In the Indian context, studies have analysed the pollution content of India's manufacturing export and import (Mukhopadhya and Chakraborty 2005, Sawhney and Rastogi 2015). Mukhopadhya and Chakraborty (2005) empirically showed that India exports cleaner goods as opposed to its import, thereby challenging the possibility of pollution haven effect. In contrast to this, while analysing the manufacturing trade of India, Sawhney and Rastogi (2015) empirically observed that in the post liberalisation era, India has specialised in polluting industries. They found a weak evidence of pollution haven effect in case of highly polluting industries. Unlike the earlier studies, the present chapter is not examining the pollution haven effect per se. However, while analysing the export behaviour of manufacturing plants, the chapter assess the differential role of agglomeration economies in driving the export behaviour of plants belonging to polluting vs. non polluting industries.

The empirical analysis in the present study shows that both industrial agglomeration economies as well as the within-industry concentration of exporters positively and significantly affect the internationalisation process of the Indian manufacturing plants. There is weak evidence of cross-industry export spillover. While distinguishing between polluting vs. non-polluting industries, the study concludes that it is true that industry-specific agglomeration economies as well as within industry exporter's concentration positively affects the export behaviour of manufacturing plants belonging to both polluting as well as non-polluting industries. However, the effect of cross-industry exporters' spillover is insignificant for plants belonging to polluting industries. The combined effect of both overall industry-specific agglomeration as well as export spillover are found to higher in facilitating the export behaviour of plants belonging to non-polluting industries as opposed to polluting industries.

The *first section* of the chapter presents a brief review on the literature analysing the linkage between agglomeration economies and export behaviour of firm/plants. It also elaborates existing studies, examining the effect of trade on environment in presence of agglomeration economies. The *second section* describes the distribution pattern of exporting plants across Indian states as well as across industries. The impact of agglomeration economies on the internationalisation of manufacturing plants has been empirically examined in *section three* of this chapter. *Section four* discusses the empirical results. The *last section* concludes the chapter.

4.1 Literature Review

4.1.1 Agglomeration Economies and Export Behaviour

Studies in the new trade theory literature have emphasized that firm- level heterogeneity[29], including the productivity differential, within the same industry is one of the significant drivers of the internationalisation of the manufacturing firms (Roberts and Tybout 1997, Clerides et al. 1998, Bernard and Jensen 1999, Metlitz and Trefler 2012, Wagner 2007,).Entry into the foreign market entails irreversible additional costs (sunk costs) in terms of gathering information or establishing distribution channels across foreign markets. It has been posited that a minimum productivity level (productivity cut-off or threshold) is required by a firm to bear the pre-entry cost of the export market. Empirically it has been observed that exporting firms are more productive as opposed to the non-exporting firms (Bernerd and Jensen 1999 Robert and Tybout 1997). There are two opposing hypotheses that explain whether this gain in productivity of an exporter is *ex ante or ex post* the entry into the export market. First hypothesis posits that, it is the productive firms that self-select into the export market i.e. *ex-ante* productivity differential across firms facilitates foreign market entry (Bernard and Jensen 1999, Baldwin and Gu 2003).

[29] Both the classical as well as neoclassical trade theories assumed that all firms within an industry are homogeneous. The new trade theory models assumed the presence of imperfect competition. In contrast to the classical and neoclassical theories, the new trade theories modelled the across firm heterogeneity within the same industry.

The second hypothesis relates to the process of learning by exporting i.e. firms after entering the foreign market become productive through knowledge spillovers imparted by its foreign counterpart. In the existing literature empirical evidence of productivity gain among firms after entering the export market is mixed. It is found to be null (Delgado et al 2002, Clerides et al. 1998) or even sometimes negative (Alvarez and Lopez 2005). However, there are some empirical studies that have observed an *ex post* productivity gain (Greenaway and Yu 2004). Apart from the productivity differential these studies have examined the impact of other firm-level characteristics like age, capital intensity, ownership structure, and the size in driving the export behaviour of firms.

It has been observed that the location of a firm within the country may have a significant impact in shaping the process of self-selection of firm into the export market or ability of a firm to learn from the export market which in turn gets manifested in the form of productivity differential (Aitken and et al. 1997, Greenaway and Knellar 2008, Koenig 2009, ITO et al 2015 Farole and Winkler 2013, Pose et al 2013, Yi J 2014). The essence of the sunk costs indicates that it involves intensive investment in the field of research on the foreign market competition and consumer's taste and preferences, adjustment of the packaging and quality of products as per the foreign consumer's demand. A potential entrant into the export market may gain from the spatial proximity of the incumbent exporters, who already possess knowledge of the foreign markets. Moreover concentration of the existing exporters also facilitates distribution of goods of the new entrant through already established distribution channel in the foreign market. Existing studies in the literature have assumed that the sunk cost of entry into the export market is a decreasing function of local exporter's network, thereby improving the profit margin or the minimum productivity level to enter the export market. The economies in terms of knowledge spillover arising from the spatial proximity of exporters are termed as export spillover effect. Empirical evidences suggest that the impact of this spillover effect on the export decision of a firm is mixed.

Aitken and et al. (1997) found positive spillover effects from the exporting activity of the foreign-owned firms (i.e. multinational firms) in the Mexican manufacturing sector over the year 1986-90. Unlike Aitken and et al (1997), Greenaway and Knellar (2008) found a positive and significant effect of export spillovers from the exporting activity of the firms irrespective of its ownership structure. While analysing the export behaviour of the manufacturing firms in United Kingdom during 1988-2002, they also concluded that spillover effects are industry and region specific. Farole and Winkler (2013) and Pose et al (2013) also found evidence of positive industry-specific export spillover effect in case of Indonesian manufacturing firms.

While analysing the export spillover effect, the above mentioned studies have controlled for the overall industrial diversity of a region using raw measures of spatial concentration of industries like diversity index or Herfindahl Hirschman index; baring Ito et al (2015). These studies did not capture the degree of industrial agglomeration using Ellison Glaeser (EG) index, which can control for the industry specific localisation economies. Another advantage of using the EG index is it measures the spatial concentration of industries in excess of the plant-level concentration within the industry. Analysing the impact of industry specific localisation economies on the export decision of firms is an emerging literature (Ito et al 2015).

The significance of agglomerating forces in driving the export-decision of firms is an established literature both in the context of developed vs. developing countries (Greenaway and Knellar 2008, Koenig 2009, Aitken and et al. 1997, Farole and Winkler 2013 and Pose et al 2013). However, in the Indian context the literature is sparse (Mukim 2013, Pradhan and Das 2014).

4.1.2 Agglomeration Economies and Export Behaviour of Manufacturing Plants

-experience of India

While analysing the export performance of the Indian manufacturing firms, existing studies have examined the impact of heterogeneity in firm-level characteristics viz; productivity, technology profile, skill intensity, age and wage on internationalisation of firms (Kumar and Siddharthan 1994, Heish and Klenow 2009, Topalova and Khandelwal 2011,). Moreover, there are also empirical studies on elucidating the self-selection vs. learning by exporting hypothesis in the context of Indian manufacturing firms (Mallick and Yang 2013, Pattnayak et al 2014). However, these studies have paid little attention to the location-specific factors in driving export decision of manufacturing firms.

In the Indian context analysing the role of regional factors in shaping the firm's export decision is an emerging literature (Mitra et al 2002, Mukim 2013, Pradhan and Das 2015). While analysing the spatial distribution pattern of exporting activity of Small and Medium Scale Enterprises (SMEs), Pradhan and Das (2015) observed that the exporters are mainly concentrated in the coastal states of Southern and Western India. The disparity in the regional development of exports of SMEs was driven by the availability of locational factors like technological knowledge, skilled labour, in flow of foreign direct investments, port facilities and urban amenities. In addition to these factors, other regional infrastructural amenities like advanced road transport network, availability of power supply required for the functioning of ware-housing facilities are also found to have a positive impact on the productivity of manufacturing plants (Mitra et al 2002). The productivity gain in turn accelerates the internationalisation process of the overall manufacturing sector of the country.

The rising emphasis on the industrial clustering policy to promote export growth of the manufacturing sector have also encouraged some of the studies to analyze the export performance of the policy-induced industrial clusters like industrial parks, clusters of export-oriented units popularly known as the Special Economic Zone (SEZ) (Aggarwal 2006, Pal and Mukherjee 2018, Alkon 2019). However, these studies did not assess the impact of underlying agglomerating forces *viz*, the industry-specific localisation economies, economies associated with exporter's concentration in shaping the internationalisation process of the organised manufacturing plants.

While analyzing the role of location-specific factors in driving the export behaviour of Indian manufacturing firms, Mukim (2013) empirically observed that concentration of incumbent exporters within the same industry have a negative and significant impact on the export decision of a potential entrant after controlling for other firm-level and regional characteristics. This reflects the presence of congestion effects due to the overcrowding of export infrastructure or in terms of availability of factors of production thereby creating competition among firms, engaged in exporting of substitute goods. Unlike Mukim (2013), the present chapter analyses the role of regional factors on the export behaviour of organised manufacturing plants after controlling for other plant-level and regional characteristics in a dynamic framework over the period 2008-09 to 2013-14. Apart from analysing the impact of the concentration of incumbent exporters, the present study also controls for the industry-specific localisation economies, thereby identifying the channel through which agglomeration economies is affecting the export behaviour of manufacturing plants. While estimating the industry-specific agglomeration economies, unlike Mukim (2013), the present study has adjusted the empirical estimates for the spillover effect of the adjacent regions using the concept of spatial weighing techniques.

4.1.3 Trade and Environment – the role of agglomeration economies

The degree of openness of an economy has been observed to have a significant impact on its environmental quality (Grossman and Krueger 1991, Copeland and Taylor 1994, Antweiler 2001, Cole and Elliot 2003). There are three mechanisms through which international trade affects the degree of environmental pollution of an economy *viz*; the scale effect, composition effect and technique effect. Firstly, the liberalisation of trade increases the scale of economic activity, assuming that the nature of activities constant, the total amount of pollution will increase; this is termed as the scale effect.

Secondly, it has been observed that with free trade, countries tend to specialise in sectors in which they have comparative advantage. This in turn changes the composition of the output produced by countries. If the comparative advantage is driven by the difference in environmental regulations, assuming other factors constant, then free trade will be damaging for the country characterised by less strict environmental regulations. The less strict environmental regulation entails lower cost of compliance, leading to specialisation in pollution-intensive industries. Moreover, the Environmental Kuznet's Curve Hypothesis posits that higher the income, higher will be the degree of stringency of environmental regulations in a country. This implies that developing countries tend to have a comparative advantage in pollution-intensive industries, thereby becoming *pollution havens*, as opposed to the developed nations, mostly engaged in clean production and characterised by the stringent environmental laws (Cole and Elliot 2003). However, if the comparative advantage is driven by the difference in factor-endowment (capital-labour effect) then the effect on the environment is ambiguous as trade will lead countries to specialise in sector that uses its abundant factors[30] (Grossman and Krueger 1991).

Thirdly, free trade leads to technology spillover across countries. The technological spillover from developed to developing nations, helps the developing nations to improve their production technology. This in turn reduces the pollution-content of per unit output produced in developing countries (Grossman and Krueger 1991).

[30] Capital-abundant developed nations specialises in capital-intensive polluting industries. On the other hand, developing nations characterised by abundant labour, specializes in labour-intensive less polluting industries. However, it has been argued in the literature that all capital-intensive industries are not polluting for example manufacturing of aircraft and spacecraft. Simultaneously all labour-intensive industries are not clean for example tanning of leather, manufacturing of yarn under textiles industries. Therefore the effect on environment remains ambiguous. It depends on the pollution content of the total output produced by the country.

While empirically analysing the impact of trade on the environmental quality of a country, studies have found that the net result depends on the relative magnitude of scale, composition and technique effect (Grossman and Krueger 1991, Antweiler 2001, Cole and Elliot 2003). The empirical evidence of trade-induced composition effect is mixed in the literature and it varies across countries and pollutants used in the analysis as opposed to the scale effect and technique effect[31]. Grossman and Krueger (1991), while analysing the impact of free trade agreement (NAFTA) on Mexico's air quality, observed that trade-induced composition effect is driven by factor-endowment differences as opposed to the difference in the cost of compliance to the environmental regulations. It was observed that with free trade, Mexico specialised in unskilled labour-intensive industries and agricultural activities. These activities entail lower energy consumption, leading to reduction in the level of air pollution in Mexico.

In contrast to this, Antweiler (2001) and Cole and Elliot (2003), observed that the trade-induced composition effect is driven by both difference in cost of compliance to environmental regulations as well as difference in factor-endowment. The effect of difference in the stringency of environmental regulation or in other words the evidence of pollution haven hypothesis was found to be smaller. They argued that following the pollution haven hypothesis, free trade leads to relocation of pollution-intensive industries to developing countries in an attempt to minimise the cost of compliance, thereby increasing the pollution content of the total output produced in the country. However, if the pollution-intensive industries are capital-intensive then the cost of capital in capital-scarce developing countries may outweigh the benefits of relocation to reduce cost of compliance to environmental regulations.

There exists another strand of literature which has attempted to analyse the lack of empirical evidence of pollution haven hypothesis across countries (Zeng and Zhao 2009, Cole et al. 2010). Zeng and Zhao (2009) theoretically showed that with asymmetric country size, presence of agglomeration externalities in manufacturing sector may act as a deterrent for the industry to relocate to another country characterised by laxity in environmental regulations. Their results were based on the assumption that the difference in the cost of compliance of environmental regulations between two countries is small. Cole et al. (2010) empirically validated the effect of agglomeration economies while testing the pollution haven hypothesis

[31] Most of the studies have observed that trade leads to expansion of output, thereby increasing the total amount of pollution. However, trade also induces technological spillover. The adoption of advanced technologies leads to net reduction in the pollution content of the output produces.

in case of Japan’s net import from the rest of the world, in 41 manufacturing sector, using industry-level data over the period 1989-2003. They observed that the presence of agglomeration economies (captured by the industry-level Gini coefficient), especially for industries characterised by high transport costs and fixed costs (immobile), reduces the impact of difference in environmental regulations on the trade pattern. They concluded that the empirical evidence of pollution haven effect is dependent on the industry-level characteristics including their degree of regional concentration within a country.

It has been observed empirically that the agglomeration economies have a significant and positive impact on the productivity of labour, thereby leading to the rise in income of a region. The rise in income accentuates demand for stricter environmental regulations, leading to the improvement of the environmental quality (Cheng 2016). It has been well established in the literature that agglomeration economies also stimulates technological innovation and knowledge spillover across manufacturing firms (Feldman 1999). The technological progress may reduce the per unit pollution content of the total output produced in the economy. The benefits from agglomeration economies may outweigh the cost of compliance to environmental regulations.

The analysis of examining the effect of trade on environment in presence of agglomeration economies is an emerging literature both in the context of developed as well as developing countries. Earlier studies in the Indian context have examined the composition of India’s export vs. import basket, thereby discussing the pattern of specialisation of Indian industries in the post liberalisation era (Sawhney and Rastogi 2015). While analysing the impact of trade on environmental quality, Mukhopadhya and Chakraborty (2005) estimated the pollution terms of trade in terms of three pollutants *viz;* NO2, CO2 and SO2 and concluded that exporting goods produced in India are environment friendly as opposed to the goods imported by India. Unlike existing studies, the present study goes further to analyze the effect of export behaviour of plants after distinguishing between polluting vs. non polluting industries in presence of agglomeration economies within the country.

4.2 Pattern of Development of Exporting Plants in Indian manufacturing sector

4.2.1 Data

The availability of establishment data across countries has widened the scope of empirical research on agglomeration economies by allowing researchers to assess the role of a single firm in generating the agglomerative forces, leading to the formation of industrial clusters and cities. In the Indian context, Annual Survey of Industries (ASI) annually publishes a factory-level[32] panel database with detailed information on the geographical location of the plant in Indian organised manufacturing sector along with other plant-level characteristics like their ownership structure, different fixed assets used, and raw materials consumed including different types of fuel consumed. It also provides information on the major products produced by plants and their export share .This gives us a scope to identify the efficient production facilities of an industry, engaged in exporting activity along with their geographical location.

Other Indian database on the manufacturing sector is the CMIE Prowess database where we get information on the geographical location of plants belonging to a firm. However, it does not provide information on other plant-level characteristics like export share, output, capital assets, employment etc. These characteristics are available at the firm-level. The CMIE Prowess database is the annual financial statement of manufacturing and service sector firms across India. In contrast to this, Annual survey of Industries (ASI) is a complete survey data collected through designing of questionnaire by the Industrial wing of Central Statistical Office of Government of India. This in turn improves the transparency and credibility of the data. According to the data collection rule of the survey, each factory registered under some industry has to submit the return to the Statistical Officer. While analyzing the impact of agglomeration economies (defined at the four-digit industry level) on the export behaviour of manufacturing plants, the present study uses the ASI factory-level panel database. Unlike existing studies in the Indian context, the panel data gave us the scope to analyze the changing pattern of the industrial concentration over time across states, calculated based on plant-level information.

The ASI factory-level database provides information on the plant-level export share from 2008-09 onwards. The present chapter analyses the export behaviour of manufacturing plants

[32] The database consists of factory-identifiers over time. Each factory can have single or multiple plants. Using the multiplier all the estimates have been calculated after considering the number of plants within a factory. So, in this study the term plant level characteristics have been used instead of factory-level.

across 27 Indian states. While cleaning the data, we followed Dougherty et al (2011) and Harrison et al (2012) and dropped the observations for which data on key variables like output, fixed capital, man-days employed are missing or have negative values. In this analysis all the manufacturing plants can be classified into 125 four-digit level industries. The monetary value of the nominal variables has been deflated by using the wholesale price index (WPI) of corresponding industry. The data for WPI has been taken from the Ministry of Statistics and Programme Implementation. Deflator for fixed capital has been constructed using the whole sale price index of plant and machinery. Apart from exporter's network and industrial agglomeration, we have also included other location-specific factors in the analysis *namely,* per capita power availability and road density. The data on power and road density has been obtained from the Ministry of Power and Ministry of Road Transport and Highways respectively.

4.2.2 Distribution Pattern of Exporting Plants across States

While analysing the geographical spread of the output of the organised manufacturing sector, we observed that states like Maharashtra, Andhra Pradesh, Karnataka, Haryana, Punjab, Rajasthan, Gujarat, West Bengal, Tamil Nadu and Uttar Pradesh together constitutes the bulk and these states are also the hub of most of exporting plants in India. These states together are the home for more than 85% of the total exporting plants of the organised manufacturing sector. During 2008-09 to 2013-14, the overall exporting activity in the organised manufacturing sector has declined as can be observed from **Table A.4.1** in the appendix. However, from **Table 4.1** below, we can observe that during this period there has been an increase in the percentage share of exporting plants in some of the inland states like Haryana, Uttar Pradesh and Rajasthan. This is coupled with a decrease in the percentage share of exporting plants in the coastal states of the country *viz;* Tamil Nadu, Maharashtra Gujarat. This indicates the rising importance of network effect or agglomeration externalities arising beyond the natural locational advantages (availability of coastline) in driving the internationalisation process of the manufacturing plants.

Table 4.1 Distribution of Exporting Plants across Top Ten Exporting States of India

State	Exporting Plants (2008-09)	%Share of Total Exporting Plants in India (2008-09)	Exporting Plants (2013-14)	% Share of Total exporting Plants in India (2013-14)
Tamil Nadu	1958	19.4	1945	18.5
Maharashtra	2519	25.0	1711	16.3
Uttar Pradesh	1008	10.0	1311	12.5
Gujarat	1126	11.2	834	7.9
Haryana	535	5.3	725	6.9
Punjab	466	4.6	635	6.0
Rajasthan	344	3.4	591	5.6
Andhra Pradesh	352	3.5	573	5.5
Karnataka	448	4.4	520	4.9
West Bengal	393	3.9	435	4.1

Source: Author's Calculation based on ASI-factory level data

Despite formulation of several policies to ensure balanced regional development of industries across the country, states like Assam, Nagaland, Manipur, and Mizoram featured as the peripheral states in terms of manufacturing export during the period of our analysis. Figure 4.1a) and b) depicts the comparison of the distribution of exporting plants of organised manufacturing sector across Indian states in 2008-09 vs. 2013-14 respectively.

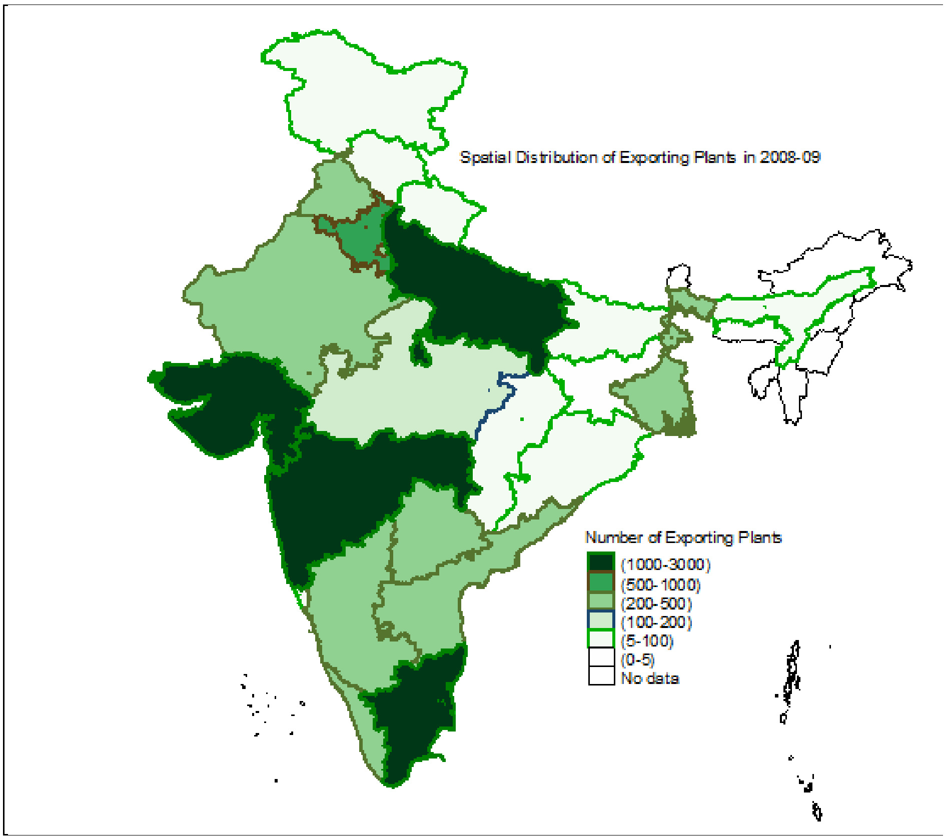

Figure 4.1a) Spatial Distribution of Export Plants across Indian States in 2008-09

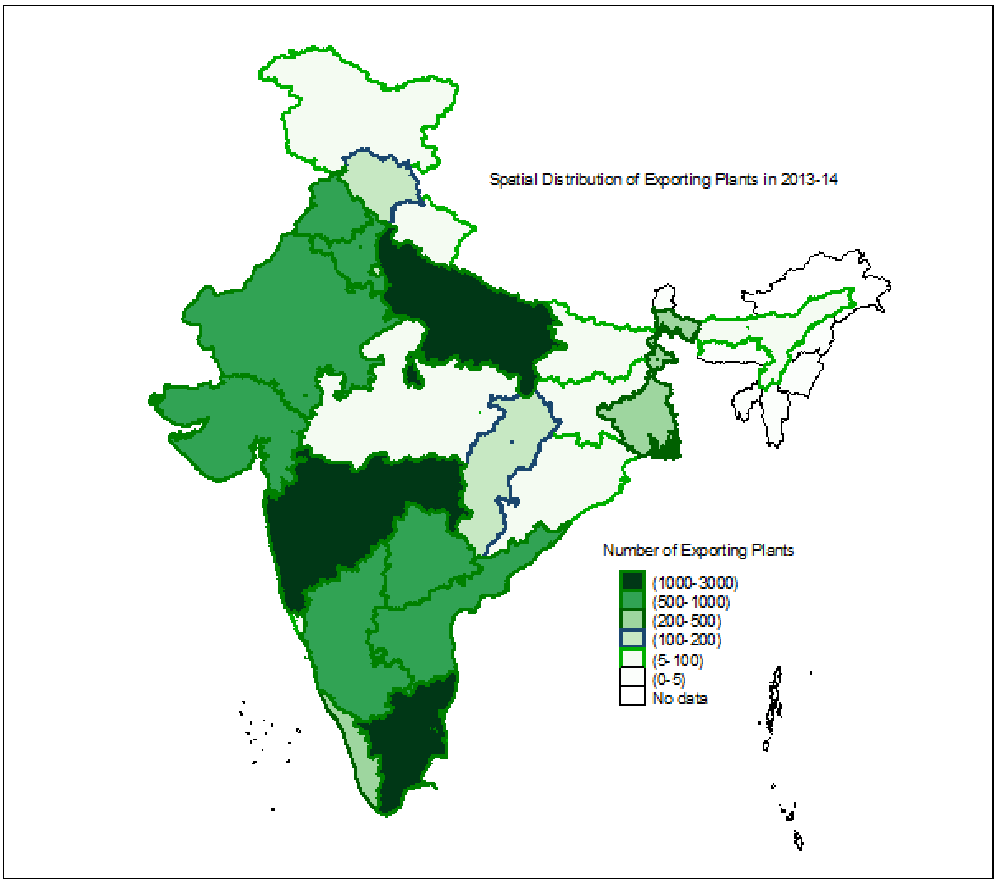

Figure 4.1b) Spatial Distribution of Export Plants across Indian States in 2013-14

4.2.3 Distribution Pattern of Exporting Plants across Industries

While analyzing the exporting activity across industries (defined at the four digit level) it has been observed that industries with higher percentage share of exporting plants like manufacturing of wearing apparel, pharmaceuticals, food products, plastics products, fabricated metal products, are also highly agglomerated (the rule of thumb EG>0.05 indicates a high degree of agglomeration). The **Table 4.2** below lists the top ten exporting industries which together accounts for more than 40% of the total exporting plants in Indian organised manufacturing sector.

Table 4.2 Distribution of exporting plants across top ten exporting industries in 2013-14

Manufacturing Industry	Total Number of plants (2013-14)	% Share of Total Exporting plants in India (2013-14)	Ellison Glaeser Index of Agglomeration^{SW}(EG) (2013-14)	Pollution Category[a]
Wearing apparel	3495	10.3	0.18	Green
Knitted and crocheted apparel	2181	5.9	0.55	Green
Pharmaceuticals	3875	4.2	0.09	Red
Plastic Products	7354	3.5	0.07	Green
Fabricated Metal Products n.e.c	5200	3.4	0.14	Green
Food Products n.e.c	4036	3.1	0.17	Green
Preparation and Spinning of textile fibres	4041	2.8	0.12	Orange
Grain Mill products[b]	13011	2.7	0.10	-
Jewellery& Related Products	922	2.6	0.35	White
Parts and Accessories of motor vehicles	3893	2.4	0.15	White

Source: Author's Calculation

a: CPCB definition; b: categorization not available in the CPCB

From the last column of **Table 4.2**, it can be observed that the composition of the highly agglomerated manufacturing export is non-polluting- industries, classified under the green and white categories[33]. Moreover, it has been observed that the average export intensity of plants categorized under the non-polluting industries is significantly greater than the average export intensity of plants categorized under the polluting industries, the t-test results are reported in **Table 4.3** below. The export intensity has been defined as the share of export to the total output produced by a plant.

Table 4.3 Export Intensity of Plants classified under Polluting vs. Non-Polluting Industries

Characteristics	Non-Polluting Industries	Polluting Industries	Difference
Export Intensity(2008-09)	9.8	4.4	5.3***
Export Intensity(2013-14)	7.4	4	5.79***

Source: Author's calculation

[33] Depending on the pollution index score, CPCB has classified the manufacturing industries into four Pollution category: Red (The score of the pollution index>60); Orange (41≤Pollution Index score≤59); Green (21≤Pollution Index score≤40); White category (Pollution Index score≤20).While mapping the four-digit industries (130 industries) for the year 2008-09 &2013-14 with the CPCB pollution categories, 10% of the industries could not be defined under the above mentioned four categories of CPCB.

4.3 Impact of Agglomeration Economies on Export Behaviour of Manufacturing Plants

4.3.1 Empirical Model and Methodology

In this section, the impact of agglomeration economies on export behaviour of manufacturing plant has been analyzed by using dynamic probit model. Heckman (1981) while estimating the probability of plant to export, identified that the error term in a dynamic probit model, is correlated to the within plant unobserved heterogeneity and the experience of exporting in the initial period. He corrected for the initial period condition by estimating the joint probability distribution of all values of *y* (export share of plant) in all time period together i.e. by estimating the probability distribution of $(y_0, y_1, y_2, ..., y_T)$. In contrast to this Woolridge (2005) later suggested that the initial period problem can be solved by estimating the conditional maximum likelihood (CML) estimator of the distribution of $(y_1, y_2, ..., y_T)$ which assumes that the distribution of *y* is dependent on the experience of exporting in the initial period(y_0) and other plant-level additional regressors included in the model.

In the present study, the dynamic export behaviour of a plant *j* belonging to industry *i* located in state[34] *m* at time *t* has been estimated by using the Woolridge method of dynamic probit model as denoted by equation (1) below,

$$\begin{aligned} \Pr[y_{ijmt} = 1 | y_{j0}, y_{ijmt-1}, \gamma_j, X_{mt}, Z_{jt}, D_{it}] &= \Phi(y_{ijmt-1}, \beta X_{mt}, \gamma Z_{jt}, \delta D_{it}, \tau y_{j0}, \gamma_j) = F(I) \\ I &= \rho y_{ijkt-1} + \tau y_{j0} + X_{mt}\beta + Z_{jt}\gamma + D_{it}\delta + \gamma_j + \delta_i + \lambda_t + \varepsilon_{ijmt} \end{aligned} \quad (1)$$

where, t = 2008-09 to 2013-14

The Woolridge method of dynamic probit estimation assumes that the probability of a plant to export in the current period *t* is conditional upon its export status in period *t-1* and the initial period of export, denoted by y_{j0} in equation (1). Moreover, the model assumes that the unobserved heterogeneity within the plant is conditional upon the initial period condition and the other plant –level exogenous variables denoted by Z_j in the above equation (1) i.e. $\Phi(\gamma_j) = (y_{j0}, Z_j)$ .We define a function I which is linearly related to X, Z and D where matrix

[34] While analyzing the dynamic export behaviour of plants, state has been used as the spatial unit of analysis. The state codes for plant are not available for successive periods. This has been explained in detail in the data section.

X denotes the state-specific characteristics, matrix Z denotes the plant-level characteristics and matrix D denotes the industry-specific characteristics respectively. In the above equation both the within plant unobserved heterogeneity (γ_j) as well as time-varying heterogeneity (λ_t) has been controlled by including plant and time fixed effect respectively. Moreover, industry-level characteristics (δ_i) not included in matrix D has been also controlled by incorporating industry dummies in the model.

The *plant-level characteristics* represented by matrix Z in equation (1) includes:

Productivity: Heterogeneity in the plant-level productivity is one of the major factors in determining the export behaviour of a plant. The more productive plants are highly efficient and can successfully bear the pre-entry or the sunk costs required for export market participation. Studies have found that productivity of the plant has a positive impact on the export behaviour of plants (Wagner 2007). In this analysis the total factor productivity of the manufacturing plants, has been estimated using the Levinsohn Petrin methodology. The productivity of plants as been estimated as a residual of the Cobb Douglas production function as mentioned in the equation below;

$Y_{it} = A_{it} * L_{it}^{\beta} * K_{it}^{\gamma}$ where, L denotes labour and K denotes capital (2)

The estimation of productivity involves a simultaneity bias, arising from the correlation between unobservable productivity shocks and input levels. If a plant has prior knowledge about the productivity shock then the input decision of plants is partly driven by this prior belief. The Levinsohn Petrin methodology controls for the unobservable productivity shock by using intermediate material input or fuels used by the plant as a proxy under the assumption that demand for intermediate inputs is a monotonic function of productivity. In this exercise we have used plant-level fuel used as a proxy for the unobservable productivity shocks.

Age: It has been argued in the literature that that obsolete technologies of the older plants may affect the productivity of the plant negatively thereby reducing their probability to get selected into the export market. This indicates that the lower the age of a plant higher will be the probability to export. The age variable in this study has been constructed by using the information on the year of incorporation of plants.

Size: The size of the manufacturing plants is found to have a positive impact on the export decision of the manufacturing plants (Greenaway 2008, ITO et al 2015). The present study uses fixed capital as a proxy to capture the size of the manufacturing plants.

Sunk cost: The sunk cost or the pre-entry cost into the export market is one of the important determining factors in plant's export market participation. In the trade theory literature this is also termed as hysteresis effect and this can be captured by the previous period export status of the plants (Clerides et al 1998 and Roberts and Tybout 1997, Greenaway 2008, Yi 2014, ITO et al 2015). This also reflects the importance of the hypothesis "learning-by-exporting" as a determining factor for the productivity differential across plants. This has been captured in the present analysis by the lagged period export status of manufacturing plants.

Ownership Structure: The ownership structure reflects many unobserved attributes of a plant like managerial efficiency, quality of the product produced etc. (Bernerd and Jensen 2004). While empirically analysing the export behaviour of manufacturing plants, studies have made distinction between private, public and foreign ownership. It has been observed that foreign ownership has a significant and positive impact on the export behaviour of plants (Bernerd and Jensen 2004). While analysing the impact of ownership on export behaviour of plants, the present study has distinguished between public vs. private ownership structure[35]. The variable ownership dummy included in the model takes the value of 1 if the ownership is private and 0 otherwise.

Import Intensity: The import of intermediate raw materials has been found to have a positive and significant effect on the export behaviour of manufacturing plants (Kumar and Siddharthan 1994, Kasahara and Rodrigue 2004, Kugler and Verhoogen 2009). It has been argued in the literature that imported inputs positively affect the productivity of plants, reflecting the diffusion of foreign knowledge and technology in the domestic production structure. In the present study, the import intensity has been constructed as the ratio of imported input to the total input used in the production process.

The industry-level characteristics represented by matrix D includes;

Agglomeration economies: This captures the industry-specific localisation economies which are found to have a productivity enhancing effect in the literature (Lall and et al 2004

[35] The Annual Survey of Industries factory-level data does not provide any information on the foreign ownership structure.

Baldwin et al. 2008, Martin et al. 2011). This in turn affects the probability of a plant to export. The network of plants within an industry is found to have a positive impact on the export decision of manufacturing firms (ITO et al 2015). The present study uses two alternative measures of industrial agglomeration economies have been used *viz*; the spatial Gini Index and Ellison Glaeser Index. While estimating the agglomeration economies, the labour pool channel has been estimated i.e. both the indices are calculated based on the information on employment data.

The agglomeration indices have been calculated based on the state-level data, defined by boundaries. One of the limitations of using the spatial data with pre-defined boundaries is that it ignores the spillover effect of the adjacent regions. In the spatial econometrics literature this has been identified as 'checkerboard problem' or modified area unit problem (Arbia 2001, Getis and Aldstadt 2004, Guimaraes et al 2011, Martin et al 2011). In order to correct this bias both the indices have been modified to incorporate the spillover effect of the neighbouring regions. The spillover effect of economic activity of adjacent regions has been captured by weighing the regional share in equation by using the contiguity based spatial weights matrix*; W.* The spatially weighted Gini index and the Ellison Glaeser Index of agglomeration of industry *i* is represented in vector form by equation (3) below,

$$\gamma^{SW}{}_{i} = \frac{G_s - (1 - s_m' W s_m) H_i}{(1 - s_m' W s_m) \sum_{m=1}^{M} (1 - H_i)} \tag{3}$$

where, $G_s = (s_i - s_r)' W (s_i - s_r)$ is the spatially weighted Gini Index where s_{mi} is the output share of industry *i* in state *m* in aggregate output of industry *i*, and s_m the output share of region *m* in aggregate industrial output. $H_i = \sum_{j=1}^{N} (s_j)^2$ where, s_j is the output share of firm *j* in industry *i* and N is the total number of plants within the industry i. $W_{M \times M}$ contiguity-based spatial weight matrix has been calculated from the shape files (with the information on latitude and longitudes) of Indian states using the GeoDa software. An element of the matrix W is given by $w_{m1 \times m2} = 1$ if region *m1* and *m2* share and common border and $w_{m1 \times m2} = 0$ if region *m1* and *m2* has no common border. The matrix has been row standardized in order to provide equal weightage to all the neighbours, a standard approach in spatial econometrics literature (Getis and Aldstadt 2004).

Exporter's Concentration: Spatial Concentration of exporters act a channel of information spillover from the international markets thereby positively affecting the export of a potential entrant (Green away and Knellar 2008 Farole and Winkler 2013, Mukim 2013, Pose et al 2013, Yi 2014, ITO et al 2015). A negative effect may indicate the congestion among exporters due to overcrowding at the export-related infrastructure or competition among exporters due to the availability of inadequate factors of production of that region or competition among exporters producing related goods. In this study two alternative measures have been used to capture the export spillover effect *viz,* exporters' concentration within the same industry located in the same states as well as exporters' concentration in cross-industries but located in the same state. The exporters' concentration measure has been calculated by using the information on labour employed in exporting plants. This captures the economies (or diseconomies) arising due to sharing of labour specialised with exporting knowledge within the same industry or cross-industries.

Other Location-specific characteristics: Location of the plant in urban areas will have an added advantage in terms of export infrastructure, availability of advanced transport network, high market demand and other urban amenities as opposed to its location in rural areas. The availability of transport network plays a significant role in affecting the export behaviour of plants. Moreover, exporting also involves highly developed ware-housing facilities. This requires availability of power. Thus states well endowed with installed power capacity may have an advantage in the exporting process. In this study the road density and the state-wise installed power capacity have been used as a measure to control for the infrastructural facilities of a region. The presence of SEZ in a state may have a positive impact on the export behaviour of plants located in that region. This policy-induced cluster of export oriented units embodies several infrastructural and governance facilities coupled with incentives like tax cut, capital subsidy etc. The effect of SEZ has been controlled by including SEZ dummy which takes a value of 1 for states endowed with SEZ and 0 otherwise.

4.4 Empirical Results

4.4.1 Export Behaviour of all plants

While analysing the impact of agglomeration economies on the export behaviour of manufacturing plants, it can observed from specification R (1) R (4) and R (5) from **Table**

4.4a) below, industry-specific agglomeration economies, measured by spatially weighted Ellison Glaeser Index(EG) of industrial agglomeration (capturing the labour pool effect) positively affects the plant's probability to export. The sharing of labour with industry-specific knowledge positively affects the export of manufacturing plants. It can be observed from specification R (2) - R (5), that the incumbent exporter's concentration within the same industry and state has a positive and significant impact on the export behaviour of manufacturing plant. This indicates that labour pool equipped with both industry-specific knowledge as well as knowledge on export positively and significantly affects plants' probability to export. From specification R(2), it can be observed that labor pool of exporting plants belonging to other industry within the state also have a positive impact on the export probability. However, when the policy-induced clustering of export-oriented units i.e. the presence of SEZ in a state has been controlled in specification R (3), the effect of cross-industries on the export probability becomes insignificant. The presence of SEZ within a state is found to have a significant and positive impact on the manufacturing plants' probability to export. The SEZ captures the effect of concentration of both related as well as unrelated export-oriented units along with the economies arising from the infrastructural facilities embodied within it. It can be observed from specification R (1) – R (5) that the availability of road network across Indian states has a significant and positive impact on the export probability of manufacturing plants. However, power availability of a state appeared to be insignificant in affecting the export behaviour of manufacturing plants.

It can be observed that the plant-level characteristics like lagged period export status, productivity, ownership structure and import intensity, in specifications R (1) – R (5) has a significant and positive impact on the export probability. The positive coefficient of prior exporting knowledge, captured by lagged period export status of plant, indicates the presence of '*learning by exporting effect'* in Indian organised manufacturing sector. Moreover, the productivity coefficient confirms the fact that the productive plants are engaged in exporting activity. The ownership dummy captures the effect of private vs. public ownership structure of plants. The coefficient indicates that the private ownership structure of plants has a significant impact on the export behaviour of plants. In specification R (5) it can be observed that import-intensity of a plant positively and significantly affects the export behaviour of a plant. This illustrates the presence of a global production network; manufacturing plants are importing intermediate inputs and after further value addition, exports the finished products to international markets. Moreover, the location of a plant in urban area, captured by the positive coefficient of urban dummy in specifications R (1), R (4) and R (5) provides an additional impetus to the plant to export. In all the specifications R (1) - R (5), the initial period export status has been also included, thereby correcting for the initial condition bias of the error term in a dynamic framework.

It can be concluded that industrial agglomeration economies and within-industry concentration of incumbent exporters' have a positive and significant impact on the export behaviour of manufacturing plants in Indian organised sector after controlling for other location-specific and plant-level characteristics that may affect the plant's probability to export.

Similar results have been obtained by using an alternative measure for industrial agglomeration economies viz; the spatial Gini Index. The result has been reported in **Table A.4.2** in the appendix of the chapter.

Table 4.4 a) Woolridge Dynamic Probit Estimates

Dependent Variable: Export Behaviour of Plant	**R(1)**	**R(2)**	**R(3)**	**R(4)**	**R(5)**
Plant level characteristics					
Lagged Export Status	0.543***	0.435***	0.439***	0.481***	0.472***
	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)
Productivity	0.056**	0.064**	0.064**	0.061**	0.057**
	(0.025)	(0.026)	(0.026)	(0.025)	(0.026)
Ownership Dummy	0.418***	0.325***	0.323***	0.370***	0.366***
	(0.066)	(0.066)	(0.066)	(0.065)	(0.065)
Size	0.010	0.011	0.011	0.010	0.008
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Age	-0.088	-0.061	-0.067	-0.068	-0.065
	(0.123)	(0.123)	(0.123)	(0.123)	(0.123)
Imported Input Intensity					0.615***
					(0.138)
Industry Characteristics					
EG^{sw}	0.255***	0.057	0.056	0.126***	0.138***
	(0.030)	(0.044)	(0.044)	(0.030)	(0.030)
Incumbent exporters within the same industry and state		0.062***	0.060***	0.069***	0.068***
		(0.005)	(0.005)	(0.005)	(0.005)
Incumbent exporters in other industry but same state		0.045***	-0.001	0.019	0.023
		(0.012)	(0.016)	(0.015)	(0.015)
Location-specific Characteristics					
Road Density	0.172***	0.150***	0.193***	0.156***	0.135***
	(0.028)	(0.028)	(0.030)	(0.030)	(0.030)
Per capita power availability	0.109***	-0.028	0.002	0.043	0.031
	(0.032)	(0.033)	(0.034)	(0.033)	(0.033)
SEZ Dummy			0.360***	0.222***	0.183**
			(0.085)	(0.084)	(0.084)
Urban Dummy	0.148***	0.043	0.032	0.148***	0.148***
	(0.031)	(0.032)	(0.032)	(0.030)	(0.030)
Plant Fixed Effect	yes	yes	yes	yes	yes
Time Fixed Effect	yes	yes	yes	yes	yes
Industry Dummy	no	yes	yes	no	no
Observations	37,257	37,257	37,257	37,257	37,257
Number of factory	7,454	7,454	7,454	7,454	7,454
Likelihood-ratio test of rho=0	2576	3172	3162	2948	3007

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.4.2 Export Behaviour of plants- polluting vs. non polluting industries

While analysing the behaviour of exporting plants, this section of the chapter distinguishes between polluting vs. non polluting industries. It can be observed from **Table 4.4b)** below, the industry-specific agglomeration economies of both polluting as well as non polluting industries significantly affect the export behaviour of plants. The within industry export spillover is also positive in case of both polluting as well as non polluting industries. However, the effect is stronger in case of non-polluting industries compared to the polluting counterpart. There is weak evidence of industry-specific agglomeration economies in facilitating the export behaviour of manufacturing plants belonging to polluting industries. The cross-industry export spillover effect differs between polluting vs. non-polluting industries. The economies arising from the concentration of non-polluting industries (related or unrelated) significantly affects the export behaviour of a plant as shown in specifications R (7) - R (10). In contrast to this the concentration of polluting industries (related or unrelated) in a state may give rise to some diseconomies which in turn negatively affects the export behaviour of plants as shown in specification R (2) - R (5). However, the coefficients are statistically insignificant.

Other locational factors like the availability of network of road across states plays a significant role in driving the export behaviour of both polluting and non-polluting industries. This indicates that the transportation facilities have an inevitable role in accentuating the internationalisation process of the manufacturing sector irrespective of the nature of the industry, as shown in specifications R (1) – R (10). The availability of power in a state positively affects the exporting behaviour of plants belonging to polluting industries whereas the effect is insignificant in driving the export behaviour of plant in non-polluting industry. This is reflective of the underlying comparative advantage theory[36]; states well endowed with power capacity positively affect the exports of plants belonging to polluting industries. This is based on the assumption that polluting industries are considered to be energy intensive in their production process as opposed to the non-polluting industries.

The coefficient of urban dummy reflects the impact of the benefits a plant may enjoy owing to its location in urban area and starting to export. The urban amenities appear to be statistically insignificant in driving the export behaviour plants belonging to polluting

[36] Plants belonging to polluting industries will gain by starting to export in states well endowed with power facilities. This will affect their per unit production cost due to the availability of cheap intermediate inputs.

industries. It has been observed in the earlier chapter that the polluting industries are mostly located in rural areas. However, the effect is positive and significant in driving the export behaviour of plants belonging to non-polluting industries.

While analysing the plant level characteristics in driving the export behaviour of plants, it can be observed that in case of polluting industries the previous period exporting activity positively and significantly affects the current period probability to export. The coefficient of productivity is insignificant in affecting the export behaviour. In contrast to this, both the previous period export as well as the productivity significantly drives the export probability of plants belonging to non polluting industries. The positive and significant coefficient of imported input intensity in specification R (10) indicates the presence of global production network in case of non-polluting industries. However, the effect is insignificant in case of polluting industries. In other words, the global production network promotes export of non-polluting industries as opposed to the polluting industries. The import of intermediate raw materials positively and significantly accentuates the export of non-polluting industries in Indian manufacturing sector. The ownership dummy has a positive and significant impact on the export behaviour of plants irrespective of the nature of their industries. However, the coefficient indicates that private ownership has stronger impact in driving the export probability of a plant belonging to polluting industries compared to the plants belonging to non polluting industries.

From this analysis it is evident that within country locational characteristics have a significant impact on the export behaviour of both polluting as well as non polluting industries. If both the industry-specific agglomeration economies as well as the effect of export spillover are considered together then it can be observed that the impact of agglomeration economies is greater in case of affecting the export behaviour of plants belonging to non-polluting industries as opposed to polluting industries. In case of polluting industries we get a weak evidence of agglomeration economies.

Table 4.4 b) Woolridge Dynamic Probit Estimates- Polluting vs. Non- Polluting Industries

	Polluting Industries					**Non-Polluting Industries**				
Export Behaviour of Plant	R(1)	R(2)	R(3)	R(4)	R(5)	R(6)	R(7)	R(8)	R(9)	R(10)
Plant level Characteristics										
Lagged Export Status	0.608***	0.503***	0.507***	0.559***	0.563***	0.520***	0.415***	0.419***	0.455***	0.441***
	(0.082)	(0.081)	(0.081)	(0.082)	(0.082)	(0.058)	(0.058)	(0.058)	(0.059)	(0.059)
Productivity	0.033	0.035	0.035	0.034	0.032	0.073**	0.089**	0.089**	0.084**	0.079**
	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
Ownership Dummy	0.434***	0.358***	0.352***	0.408***	0.408***	0.320***	0.210*	0.214**	0.241**	0.237**
	(0.083)	(0.084)	(0.084)	(0.083)	(0.083)	(0.109)	(0.108)	(0.108)	(0.108)	(0.109)
Size	0.041	0.042	0.041	0.045	0.043	-0.017	-0.016	-0.015	-0.016	-0.019
	(0.044)	(0.045)	(0.045)	(0.044)	(0.044)	(0.038)	(0.037)	(0.037)	(0.037)	(0.037)
Age	0.185	0.184	0.179	0.178	0.174	-0.234	-0.190	-0.196	-0.197	-0.187
	(0.199)	(0.199)	(0.199)	(0.198)	(0.198)	(0.158)	(0.160)	(0.160)	(0.159)	(0.160)
Imported Input Intensity					0.231					0.808***
					(0.238)					(0.172)
Industry Characteristics										
EG^{sw}	0.216***	0.023	0.019	0.131***	0.137***	0.278***	0.145**	0.143**	0.129***	0.148***
	(0.045)	(0.060)	(0.060)	(0.045)	(0.045)	(0.041)	(0.072)	(0.072)	(0.041)	(0.041)
Incumbent exporters within the same industry and state		0.047***	0.045***	0.064***	0.065***		0.062***	0.060***	0.069***	0.067***
		(0.008)	(0.008)	(0.007)	(0.007)		(0.007)	(0.007)	(0.007)	(0.007)
Incumbent exporters in other industry but same state		0.025	-0.012	-0.006	-0.005		0.094***	0.053**	0.054**	0.060**
Location- Specific Characteristics										
Road Density	0.127***	0.104**	0.139***	0.108**	0.098**	0.188***	0.168***	0.203***	0.183***	0.156***
	(0.041)	(0.041)	(0.044)	(0.044)	(0.044)	(0.036)	(0.037)	(0.041)	(0.040)	(0.040)
Per capita power availability	0.205***	0.028	0.064	0.121**	0.105**	0.020	-0.045	-0.029	-0.020	-0.028
	(0.050)	(0.051)	(0.053)	(0.053)	(0.052)	(0.041)	(0.043)	(0.044)	(0.042)	(0.042)
SEZ Dummy			0.317***	0.108	0.091			0.285**	0.243**	0.184
			(0.120)	(0.116)	(0.116)			(0.122)	(0.121)	(0.122)
Urban Dummy	0.010	-0.028	-0.036	0.034	0.014	0.221***	0.103**	0.094**	0.195***	0.219***
	(0.045)	(0.044)	(0.045)	(0.044)	(0.044)	(0.043)	(0.045)	(0.045)	(0.042)	(0.043)
Plant Fixed Effect	yes	yes	yes	yes	yes	yes	Yes	yes	Yes	yes
Time Fixed Effect	yes	yes	yes	yes	yes	yes	Yes	yes	Yes	yes
Industry Dummy	no	yes	yes	no	no	no	Yes	yes	No	no
Observations	18,947	18,947	18,947	18,947	18,947	18,310	18,310	18,310	18,310	18,310
Number of factory	3,935	3,935	3,935	3,935	3,935	3,809	3,809	3,809	3,809	3,809
Likelihood-ratio test of rho=0	939.2	1180	1178	1072	1104	1612	1926	1921	1822	1850

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.5 Conclusion

The internationalisation process of the organised manufacturing plants in India has been uneven across Indian states. States with higher share of manufacturing output are also found to be the hub of exporting activities within the country. During the period of the analysis, it has been observed that the exporting activity activities of the organised manufacturing sector have been spreading towards the inland states. This is coupled with a decrease in the percentage share of exporting plants in the coastal states, especially the one characterised by higher share of manufacturing output. This dynamic pattern indicates the rising importance of network effect from of the geographical concentration of economic activities in shaping the internalitionalisation process of manufacturing plants within the country.

The present chapter used dynamic probit model to examine the role of location specific attributes *viz*, industrial agglomeration economies, exporter's concentration and infrastructural facilities in affecting the export behaviour of the manufacturing plants after controlling for various plant-level characteristics over 2008-09 to 2013-14. The industrial agglomeration economies have been observed to have a positive and significant impact on the export behaviour of plants, indicating the positive externalities arising from sharing of labor pool equipped with industry-specific knowledge. The positive impact of industrial agglomeration economies in affecting the export behaviour of plants has been also confirmed in the literature in case of Chinese manufacturing sector (Ito et al 2015). However, while distinguishing between polluting vs. non-polluting nature of industries in the model, it has been observed that the effect of agglomeration economies in facilitation the export of plants is higher in case of non-polluting industries as opposed to the polluting industries.

The results also show that there is presence of within-industry positive export spillover in organised manufacturing sector. The labour pool equipped with both industry-specific knowledge as well as knowledge on exporting activity, positively and significantly affects the plant's probability to export. However, the results show a weak evidence of cross-industry labour pool engaged in exporting activity. Other studies in the literature like Farole and Winkler (2013), Pose and et al (2013), Greenaway and Knellar (2008) also observed a positive export spillover effect in case of Indonesia and UK's manufacturing sector respectively.

Other locational factors like road transport facilities also have a significant impact in driving the export behaviour of the manufacturing plants. The presence of the policy-induced special economic zone within a state positively and significantly affects the export of a plant located in that state. The results obtained from the analysis also show that the learning- experience from previous period of exporting activity positively affects the export behaviour of manufacturing plants. Moreover, the private ownership structure and size of plants have a positive and significant impact on the export behaviour of manufacturing plants. The age is found to have a negative impact, indicating higher the age lower is the probability of a plant to export. However, the impact is found to be statistically insignificant.

The impact of locational characteristics in driving the export behaviour of plants is also observed to differ across the nature of industries. The states well endowed with power capacity significantly accentuates the export of plants belonging to polluting industries. As opposed to this, the effect is found to be insignificant in case of the non-polluting industries. Similarly, the location of a plant in urban area significantly facilitates the export behaviour of plants belonging to non-polluting industries whereas the effect is insignificant in case of the polluting plants.

It can be concluded that both the locational characteristics like network of road as well as industry-specific agglomeration economies have a positive and significant impact in accentuating the internationalisation process of the manufacturing plants belonging to non-polluting industries as well as polluting industries. However, the cross-industry export spillover in case of plants belonging to the polluting industries is insignificant. This indicates that the concentration of cross-industry exporters facilitates export behaviour of plants belonging to non-polluting industries as opposed to plants belonging to polluting industry. It seems like agglomeration economies in the Indian manufacturing is highly significant in sector facilitating export of *cleaner* industries as opposed to export from *dirty* industries.

Appendix

Table A.4. 1 Percentage of Exporting Plants in Indian Organised Manufacturing Sector

Year	Number of Factory	Number of Plants	Number of Exporting Plants	Percentage Share of Exporting Plants (%)
2008-09	32845	124198	10092	8.1
2009-10	36452	128072	8866	6.9
2010-11	39443	148564	10593	7.1
2011-12	40209	151830	12418	8.2
2012-13	43219	145539	10299	7.1
2013-14	44916	151140	10500	6.9

Source: Author's calculation based on ASI-factory-level database

Table A.4.2 Woolridge Dynamic Probit Model

VARIABLES	R(1)	R(2)	R(3)	R(4)	R(5)
Plant level characteristics					
Lagged Export Status	0.544***	0.435***	0.439***	0.481***	0.472***
	(0.047)	(0.047)	(0.047)	(0.047)	(0.047)
Productivity	0.056**	0.064**	0.064**	0.061**	0.057**
	(0.025)	(0.026)	(0.026)	(0.025)	(0.025)
Ownership Dummy	0.423***	0.325***	0.323***	0.372***	0.368***
	(0.066)	(0.066)	(0.066)	(0.065)	(0.065)
Size	0.010	0.011	0.011	0.011	0.009
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Age	-0.091	-0.063	-0.070	-0.072	-0.068
	(0.123)	(0.123)	(0.123)	(0.123)	(0.123)
Imported Input Intensity					0.610***
					(0.138)
Industry Characteristics					
Spatial Gini Index^{SW}	0.261***	0.068	0.068	0.151***	0.158***
	(0.033)	(0.048)	(0.048)	(0.032)	(0.032)
Incumbent Exporters within the same industry and state		0.062***	0.060***	0.070***	0.070***
		(0.005)	(0.005)	(0.005)	(0.005)
Incumbent Exporters in other industry but same state		0.045***	-0.001	0.018	0.022
		(0.012)	(0.016)	(0.015)	(0.015)
Location-specific Characteristics					
Road Density	0.170***	0.151***	0.193***	0.155***	0.134***
	(0.028)	(0.028)	(0.030)	(0.030)	(0.030)
Per capita Power Availability	0.111***	-0.028	0.001	0.042	0.030
	(0.032)	(0.033)	(0.034)	(0.033)	(0.033)
SEZ Dummy			0.360***	0.222***	0.183**
			(0.085)	(0.083)	(0.084)
Urban Dummy	0.144***	0.042	0.032	0.146***	0.146***
	(0.031)	(0.032)	(0.032)	(0.030)	(0.030)
Plant Fixed Effect	yes	yes	yes	yes	yes
Time Fixed Effect	yes	yes	yes	yes	yes
Industry Dummy	no	yes	yes	no	no
Observations	37,270	37,270	37,270	37,270	37,270
Number of factory	7,454	7,454	7,454	7,454	7,454
Likelihood-ratio test of rho=0	2564	3173	3163	2955	3013

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Chapter 5

Impact of Industrial Agglomeration on Air Quality across Indian States

Introduction

Industrialisation accompanied by rapid urbanisation has been an inevitable pattern of the development process across nations. Although, industrialisation may seem to be the key for achieving economic growth, its negative impact on the environment is one of the major factors that have made most of the nations, especially the developing nations, grapple with the environmental problems like air pollution, water pollution etc. Since 2010, India, Pakistan and Bangladesh have experienced a sharp increase in the air pollution levels, while China has shown a declining trend (WHO 2016). The manufacturing industries are associated with harmful emissions of toxic pollutants like oxides of sulphur, carbon and nitrogen, particulate matters, ozone gases etc. Some of the recent literature in the context of developing countries empirically observed that that these pollutants escalate the global temperature and have adverse health impacts (Guttikunda and Goel 2013, Greenstone and Hanna 2014); nudging researchers and policy makers to examine the trade off between the economies and diseconomies associated with the process of industrialisation.

The manufacturing process entails consumption of energy and with the increase in the scale of production; the demand for energy also increases. This has a two-fold effect on the environment as both the generation as well as the consumption of energy exacerbate environmental pollution. Moreover, the composition of the manufacturing sector i.e. the nature of industries; polluting vs. non-polluting industries and the technology used in the production process also affects the level of environmental pollution.

The degree of concentration of the manufacturing activities further aggravates the environmental problems. It has been observed that the degree of agglomeration of manufacturing sector in India is moderate. Some of the states like Maharashtra, Gujarat, West Bengal, Uttar Pradesh, accounting for higher share of the total manufacturing output, also specialises in polluting industries. Does this indicate that while achieving industrial growth, these states have actually deteriorated in terms of their environmental quality? This chapter empirically examines the impact of agglomeration of manufacturing sector on the air quality across India states for the year 2013-14, using a spatial modelling framework.

While analysing the impact of agglomeration of manufacturing sector on the air quality across Indian states, the study uses two major air pollutants, *viz* SO2 and NO2. It has been observed that the annual average concentration level of SO2 in air across Indian states for the year 2013-14 is low as per the definition of the national ambient air quality standards defined by the Central Pollution Control Board (CPCB). However, the levels of concentration of NO2 in some of the states like Maharashtra, West Bengal, Delhi and Rajasthan exceeds the moderate level of the national ambient air quality standards for NO2. From a preliminary analysis it is observed that states with specialisation in the manufacturing sector also registered a relatively higher concentration of both the pollutants.

The level of concentration of pollutants in the air within a particular state is also observed to have an impact on the level of the concentration of pollutants of the adjacent regions. The presence of this spatial dependency leads to biased and inconsistent estimates of the linear regression model. While empirically analysing the impact of agglomeration of the manufacturing sector, spatial autoregressive modelling technique has been used in the chapter. This method, not only corrects for the spatial dependency of the dependent variable (i.e. in this analysis the level of concentration of pollutants in the air) by incorporating the spatial lag values but also adjust for -the regional spillover effect for other explanatory variables included in the analysis.

The degree of agglomeration of the overall manufacturing sector within a state, captured by the location quotient index, is observed to have a statistically significant impact on the level of concentration of SO2 in the air across Indian states, after controlling for other state level characteristics, including the degree of environmental stringency. However, the impact was found to be insignificant in case of the level of concentration of NO2 in the air. Other than manufacturing agglomeration, the number of registered motor vehicles plying on the roads across Indian states was found to have a significant and positive impact on increasing the level of atmospheric concentration of NO2. This indicates that apart from industrial pollution, vehicular emission is one of the major factors in aggravating the air pollution across Indian states.

The *first section* of the chapter gives a brief review on the theoretical background of the linkage between agglomeration of industries and environmental pollution. The section also elaborates empirical methodological issues while analysing the linkage between agglomeration of industries and environmental pollution both in the context of developed as well as developing countries, including the experience of India. The *second section* of the chapter elaborates the linkage between manufacturing agglomeration and Indian air quality using the preliminary descriptive statistic results. The *third section* uses empirical modelling techniques to capture this linkage and discusses the results. The *final section* concludes the chapter.

5.1 Literature Review

5.1.1 Industrial Agglomeration and Diseconomies

Economic activities especially manufacturing activities tend to concentrate in certain regions. Presence of cities and its growth over time[37] is the best evidence of this uneven spatial distribution of economic activities. The presence of specialised labor pool, large market demand, availability of infrastructural facilities, natural advantages of a region like availability of mineral resources and other region specific externalities arising from the interaction of economic agents (example knowledge spillovers) are some of the driving forces, also termed as, *centripetal forces* that leads to concentration of manufacturing industries in a specific region within a country. However, increased concentration of industries limits the availability of physical space and other resources of a region− resulting in agglomeration diseconomies (Henderson 1974 as quoted in Fujita and et al. 1999) like increased rent of land, rise in wage, depletion of natural resources, overuse of communication and transportation facilities, polluted air and water, sewerage and waste disposal problems. These are also termed as *centrifugal forces* as these impede further concentration of industries in a region, leading to the dispersion from the overcrowded core to uncluttered periphery, within a country (Brakman et al 1996, Zheng 2001). The spatial development pattern of manufacturing activities in a region depends upon the relative magnitude of the centripetal vs. centrifugal forces (Krugman 1999, Verhoef and Nijkamp 2002, and Kyriakopoulou and Xepapadeas 2013). While analysing the land use pattern within a city and its sustainability over time, studies in the urban economics literature have analysed the prevalence of agglomeration diseconomies in terms of traffic congestion and crowding of population (Oron et al 1973). However, analysing diseconomies associated with industrial agglomeration, especially the extent of environmental pollution, is an emerging literature

[37] According to a report by United Nations (2015) more than 54% of the world's population resides in the urban areas and it is projected that by 2050 more than 66% of the world's population will reside in urban areas.

(Verhoef and Nijkamp 2002, Lange and Quass 2007, Kyriakopoulou and Xepapadeas 2013, Zheng and Kahn 2013, Zhu et al 2014, Sun and Yuan 2015, Cheng 2016, Kahn et al. 2019).

5.1.2 Industrial Agglomeration and Environmental Quality

Industrialization especially the manufacturing process is associated with toxic emissions which alter the environmental quality- air, water and land, across regions and also have severe health impacts. While analyzing the spatial development pattern of manufacturing activities across regions, it has been observed theoretically that the embodied pollution act as a centrifugal force, leading to the dispersion of industries over time (Verhoef and Nijkamp 2002, Lange and Quass 2007, Kyriakopoulou and Xepapadeas 2013). The environmental pollution also crowds out benefits obtained from agglomeration of industries within a region. Verhoef and Nijkamp (2002) in a general spatial equilibrium monocentric city model showed that the environmental pollution in a central industrial district may outweigh the agglomeration economies *viz*, the knowledge spillovers among labourers and scale of production, present in the industrial centre. The different simulation results in their model showed that the presence of pollution may even encourage workers to re-locate away from industrial sites to regions with cleaner environment. This in turn increases the commuting costs of workers thereby affecting the labour supply and productivity of workers. They also showed that in the long run sustainability of the industrial district depends on the relative magnitude of environmental costs (in the form of emission taxes) imposed on producers versus the benefits reaped from the agglomeration economies. Unlike the monocentric city model, Kyriakopoulou and Xepapadeas (2013) theoretically showed that to internalise the cost of environmental pollution associated with the concentration of manufacturing activities it is optimal for an urban planner to have bi-centric city model i.e. two industrial districts. This reduces the accumulation of environmental pollution within a single region and thereby reduces the severity of the damage. In a general spatial equilibrium framework, they showed that the presence of environmental pollution alters the natural advantage of a region (for example presence of coastline) and other region-specific agglomeration economies arising from the interaction between natural advantages of a location and economic agents, thereby leading to dispersion of activities.

Unlike the central business district models of urban economic theory, Lange and Quass (2007) model using the new economic geography core-periphery framework, showed that environmental pollution combined with the transportation costs (used as a proxy to capture the degree of inter-regional trade freedom) endogenously determines the spatial development pattern of manufacturing activities, leading to different sizes of agglomerations viz, symmetric, partial and spreading, across regions within a country. Lange and Quass (2007) assumed that degradation of environmental quality is not local i.e. industrial emission in one region has negative spillover effect on the environment of adjacent regions. They observed, that with the increase in the skilled labor endowment in a region, environmental damages associated with the industrial agglomeration reduces, thereby leading to further expansion of the cluster in the model. It has been argued that empirically assessing the degree of environmental degradation, associated with industrial clusters is challenging, owing to the multidimensionality of the environmental damages caused. Studies empirically analysing the impact of industrial agglomeration on the degradation of environmental quality, both in the context of developed (Greenstone 2002, Kahn and Mansur 2013) as well as developing countries is sparse (Zheng and Kahn 2013, Zhu et al 2014, Cheng 2016, Kahn et al. 2019).

It has been observed empirically in both developed as well as developed nations, that the concentration of manufacturing activities aggravates the environmental pollution of a region. It is also true that the latter, simultaneously determines size of the industrial clusters formed in that region and adjacent regions (Kahn and Mansur 2013, Zhu et al 2014, Cheng 2016). The differential environmental policies across region, within a country, plays a significant role in determining the degree of industrial concentration and its nature in terms of the type of industries getting agglomerated in a region (Greenstone 2002). While analysing the impact of the Clean Air Act on the spatial development pattern of polluting manufacturing industries in US, Greenstone (2002) observed that the counties that failed to attain the air quality standards as per the federal rule, registered a decline in the employment and output of the pollution-intensive industries. Similar to Greenstone (2002), Kahn and Mansur (2013) also observed that the geographical clustering of polluting industries like manufacturing textiles, coal and petroleum takes place in counties characterised by less stringent environmental regulations. However, they observed that the degree of overall manufacturing concentration remained unaffected by the differential environmental regulations across regions.

The rapid industrialisation and rising population density in cities accompanied by poorly regulated environmental policies across developing countries has aggravated the severity of the damages posed by the environmental pollution problems across the world. Among the developing countries, China India and Brazil are among the top 10 polluters (in terms of air pollution) in the world (Ji 2015). While analysing the cause and implications of urban pollution across developing countries, Kahn et al. (2019) posited that presence of heavy scale manufacturing clusters within a city aggravates the level of pollution thereby rendering it less competitive compared to other cleaner regions specialised in services industries. The toxic emissions are found to alter the learning ability and productivity of workers, leading to loss of skill formation. The workers dwelling in cities, near their working site are faced with a trade-off between the benefits obtained from urban amenities vs. the health costs they have to bear due to the exposure to pollution (Zheng and Kahn 2013). This indicates a force of dispersion endogenously arises leading to spreading of manufacturing activities across regions.

While analysing the extent of environmental pollution due to manufacturing clustering across Chinese cities, Zhu et al (2014) observed that pollution intensive industries have caused severe environmental damages especially in the coastal regions of China. They conducted a primary survey across firms belonging to three major polluting industries viz; thermal power plants, manufacturing yarns and paper and paper products. Their survey analysis showed that rise in environmental standards by China's government, in the coastal regions nudged the firms to restructure their production process through innovation and relocating their polluting plants to inland regions, which were characterised by lax environmental standards indicating the presence of pollution haven effect. They concluded that the degree of manufacturing concentration in a region plays a significant role in formulating spatially differentiated environmental policies in country. While examining the spatial correlation of polluting industries and air pollution across Chinese cities, (Cheng 2016) also concluded that the severity of environmental pollution can be reduced by restricting further concentration of industries within an already agglomerated region. These results are congruent with the theoretical conclusions of Kyriakopoulou and Xepapadeas (2013) and Lange and Quass (2007).

Most of the studies in the context of developing countries are focused on analysing the correlation between concentration of Chinese manufacturing activities and the degradation of environmental qualities. In the Indian context, no study has examined the impact of industrial agglomeration on the degradation of environmental quality. This chapter of the thesis examines how agglomeration of the overall manufacturing activities (both organised as well as unorganised sector) has degraded the quality of air across Indian states.

There have been studies on analysing the trend of air quality across Indian cities and its impact on the health of city dwellers (Guttikunda and Goel 2013, Greenstone et al. 2014, Gurjar et al. 2016). While analysing the different sectoral contribution to the deteriorating air quality of Delhi, Guttikunda and Goel (2013) observed that in the year 2010 manufacturing industries contribute about 14-21% of the total particulate matters present in the air. They used atmospheric dispersion modelling techniques[38] to estimate the impact of deteriorating air quality on mortality rate. Similarly, Greenstone et al. (2014) also assessed the impact of both air as well as water pollution on infant mortality rate across Indian cities using a difference in-difference method after controlling for the degree of stringency of environmental policies across Indian cities. They concluded that under weak institutional framework it is possible to improve the air quality by amending policies provided there is demand or public support for it. However, improvement in air quality was found to be insignificant in affecting the change in infant mortality rate across Indian cities.

In contrast, to Guttikunda and Goel (2013), Gurjar et al (2016) analysed the trend of three air pollutants *viz;* SO2, NO2, and particulate matter (PM) across three Indian megacities of Delhi, Mumbai and Kolkata and the relevance of different government policies in that context. They concluded that presence of large *number* of industries, power plants, dense vehicular population, unplanned urbanisation, presence of thermal power plants are some of the major factors behind deteriorating air quality of Delhi, Kolkata and Mumbai. They also identified that industries like iron and steel smelting; production of basic metals, metal products and machinery, fertilizer, other metallic product and cement are the other important sources of oxides of sulphur and nitrogen.

5.1.3 Industrial Agglomeration and Environmental Quality-*experience of India*

The Central Pollution Control Board (CPCB 2009) of India has attempted to identify polluted industrial clusters based on the deterioration of environmental quality across India, using the source-pathway-receptor modelling technique. This modelling technique firstly, estimates the sources of pollution, secondly the pathways through which the pollution dissipates viz. air, water and land and thirdly, estimates the impact on the receptors (human/environment). In the year 2009, using this modelling technique CPCB formulated a Comprehensive Environmental Index (CEPI) and 88 industrial clusters were scored across the country. According the latest assessment, CPCB (2013), out of 88 industrial clusters, surveyed, 43

[38] Atmospheric dispersion modelling techniques are used to examine the pattern of dispersion of pollutants present in the air.

industrial clusters (with CEPI>70) were found to be critically polluted across the country[39]. Most of the polluting industrial clusters were found to be in states like Delhi, Gujarat, Maharashtra, West Bengal and Uttar Pradesh.

Several policies have been formulated by the Government of India to mitigate the environmental pollution emerging from industrial emission. Most of the policies can be categorised under the command-and- control approaches. The CPCB sets industry-specific emission standards[40] for the manufacturing industries and compliance to these standards are monitored by government authorities. Banning on certain operational process, relocation of polluting industries and closure of polluting plants are some of the mitigation action plans, has used by CPCB over time. However, the delay in implementation of the action plans and judicial hurdles (Greenstone et al. 2017) has aggravated the incidence of non-compliance to the emission standards by manufacturing plants, resulting in deterioration of environmental quality across Indian states. Moreover, the absence of transparency and non-maintenance of industry-level or plant- level emission data has left the manufacturing plants unquestioned to continue its operation.

While analysing the sources and trend of degradation in environmental quality across India, the above mentioned studies (Guttikunda and Goel 2013, Greenstone et al. 2014, Gurjar et al 2016) did not capture the regional spillover effect of pollution across space which plays a significant role in determining the spatial development pattern of economic activities across region (Kyriakopoulou and Xepapadeas 2013 and Lange and Quass 2007, Cheng 2016). Moreover, these studies did not consider the underlying simultaneity between the formation of industrial clusters and the degree of environmental pollution associated with it. On one hand the rising scale of manufacturing activity, accompanied by rising energy consumption increases the total emissions. On the other hand the level of pollution within a region imparts negative externalities (loss of workers productivity) which repel the concentration of manufacturing activities in that region. In this context, the present study fills the gap in the literature by analysing the impact of agglomeration of organised manufacturing sector on the air quality of Indian states, using a spatial modelling framework for the year 2013-14.

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[39] http://pib.nic.in/newsite/printrelease.aspx?relid=94969

[40] http://cpcb.nic.in/effluent-emission/

5.2 Industrial Agglomeration and Air Quality across Indian States

5.2.1 Data

While analysing the spatial development of the overall manufacturing sector across Indian states, state-wise sectoral Gross State Domestic Product (GSDP) data has been used. The RBI Handbook of Statistics on Indian Economy annually publishes state-wise GSDP data and its sectoral break-ups *viz*, manufacturing, agriculture and services. Alternatively, the level of agglomeration of the polluting industries[41] in the organised manufacturing sector and other state-wise plant-level characteristics like percentage of exporting plants, percentage of plants with ISO-14000 certification have been calculated using the Annual Survey of Industries factory level data for the year 2013-14. This database gives detailed information on different factory-level characteristics along with their state-wise location. However, one of the major limitations of this data is that it does not provide the coordinate-wise (latitude and longitude) location of an industry or plant within a state. The true spatial modelling framework entails identification of unique coordinates of the unit of analysis, but – here the analysis of the impact of industrial agglomeration on air quality is limited at more aggregated level i.e.at the state-level. In this chapter, both the agglomeration of overall manufacturing as well as the agglomeration of polluting industries has been calculated at the state-level. The information on the coordinates of each state has been obtained by using the Indian shape files developed by the Indian Institute of Remote Sensing (IIRS).

While analysing the impact of agglomeration of manufacturing on the air quality, the annual city-wise air quality data, published by the Central Pollution Control Board (CPCB) has been used in this chapter. Under the National Air Quality Monitoring Programme (NAMP) initiated by the CPCB, the concentration level of the criteria pollutants[42], viz; sulphur dioxide (SO2), nitrogen dioxides (NO2) and particulate matter (PM10) is assessed at different monitoring stations across Indian cities. The state-level air quality data, for the empirical analysis of this chapter has been obtained by taking simple average of the concentration level of pollutants across cities within a state for the year 2013-14. The air quality data on both the pollutants was obtained for 30 states. These states together constitute 99% share of the total manufacturing output of India. The states excluded from the analysis are peripheral states viz;

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[41] According to the definition of CPCB all the industries categorized under the red category has been defined as polluting industries in this chapter.

[42] Criteria pollutants are pollutants in the air for which a national quality standard is defined by the Government of the country.

Andaman and Nicobar Island, Daman and Diu, Dadra and Nagar Haveli, Arunachal Pradesh Lakshadweep and Manipur. The share of these states in total manufacturing output is negligible. The analysis has been conducted based on two pollutants *viz*; SO2 and NO2.

Other state-level characteristics like the number of registered motor vehicles and population density have been obtained from the annual reports of the Ministry of Road Transport and Highways and Census of India respectively.

5.2.2 Industrial Agglomeration and Air Quality across Indian States

Industrial Agglomeration

In this chapter, both the degree of overall agglomeration of the manufacturing sector[43] as well as the agglomeration of the polluting industries for each state has been captured by using the Location Quotient Index (LQ) (Cheng 2016). This index captures the degree of specialisation of an economic activity within a state, relative to the national average. The LQ of the manufacturing sector (i) within state m can be defined as,

$$LQ_{im} = \left[\frac{output_{im} / \sum_{i} output_{im}}{\sum_{m} output_{im} / \sum_{i}\sum_{m} output_{im}}\right] \tag{1}$$

Similarly, the degree of agglomeration of industry *i* within state *m* has been calculated using equation (1).

From the preliminary analysis, it is observed that in the year 2013-14, some of the states with specialisation in manufacturing sector (LQ>1) also show a high degree of concentration of polluting industries. **Table 5.1** below shows that Gujarat and West Bengal have specialisation in polluting industries (LQ>1). Industries like manufacturing of pharmaceuticals, paper and pulp in Gujarat, manufacturing of iron and steel, food products and basic chemicals in West Bengal, constitute the bulk of the manufacturing output in these states. Other states like Karnataka, Maharashtra and Uttar Pradesh also show a higher degree of concentration of polluting industries followed by Tamil Nadu and Uttarakhand. In contrast to this, although Haryana specialises in manufacturing sector (with an LQ of 1.2), the degree of concentration of polluting industry within the state is low. Manufacturing of parts and accessories of motor

[43] The overall agglomeration of the manufacturing sector (both organised as well as unorganised sector) indicates the degree of specialisation of a state in manufacturing activity compared to other economic activities like services, agriculture and other activities within a state.

vehicles and finished textile products constitute 22% of the total manufacturing output of Haryana.

Table 5.2 Location Quotient of Overall Manufacturing and Polluting Industries across States

State	Share in Total GSDP Manufacturing (%)	LQ of Overall Manufacturing Sector	LQ of Polluting Industry
Maharashtra	19.0	1.3	0.9
Gujarat	12.9	1.7	1.4
Tamil Nadu	10.8	1.2	0.6
Karnataka	7.0	1.0	0.9
Uttar Pradesh	6.7	0.8	1.0
West Bengal	4.5	0.8	1.3
Haryana	4.4	1.2	0.4
Telangana	3.4	0.8	1.0
Uttarakhand	3.3	2.4	0.6
Rajasthan	3.2	0.6	0.9

Source: Author's calculation based on RBI and ASI databases

Air Quality

While analysing the air quality data (the two major pollutants NO2 and SO2 have been considered in the study) across Indian states, it has been observed that as per the national ambient air quality standards[44] defined by the CPCB, the ambient concentration level of SO2 is low in India in the year 2013-14 i.e. within the range of 0-25µg/m3. It can be observed from the **Figure 5.1 a)** that states with higher manufacturing sector share have relatively higher SO2 concentration.

[44] The standards are defined in Table A.5.3 in the appendix of the Chapter.

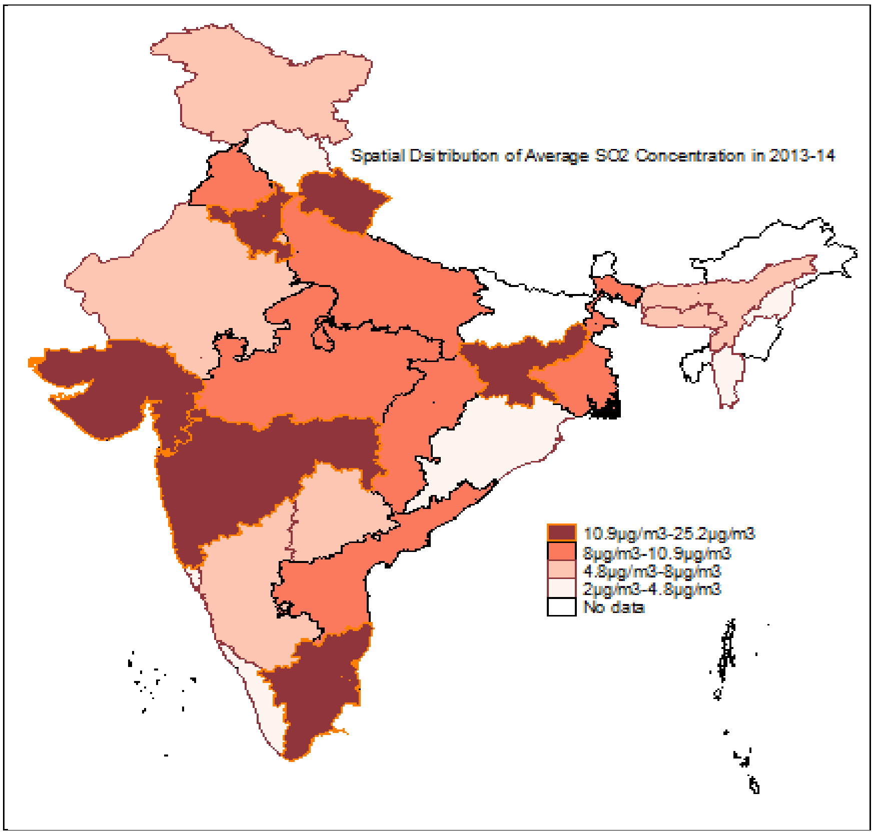

Figure 5.1a) Spatial Distribution of SO2 concentration across Indian States in 2013-14

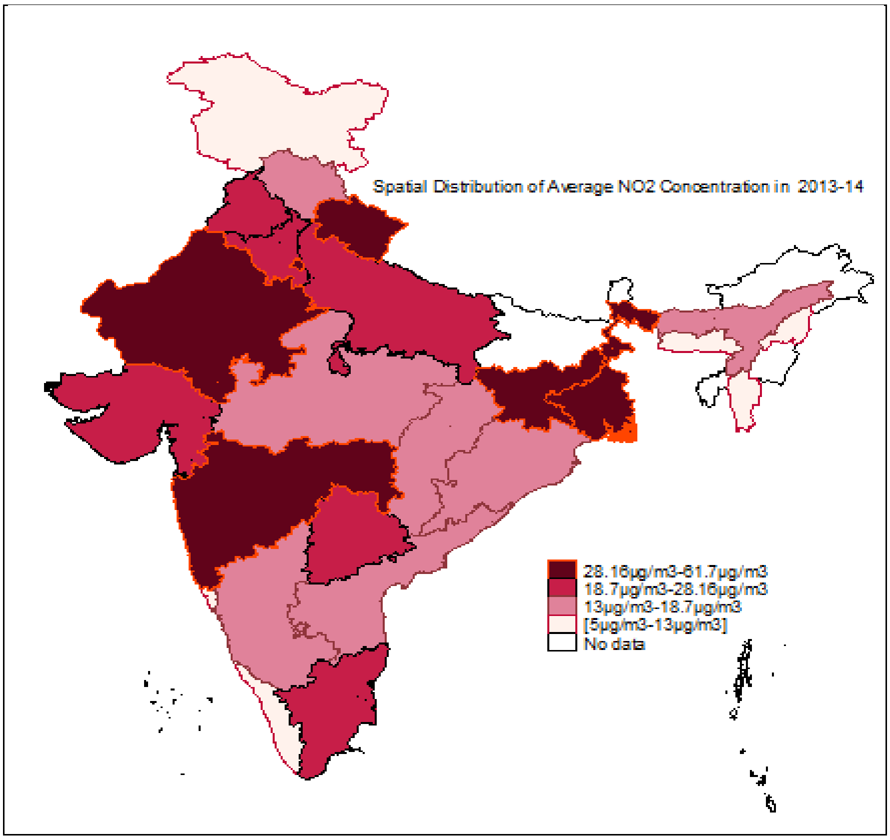

Figure 5.1b) Spatial Distribution of NO2 concentration across Indian States in 2013-14

The ambient concentration of NO2 in some of the cities of states like Maharashtra, West Bengal, Uttar Pradesh, Rajasthan and Delhi are in the high range of- 41 µg/m3-60 µg/m3 according to the national ambient standards. **Figure 5.1b)** depicts the distribution of the concentration of NO2 across Indian states in the year 2013-14. It can be observed that states with higher manufacturing accounts for a relatively higher level of concentration compared to the other states.

The pollutants in the air remain suspended and can travel several kilometres across regions. While modelling the impact industrial agglomeration on the air quality of state *m*, it is also true that the concentration of pollutants in the air of the adjacent states may have an impact on the air quality of state *m*-depending on the wind pattern and distance, based on the meteorological model of the region. The spatial dependence of SO2 and NO2 has been examined using the Moran's I- statistic.

Spatial Dependence of Air pollutants

The Moran's I statistic measures the degree of spatial autocorrelation in the data (Moran 1948, Pisati 2012). It captures the similarity in the values of in region *m* with the values of adjacent regions. The perfect similarity in values of two adjacent regions (I=1) indicates spatial clustering. The similarity in the values of SO2 concentration in state *m* with the values of SO2 concentration of its neighbouring state *l* can be defined as,

$$I = \frac{\sum_{m=1}^{M}\sum_{l=1}^{M} w_{ml}(y_m - \overline{y})(y_l - \overline{y})}{\frac{1}{M}\sum_{m=1}^{M}(y_m - \overline{y})^2 \sum_{m=1}^{M}\sum_{l=1}^{M} w_{ml}}$$

where, w_{ml} is the spatially weighted distance-based matrix. This captures the degree of proximity between two regions *m* and *l*. y_m is the value of the level of concentration of SO2 in region *m* and y_l is the value of the level of concentration of SO2 in region *l*. $\overline{y}$ is the average value of SO2.

Table 5.2 Moran-I Statistic for Air Pollutants

Pollutants	Moran-I	E(I)	p-value*
SO2	0.012	-0.029	0.224
NO2	0.1	-0.029	0.007

Source: Author's calculation

The Moran – I statistic in **Table 5.2** has been calculated under the null hypothesis that there is no spatial autocorrelation.

$E(I) = -\frac{1}{M}$; where, *E(I)* is the expected value of *I* and *M* is the total number of regions (here state) within a country.

If I>E (I) it indicates positive spatial autocorrelation. Conversely, if I<E (I), this indicates negative spatial autocorrelation. From Table 5.2 we can observe that, in case of both the pollutants there is positive spatial autocorrelation. However, the spatial dependence in case of SO2 is not statistically significant. The Moran I scatter plot is given in the appendix of the chapter in **Figure A.5.1a)** and **A.5.1b)**

5.3 Impact of Industrial Agglomeration on Air Quality across Indian States

5.3.1 Empirical Model and Methodology

While analyzing the impact of industrial agglomeration on air quality across Indian states, firstly, a simple linear model has been used under the assumption that there is no spillover effect of pollutants across states.

$$y_m = \beta_0 + \beta_1 X_m + \varepsilon_m \qquad (1)$$

$\varepsilon_m \overset{iid}{\sim} N(0, \sigma^2)$ is the idiosyncratic error tem

where, *y* denotes the level of concentration of the pollutant in air in state *m*. *X* is the matrix of state-level characteristics that may impact the air quality of state *m*. The agglomeration of overall manufacturing sector (organised and unorganised sector), and the agglomeration of polluting industries in organised sector are included in the model. The state-level *environmental stringency* affects the level of air pollution within a state. In this analysis, the Gross State Domestic per capita (GSDP per capita) is used as a proxy to control for the environmental stringency. Following the environmental Kuznets curve hypothesis, increase in income leads to rise in demand for good quality of environment, thereby leading to adoption of stringent environmental policies and vice-versa. The higher the income of a state, higher will be the degree of stringency of environmental laws and lower will be the concentration of pollutants in the air. The non-linearity in the relationship between environmental quality and income has been captured by incorporating the quadratic term of

GSDP per capita. Moreover, the quadratic term also captures the income growth of a region. This serves as a proxy for the stage of development of state *m*. It has been argued in the literature that with the growth in income, there is also a shift in the sectoral composition- agriculture, manufacturing services and other tertiary sectors. While analysing the impact of spatial development pattern of the manufacturing sector on environment, it is also pertinent to control for the stage of development of the state.

Other state-level characteristics included in the study are share of services in the gross domestic product (GSDP), registered motor vehicles, share of agriculture in the gross domestic product and the population density, percentage of exporting manufacturing plants within the state . *Services* are less polluting than manufacturing of goods. Some services like recycling of effluent from manufacturing plants (common effluent treatment plants), can reduce the toxicity of the industrial pollution thereby leading to a lower level of the concentration of pollutants in air. *Agricultural activity*, especially the use of fertilisers across the farming lands is one of the major contributors of ammonia content of the air. Moreover, burning of biomass and crop residues, use of obsolete farming machineries and technology further aggravates the pollutant content of the air. Another major source of air pollution is the emission from *motor vehicles*, plying on the roads of the states. The burning of the fuels aggravates the level of sulphur dioxides, nitrogen dioxides and particles of hydrocarbons in the air. *Population density* is also included as a control variable. It positively affects the concentration of pollutants in the air. The higher the population density within a state, higher will be the economic activities accompanied by higher energy consumption. This in turn increases the emission rate followed by accumulation of air pollutants within that region.

Considering the open economy framework, trade has an impact on the environmental quality of a country via, scale effect, composition effect and technique effect. In order to control the state-level exporting activities[45], in this analysis the percentage of exporting plants in state *m* has been included as an explanatory variable. Moreover, to meet the international environmental standards, exporting manufacturing plants adopts better environmental management practices, that may lead a reduction in the concentration level of air pollutants within a region. The percentage of manufacturing plants with ISO-14000 series certificates[46]

[45] Data on international trade data across Indian states is not available. The only source that reports information on state-wise exporting plants is ASI factory level data.

[46] The adoption of ISO-14000 series certification involves the following steps: firstly, the environmental concern of the manufacturing unit is identified. For example excessive use of polluting inputs, assessment of the environmental risk of the production process. Secondly, adoption of the mitigation action after considering the

which captures the environmental awareness of manufacturing plants, has been also included as another state-level characteristic in this study. ISO-14000 series provides a comprehensive environmental management system aimed at improving the environmental performance of the manufacturing units. This is adopted and acknowledged globally. The better the environmental performance of manufacturing units, lower will be the emission rate. This in turn will ensure lesser concentration of pollutants in the air. The unobserved heterogeneity across states has been controlled by clustering the error term by states.

It has been argued in the literature that the level of pollution in region *m* may affect the pollution level of adjacent region *l*, where $m \neq l$. In the spatial econometric literature this is termed as spatial dependence. While modelling the air quality across states, the simple linear regression model as shown by equation (1) cannot capture this spatial dependence among pollutants. Moreover, the presence of spatial dependence can cause omitted variable bias in the estimates obtained by using simple linear regression model. This bias is corrected by analysing the impact of manufacturing agglomeration on air quality across Indian states for the year 2013-14 under a spatial modelling framework.

While analysing the impact agglomeration of manufacturing sector on air quality across India states, the second model uses cross-sectional (first order) autoregressive spatial[47] specification (Kelejian and Prucha 1998) as follows:

$$\begin{aligned} y_m &= \beta_0 + \beta_1 X_m + \lambda W_m y_m + u_m \qquad & |\lambda| < 1 \\ u_m &= \rho W_m u_m + \varepsilon_m \qquad & |\rho| < 1 \end{aligned} \qquad (2)$$

y_m is the $m \times 1$ vector of the concentration of pollutant in the air, X_m is the vector of $m \times k$ exogenous variables viz; agglomeration of overall manufacturing sector, agglomeration of polluting industry, share of services in GSDP, share of agriculture in GSDP, registered motor vehicles and population density and W_m is the spatial weighing matrices with the dimension of $m \times m$. The term $\lambda W_m y_m$ in equation (2) represents the spatial lag dependence of the dependent variable y_m. The spatial autoregressive model as represented by equation (2)

stringency of local environmental laws and assessing the costs associated with it. Thirdly, it requires the formulation of the environmental policy statement for the manufacturing unit. Fourthly, based on the policy statement, targets are set. Fifthly, the environmental management system is implemented and periodically reviewed.

[47] The first order spatial autoregressive models considers the spillover effect of immediate neighbouring region only and not the effect of the neighbour's of the neighbouring region.

assumes that the value of air pollution in region *m* is affected by the value of air pollution in region *l where m≠l.* Moreover, the residuals of region *m* may be also affected by the residuals of region *l.* This is incorporated in the error equation by the term $\rho W_m u_m$.

The spatial weighted matrix has been calculated based on the coordinate axes of the Indian shape files. The weights can be generated either by calculating the number of neighbours of region *m (known as contiguity based spatial weights)* or by calculating the distance between the neighbours of region *m*. In the present analysis the *distanced-based spatial weights* has been used.

5.3.2 Empirical Results

While analysing the impact of industrial agglomeration on state air quality, ambient concentration level of two different air pollutants have been used in the study. The ordinary least square (OLS) estimates for equation (1) has been reported in **Table 5.3** below. It can be observed that both the agglomeration of the overall manufacturing sector positively and significantly affects the level of atmospheric concentration of SO2 across states after controlling for the degree of environmental stringency of the state, as shown in specification R (1), R (3) and R (4) and R(5). The agglomeration of polluting industries of the organised sector is observed to have insignificant in affecting the level SO2 concentration in the air, as can be observed from specification R (2) and R(6). In contrast to this, the concentration of overall manufacturing sector does not affect the level of concentration of NO2 in the air. The number of motor vehicles is found to have a positive and significant impact on the concentration of NO2 in the air, as shown in specifications R (9) - R (12). There is a weak evidence of the impact of vehicular emission on the SO2 concentration in the air, as can be observed in specification R (3) below.

It can be observed that the model (1) in the open economy framework also gives similar results, as shown by specifications R (5) - R (6) and R (11) - R (12). The impact of GSDP per capita square term appears to be insignificant. Other state-level characteristics are observed to be statistically insignificant in affecting the pollutants concentration level across state. All the estimates reported in **Table 5.3** below has been corrected for the across state unobserved heterogeneity by clustering the error term.

Table 5.3 Simple Linear Model (OLS Estimates)

Dependent Variable	Annual Average Concentration of SO2						Annual Average Concentration of NO2					
	R(1)	R(2)	R(3)	R(4)	R(5)	R(6)	R(7)	R(8)	R(9)	R(10)	R(11)	R(12)
Agglomeration of Manufacturing Sector	0.443***		0.352***	0.353**	0.412*		0.181		0.115	0.109	0.075	
	(0.108)		(0.121)	(0.132)	(0.226)		(0.172)		(0.085)	(0.087)	(0.166)	
Agglomeration of Polluting Industries[@]		0.158*				0.135		0.134				0.001
		(0.086)				(0.099)		(0.113)				(0.091)
GSDP per capita	5.677	7.293	3.109	8.046	0.783	-2.433	2.622	4.993	8.330**	10.635	17.172	16.139
	(4.545)	(4.573)	(5.026)	(6.275)	(9.689)	(9.482)	(7.524)	(7.120)	(3.556)	(6.440)	(10.128)	(10.137)
GSDP per capita^2	-0.274	-0.339	-0.144	-0.362	-0.024	0.135	-0.128	-0.232	-0.399**	-0.499	-0.805*	-0.756
	(0.209)	(0.208)	(0.235)	(0.285)	(0.449)	(0.437)	(0.356)	(0.334)	(0.166)	(0.297)	(0.470)	(0.468)
Environmental Awareness of Manufacturing Plants					-0.037	-0.033					0.033	0.035
					(0.032)	(0.031)					(0.025)	(0.025)
Share of Services in GSDP				0.216	0.169	0.220				0.183	0.194	0.259
				(0.277)	(0.419)	(0.432)				(0.216)	(0.306)	(0.366)
Share of Agriculture in GSDP			0.099	0.274	0.269	0.303*			-0.242***	-0.135	-0.133	-0.125
			(0.079)	(0.177)	(0.190)	(0.157)			(0.071)	(0.125)	(0.132)	(0.124)
Registered Motor Vehicles			0.111*	0.052	0.051	0.054			0.249***	0.217***	0.203***	0.207***
			(0.060)	(0.081)	(0.097)	(0.093)			(0.050)	(0.064)	(0.063)	(0.063)
Population Density				0.184	0.107	0.027				0.098	0.176	0.156
				(0.131)	(0.133)	(0.153)				(0.117)	(0.154)	(0.159)
Percentage of Exporting Manufacturing Plants					0.006	0.029					0.009	0.013
					(0.035)	(0.035)					(0.021)	(0.019)
Observations	30	29	30	30	29	29	30	29	30	30	29	29
R-squared	0.351	0.111	0.434	0.486	0.447	0.343	0.072	0.080	0.633	0.656	0.659	0.654

Robust standard errors clustered by states in parentheses

*** p<0.01, ** p<0.05, * p<0.1

@ Data on Mizoram is missing in ASI factory level data

While controlling for the spatial dependence of pollutants by using a spatial autoregressive (SAR) model, equation (2) , mentioned in sub-section 5.3.2, has been estimated using the generalised method of moments and instrumental variable approach (Drukker et al. 2013a). The SPREG GS2SLS estimator uses the spatially lagged values of the exogenous variables as instruments. This method also allows spatial interaction of the control variables with the error term. From **Table 5.4 below**, it can be observed from specifications R(1), R(3) and R(4) the agglomeration of the overall manufacturing sector positively and significantly affects the SO2 concentration in the air, after controlling for other state-level characteristics including the environmental stringency. There is a weak evidence of the concentration of the organised polluting industries in affecting the SO2 concentration in the air. However, it is not true in case of the level of NO2 concentration in the air. It can be observed from specification R (6) - R (10) neither the agglomeration of overall manufacturing nor the agglomeration of polluting industries affect the level of concentration of NO2 in the air, after controlling for other state-level characteristics.

It can observed that from R (1) –R (4) the value of λ, i.e. spatial lag component is statistically insignificant. This indicates that the level of concentration of SO2 in the air in state *m* is not dependent on any characteristics (all the explanatory variables included in the model) of state *l*. For example, the agglomeration of manufacturing industry in state *l* will not affect the level of concentration of SO2 in the air in state m. This also indicates that the level of concentration of SO2 in the air in state *m* is not affected by the level of concentration of SO2 in state *l*, assuming that state *l* and m are neighbours. However, the value of ρ is significant, indicating the fact that there is spatial dependence in the error term. In other words, any exogenous shock in state *l* will have an impact on the level of concentration of SO2 in state *m*. This indicates that in case of SO2 concentration in air the spatial dependence between two adjacent states; *m* and *l* can be observed by the correlation of their error terms.

The level of concentration of NO2 in the air of state *m* is highly dependent on the characteristics of the adjacent state. The spatial lag term is positive and significant, as depicted in specifications R (6) - R (10). The spatial error term appears to be insignificant across all the specifications indicating the absence of correlation in the error term across state.

The statistically significant spatial dependence across all the specifications either via the spatial lag term or the spatial error term indicates the fact that the OLS results are biased and inefficient.

The results obtained from the OLS model cannot be compared with the results obtained from the estimation of spatial autoregressive model as the latter captures the spatial dependence among variables, thereby controlling for the regional spillover effect across region.

Table 5.4 Spatial Auto Regressive Model (SPREG GS2SLS Estimates)

	Annual Concentration of SO2					Annual Concentration of NO2				
	R(1)	R(2)	R(3)	R(4)	R(5)	R(6)	R(7)	R(8)	R(9)	R(10)
Agglomeration of Manufacturing Sector	0.272**		0.251**	0.291**		-0.023		-0.030	-0.052	
	(0.115)		(0.110)	(0.125)		(0.144)		(0.142)	(0.158)	
Agglomeration of Polluting Industries@		0.156			0.203*		-0.060			-0.053
		(0.117)			(0.122)		(0.129)			(0.140)
GSDP per capita	-0.353	-0.631***	-0.193	-0.199	-0.413	-0.555	-0.518	-0.405	-0.402	-0.353
	(0.272)	(0.243)	(0.280)	(0.280)	(0.262)	(0.365)	(0.339)	(0.379)	(0.379)	(0.363)
GSDP per capita^2	0.034	0.057***	0.022	0.023	0.040*	0.047	0.045	0.035	0.035	0.031
	(0.024)	(0.022)	(0.024)	(0.024)	(0.022)	(0.031)	(0.029)	(0.032)	(0.032)	(0.031)
Environmental Awareness of Manufacturing Plants				-0.014	-0.006				0.008	0.007
				(0.020)	(0.020)				(0.025)	(0.025)
Share of Agriculture in GSDP	0.376***	0.408***	0.381***	0.373***	0.399***	0.224	0.226*	0.212	0.218	0.215
	(0.117)	(0.121)	(0.112)	(0.113)	(0.112)	(0.139)	(0.137)	(0.138)	(0.140)	(0.138)
Share of Services in GSDP	0.284	0.103	0.287	0.260	-0.016	0.487	0.605	0.469	0.497	0.589
	(0.298)	(0.400)	(0.290)	(0.292)	(0.397)	(0.340)	(0.420)	(0.336)	(0.348)	(0.458)
Registered Vehicles	0.097	0.125*	0.033	0.034	0.033	0.241***	0.237***	0.188*	0.188*	0.184*
	(0.065)	(0.064)	(0.078)	(0.078)	(0.079)	(0.087)	(0.084)	(0.098)	(0.098)	(0.097)
Population Density	0.146	0.176	0.148	0.142	0.183*	0.109	0.104	0.111	0.117	0.114
	(0.109)	(0.114)	(0.105)	(0.106)	(0.105)	(0.127)	(0.126)	(0.125)	(0.127)	(0.126)
Percentage of Exporting Manufacturing Plants			0.054	0.050	0.068*			0.056	0.057	0.053
			(0.037)	(0.037)	(0.037)			(0.047)	(0.047)	(0.046)
Spatial Lag(λ)	0.069	0.057	0.072	0.063	0.061	0.117**	0.116**	0.117**	0.115**	0.113**
	(0.061)	(0.062)	(0.057)	(0.057)	(0.055)	(0.050)	(0.051)	(0.049)	(0.049)	(0.049)
Spatial error(ρ)	-0.226*	-0.277**	-0.296**	-0.286**	-0.368***	0.018	0.051	-0.012	-0.008	0.016
	(0.121)	(0.110)	(0.126)	(0.134)	(0.116)	(0.163)	(0.180)	(0.179)	(0.175)	(0.199)
Number of states	30	29	30	29	29	30	29	30	29	29

Standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

@ Data on Mizoram is missing in ASI factory level data

5.4 Conclusion

The chapter empirically analyzed the diseconomies associated with the agglomeration of manufacturing sector across Indian States. The diseconomies has been captured by examining the impact of agglomeration on the annual average concentration level of NO2 and SO2 across Indian states for the year 2013-14 using the spatial autoregressive modelling techniques. This modelling technique corrects for the spatial dependence bias across regional characteristics included in the analysis. From the preliminary data analysis, it has been observed that the states like Gujarat, Maharashtra, Uttar Pradesh, West Bengal, Haryana, Uttarakhand and Tamil Nadu, show higher degree of concentration of the manufacturing sector in the year 2013-14. It has been also observed that some of these states like Gujarat and West Bengal specialises in polluting industries. At the same time while analysing the spatial distribution of the average concentration of NO2 and SO2 across Indian states, there exists an inequality, with a higher level of concentration being biased towards the industrially (manufacturing) advanced states.

While empirically modelling the impact of agglomeration of manufacturing sector on the level of concentration of air pollutants, it was observed that the overall agglomeration of manufacturing sector (both the organised and unorganised sector) significantly aggravates the level of concentration of SO2 in the air across Indian states, after controlling for other state-level characteristics including the environmental stringency of each state. The effect of overall agglomeration of polluting industries (under organised sector) is found to be insignificant in increasing the level of concentration of SO2 in the air. However, the impact of agglomeration on the level of atmospheric concentration of NO2 is found to be statistically insignificant. The results from spatial autoregressive model confirms the presence of regional spillover effect in case of both the air pollutants i.e. the level of concentration of pollutants in a state can be significantly affected by the level of concentration of air pollutants and other characteristics of the neighbouring states. In case of SO2, the spatial dependence is indicated through the residual error term whereas in NO2, the spatial dependence was reflected via the spatial lag term.

Other than the agglomeration of the manufacturing sector, the vehicular emission across states was also found to be a significant driver of the level of concentration of both the pollutants used in the analysis. The entire analysis of the chapter is based on *state*-as the spatial unit of analysis. However, the analysis can be further extended at the district level in future.

It is true that the expansion of the manufacturing sector is inevitable in achieving growth of the Indian economy. However, internalising the negative externalities associated in the process, demands a revisiting of the existing environmental policies, especially related to the industrial pollution, within the country accompanied by a reduction of the implementation hurdles of these policies. Moreover, the consideration of the degree of agglomeration of the manufacturing industries and the ambient concentration of air pollutants should be considered simultaneously while allowing the establishment of a new plant in a particular region within the country. Agglomeration of manufacturing industries in an already environmentally polluted region may further escalate the problems associated with it. The presence of region spillover effects or in other words the evidence of the presence of spatial dependence in air pollutants indicate that, while analysing the pollution level of a region, it is pertinent to examine the pollution level of the neighbouring regions. Recent initiatives of the Government of India to develop comprehensive zoning atlas for the location of industries for new investors, after inclusion of environmental parameters, may act as a hitch in further exacerbation of the air pollution problems in India, specifically induced by the manufacturing industries.

Table A.5.1 Descriptive Statistics of Variables

Variable	Observation	Mean	Std. Dev.	Min	Max
SO2 Average	30	8.48	5.26	2.00	25.20
NO2 Average	30	21.08	13.37	4.00	61.70
LQ of Polluting Industry	29	1.05	0.46	0.003	1.87
LQ of Overall Manufacturing Sector	30	1.00	0.62	0.05	2.43
Share of Services in GSDP	30	0.45	0.13	0.15	0.87
Share of Agriculture in GSDP	30	0.11	0.06	0.00	0.25
Population Density	30	1446.45	3136.90	52.18	11463.25
Registered Motor Vehicles	30	6376.13	6657.04	43.00	23394.00
GSDP Per capita	30	59936.33	31994.92	17163.00	159797.00
Percentage Share of Exporting Plants	29	3.67	3.03	0.00	12.14
Percentage Share of Plants with ISO-14000series certificates	29	6.24	4.88	1.65	26.29

Table A.5.2 Correlation Matrix of Variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
SO2 Annual Average(1)	1										
NO2 Annual Average(2)	0.253	1									
LQ Of Polluting Industry(3)	-0.204	-0.194	1								
LQ of Overall Manufacturing Sector(4)	0.372*	-0.167	0.258	1							
Share of Services in GSDP(5)	-0.235	0.343	-0.077	-0.417*	1						
Share of Agriculture in GSDP(6)	0.0393	-0.144	0.020	-0.404*	-0.469*	1					
Population Density(7)	-0.27	0.316	-0.057	-0.35	0.687***	-0.383*	1				
Registered Motor Vehicles (8)	0.293	0.339	-0.126	-0.056	0.092	0.098	-0.0857	1			
GSDP Per capita (9)	-0.071	0.032	-0.292	0.426*	0.189	-0.685***	0.241	-0.099	1		
Percentage Share of Exporting Plants(10)	0.175	0.354	-0.286	0.093	0.044	-0.079	-0.0691	0.515**	0.100	1	
Percentage Share of Plants with ISO-14000 series certificates (11)	-0.112	-0.138	0.090	0.467*	-0.158	-0.213	-0.265	-0.207	0.452*	0.0302	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.5.3 National Ambient Air Quality Standards

Pollution level	Annual mean concentration standards (μg/m3)	
	NO2	SO2
Low	0-20	0-25
Moderate	21-40	26-50
High	41-60	51-75
Critical	>60	>75

Source: CPCB, 2012

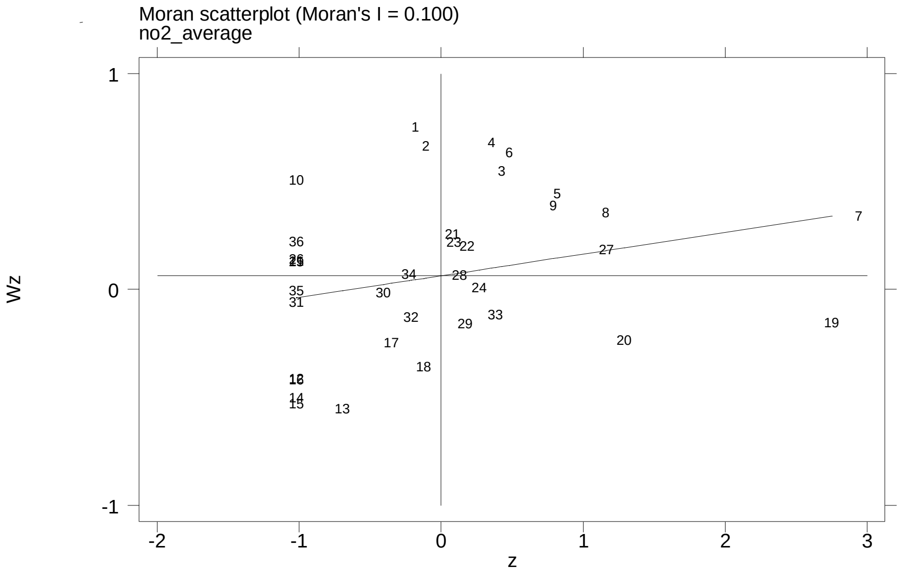

Figure A.5.1a) Moran-I Scatter Plot of Annual Average NO2 concentration

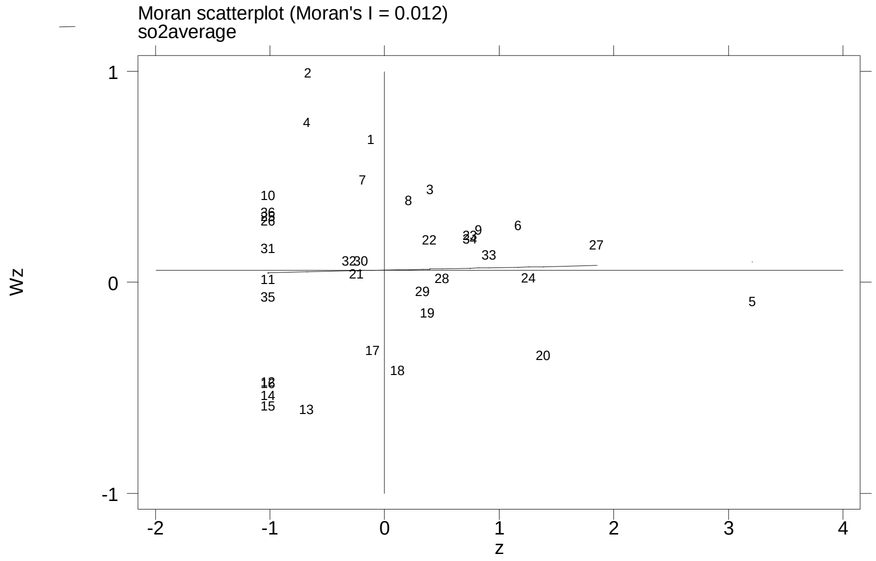

Figure A.5.1b) Moran-I Scatter Plot of Annual Average SO2 concentration

Chapter 6

Conclusion

The spatial development of the organised manufacturing sector in India show a *core-periphery* dichotomy pattern with 80% of the manufacturing output being concentrated in states like Tamil Nadu, Maharashtra, Uttar Pradesh, Kerala, Karnataka, Andhra Pradesh, Gujarat, West Bengal, Rajasthan and Haryana. These states are also found to be the hub of exporting activities in India. The north-eastern states and northern states specifically, Manipur, Meghalaya, Mizoram, Nagaland, Jammu and Kashmir, Uttarakhand and Himachal Pradesh, are the *peripheral* states in terms of their share in total organised manufacturing output in India. The organised manufacturing export activities are also negligible in the north eastern states of India.

While analysing the evolution of industries across Indian states over the period 2000-01 to 2013-14 the study observes that some of the industrially laggard states like Uttarakhand, Jammu and Kashmir, Himachal Pradesh, and Meghalaya have registered a high growth in terms of both manufacturing output as well as employment. It seems like eventually the manufacturing industries are spreading across states. Moreover, the organised exporting activities have also shown a significant growth in inland states like Haryana, Rajasthan and Punjab during the period 2008-09 to 2013-14 coupled with a fall in exporting activities in some of the coastal states in India. This dynamism in the spatial distribution of manufacturing activities indicates the rising importance of the presence of agglomeration economies (or diseconomies) within industries as well as across Indian states.

The study finds that out of total 125 industries, defined at the four digit level of NIC-2008 classification, 44% of the industries are highly agglomerated in the organised manufacturing sector in the year 2013-14. The regional spillover effect (or the *neighbourhood effect*) of adjacent states has been considered while calculating the degree of industrial agglomeration. The low-tech polluting industries show a higher degree of industrial agglomeration compared to the non-polluting industries in the Indian manufacturing sector. Some of industrially advanced states are also hub of polluting industries, baring Haryana. However, over the period of analysis, states like Maharashtra and Rajasthan have registered a significant drop in the share of polluting industries. In contrast to this some of the peripheral states like Jammu and Kashmir, Meghalaya have shown an increase in the share of polluting industries in their total manufacturing output. From the preliminary analysis, it seems like over time the polluting industries have shifted from some of the industrially advanced states to the peripheral states, characterised by lax environmental regulations, indicating a pollution haven effect across Indian states. However, the present study has not looked into the difference in the environmental regulations behind the dispersion of industries across Indian states. So, nothing can be commented on the empirical evidence of pollution haven effect across Indian states. This is a potential area for future research and Chapter 3 of the present study can be extended further in this context.

While analysing the export behaviour of manufacturing plants using a dynamic probit model over the period 2008-09 to 2013-14, the study concludes that there is positive and significant impact of industry-specific agglomeration economies (labor pool effect) in shaping the internationalisation process of the manufacturing plants after controlling for plant-level characteristics, other location specific characteristics, like availability of network of road and installed power availability within a state. The effect of both within-industry export spillover as well as overall industry specific agglomeration economies is highly significant in facilitating the export behaviour of plants belonging to polluting as well as non-polluting industries. The localisation economies (both the overall industrial agglomeration economies as well as within-industry agglomeration of exporters) in case of polluting industries facilitate the export behaviour of plants. However, the concentration of cross-industry exporters (also the presence of SEZ which are also clusters of unrelated industries) has an insignificant effect in facilitating the export behaviour of plants belonging to polluting industries. This indicates that while formulating the industrial clustering policies to promote manufacturing export of India, it is pertinent to consider the nature of industries.

The availability of transport network captured by the road density is found to be a significant factor in driving the export behaviour of manufacturing plants irrespective of the nature of the industry. The availability of state-level installed power capacity is found to be highly significant in facilitating the export propensity of plants belonging to polluting industries. In contrast to this, the effect is insignificant in case of plants belonging to non-polluting industries. This can be related to the comparative advantage theory; polluting industries, characterised by energy intensive technology start to export from states with well endowed power availability. The easy availability of resources (raw material) has a cost reduction effect thereby increasing the productivity of manufacturing plants belonging to polluting industries. This gain in productivity in turn drives them to enter the export market. While analysing the plant-level characteristics, the study finds that the productive plants have higher propensity to export. Moreover, the lag period export status is also positive and significant, indicating the presence of learning from exporting hypothesis among the Indian manufacturing plants.

It is true that industrial agglomeration generates economies which in turn facilitate the export behaviour of Indian manufacturing plants. However, the manufacturing process is highly polluting and their concentration may further aggravate the environmental problems associated with it. While analysing the diseconomies associated with the industrial agglomeration, the present study analyses the impact of agglomeration of the overall manufacturing sector on the degradation of air quality across Indian states for the year 2013-14. In this study, two major air pollutants are considered *viz;* the SO2 and NO2. Using a spatial modelling framework the study concludes that the agglomeration of overall manufacturing sector has a significant effect on increasing the concentration of SO2 in the air. However, the result is insignificant in case of NO2 concentration in the air. There is no evidence of agglomeration diseconomies from the concentration of polluting industries belonging to the organised sector in degrading the air quality of Indian states. It seems like the pollution arising from the unorganised manufacturing sector has a significant impact on the degradation of air quality; especially in terms of increasing the level of atmospheric SO2 concentration across Indian states.

While modelling the impact of agglomeration diseconomies on air quality, the spatial autoregressive technique used in the analysis, captures the degree of spatial dependence among the air pollutants and industrial activities, thereby controlling for the cross-regional spillover effect. The results obtained from this analysis indicate that the industrial locational policies; especially the clustering policies in India should include the environmental parameters to reduce the damages associated with the manufacturing process. The spatial unit of analysis in the present study is state. This can be further extended at a much disaggregated level of spatial unit of analysis *viz;* at the district level.

The present study observes that agglomeration economies in Indian manufacturing industries facilitate the export behaviour of manufacturing plants. Moreover, the concentration of cross-industry exporter's agglomeration has a positive and significant impact on the export behaviour of manufacturing plants belonging to non-polluting industries as opposed to the plants belonging to polluting industries. This indicates that cross-industry agglomeration economies in Indian manufacturing industries facilitate cleaner export.

However, the study also observed that the diseconomies associated with the industrial agglomeration have a significant impact on deteriorating the air quality across Indian states. This raises the debate about the environmental sustainability of the industrial clustering policy. While formulating the industrial clustering policies it is also important to internalise the environmental cost associated with it. Formulation of industry-specific location policies after considering the polluting nature of industries seems to be an important area that demands further attention of the policy makers of India.

Bibliography

Aggarwal, Aradhna and Prakash Singh Archa (2013), Regional Development Policies in India, in Thomas Farole (eds.) The Internal Geography of Trade: Lagging Regions and Global Markets, Washington D.C.: World Bank, 229-255.

Aggarwal, Aradhana (2006), "Special economic zones: revisiting the policy debate", Economic and Political Weekly, 4533-4536

Aitken, B., Hanson, G. H., and Harrison, A. E. (1997), "Spillovers, foreign investment, and export behaviour" *Journal of International economics*, 43(1-2):103-132.

Alkon, Meir (2018), "Do special economic zones induce developmental spillovers? Evidence from India's states", *World Development*, 107:396-409.

Alonso-Villar, Olga., Chamorro-Rivas, Jose-Maria, and González-Cerdeira, Xulia. (2004), "Agglomeration economies in manufacturing industries: the case of Spain", *Applied Economics*, *36*(18): 2103-2116.

Alvarez, Roberto, and Lopez, Ricardo A. (2005), "Exporting and performance: evidence from Chilean plants", *Canadian Journal of Economics*, 38(4):1384-1400.

Amirapu, A., Hasan, R., Jiang, Y., and Klein, A. (2019), "Geographic concentration in Indian manufacturing and service industries: Evidence from 1998 to 2013", Asian Economic Policy Review, 14(1), 148-168.

Anselin, L. (1988), Spatial econometrics: Methods and models. Dordrecht: Kluwer Academic Publishers

Antweiler, Werner, Copeland, Brian. R, and Taylor, M. Scott (2001), "Is free trade good for the environment?", *American economic review*, 91(4):877-908.

Arbia, Giuseppse (2001), "The role of spatial effects in the empirical analysis of regional concentration", *Journal of Geographical systems, 3(3),* 271-281.

Awasthi, Dinesh N. (1991), *Regional pattern of industrial growth in India*, New Delhi: Concept Pub.

Baldwin, John R., and Gu, Wulong (2003), "Export-market participation and productivity performance in Canadian manufacturing", *Canadian Journal of Economics*, 36(3): 634-657

Baldwin, John. R., Brown, W. M., and Rigby, D. L. (2010), "Agglomeration economies: Micro-data panel estimates from Canadian manufacturing", *Journal of Regional Science*, *50*(5), 915-934.

Bernard, A. B., & Jensen, J. B. (1999), "Exporting and productivity,National bureau of economic research", (No. w7135),

Bernard, Andrew. B. and Jensen, J. Bradford. (2004), "Why some firms export", *Review of economics and Statistics*, 86(2): 561-569.

Brakman, Steven, Garretsen, Harry, Gigengack, Richard, Marrewijk, Charles, and Wagenvoort, Rien (1996), "Negative feedbacks in the economy and industrial location", *Journal of Regional Science*, 36 (4): 631-651.

Chakravorty, Sanjoy. (2003), "Industrial location in post-reform India: patterns of inter-regional divergence and intra-regional convergence", *The Journal of Development Studies*, *40*(2): 120-152.

Cheng, Zhonghua (2016), "The spatial correlation and interaction between manufacturing agglomeration and environmental pollution", *Ecological indicators*, *61*(2): 1024-1032.

Ciccone, Antonio, and Hall, R. E. (1993), "*Productivity and the density of economic activity*", National Bureau of Economic Research, (No. w4313)

Cingano, Federico, and Schivardi, F. (2004), "Identifying the sources of local productivity growth. *Journal of the European Economic association*, *2*(4): 720-742.

Clerides, Sofronis K., Lach, Saul, and Tybout, James. R. (1998), "Is learning by exporting important? Micro-dynamic evidence from Colombia, Mexico, and Morocco", *The Quarterly Journal of Economics*, 113(3): 903-947.

Cole, Mathew A., Elliott, Robert J., and Okubo, Toshihiro (2010), "Trade, environmental regulations and industrial mobility: An industry-level study of Japan", *Ecological Economics*, 69(10):1995-2002.

Colmer, J. (2015), *Urbanization, Growth, and Development: Evidence from India*. Mimeo

Copeland, Brian. R. and Taylor, M. Scott (1994), "North-South trade and the environment", *The Quarterly Journal of Economics*, 109(3): 755-787.

Deichmann, Uwe, Lall, S. V., Redding, S. J., and Venables, A. J. (2008), " Industrial location in developing countries", *The World Bank Research Observer*, *23*(2): 219-246.

Delgado, Miguel A., Farinas, Jose. C., and Ruano, Sonia. (2002), "Firm productivity and export markets: a non-parametric approach", *Journal of international Economics*, 57(2):397-422.

Desmet, Klaus, Ghani, E., O'Connell, S., and Rossi-Hansberg, E. (2015), "The spatial development of India", *Journal of Regional Science*, *55*(1):10-30.

Devereux, Michael. P., Griffith, R., & Simpson, Helen (2004), "The geographic distribution of production activity in the UK", *Regional science and urban economics*, *34*(5):533-564.

Drukker, David. M., Prucha, Ingmar. R., and Raciborski, Rafal, (2013a), "Maximum likelihood and generalized spatial two-stage least-squares estimators for a spatial-autoregressive model with spatial-autoregressive disturbances", *The Stata Journal*, *13*(2): 221-241.

Ellison, Glenn, and Glaeser, Edward L. (1999), "The geographic concentration of industry: does natural advantage explain agglomeration?", *The American Economic Review*, *89*(2): 311-316

Farole, Thomas, and Winkler, Deborah, (2013), "Firm location and the determinants of exporting in low-and middle-income countries", *Journal of Economic Geography*, 14(2):395-420

Feldman, Maryann P. (1999), "The new economics of innovation, spillovers and agglomeration: A review of empirical studies", *Economics of innovation and new technology*, 8(1-2): 5-25.

Fernandes, A. M., and Sharma, G. (2012), "Together We Stand? Agglomeration in Indian Manufacturing, Working paper

Fujita, Masahisa, Paul Krugman and Anthony J. Venables (1999), *The Spatial Economy-Cities, Regions and International trade*, Massachusetts: The Massachusetts Institute of Technology Press.

Getis, Arthur, and Aldstadt, Jared. (2004), "Constructing the spatial weights matrix using a local statistic", *Geographical analysis, 36(2),* 90-104.

Ghani, E., Goswami, A. G., and Kerr, W. R. (2012). *Is India's manufacturing sector moving away from cities?* National Bureau of Economic Research, No. w17992

GoI (2017), *Economic Survey 2017-18;* New Delhi, Delhi: Ministry of Finance, Department of Economic Affairs, Economic Division.

Greenaway, David, and Kneller, Richard (2008), "Exporting, productivity and agglomeration", *European economic review*, 52(5): 919-939.

Greenaway, David., and Yu, Zhihong (2004), "Firm-level interactions between exporting and productivity: Industry-specific evidence", *Review of World Economics*, 140(3): 376-392

Greenstone, Michael (2002), "The impacts of environmental regulations on industrial activity: Evidence from the 1970 and 1977 clean air act amendments and the census of manufactures", *Journal of political economy*, *110*(6): 1175-1219.

Greenstone, Michael, and Hanna, Rema (2014), "Environmental regulations, air and water pollution, and infant mortality in India", *American Economic Review*, 104(10): 3038-3072.

Greenstone, Michael, Harish, S., Pande, R., and Sudarshan, A (2017). The Solvable Challenge of Air Pollution in India, *National Bureau of Economic Research,* working Paper.

Grossman, G. M., & Krueger, A. B. (1991), "Environmental impacts of a North American free trade agreement", *National Bureau of Economic Research*, (No. w3914)

Guimaraes, P., Figueiredo, O., and Woodward, D. (2011), "Accounting for neighboring effects in measures of spatial concentration", Journal of Regional Science, *51(4): 678-693.*

Gurjar, B. R., Ravindra, Khaiwal, and Nagpure, Ajay Singh (2016), "Air pollution trends over Indian megacities and their local-to-global implications", *Atmospheric Environment*, *142*: 475-495.

Guttikunda, Sarath. K. and Goel, Rahul (2013), "Health impacts of particulate pollution in a megacity—Delhi, India", *Environmental Development*, 6:8-20.

Hanson, G. H. (2001), "Scale economies and the geographic concentration of industry", *Journal of Economic Geography*, *1*(3), 255-276.

Henderson, V., Kuncoro, A.,and Turner, M. (1995), "Industrial development in cities", *Journal of political economy*, *103*(5):1067-1090.

Hsieh, Chang-Tai.and Klenow, Peter. J. (2009), “Misallocation and manufacturing TFP in China and India”, The Quarterly journal of economics, 124(4): 1403-1448.

Ito, B., Xu, Z., & Yashiro, N. (2015), Does agglomeration promote internationalization of Chinese firms? China Economic Review, 34, 109-121

Kahn, M. E., Lozano Gracia, N., & Soppelsa, M. E. (2019), Does Pollution Hinder Urban Competitiveness?, Working paper

Kasahara, H., & Rodrigue, J. (2008), Does the use of imported intermediates increase productivity? Plant-level evidence. Journal of development economics, 87(1), 106-118.

Kelejian, Harry. H., and Prucha, Ingmar. R. (1998), “A generalized spatial two-stage least squares procedure for estimating a spatial autoregressive model with autoregressive disturbances”, *The Journal of Real Estate Finance and Economics*, *17*(1): 99-121.

Koenig, Pamina, Mayneris, Florian and Poncet, Sandra (2010), “Local export spillovers in France. *European Economic Review*, *54*(4), 622-641.

Krugman, Paul (1999), “The role of geography in development”, *International regional science review*, *22*(2):142-161.

Kugler, Maurice, and Eric Verhoogen. "Plants and imported inputs: New facts and an interpretation." American Economic Review 99.2 (2009): 501-07.

Kumar, Nagesh, and Siddharthan, N. S. (1994), “Technology, firm size and export behaviour in developing countries: the case of Indian enterprises”, *The Journal of Development Studies*, 31(2):289-309.

Kyriakopoulou, Efthymia, and Xepapadeas, Anastasias (2013), “Environmental policy, first nature advantage and the emergence of economic clusters”, *Regional Science and Urban Economics*, 43(1): 101-116.

Lall, Somik V., Shalizi, Zmarak, and Deichmann, Uwe (2004), “Agglomeration economies and productivity in Indian industry,” *Journal of Development Economics*, *73*(2), 643-673.

Lange, Andreas, and Quaas, Martin F. (2007), “Economic geography and the effect of environmental pollution on agglomeration”, *The BE Journal of Economic Analysis & Policy*, *7*(1):1682-1935

Lu, Jiangyong and Tao, Zhigang (2009), "Trends and determinants of China's industrial agglomeration", *Journal of urban economics*, *65*(2):167-180.

Mallick, Sushanta, and Yang, Yong (2013), "Productivity performance of export market entry and exit: Evidence from Indian firms", *Review of International Economics*, 21(4): 809-824.

Martin, P., Mayer, T., & Mayneris, F. (2011), "Spatial concentration and plant-level productivity in France", Journal of Urban Economics, 69(2), 182-195

Maurel, Francoise, and Sédillot, Beatrice (1999), "A measure of the geographic concentration in French manufacturing industries", *Regional Science and Urban Economics*, *29*(5): 575-604**.**

Melitz, M. J., & Trefler, D. (2012), "Gains from trade when firms matter", *Journal of Economic Perspectives*, 26(2):91-118

Ministry Of Environment and Forests, Government of India (2009), *Criteria for Comprehensive Environmental Assessment of Industrial Clusters*, Central Pollution Control Board, Ministry of Environment and Forests (EIAS/4/2009-10), New Delhi.

Mitra, A., Varoudakis, A., & Veganzones-Varoudakis, M. A. (2002), "Productivity and technical efficiency in Indian states' manufacturing: the role of infrastructure", Economic development and cultural change, 50(2): 395-426

Mukhopadhyay, Kakali, and Chakraborty, Debesh, (2005), "Environmental impacts of trade in India", *The International Trade Journal*, *19*(2): 135-163.

Mukim, Megha (2013), Location and the Determinants of Exporting: Evidence from Manufacturing firms in India, in Thomas Farole (eds.) The Internal Geography of Trade: Lagging Regions and Global Markets, Washington D.C.: World Bank

Oron, Yitzhak, Pines, David, and Sheshinski, Eytan (1973), "Optimum vs. equilibrium land use pattern and congestion toll", *The Bell Journal of Economics and Management Science*, 4(2): 619-636.

Pal, Parthapratim and Mukherjee Arpita (2018), "Special Economic Zones Face the WTO Test", Economic Political Weekly, 53(3), 20-22

Pattnayak, Sanja. S, and Thangavelu, Shandre. M. (2014), "Productivity and Learning-by-exporting: A Firm-level Analysis of Indian Manufacturing", *The World Economy*, 37(7):1016-1026.

Pradhan, Jaya Prakash, and Das, Keshab (2015), "Regional export advantage of rising power SMEs: Analytics and determinants in the Indian context", *Critical perspectives on international business*, 11(3/4): 236-258.

Roberts, M. J., & Tybout, J. R. (1997), "The decision to export in Colombia: An empirical model of entry with sunk costs", *The American Economic Review*, 545-564.

Rodríguez-Pose, Andres., Tselios, Vassilis., Winkler, Deborah, and Farole, Thomas (2013), "Geography and the determinants of firm exports in Indonesia" ,*World Development*, 44: 225-240.

Rosenthal, S. Stuart and William C. Strange (2001), "The Determinants of Agglomeration", *Journal of Urban Economics* 50:191-229.

Sawhney, Aparna, and Rastogi, Rashmi (2015), "Is India specialising in polluting industries? Evidence from US-India bilateral trade", *The World Economy*, *38*(2): 360-378.

Sun, Puyang, & Yuan, Yan (2015), "Industrial Agglomeration and Environmental Degradation: Empirical Evidence in Chinese Cities", *Pacific Economic Review*, *20*(4): 544-568.

Topalova, Petia and Khandelwal, Amit Khandelwal (2011), "Trade liberalization and firm productivity: The case of India", *Review of economics and statistics*, 93(3): 995-1009.

United Nations, Department of Economic and Social Affairs, Population Division (2015), *World Urbanisation Prospects -The 2014 Revision*, United Nations Press, New York, United States of America.

Venables, Anthony. J. (2005), "Spatial disparities in developing countries: cities, regions, and international trade", *Journal of Economic Geography*, *5*(1): 3-21.

Verhoef, Erik. T, and Nijkamp, Peter. (2002), "Externalities in urban sustainability: environmental versus localization-type agglomeration externalities in a general spatial equilibrium model of a single-sector monocentric industrial city", *Ecological Economics*, 40(2): 157-179.

Wagner, Joachim, (2007), "Exports and productivity: A survey of the evidence from firm-level data", World Economy, 30(1): 60-82.

Wooldridge, Jeffrey. M. (2005), "Simple solutions to the initial conditions problem in dynamic, nonlinear panel data models with unobserved heterogeneity", *Journal of applied econometrics*, *20*(1): 39-54.

World Health Organisation (2016), *Ambient air pollution: A global assessment of exposure and burden of disease*, WHO Press, Geneva, Switzerland.

Yi, Jingtao (2014), "Firm heterogeneity, sunk costs, spatial characteristics and export market participation: Evidence from China", *The Journal of International Trade & Economic Development*, 23(3):361-386

Zeng, Dao. Zhi, and Zhao, Laixun (2009), "Pollution havens and industrial agglomeration", *Journal of Environmental Economics and Management*, 58(2):141-153.

Zheng, Siqi and Mathew E. Kahn (2013), "Understanding China's Urban Pollution Dynamics", *Journal of Economic Literature* 51(3):731-772.

Zheng, Xiao-Ping (2001), "Determinants of agglomeration economies and diseconomies: empirical evidence from Tokyo", *Socio-Economic Planning Sciences*, 35 (2):131-144.

Zhu, Shengjun., He, Canfei and Liu, Ying (2014), "Going green or going away: Environmental regulation, economic geography and firms' strategies in China's pollution-intensive industries", *Geoforum*, *55*:53-65.

Zou Ji (2015), "Rising pollution in the developing world", *World Economic Forum Report,* Switzerland