Productivity Dynamics in the Indian Pharmaceutical Industry: Evidences from Plant-level Panel Data

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Abstract

This paper investigates the effects of plants' dynamics on productivity growth in the Indian pharmaceutical industry across five regions: north, north-west, west, south and the rest of India, during the period from 2000-01 to 2005-06, using the unit-level panel database drawn from the Annual Survey of Industries. The selected regions differ in the degree and age of agglomeration of the pharmaceutical industry. The empirical analysis is based on the decomposition methodology of aggregate productivity growth. This methodology decomposes productivity growth between two points in time into the contribution from four broad factors: improvement in incumbents' productivity (within effect), reallocation of resources from less productive to more productive producers (reallocation effect), entry of more productive firms (entry effects), and exit of less productive firms (exit effect). Our empirical findings reveal that productivity growth is relatively higher in the agglomerated regions. Further, the effects of plant dynamics on productivity growth differ depending on the age and dynamism of agglomerations. Rather large positive entry effects are found in the region where the formation of agglomeration is a recent phenomenon. In the mature and most dynamic region reallocation effects of surviving plants are large and robustly positive. In other areas however 'within effects' of surviving plants are robustly positive.

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1. Introduction

This paper uses a micro panel data set of firms in the Indian Pharmaceutical industry to analyse the impact of industry dynamics on total productivity growth across five selected regions over the period 2000-01 to 2005-06. Inspired by the 'creative destruction' process proposed by Schumpeter (1942) the study examines firms' strategic entry and exit behaviour, and measures the contribution of new, continuing and exiting firms to aggregate productivity growth in the pharmaceutical industry across the selected regions. These regions differ in terms of the age and degree of agglomeration. Our hypothesis is that productivity growth of continuing, entering and exiting plants differ across regions depending on the degree and age of agglomeration. The empirical analysis is based on the decomposition methodology of aggregate productivity growth pioneered by Baily et al. (1992). Following the analysis of Aggarwal and Sato (2011), it uses three different methodologies: Griliches and Regeve (1995), Foster, Haltiwanger, and Krizan (2001), and Melitz and Polanec (2009). The analysis is based on plant or ''factory'' level data for the period 2000-01 to 2005-06 drawn from the Annual Survey of Industries (ASI). Given the data constraints, the analysis focuses on the large factory sector ``census sector''. Small sector ``sample sector'' is out of the purview of the study.

The Indian pharmaceutical industry has seen steady growth during last three decades and has emerged as one of the leading global players in generics. It has also registered evolutionary dynamics driven by the survival, entry and exit of firms and plans.

Economic reforms since 1991, which substantially relaxed barriers to business and trade, have progressively induced the new entry of firms and plants into the pharmaceutical industry. FDI has been permitted up to 100% for manufacture of drugs and pharmaceuticals. Under the new WTO compatible intellectual protection regime introduced in 2005, multinational pharmaceutical companies are creating research centres and manufacturing plants in India. They are also outsourcing drug discovery operations and clinical trials to Indian companies. The degree of price control on drugs has been gradually reduced. These factors contribute to increases in the competitive pressure on surviving firms and the rise in number of the entering firms.

Generally speaking, while entry barriers are considerably relaxed, exit policy is still regulated in India. However, pharmaceutical industry is exceptional. India complies with WHO Certification Scheme for Good Manufacturing Practices (GMP) on the quality of pharmaceutical products. GMP which is defined in Schedule M of the Drugs and Cosmetics Rules, 1945 has become mandatory since 2005. According to the official estimates, in 2001, 327 pharmaceutical manufacturing plants had been closed or had their licenses suspended or may have shifted to some other States. 370 plants were not in a position to comply GMP. Since GMP has been made mandatory from 2005, these units have been closed (Planning Commission 2002: par. 7.1.192). In addition to the increase in the competitive pressure, GMP compliance has possibly induced the exit of small and inefficient firms and plants from the markets.

The Indian pharmaceutical industry thus makes a good case study for the process of ``creative destruction'' which Schumpeter (1942) proposed in order to explain the dynamics of industry evolution.

The rest of the study is organised as follows: Section 2 provides an overview of the Indian pharmaceutical industry at both the national and regional levels. Section 3 presents the empirical methodology and the data, and evaluates the entry and exit effects on region-wise productivity growth. Section 4 offers some concluding remarks.

2. Overview of the Indian Pharmaceutical Industry at the National and Regional Levels

2.2 Industrial development of Indian pharmaceutical Industry

India is one of the major drug producing countries in the world, being the fourth largest producers by volume and the thirteen largest by value, with about 20-22% share in global generic production.

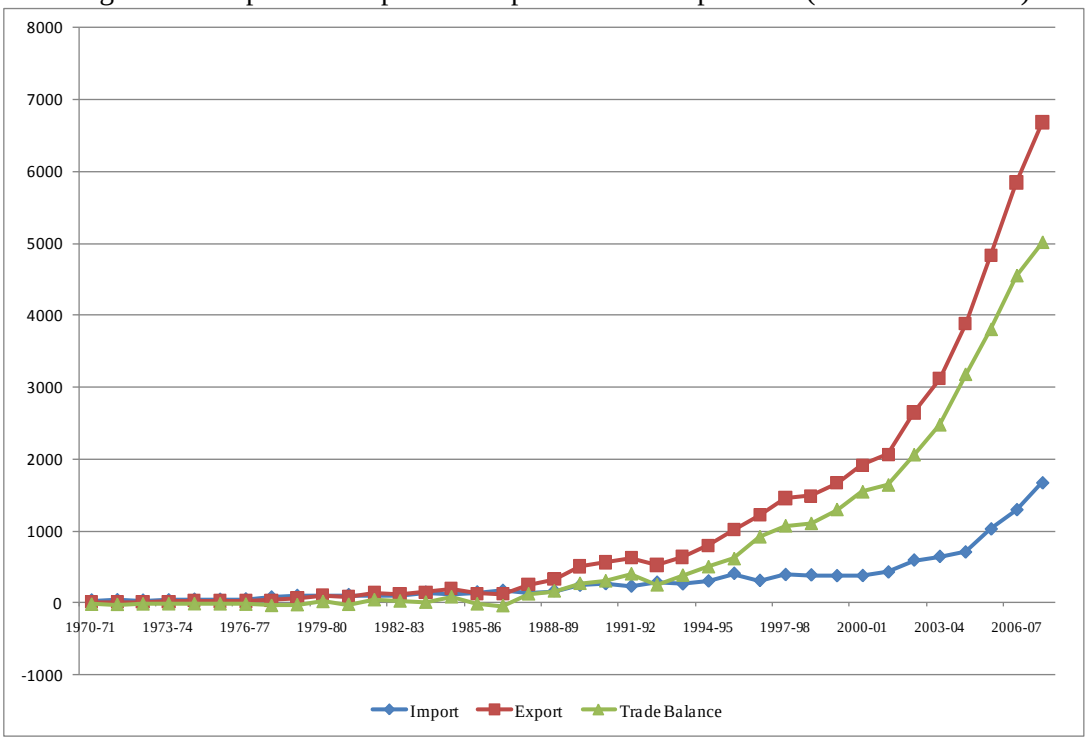
The Indian pharmaceutical industry, which had little technological capabilities to manufacture drugs indigenously in the 1950s, has achieved self-sufficiency in pharmaceutical production and emerged as one of the largest drug exporter in the world in the late 1980s.

Behind the development of the industry are the weak patent regime under the Patent Act of 1970 and the Drug Policy, 1978.

The Patent Act of 1970 recognised only process patents, and reduced a patent period from sixteen years to seven years. The Act allowed Indian pharmaceutical companies to produce alternative process for drug that were not patented in India. The Act encouraged reverse engineering and the development of alternative process for products patented in other counties.
The Drug Policy, 1978 was the first comprehensive drug policy enacted in India. The basic framework of the Policy remained largely valid even up until the 1990s. The basic objective of the Policy was to achieve self-sufficiency in the production of drugs. The Policy emphasised the role of R&D and technology, and enhanced the technological capabilities of the Indian pharmaceutical industry through providing R&D promotion measures. Several measures to guide and control foreign companies with 75% share of the domestic market were implemented to be consistent with the basic objective of the Drug Policy, 1978 and promote to produce bulk drugs and intermediates.

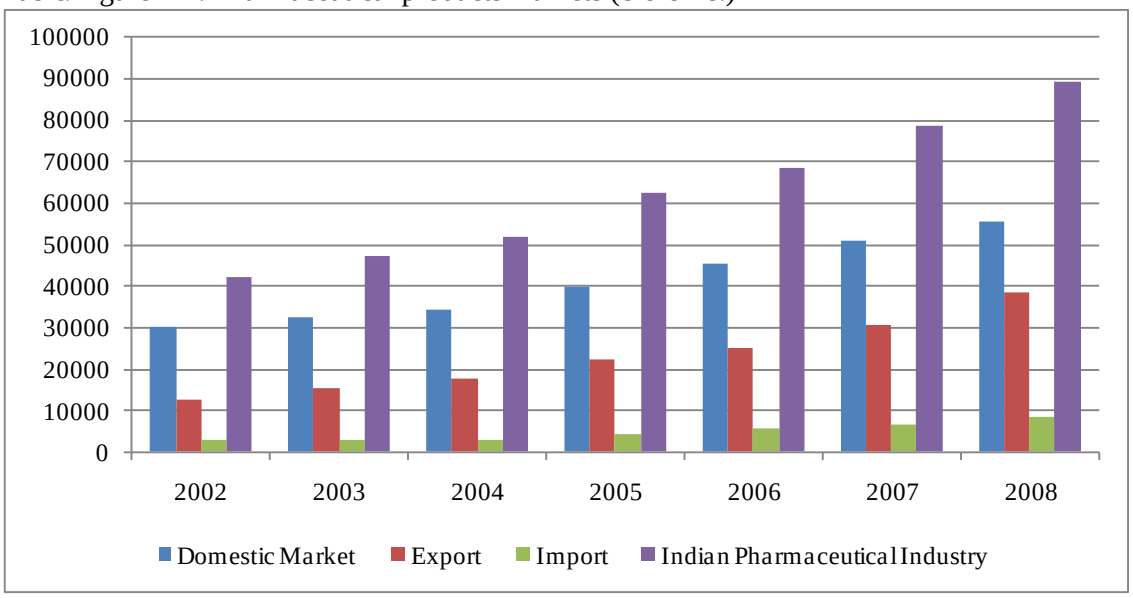
Indian pharmaceutical industry that worked on the basis of reverse engineering and process innovation achieved self-sufficiency in technology, and has been strengthening export orientation in the tide of economic liberalisation since the early 1980s. The industry started to show good promise of global competitiveness, and today continues to expand its presence worldwide. The balance of pharmaceutical trade has moved into the black and trade surplus has been increasing since 1987. In the late 1990s, India achieved favourable pharmaceutical trade balance all over the world. The industry has emerged as the seventeenth largest drug exporters in the world and exports about 40% of the production. The industry has been growing at annual growth rate of 10%, the export has been growing at about 20%. The export is the driving force behind the industry. Figures 2-1 to 2-3 depict the growth and composition of the Indian pharmaceutical industry.

Table/Figure 2-1: Export and import of the pharmaceutical products (million US dollar)



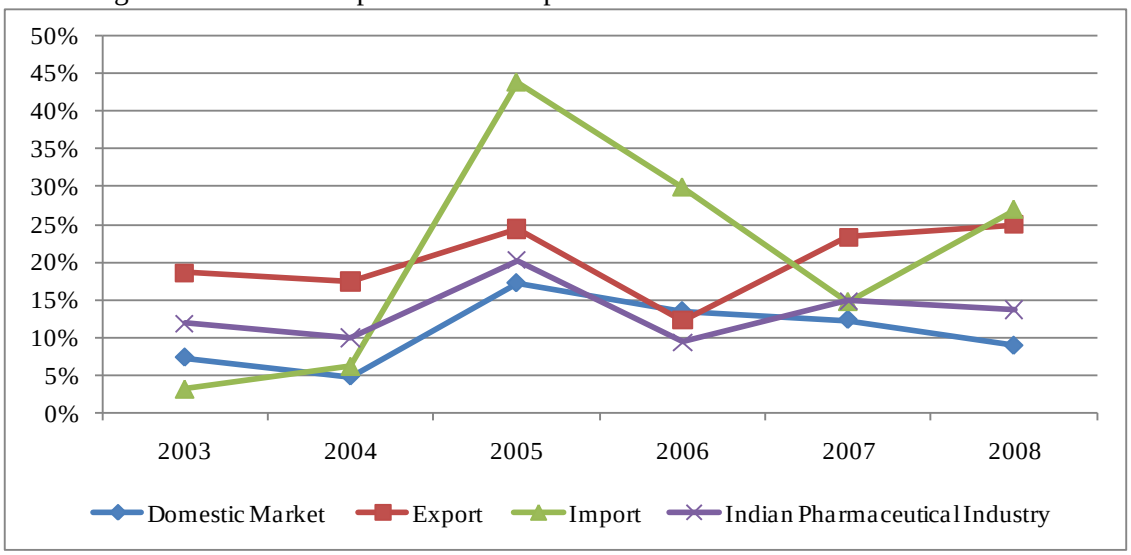
Source: RBI (2009), Pharmexcil (2009), Department of Pharmaceuticals (2010).

Table/Figure 2-2: Pharmaceutical products markets (crore Rs.)



Source: Department of Pharmaceuticals (2010).

Table/Figure 2-3: Growth of pharmaceutical products markets



Source: Department of Pharmaceuticals (2010).

Now, we will review important shift in policies related to pharmaceutical industry, (1) the introduction of pharmaceutical product patents, (2) the mandatory of implementation of GMP(Good Manufacturing Practice: GMP).

(1) The introduction of pharmaceutical product patents

In 2005, India had to amend the Patent Act of 1970 to comply with the TRIPS Agreement. The amendment of The Act changed the institutional factors which supported the growth of the Indian Pharmaceutical Industry.

TRIPS Agreement forced not only to introduce pharmaceutical product patents but also to ensure the 20year-periods of patent protection at the least. In March 2005, India completed the amendment of the Patent Act of 1970 to comply with TRIPS Agreement. The new patent act came into force on April 4, 2005. It introduced product patens for drug, food and chemical products and the patent term was increased to 20 years. The Indian patent regime has become fully TRIPS compliant.

The introduction of pharmaceutical product patent brings new business opportunity to the Indian pharmaceutical industry. In 2000s, Pharmaceutical Outsourcing business has been increasing in India. In the past, Foreign pharmaceutical companies tend to hesitate to manufacture new drugs in India because of the Patent Act of 1970, which did not recognised product patent on pharmaceutical products. Recently, however, foreign companies have been increasing to outsource manufacturing of their new drugs. The introduction of product patent by the amendment of the Patent Act of 1970 made it impossible for Indian companies not licensed to manufacturing patented drugs. The incentive of Indian companies to misappropriate the knowhow gained from contractors (foreign companies) was to be lowered. On the other hand, in terms of foreign companies, the amendment of the Patent Act of 1970 that introduces product patent in India lowered the risk of outsourcing to Indian companies.

Recently, Contract Research and Manufacturing Services (CRAMS) business has been growing rapidly in India. Many Indian companies entered into CRAMS, and the number of the specialised CRAMS companies has increased. In addition to the liberalisation of FDI regulation

in pharmaceutical sector in 2002 that allows FDI up to 100% under the automatic route, the introduction of pharmaceutical product patent has also accelerated the advance of foreign companies into India, and several Indian companies were taken over by foreign companies.

(2) The mandatory of implementation of GMP (Good Manufacturing Practice: GMP).

In India, The Drugs & Cosmetics Act, 1940 and Rules, 1945 regulates drug regulatory affairs. The Act and Rules regulate the drugs imported, manufactured, distributed, and sold. No pharmaceutical products can be imported, manufactured, stocked, distributed, and sold unless it meets the quality standards laid down in The Act. India decided to introduce Good Manufacturing Practice (GMP) in the Drug Policy, 1986. GMP was laid down in Schedule M of The Rules and came into force in 1987.The introduction of GMP has contributed the enhancement of trust of Indian products in the global market. In addition, complying with GMP standards of U.S. and Europe has increased export to western countries, and tapped and has expanded the opportunity for contract manufacturing.

In order to upgrade requirements to WHO-GMP standards and eradicate counterfeit drugs and substandard drugs, Schedule M was amended in December, 2001. After the amendment of Schedule M in December 2001, it is mandatory for all manufacturers to comply with new GMP. From 11rd December 2001, the manufacturing facilities not complied with new GMP could not get any manufacturing license from each State Drug Control Administration. Furthermore, the manufacturing facilities which got manufacturing license before December 2001 must implement the new GMP until 31December, 2001.If they cannot do so, their manufacturing licenses are revoked and their manufacturing facilities are closed down forcibly.

While the large, medium, and some of small companies have upgraded their manufacturing facilities, most of small companies have not upgraded. One of reasons why small companies can't upgrade their manufacturing facilities is that they don't have the capacity to raise the funds to upgrade. It requires more than Rs. 2.5 crore to comply with the new GMP. Even if they could afford to do so, they feared that they would lose the status of small scale industry (SSI) once they invested in GMP. This is because the investment limit to eligible to be small scale industry was Rs.1crore.

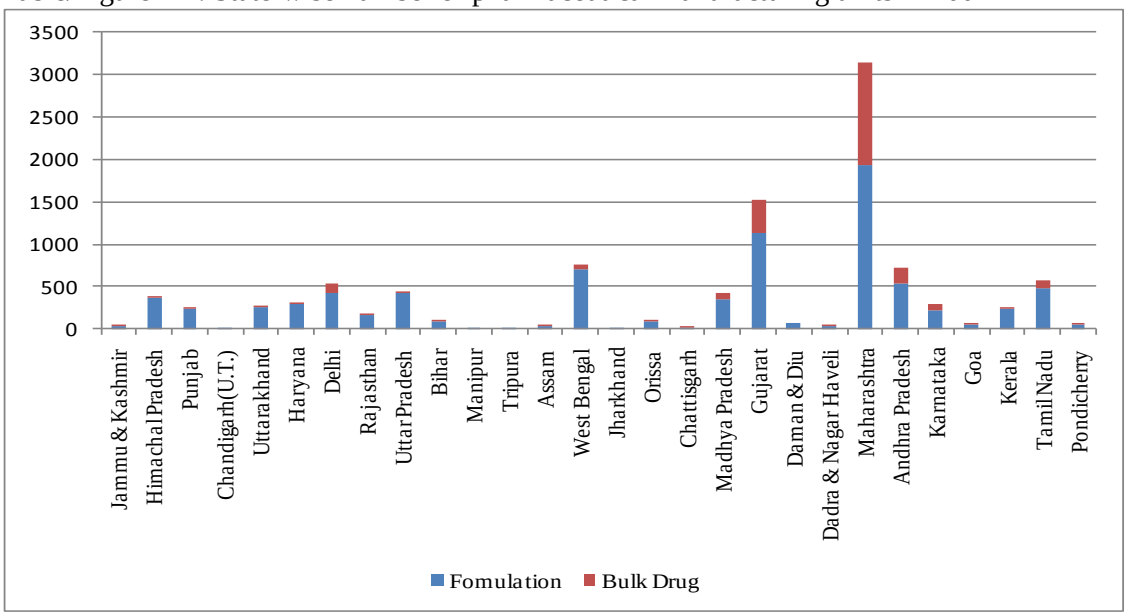
The Indian government made several concessions to support small companies implement GMP. The deadline of implementation of GMP was postponed from 31 December 2003 to 31 December 2004, and finally the deadline was postponed for six month until 30 June 2005. The government provides each state drug control administrations with authority to postpone the deadline. In addition, the investment limit to eligible to be small scale industry was raised from Rs.1crore to Rs. 5 crore. Regardless of government's support, a large number of small firms have been weeded out. The states that saw most of closure or suspension of licenses were Maharashtra, Gujarat, West Bengal, Madhya Pradesh, and Andhra Pradesh. In Maharashtra, Gujarat, Andhra Pradesh, there are many GMP compliant facilities. Karnataka has the highest compliant rate in India which was over 80% because of aggressive support of the Karnataka state government.

2.2 Regional development of Indian pharmaceutical Industry

Indian pharmaceutical Industry has formed several industrial agglomerations in many parts of India. Major pharmaceutical industrial agglomerations are Maharashtra, Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, Haryana, Punjab, Delhi, Goa, Himachal Pradesh, Uttarakhand, Daman & Diu, and Dadra Nagar & Haveli. Figures 2-4, 2-5 show the state-wise distribution of manufacturing facilities. Table 2-6 shows the state-wise distribution of manufacturing facilities

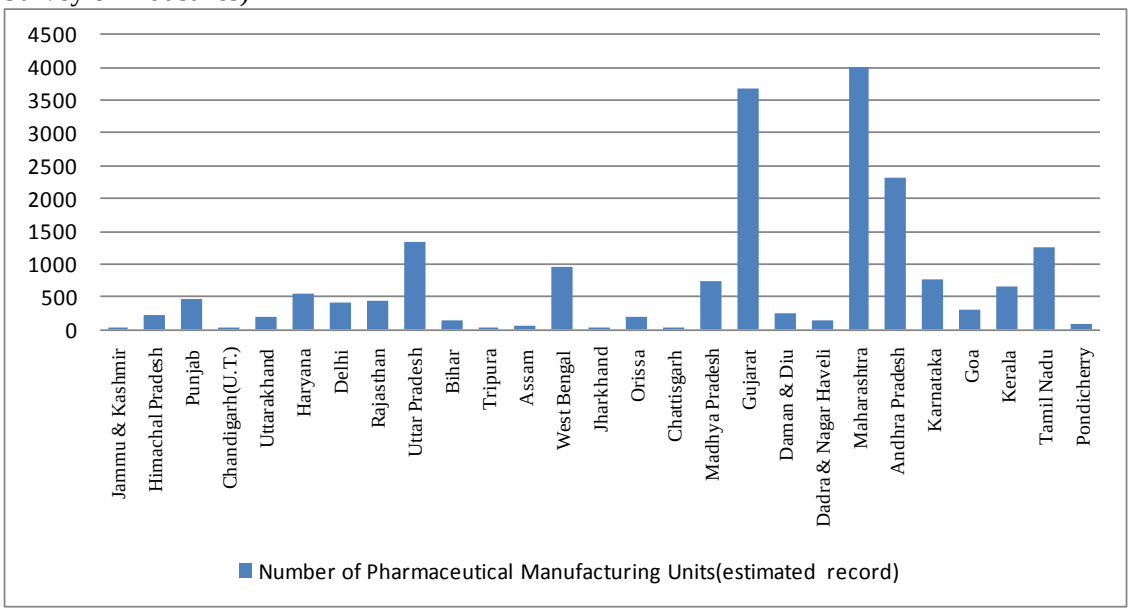
of leading pharmaceutical companies-both Indian and foreign companies- in India. In April 2000, the Indian government released the Special Economic Zones Policy. Now 40 pharmaceutical and bio SEZs has been approved. In all 40 SEZs are located in these agglomerations (Figure2-7).

Table/Figure 2-4: State-wise number of pharmaceutical manufacturing units in 2007



Source: NPPA (2007).

Table/Figure 2-5: State-wise number of pharmaceutical manufacturing units in 2005 (Annual Survey of Industries)



Source: Central Statistical Organisation, Annual Survey of Industries, 2005-06, unit-level data.

Table/Figure 2-6: State-wise locational distribution of manufacturing units of major pharmaceutical companies

		Formulation	Bulk Drug	State Total
Andhra Pradesh	Aurobindo	2	2	15
	DiVi's	2	1	
	Dr. Reddy's	4	1	
	Jubilant	1		
	Piramal Healthcare		1	
	Ranbaxy	1		
Delhi	Cipla	1		10
	Glenmark	1		
	Ranbaxy	6		
	Abbott	1		
	Sanofi Aventis	1		
Goa	Cipla	1		3
	Glenmark	1		
	Merck	1		
Gujarat	Cadila	8	2	37
	Dishman	2	1	
	Jubilant		1	
	Lupin	1		
	Sun	5	2	
	Torrent	7	3	
	Wockhardt	1		
	Glaxo Smith Kline	1		
	Pfizer	1		
	Sanofi Aventis	1		
	Wyeth	1		
Haryana	Ranbaxy	1		3
	Eli Lilly		1	
	Glaxo Smith Kline		1	
Himachal Pradesh	Cadila Healthcare	1		11
	Cipla	1		
	Dr. Reddy's	1		
	Glenmark	1		
	Piramal Healthcare	1		
	Ranbaxy	3	1	
	Torrent	1		
	Wockhardt	1		
Karnataka	Biocon	1	2	12

	Cipla	1		
	Jubilant	1		
	AstraZeneca	1		
	Bayer	1		
	Glaxo Smith Kline	3	2	
Madhya Pradesh	Lupin	3		8
	Piramal Healthcare	2		
	Ranbaxy	2		
	Merck	1		
Maharashtra	Cadila Healthcare	1		96
	Cipla	8	1	
	Dishman		1	
	Dr. Reddy's	1		
	Glenmark	8	1	
	Jubilant		1	
	Lupin	5	1	
	Piramal Healthcare	11	1	
	Ranbaxy	3	1	
	Sun	6	2	
	Torrent	1		
	Wockhardt	8	1	
	Abbott	1	2	
	Bayer	2	2	
	Boehringer Ingelheim	2		
	Glaxo Smith Kline	4	1	
	Johnson & Johnson	4	1	
	Merck	4		
	Novartis	5	1	
	Pfizer	3		
	Sanofi Aventis	2	1	
	Wyeth	2		
Punjab	Ranbaxy	3		3
Tamil Nadu	Sun	2		4
	Wockhardt	1		
	Sanofi Aventis	1		
Uttarakhand	Jubilant	1		1
West Bengal	Sun	1		3
	Ranbaxy		1	
	Pfizer	1		
Dadra & Nagar Haveli	Sun	3		3

Daman & Diu	Wockhardt	2		3
	Johnson & Johnson	1		
Pondicherry	Dr. Reddy's	1		1

Source: NPPA (2007).

Table/Figure 2-7: Special Economic Zone (SEZ) for pharmaceuticals and bio-technology science under SEZ Act, 2005

	Formal Approvals	Principle Approvals	Operational
Punjab	1		
Haryana	2		
Gujarat	5		1
Maharashtra	9		1
Goa	3		
Andhra Pradesh	13	2	2
Karnataka	3	1	1
Tamil Nadu		1	
Total	36	4	5

Source: SEZ in India, Department of Commerce, Ministry of Commerce & Industry, Government of India, http://www.sezindia.nic.in/about-asi.asp

As these figures and tables show, we can confirm the situation of regional pharmaceutical industrial agglomeration in India. We point out three contributing factors in the formation of regional pharmaceutical agglomeration. The factors are (1) the linkage between public research institutions and private sector companies, (2) the spin-off of engineers of public enterprises, and (3) the extensional development of large companies in India.

In the early stage of the development of the industry, the public research institutions and public enterprises played important role in manufacturing of drugs and research and development activities.

The government established public research institutions and public enterprises in the early 1950s. The development of the industry is based on close linkage between public research institutions and private sector companies. The technologies that public research institution developed were transferred to private sector companies and then private sector companies commercialised these technologies. Since the private companies had little own research capabilities in the early stage of the development, the cooperation with public research institutions was crucial. Therefore, the pharmaceutical industrial agglomerations were formed around the public institutions. The agglomerations were also formed around the public enterprises because the engineers of public enterprises started their own ventures. Dr. K. Anji Reddy who is the founder of Dr. Reddy’s Laboratories is the most famous case that the engineer of the public enterprise, Indian Drugs and Pharmaceutical Limited (IDPL) started a venture. Hyderabad where is the largest agglomeration of bulk drug manufacturers and have the public research institution, Indian Institute of Chemical Technology, Hyderabad (IICT-H) and the public enterprise, IDPL is one of the good example of pharmaceutical industrial agglomeration(Figure 2-8).

Table/Figure 2-8: Public sector pharmaceutical research institutes and manufacturing units

	Year of Establishment	Location	Note
Public Research Institutes			
Central Drug Research Institutes(CDRI)	1951	Lucknow, Uttar Pradesh	
Indian Institute Chemical Technology, Hyderabad (IICT-H)	1956	Hyderabad, Andhra Pradesh	
National Chemical Laboratory(NCL)	1950	Pune, Maharashtra	
Central Public Sector Undertakings			
Indian Drugs & Pharmaceuticals Limited(IDPL)	1961	Hyderabad, Andhra Pradesh	
Hindustan Antibiotics Limited(HAL)	1954	Pune, Maharashtra	
Bengal Chemicals & Pharmaceuticals Limited(BCPL)	1981	Kolkata, West Bengal	a sick private company ,Bengal Chemicals & Pharmaceuticals Works was nationalized in 1980.
Bengal Immunity limited(BIL)	1984	Kolkata, West Bengal	a sick private company, Bengal Immunity Company Limited was taken over by the Government of India in 1978 and nationalized in 1984
Smith Stanistreet Pharmaceuticals Lmited(SSPL)	1978	Kolkata, West Bengal	a sick private company,SmithStanistreet Company Limited was taken over by the Government of India in 1972 and nationalized in 1978
Subsidiaries of State-Owned			
IDPL(Tamil Nadu)Ltd		Chennai, Tamil Nadu	
Bihar Drugs & Organic Chemicals Ltd		Muzaffarpur, Bihar	
Joint Sector Undertakings			
Rajasthan Drugs & Pharmaceuticals Limited(RDPL)	1981	Jaipur, Rajasthan	Joint sector undertakings promoted byIDPL and Rajasthan Industrial Development & Investment Corporation(RIICO).
Orissa Drugs & Chemicals Limited(ODCL)	1979	Bhubaneswar, Orissa	Joint sector undertakings promoted byIDPL and Industrial Promotion &Investment Corporation of Orissa(IPICOL)
Karnataka Antibiotics & Pharmaceuticals Limited(KAPL)	1981	Bangalore, Karnataka	Joint sector undertakings promoted by HAL in collaboration with Karnataka State Industrial & Investment Development Corporation(KSIIDC)
Maharashtra Antibiotics & Pharmaceuticals Limited(MAPL)	1979	Nagpur, Maharashtra	Joint sector undertakings promoted by HAL and State Industrial & Investment Corporation Maharashtra(SIICOM)
Manipur State Drugs & Pharmaceuticals Limited(MSDPL)	1989	Imphal, Manipur	Joint sector undertakings promoted by HAL in collaboration with Manipur Industrial Development Corporation (MANIDO)

Source: Department of Pharmaceuticals (2010) and various websites of public sector research institutes.

The Patent Act of 1970 made manufacturing possible for pharmaceutical companies such as Cipla and Alembic which had been manufacturing drug related chemical compounds before Independence and companies such as Ranbaxy which engaged drug selling agents to manufacture drugs that were patented in other countries through reverse engineering. Since then, the Indian pharmaceutical industry has developed rapidly. In the process, pharmaceutical agglomerations were formed around these companies.

Recently, some state governments conduct measures to promote industrial agglomeration. We will review these measures hereinafter.

First, the Indian government has implemented Himachal-Uttaranchal Industrial Policy in Himachal Pradesh and Uttarakhand as a development policy for backward areas (DIPP 2003a). This policy classified industries into two categories - thrust industry and negative industry. While the industries identified as thrust industry were attracted, the invitation of the industries indentified as negative industry was limited. The thrust industry lists 18 industries including pharmaceutical industry and the negative industry lists 20 types of industries. In this industrial policy, fiscal incentives such as excise duty exemption, exemption of income tax for companies, and capital investment subsidy were granted to new industrial units and to existing units on their substantial expansion.

Himachal Pradesh and Uttarakand indentified pharmaceutical industry and biotechnology industry as thrust industry, and in particular, have attracted biotechnology industry aggressively (Government of Himachal Pradesh2004, Government of Uttarakhand 2003).

Table/Figure 2-9: Industrial policy in Uttarakhand and Himachal Pradesh

	Thrust Industries		Negative List Industries
1	Floriculture	1	Tobacco and tobacco products including cigarettes and pan masala
2	Medicinal herbs and aromatic herbs etc. -processing	2	Thermal Power Plant(coal/oil based)
3	Honey	3	Coal washeries/dry coal processing
4	Horticulture and Agro based industries	4	Inorganic Chemicals excluding medicinal grade oxygen, medicinal grade hydrogen peroxide, compressed air
5	Food Processing Industry excluding those included in the negative list	5	Organic chemicals excluding Provitamins/vitamins, Hormones, Glycosides,

			sugars
6	Sugar and its by-products	6	Tanning and dyeing extracts, tanins and their derivatives, dyes, colours, paints and varnishes; putty, fillers and other mastics; inks
7	Silk and silk products	7	Marble and mineral substances not classified elsewhere
8	Wool and wool products	8	Flour mills/rice mill
9	Woven fabrics (Excisable garments)	9	Foundries using coal
10	Sports goods and articles and equipment for general physical exercise and equipment for adventure sports/activities, tourism	10	Minerals fuels, mineral oils and products of their distillation; Bituminous substances : mineral waxes
11	Paper & paper products excluding those in negative list	11	Synthetic rubber products
12	Pharma products	12	Cement clinkers and asbestos, raw including fibre.
13	Information & Communication Technology Industry Computer hardware Call centres	13	Explosive (including industrial explosives, detonators & fuses, fireworks, matches, propellant powders etc.)
14	Bottling of mineral water	14	Mineral or chemical fertilisers
15	Eco-tourism	15	Insecticides, fungicides, herbicides & pesticides (basic manufacture and formulation)
16	Industrial gases	16	Fibre glass & articles thereof
17	Handicrafts	17	Manufacture of pulp - wood pulp, mechanical or chemical (including dissolving pulp)
18	Non-timber forest product based industries	18	Branded aerated water/soft drinks (non-fruit based)
		19	Paper; Writing or printing paper, etc., Paper or paperboard, etc., Maplitho paper, etc., Newsprint, in rolls or sheets, Craft paper, etc., Sanitary towels, etc., Cigarette paper, Grease-proof paper,Toilet or facial tissue, etc., Paper & paper board, laminated internally with bitumen, tar or asphalt, Carbon or similar copying paper, Products consisting of sheets of paper or paperboard, impregnated, coated or

			covered with plastics, etc., Paper and paperboard, coated impregnated or covered with wax, etc.
		20	Plastics and articles thereof

Source: DIPP (2003a).

Haryana is one of most developed industrial state in India, recently emerged as a leading stronghold of knowledge based industry such as IT industry and biotechnology industry. The advantages of Haryana are its good infrastructures and its proximity to Delhi. In Biotechnology policy of Haryana, 2002, the state decided to set up R&D centre in order to promote R&D in the biotechnology industry. By setting up the R&D centre, Public-Private Partnerships in R&D are expected blossom. During the 11st Five Year Plan and 12th Five Year Plan, Haryana plans to set up a biotechnology cluster around Faridabad.

In Industrial policy of 2003, Punjab aimed to attract and promote biotechnology industry. The government of Delhi aimed to promote biotechnology industry through public-private partnerships between Delhi University and private sector companies.

In Industrial Policy of 2003, Gujarat State government aimed to develop Special Economic Zones (SEZs), Industrial Complex, and industrial cluster for small and medium companies (Government of Gujarat 2003). In 2001, Maharashtra state government announced Industrial Policy, 2001 and Maharashtra Biotechnology Policy 2001. In the industrial policy, the government permitted to use textile mill land for development biotechnology industry (Government of Maharashtra 2001a). In the biotechnology policy, the government decided to set up a Biotechnology Park at Pune, and the park offered GMP facilities in conformity with US FDA norms (Government of Maharashtra 2001b). This measure was important for invitation of biopharmaceutical companies because it is very costly to get a GMP certification from US FDA. In Industrial Policy 2003, Government of Goa showed its policy to set up Pharma Park and BT Park (Government of Goa 2003).

Government of Andhra Pradesh announced Biotechnology Policy in 2001 and decided to set up a biotechnology park and provided various incentives for biotechnology companies (Government of Andhra Pradesh 2001). In 2001, Government of Karnataka announced the Millennium Biotech Policy, and set up three biotech parks in the state (Government of Karnataka 2001). Karnataka has formed the largest biotechnology cluster in India. Government of Tamil Nadu announced the Biotechnology Policy in 2000, and set up Biotechnology

Enterprise Zones to promote invitation of biotechnology companies (Government of Tamil Nadu 2000).

In consideration of geographical location of Indian pharmaceutical industry we mentioned above, we classify India into four areas. First of all, we assort India into two areas, the new (emerging) area and the established (mature) area on the basis of the initial year of production of firms (Figure/Talble2-10). The new area is Area 1 (Himachal Pradesh and Uttarakhand). The established area is consisting of three sub areas, Area 2 (Delhi, Haryana and Punjab), Area 3 (Gujarat, Maharashtra, Goa, Dadra & Nagar Haveli, and Daman & Diu) and Area 4 (Andhra Pradesh, Karnataka, Tamil Nadu, and Pondicherry). We classify these areas into three categories depending on the level of their dynamism which essentially is based on the number of new units set up. Figure 2-11 shows the area-wise share of newly-built unit numbers. The area where the share of new units is the largest has been identified as the most dynamic area (Area 3); likewise, the area where the share of new units is comparatively smaller has been defined as the less dynamic area (Area 2); finally, the area which shows little dynamism (Area 4). And the area which does not fall under any of the above categories is defined as non agglomerated area (Area 5). Thus the regions are categorised as follows:

Agglomerated areas:

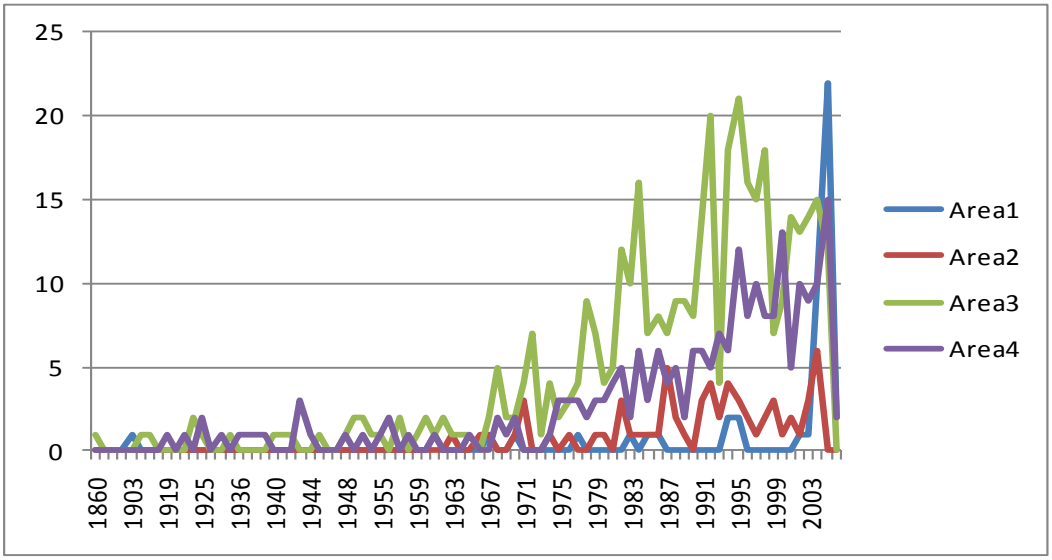
- Area 1: new and dynamic area: Himachal Pradesh and Uttarakhand,
- Area 2: established and least dynamic area: Delhi, Haryana and Punjab,
- Area 3:established and most dynamic area: Gujarat, Maharashtra, Goa, Dadra & Nagar Haveli, and Daman & Diu,
- Area 4: established old and somewhat dynamic area: Andhra Pradesh, Karnataka, Tamil Nadu, and Pondicherry

Non agglomerated areas

- The rest of the states included in Area 5

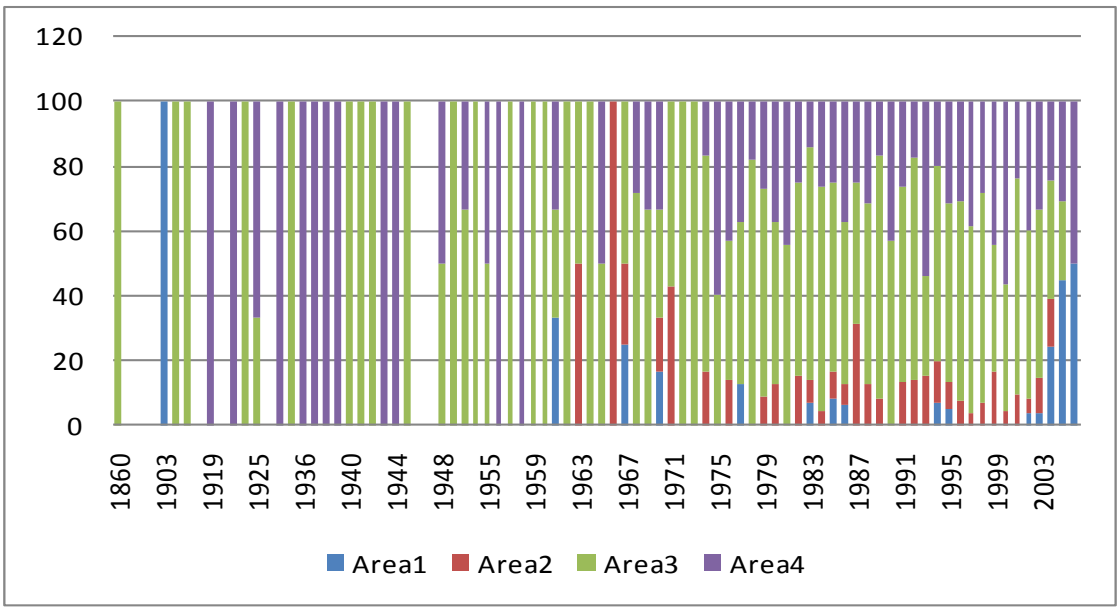
The region-wise results are shown in the following figures (Figure 2-12).

Table/Figure 2-10: Area-wise distribution of the initial year of production



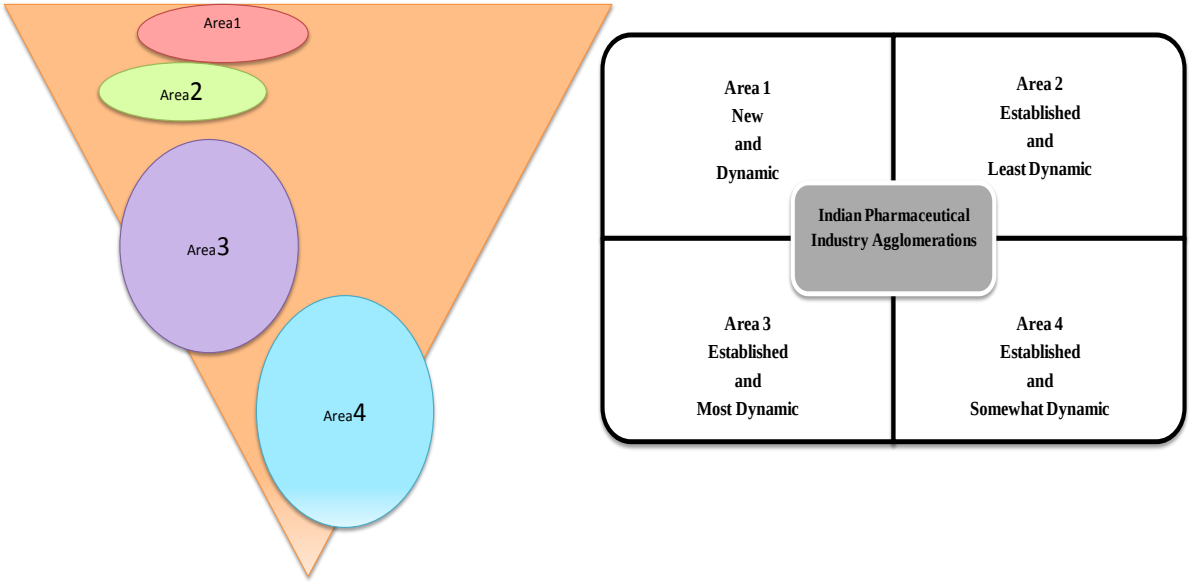
Source: Central Statistical Organisation, Annual Survey of Industry, 2005-06, unit-level data.

Table/Figure 2-11: the area-wise share of newly-built unit numbers



Source: Central Statistical Organisation, Annual Survey of Industry, 2005-06, unit-level data.

Table/Figure 2-12: Map of four agglomerated areas



3. Empirical Analysis of Business Dynamics and Productivity Growth

3.1. Empirical Method

Empirically, the dynamics of productivity growth are captured by productivity decomposition methodologies. Several decomposition methods are offered in the literature to assess sources of industry productivity growth. These methodologies decompose productivity growth between two points in time into the contribution from four broad factors:

- improvement in incumbents' productivity;
- reallocation of resources from less productive to more productive producers;
- entry of more productive firms; and
- exit of less productive firms.

These methodologies thus link macro productivity growth with micro firms' and productivity dynamics.

Baily et al. (1992) was the first study to propose decomposition of productivity into the contributions of continuing, entering and exiting plants (BHC methodology). They defined aggregate productivity as the output-weighted ($\theta_{f,t}$) average of the productivity of individual plants ($A_{f,t}$). The linear aggregation of productivity implies a geometric average of productivity

levels:

$$A_t = \sum_{f}^{n_t} \theta_{f,t} A_{f,t}$$

Difference of aggregate productivity is defined by

$$\Delta A_t = A_t - A_{t-1}.$$

Using this, they proposed the following methodology (BHC), to decompose aggregate productivity growth:

$$\Delta A_t^{BHC} = \sum_{f \in S} \theta_{f,t-1} \Delta A_{f,t} + \sum_{f \in S} (\theta_{f,t} - \theta_{f,t-1}) A_{f,t} + \sum_{f \in N} \theta_{f,t} (A_{f,t} - A_{t-1}) + \sum_{f \in X} \theta_{f,t-1} (A_{t-1} - A_{f,t-1})$$

In the above equation, the Sets S, N, and X, respectively, represent the set of continuing, entering, and exiting plants during the periods from t-1 to t. The first term measures the effect of plant-level productivity changes, weighted by the initial share. The second term which sums changes in shares using a plant's productivity as weight captures the reallocation effect. The last two terms capture reallocation driven by new plants entering and others exiting.

An alternative is provided by Griliches and Regev (1995). Their methodology is as under

$$\Delta A_t^{GR} = \sum_{f \in S} \bar{\theta}_f \Delta A_{f,t} + \sum_{f \in S} \Delta\theta_f (\bar{A}_f - \bar{A}) + \sum_{f \in N} \theta_{f,t} (A_{f,t} - \bar{A}) + \sum_{f \in X} \theta_{f,t-1} (A_{f,t-1} - \bar{A})$$

This methodology will be referred to as GR throughout the text of this study. In this formula a bar over a variable indicates the average of the variable over the base and end years. All productivity terms (except for within-effects) are expressed as average productivity of two years.

Foster et al. (2001) modify the BHC methodology. Like BHC, Foster et al. (2001) also expresses all productivity changes as differences from aggregate productivity in t-1. In addition, they decomposed the second term of BHC into a 'pure between effect', weighing the change in shares by the relative productivity in the initial period and a covariance term. This methodology will be called as FHK in this study.

$$\Delta A_t^{FHK} = \sum_{f \in S} \theta_{f,t-1}\, \Delta A_{f,t} \quad + \sum_{f \in S} \Delta\theta_{f,t} \left(A_{f,t-1} - A_{t-1}\right) \quad + \sum_{f \in S} \Delta\theta_{f,t}\, \Delta A_{f,t} + \sum_{f \in N} \theta_{f,t} \left(A_{f,t} - A_{t-1}\right) \quad + \sum_{f \in X} \theta_{f,t-1} \left(A_{t-1} - A_{f,t-1}\right)$$

This decomposition has five terms that show the contribution of various components to aggregate productivity change. The difference between the final two is called the net entry effect. In this formula an entering plant contributes positively only if it has higher productivity than the initial average and an exiting plant contributes positively only if it exhibits productivity lower than the initial average. GR measures their distance from the average productivity of both, the initial and end years.

Olley and Pakes (1996) proposed an entirely different approach, referred to OP hereafter. They defined aggregate productivity as the average of the productivity levels and decomposed it in two terms as follows:

$$A_t^{OP} = \widetilde{A_t} \quad + \sum (\theta_{f,t} - \widetilde{\theta_t}) \left(A_{f,t} - \widetilde{A_t}\right) = \widetilde{A_t} \quad + \mathrm{cov}(\theta_{f,t}, A_{f,t})$$

where $\widetilde{A_t} = \frac{1}{n_t} \sum_{i=1}^{n_t} A_{f,t}$ and $\widetilde{\theta_t} = \frac{1}{n_t} \sum_{i=1}^{n_t} \theta_{f,t}$. The first term is the unweighted productivity average and the second term captures allocation efficiency i.e. to what extent 'above average size' firms have 'above average productivity'. This decomposition distinguishes between the contributions of productivity improvements and reallocation but does not allow us to distinguish between contributions of surviving, entering and exiting. Melitz and Polanec (2009) extended this decomposition to assess the contribution of entering and exiting firms to productivity growth. This methodology is termed as "dynamic Olley and Pakes" method (hereafter referred to as DOP in this study). They challenged the FHK and GR decomposition methodologies on the grounds that their choice of reference productivity values for entering and exiting firms, and the use of fixed weights in distinguishing between contributions of productivity improvements

and market share reallocation of surviving firms has mixed up various effects and hence introduced bias in the measurement. In order to eliminate these biases, they used Olley-Pakes decomposition and modified it capture firms' dynamics. It is given by

$$\Delta A_t^{DOP} = \Delta\widetilde{A_{S,t}} + \Delta cov(\theta_{S,t'} A_{S,t}) + \theta_{N,t}(A_{N,t} - A_{S,t}) + \theta_{X,t-1}(A_{S,t-1} - A_{X,t-1})$$

where $\theta_{g,t}$ and $A_{g,t}$ represent the aggregate market share and aggregate productivity of group g in period t.

There are two major differences between the components of the above methodology and those of FHK and GR. First, both entry and exit effects in this methodology are weighted by corresponding overall market shares. The other two decompositions compare aggregate productivity of entering and exiting firms to either aggregate productivity of all firms in initial period (FHK) or the unweighted time average of aggregate productivity of all firms (GR). Second, this methodology does not assign weights to productivity change of continuing firms (within plant effects) as the other two methods and follow instead the approach of Olley-Pakes decomposition, and define reallocation only when covariance between market share and productivity increases. Third, mathematically, the three methodologies may yield very different results depending on features of firms' dynamics in the data. In an industry where the productivity of continuing firms is growing, FHK decomposition yields lower contribution of exiting firms than the DOP, whereas the opposite holds for the GR decomposition. Further, both FHK and GR decompositions yield smaller contribution of surviving plants and larger contribution of entering plants as compared with DOP. Finally, the within effects are inflated in FHK and GR due to the use of weights in measuring these effects, which according to Melitz and Polanec (2009) captures a part of reallocation effect.

Clearly, there are a wide range of estimates in the literature. Foster et al. (2001) shows that the results are sensitive to the choice of methodology, time-period, and productivity measure. The present study uses three methodologies of decomposition for the robustness of the results. These are: GR, FHK and DOP.

Hypothesis

The argument that firms benefit from a location in an agglomeration due to place-specific external economies of scale and increasing returns dates back to the early work by Marshall (1920), Ohlin (1933) and Hoover (1937). Marshall (1920) maintained

that concentrations of firms in a similar industry give rise to localization economies in the form of knowledge and information spillovers, labour pooling (advantages of thick markets for specialized skills) and backward and forward linkages. Over the ears, the theoretical literature on agglomeration economies has enriched by the emergence of new trade theories, new growth theories and new economic geography theories (see Fujita and Thisse 2002 for a comprehensive up-to-date discussion of the theory). A vast body of empirical work, stretching back over many years, has sought to identify these externalities and to quantify their effects on productivity. There are a number of excellent up-to-date surveys of the empirical literature on agglomeration (see in particular Rosenthal and Strange 2004, Eberts and McMillen 1999). There is a considerable evidence that agglomeration economies are associated with productivity enhancement, we therefore hypothesis that the productivity growth in agglomerated regions is likely to be higher than in non agglomerated areas.

Further, it is expected that entry effects rather high in new agglomerations.

3.2. Methodology and Data

The most frequently applied measures of productivity are: labour productivity (LP) and total factor productivity (TFP). As the latter accounts for the distinct effects of capital/labour inputs together with technological progress, it is often seen as favourable. The present study also uses both LP and TFP for the analysis.

The aggregate LP is measured as a weighted average of plant level productivity. It is defined as:

$$LP_t \equiv \sum_{f}^{n_t} \theta_{f,t}\, LP_{f,t} = \sum_{f}^{n_t} \theta_{f,t} \left(\frac{GVA_{f,t}}{L_{f,t}}\right)$$

The aggregate TFP is defined as:

$$TFP_t \equiv \sum_{f}^{n_t} \theta_{f,t}\, TFP_{f,t} = \sum_{f}^{n_t} \theta_{f,t} \left(\frac{GVA_{f,t}}{K_{f,t}^{\hat{\alpha}} L_{f,t}^{\hat{\beta}}}\right)$$

Weight (θ): Different parameters have been used as weights in the existing literature. These are: share of revenue, output, labour, value added, or costs. Foster et al. (2008) assert that the choice

of weight is "an open question". The most common choices are either output (or revenue) weight or employment weight. Following the traditional literature, we have used 'gross value of output' weight in the present study.

Real Gross Value Added (GVA): We obtain GVA using double-deflation method as follows:

GVA= (gross value of output)/(wholesale price index)-(total input)/(input price index)

Gross value of output (GVO) is deflated by the wholesale price index of drugs and medicines while inputs are deflated by the input price index. The input price index is constructed as the weighted average of fuel price, material price, and other input prices. Fuel price, material price and other input prices are constructed using wholesale prices, implicit deflator of national account statistics and weights from input-output tables. The data sources we use for constructing input price index are: Reserve Bank of India, *Handbook of Monetary Statistics of India* and *Database on Indian Economy*; Central Statistical Organisation, *Input-Output Transaction Table* and *National Account Statistics*.

Labour (L): Man-hours of workers are used to measure labour input.

Capital (K): Capital is defined as initial value of net fixed capital deflated by the implicit deflator of net capital stock in the resisted manufacturing sector. The data sources of the implicit deflator are: Central Statistical Organisation and *National Account Statistics*.

Elasticity of Production with respect to Production Factor($\hat{\alpha}$, $\hat{\beta}$): Semi-parametric estimation technique proposed by Levinsohn and Petrin (2003) which addresses the endogeneity problem is used in order to estimate Cobb-Douglas production function defined as $\ln \mathrm{GVA} = \mathrm{a} + \alpha \ln \mathrm{K} + \beta \ln \mathrm{L} + \mathrm{e}$. The data set which we use for the estimation is unbalanced unit-level panel data of 6 years from 2000 to 2005.

Our empirical application is based on plant or ''factory'' level data for the period 2000-01 to 2005-06, which is collected by the Central Statistical Office of India in the Annual Survey of Industries (ASI). The primary unit of enumeration in the survey is a factory in the case of manufacturing industries, and data are based on returns provided by factories. The present study uses data on various plant level production parameters such as output, sales, labour, employees, capital, materials and energy.

The ASI factory frame is classified into 2 sectors: the 'census sector' and the 'sample sector'. The sample sector consists of small plants employing 20 to 99 workers if not using electricity and 10 to 99 workers if using electricity. The census sector comprises relatively large plants. It covers all units having 100 or more workers and also some significant units which although having less than 100 workers, contribute significantly to the value of manufacturing sector's output. While the units in the census sector are approached for data collection on a complete enumeration basis every year, sample sector units are covered on the basis of a well designed sampling. The present study focuses only on the census sector data for the decomposition analysis. This is because the productivity decomposition analysis requires a consistent and exhaustive database to distinguish between continuing firms, entrants and exiters. A challenge was however posed by changes in the definition of the census sector in the recent past. For the year 1997-98, 1998-99 and 1999-2000, the census sector was limited only to factories employing 200 or more workers. From 2000-01 onwards again the factories employing 100 or more workers are under the census sector. For consistency in the analysis, we exclude the years prior to 2000-01 from our analysis and focus on the period 2000-01 to 2005-06.

Another important challenge was to distinguish between entering and exiting firms categories of firms over the period of five years. Since our database comprises of relatively larger units (100 employees or more), entry of new plants is accounted for by not only newly established plants but also by those plants that were already existing in the sample sector but they have expanded and subsequently shifted to the census sector during the study period. These two categories of entering firms need to be differentiated because of the different dynamics that they might have undergone. While the former are young firms and have later-come advantages while the latter are successful factories which have undergone learning process through passive learning or active explorations. The two categories of plants are thus expected to have very different outcomes. Newly established firms are expected to have much smaller contribution than the winners. Finally, the exiting firm is defined as the firm that stopped functioning or downsized its operations during the study period. It might not have wound up operations due to the tight exit policy but it might have become sick and downsized their production activity to join the small sector. In all, we define 5 categories of plants. Their definition and notations are provided in Table/Figure 3-1.

Table/Figure 3-1: Status of Plant

Status	Notation	Definition
Continuing survivors	S	Present in both period 2005 and 2000 in the census sector
Entering survivors	ES	Present in 2005 in the census sector and 2000 in the small sector
New entrants	EN	Present in t in the census sector, absent in 2000
Entering plants	N	ES+EN
Exiting plants	X	Present in 2000 in the census sector, drop out in 2005

It required a careful examination of plants to identify different categories of productivity dynamics. Table/Figure 3-2 summaries definitions of the effects used in the study.

Table/Figure 3-2: Components of productivity decomposition

Effect	Category of plants	Clarification
Total entry effect	N= EN+ES	Effects of newly entering, expanding and switching-in firms
Total exit effect	X	Effects of exiting and downsizing firms
Net entry effect	N+ X	This is the effect of the process of creative destruction
With-in plant effect	S	This signifies the effects of S
Reallocation effect (Between plant effects + covariance)	S	It shows improvement in allocation efficiency by S

The composition and number of plants are summarized in Table/Figure 3-3. The total number of plants increased over this period. Overall, the number of plants in our dataset increased from 352 in 2000 to 411 in 2005. Of the total 411 plants, a mere 138 (34 percent) plants are continuing survivors (S). The rest are either newly established plants (EN) or entering survivors (ES). The latter were originally small sized plants classified in the sample sector but have expanded and upgraded to qualify for the census sector. Their share varies from 20 percent to 55 percent across regions. The share of newly established plants in the total number of plants in 2005-06 varies from 11 percent in Area 4 (old and somewhat dynamic area) to as high as over 77 percent in Area 1 (new and dynamic area). Overall, the share of total entrants (N) ranges between 60 to 97 percent. Given tight exit policy, the share of exiting plans (X) in 2001 is more

remarkable. It varies from 56 percent Area 4 (old and somewhat dynamic area) and Area 5 (non agglomerated area) to 86 percent in Area 1 (new and dynamic area). Thus there have been significant business dynamics taking place in the pharmaceutical industry across the regions.

Table/Figure 3-3: Plant dynamics in Indian pharmaceutical industry across the regions during 2000-2005

Year: 2000		Area 1	Area 2	Area 3	Area 3	Area 5	Total
Continuing survivors (S)	Number	1	9	61	35	32	138
	Share	14%	41%	36%	44%	44%	
Exiting plants (X)	Number	6	13	110	44	41	214
	Share	86%	59%	64%	56%	56%	
S+X	Number	7	22	171	79	73	352
	Share	100%	100%	100%	100%	100%	

Year: 2005		Area 1	Area 2	Area 3	Area 4	Area 5	Total
Continuing survivors (S)	Number	1	9	61	35	32	138
	Share	3%	32%	36%	34%	40%	
Entering survivors (ES)	Number	6	12	86	57	33	79
	Share	20%	43%	51%	55%	41%	
New entrants(EN)	Number	23	7	22	11	16	194
	Share	77%	25%	13%	11%	20%	
Entering plants (N=ES+EN))	Number	29	19	108	68	49	273
	Share	97%	68%	64%	66%	60%	
S+N	Number	30	28	169	103	81	411
	Share	100%	100%	100%	100%	100%	

3.3. Empirical Results

Semi-parametric estimation technique proposed by Levinsohn and Petrin (2003) is used in order to obtain elasticity of production with respect to production factor. Fuel cost is set as proxy variable for unobserved productivity shock. Estimation results are shown in Table 3-4.

Table/Figure 3-4: Estimation of Cob-Douglas Production Function
(Dependent variable: ln GVA)

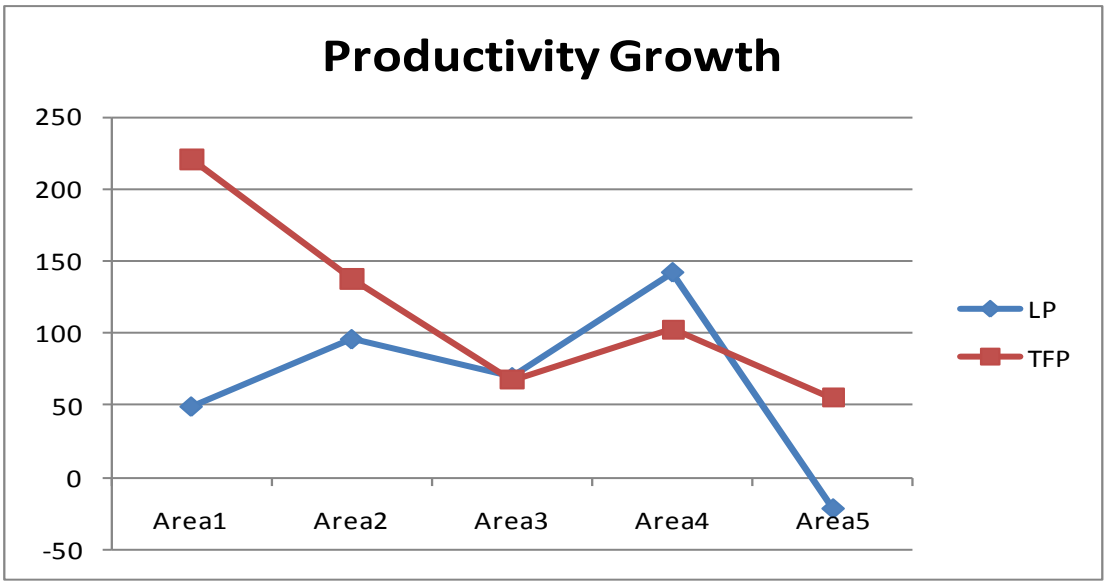
	Coefficient.	z-value
ln K	0.3986463	13.13
ln L	0.6402342	6.39
Wald test of constant returns	$\chi 2$=0.34(p-value=0.5602)	
Number of observation	1927	
Number of groups	797	
Proxy variable for productivity shock	logarithm of fuel cost	

Both estimated coefficients are positive and statistically significant at 1% level. The sum of coefficients is slightly higher than unity. But, according to Wald test of constant returns, null hypotheses on constant returns to scale are not rejected. Econometric estimation of Cob-Douglas production function is satisfactorily done. Therefore, 0.3986463 as $\hat{\alpha}$ and 0.6402342 as $\hat{\beta}$ are employed in order to obtain the TFP.

In this paper, Area 1 (new and dynamic area: Himachal Pradesh and Uttarakhand), Area 2 (old and least dynamic area: Delhi, Haryana and Punjab), Area 3 (old and most dynamic area: Gujarat, Maharashtra, Goa, Dadra & Nagar Haveli, and Daman & Diu), and Area 4 (old and somewhat dynamic area: Andhra Pradesh, Karnataka, Tamil Nadu, Pondicherry) are identified as the agglomerated regions of the pharmaceutical industry. The rest of the states are included as Area 5 (non agglomerated area). The region-wise results are shown in the following figures.

Table/Figure 3-5 presents growth rates of labour productivity (LP) and total factor productivity (TFP) across five regions in Indian pharmautitva industy over the period from 2000 to 2005. It shows that both labour and total factor productivity have increased across all the regions over this period with LP in Area 5 (non agglomerated area) being the only exception. Nevertheless, productivity growth has been particularly strong in aggoromerated regions. The productivity grew over 50 percent over this period.

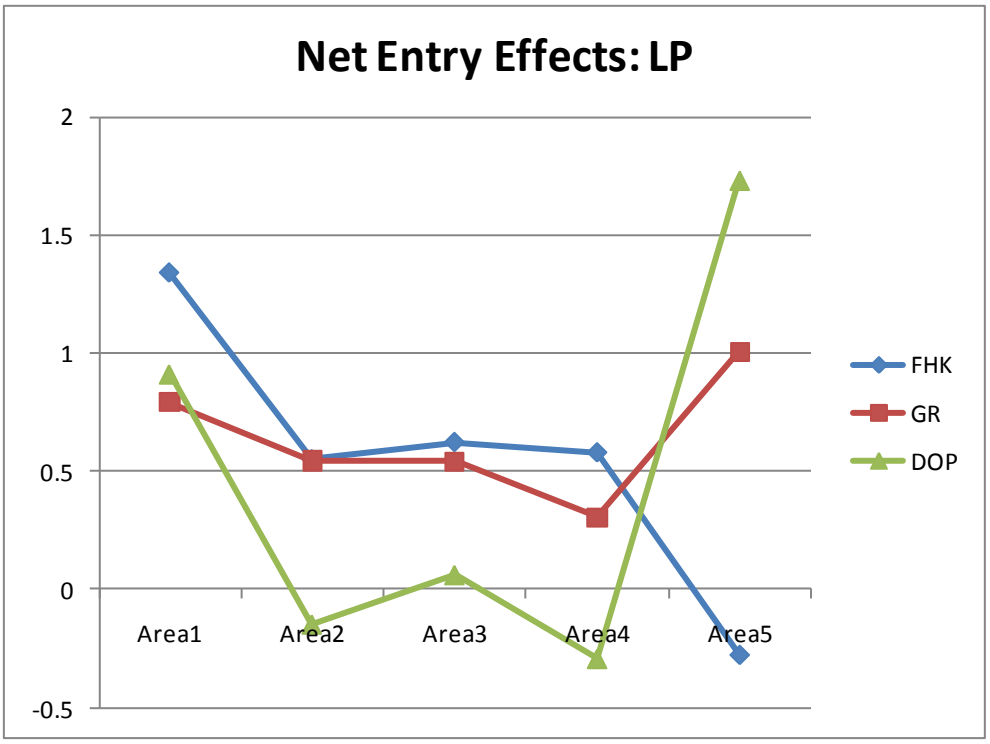
Table/Figure 3-5: Productivity growth rate across regions during 2000 to 2005



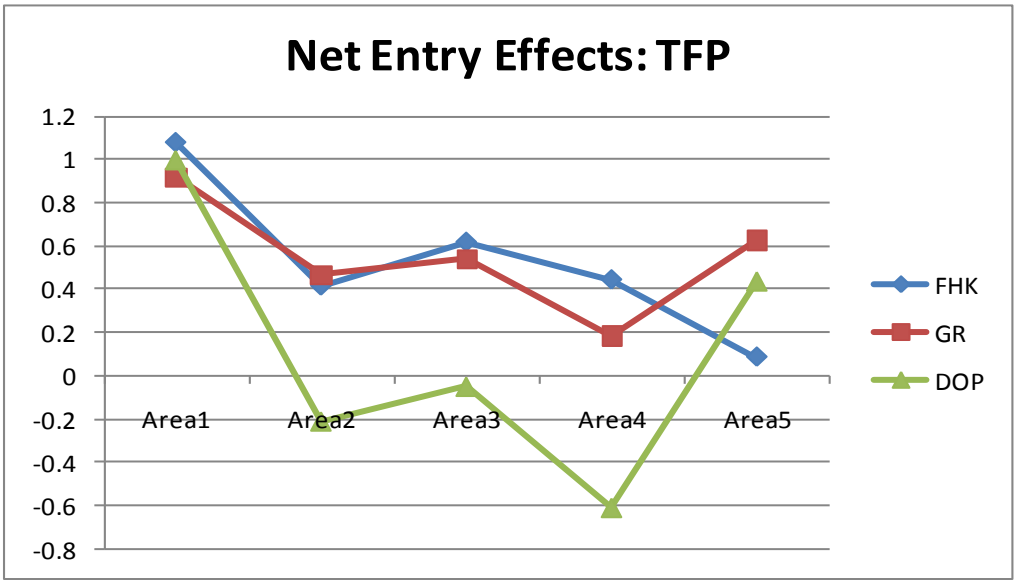
The region-wise decomposition results based on FHK, GR and DOP methodologies are presented in Table/Figure 3-6 to Table /Figure 3-10. Two things: first, since the growth rate of LP in Area 5 (non agglomerated area) is negative, it must be noted that positive (negative) contribution of each effect in the following figures of LP in Area 5(non agglomerated area) essentially means depressing (stimulating) effect on aggregate growth; second, as the decomposition results are sensitive to the choice of methodology, the present study regards the results with same sign through the three methodologies: GR, FHK and DOP as robust.

Net entry effects: Table/Figure 3-6 presents the contributions of net entry to productivity growth based on FHK, GR, and DOP methodologies. It is observed that net entry effect is positive for the LP in Area 1 (new and dynamic area) and Area 3 (old and most dynamic area), and it is also positive for the TFP in Area 1 (new and dynamic area) and Area 5 (non agglomerated area). Especially, net entry effect in Area 1 (new and dynamic area) accounts for 80 percept to 134 percent aggregate productivity growth.

Table/Figure 3-6a：Net entry effects by region: LP



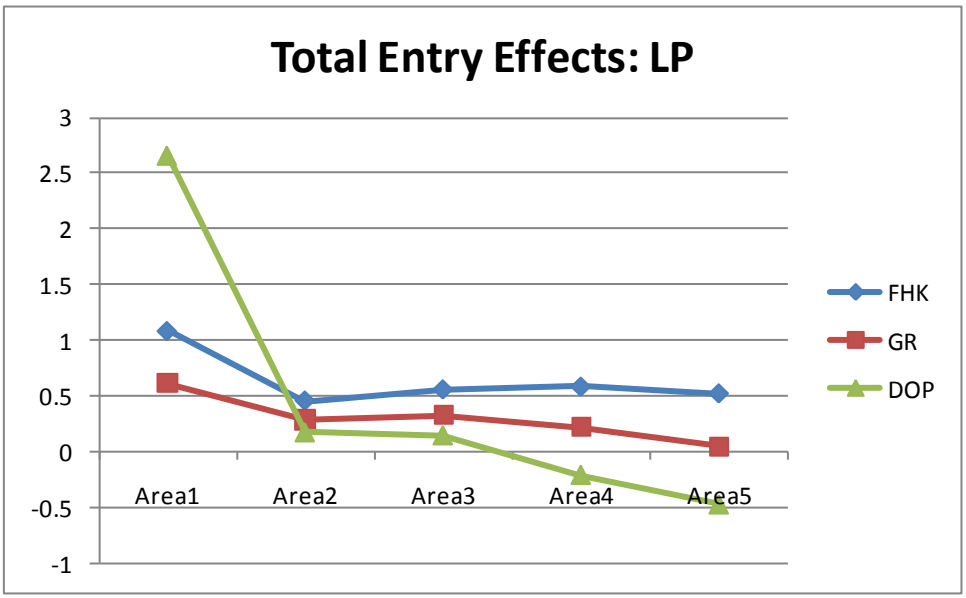
Table/Figure 3-6b：Net entry effects by region: TFP



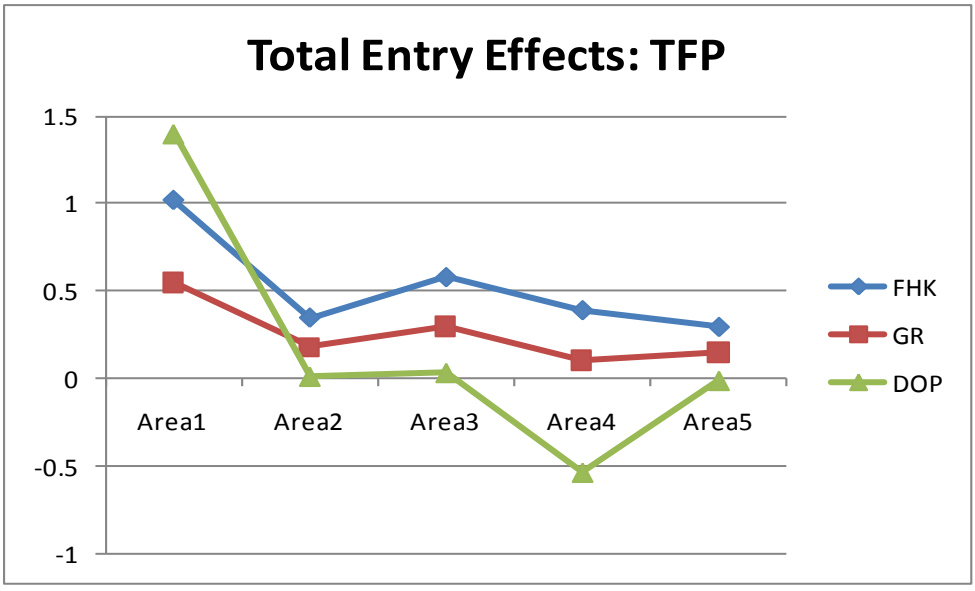
Total entry effects: Total entry effects are shown in Table/Figure 3-7. Total entry effect is positive for the both LP and TFP in Area 1 (new and dynamic area), Area 2 (old and least dynamic area) and Area 3 (old and most dynamic area). Total entry effect in Area 1 (new and

dynamic area) is rather high accounting for 55 percent to 267 percent of aggregate productivity growth.

Table/Figure 3-7a: Total entry effects by region: LP

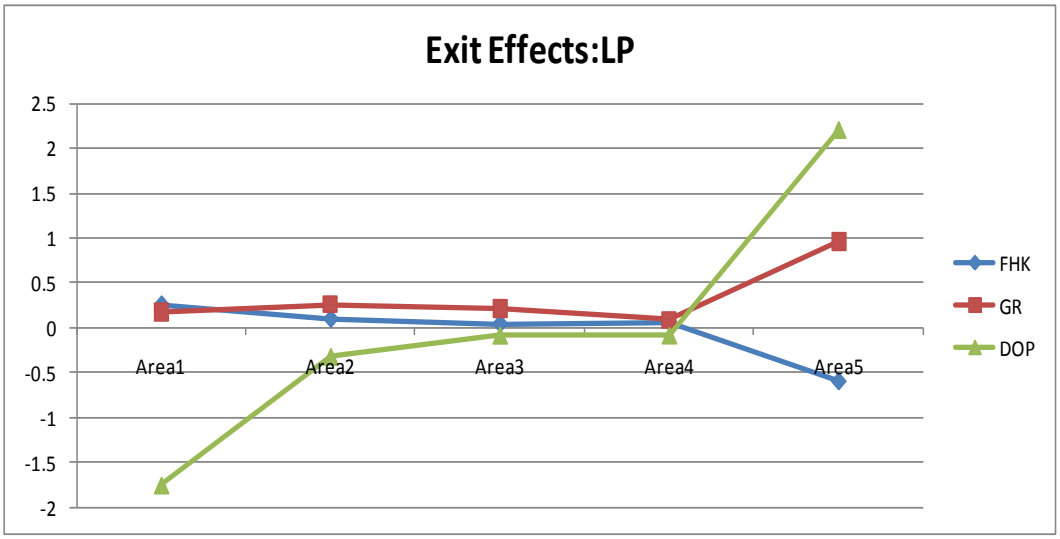


Table/Figure 3-7b: Total entry effects by region: TFP

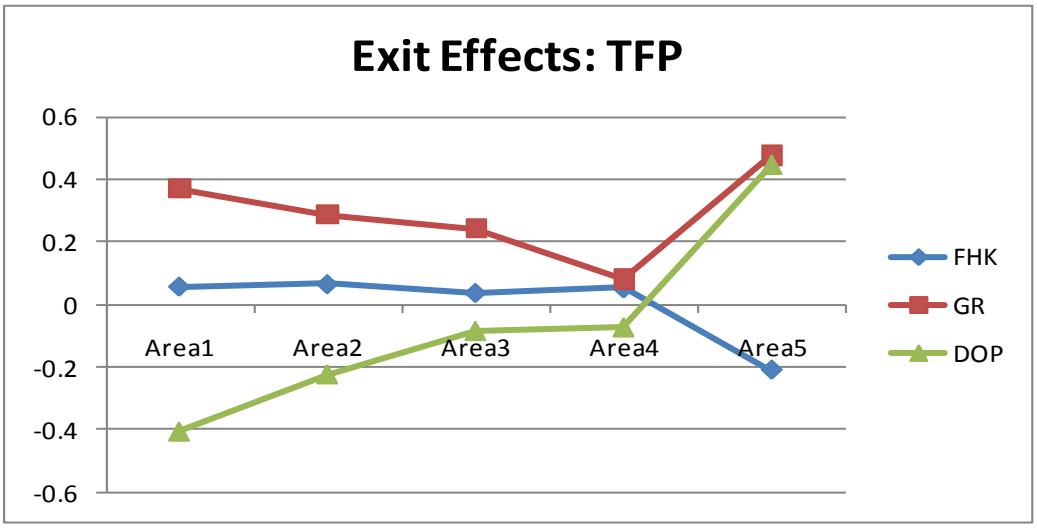


Exit effects: Table/Figure 3-8 presents exit effects. It is observed that there are no robust results in terms of our empirical strategy. In particularly, exit effect varies considerably across the three methodologies.

Table/Figure 3-8a: Total exit effects by region: LP

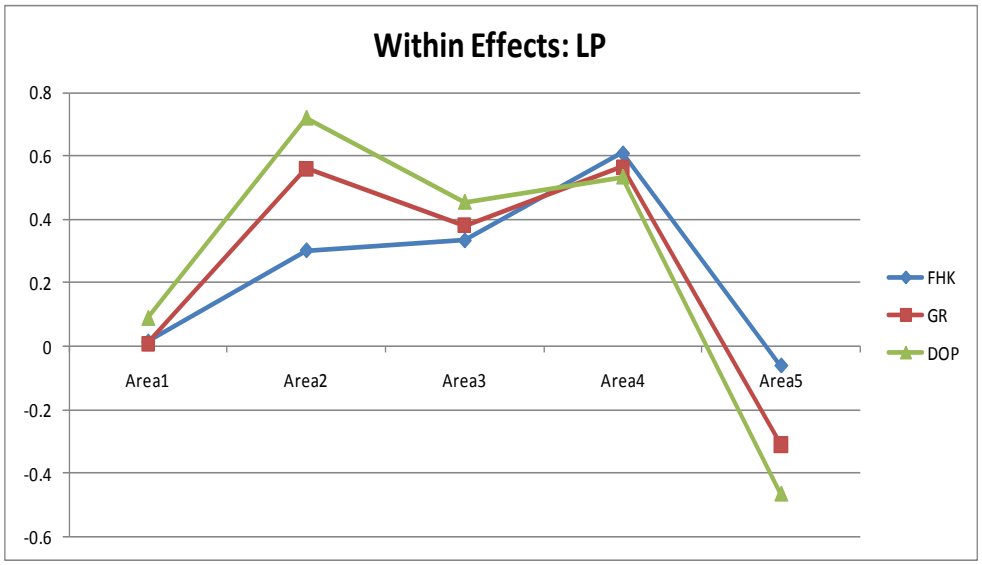


Table/Figure 3-8b: Total exit effects by region: TFP

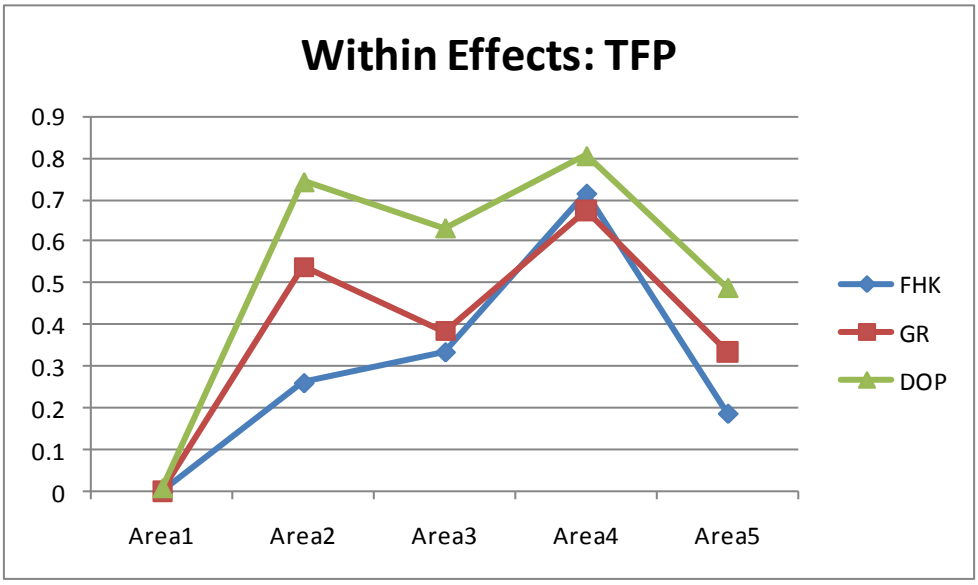


Within effect: Within effects of surviving plants are presented in Table/Figure 3-9. For the LP, within effect contribute positively the productivity growth in all regions. But, within effect is negligible in Area 1 (new and dynamic area). For the TFP, within effect is positive in Area 1 (new and dynamic area) to Area 4 (old and somewhat dynamic area) and negative in Area 5 (non agglomerated area). Within effect in Area 1 (new and dynamic area) is still negligible. It is noted that within effects are positive and significant in Area 2 (old and least dynamic area), Area 3 (old and most dynamic area) and Area 4 (old and somewhat dynamic area) accounting for 26 percent to 81 percent productivity growth.

Table/Figure 3-9a: Within effects by region: LP

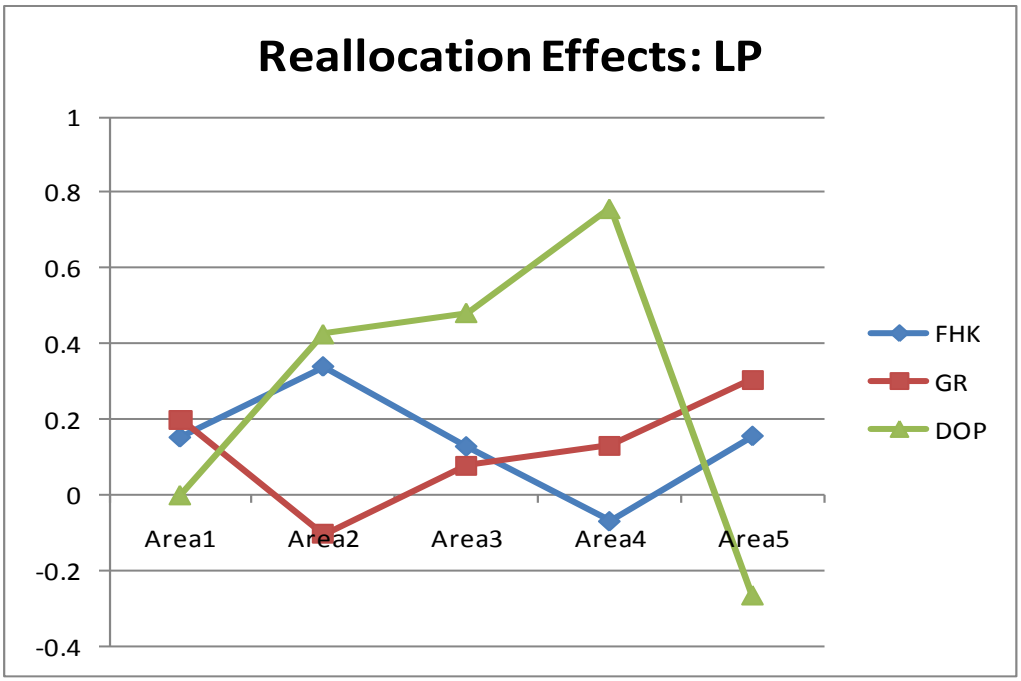


Table/Figure 3-9b: Within effects by region: TFP

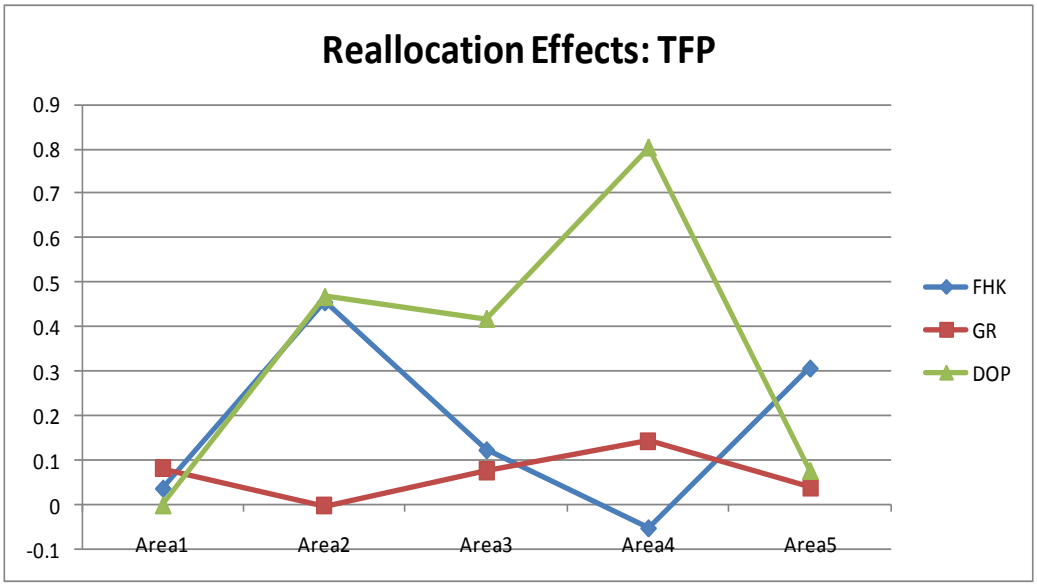


Reallocation effects: Reallocation effects as presented in table/figure 3-10 indicate that for both the LP reallocation effects are positive in Area 3 (old and dynamic area) and for TFP it is positive in Area 2 (old and least dynamic area) and Area 5 (non agglomerated area).

Table/Figure 3-10a: Reallocation effects by region: LP



Table/Figure 3-10b: Reallocation effects by region: TFP



4. Concluding Remarks

This paper investigates the effects of plants' dynamics on productivity growth in the Indian pharmaceutical industry across five regions: north, north-west, west, south and the rest of India, during the period from 2000-01 to 2005-06, using the unit-level panel database drawn from the

Annual Survey of Industries. The selected regions differ in the degree and age of agglomeration of the pharmaceutical industry. The empirical analysis is based on the decomposition methodology of aggregate productivity growth. This methodology decomposes productivity growth between two points in time into the contribution from four broad factors: improvement in incumbents' productivity (within effect), reallocation of resources from less productive to more productive producers (reallocation effect), entry of more productive firms (entry effects), and exit of less productive firms (exit effect). This study used the methods developed by Griliches and Regeve (1995), Foster, Haltiwanger, and Krizan (2001), and Melitz and Polanec (2009). The analysis uses two commonly used measures of productivity, namely labour productivity and total factor productivity.

Our empirical findings reveal that productivity growth is relatively higher in the agglomerated regions: Area 1, Area 2, Area 3 and Area 4. Further, the effects of plant dynamics on productivity growth differ depending on the age and dynamism of agglomeration. Rather large positive entry effects are found in the Area1 where the formation of agglomeration is a recent phenomenon. In the Area3 which has been a mature and most dynamic agglomeration reallocation effects of surviving plants are large and robustly positive. In Area2 and Area4 however 'within effects' of surviving plants are robustly positive. We have found no robust results on exiting effects in any region. There thus seems to be a systematic relationship between the maturity and dynamism of agglomeration and the composition of productivity growth. The largest contribution to TFP growth comes from within-firm efforts in a less dynamic but mature agglomeration while reallocation effects contribute majorly to TFP growth in a highly dynamic agglomeration. In a new and dynamic agglomeration entering firms push the level of TFP in upward direction.

In our study, there is a risk of underestimation of the entry effect on industry productivity growth as the decompositions fail to account for indirect effects of entry on the productivity of incumbents. The measured within and between plant effects could in part be due to entry. But this indirect effect of entry is not captured in these methodologies. We plan to explore the indirect effects in the second stage of this research. However the present analysis provides useful insights on the process of business dynamism taking place in the Indian pharmaceutical industry. This research thus calls for more research in this area.

References

Aggarwal, A. and T. Sato (2011) ``Firm Dynamics and Productivity Growth in Indian Manufacturing: Evidence from Plant level Dataset, " *RIEB Discussion Paper Series,* DP2011-07.http://www.rieb.kobe-u.ac.jp/academic/ra/dp/English/DP2011-07.pdf

Baily, M. N., C. Hulten and D. Campbell (1992) ``Productivity Dynamics in Manufacturing Plants," *Brookings Papers on Economics Activity: Microeconomics*, 2, pp. 187-249.

Chaudhuri, S. (2005) *The WTO and India's Pharmaceuticals Industry Patent Protection, TRIPS, and Developing Countries,* Oxford University Press.

Department of Industrial Policy and Promotion (DIPP) (2003a) ``New Industrial Policy and other concessions for the state of Uttaranchal and the state of Himachal Pradesh,*"* http://dipp.nic.in/ut_hp.htm.

Department of Industrial Policy and Promotion (DIPP) (2003b) ``Central Grant or Subsidy for Industrial units in the states of Uttranchal and Himachal Pradesh with a view to accelerating the industrial development in the States," http://dipp.nic.in/incentive/capinvsub_uthp.htm.

Department of Pharmaceuticals (2010) *Annual Report 2009-2010,* http://www.pharmaceuticals.gov.in/

Ebert, R. and D. McMillen (1999) Agglomeration Economies and Urban Public Infrastructure in Handbook of Regional and Urban Economics Vol.II edited by E.S. Mills and P. Chelshire. Elsevier Science Publisher

Foster, L., J. Haltiwanger, and C.J. Krizan (2001) ``Aggregate Productivity Growth: Lessons from Macroeconomic Evidence', in C.R. Hullten, E.R. Dean and M.J. Harper (eds.) *New Developments in Productivity Analysis,* Chicago University Press, pp.303-63.

Fujita, M. and Thisse, J.F. (2002) *Economics of agglomeration: Cities, Industrial Location, and Regional Growth*, The Cambridge University Press.

Government of Andhra Pradesh (2000) ``Industrial Policy 2000-2005," http://www.aponline.gov.in/Quick%20Links/Industrial%20Policy/Industrial%20Policy.pdf.

Government of Andhra Pradesh (2001) ``Biotechnology Policy 2001," http://www.aponline.gov.in/quick%20links/industrial%20policy/biotechnologypolicy.pdf.

Government of Goa (2003) ``Industrial Policy 2003," http://www.goachamber.org/cms/index.php?option=com_content&task=view&id=72&Itemid=16.

Government of Gujarat (2003) ``Industrial Policy 2003," http://www.gujaratindia.com/business/industrial-policy2003.htm.

Government of Haryana (1999) ``Industrial Policy, 1999," http://haryana.nic.in/policies/policies.htm.

Government of Haryana (2002) ``Biotechnology Policy-Haryana," http://www.dstharyana.org/biotech%20eng.doc.

Government of Himachal Pradesh (2004) ``Industrial Policy, 2004," http://himachal.nic.in/industry/newindustrypolicy2004.pdf.

Government of Karnataka (2001)``The Millennium Biotech Policy," http://www.bangaloreitbt.in/worddocument/pdf/Biotech_Policy_II.pdf

Government of Maharashtra (2001a) ``Industrial Policy 2001," http://www.maharashtra.gov.in/pdf/GOM_IndPolicy.pdf.

Government of Maharashtra (2001b) ``Maharashtra Biotechnology Policy 2001," http://www.midcindia.org/Lists/Policies%20Circulars%20and%20Notification/Attachments/2/BioTechPolicy.pdf.

Government of Punjab (2003) ``Industrial Policy, 2003," http://www.pbindustries.gov.in/downloads/INDUSTRIAL%20POLICY.pdf.

Governmet of Tamil Nadu (2000) ``Biotechnology Policy of Tamil Nadu," http://investingintamilnadu.com/tamilnadu/doc/policy/Tamil_Nadu_Biotechnology_Policy.pdf.

Government of Tamil Nadu (2003) ``Tamil Nadu New Industrial Policy-2003," http://www.dcmsme.gov.in/policies/state/tamilnadu/TAMILNADU2003New.pdf.

Government of Uttarakhand (2003) ``Industrial Policy, 2003," http://www.sidcul.com/sidculweb/Attachments/IP2003English.pdf.

Griliches, Z. and H. Regev (1995) ``Firm Productivity in Israeli industry 1979-1988," *Journal of Econometrics*, 92, pp.175-203.

Hoover, E (1937), Location Theory and the Shoe and Leather Industries, Harvard University Press, Cambridge.

IBEF (2010) *HARYANA*, http://www.ibef.org/download/Haryana_190111.pdf.

Kamiike, A. (2008) ``A Survey on the R&D System of the Indian Pharmaceutical Industry," *SPF India Study Group Working Paper Series*, No. 15.

Kamiike, A. (2009) ``Pharmaceutical Industry," in H. Esho and T. Sato (eds.), *India's Globalising Political Economy*, Sasakawa Peace Foundation.

Levinsohn, J. and A. Petrin (2003) ``Estimating Production Functions Using Inputs to Control for Unobservables," *The Review of Economic Studies*, Vol.70 (2), pp.317-341.

Maharashtra Industrial Development Corporation (MIDC) (2009) ``Destination Ahead-Maharashtra Pharmaceutical Sector," http://midcindia.org/Sector%20Profile/Pharma_sector_profile.pdf.

Marshall, A. (1920), Principles of Economics, MacMillan, London.

Melitz, M. J. and S. Polanec (2009) ``Dynamic Olley-Pakes Decomposition with Enty and Exit," *MICRO-DYN Working Paper* no.03/09, September.

National Pharmaceutical Pricing Authority (NPPA) (2007) *Directory of Pharmaceutical Manufacturing Units in India 2007*, New Delhi, http://www.nppaindia.nic.in/Directory-NPPA.pdf.

Ohlin, B. (1933) *Interregional and International Trade*, Harvard University Press, Cambridge

Olley, G.S. and Pakes, A. (1996) ``The Dynamics of Productivity in the Telecommunications Equipment Industry, " *Econometrica*,64(6), pp.1263-9.

Pharmexcil (2009) *Annual Report 2008-2009.*

Planning Commission (2002) *Eleventh Five Year Plan*.

Rosenthal, S. and W. C. Strange (2004)``Evidence on the nature and sources of agglomeration economics'', in J.V. Henderson and J.-F. Thisse (eds.)*Handbook of Regional and Urban Economics*, Volume4, pp.2119-2171

Schumpeter, J. (1942) *Capitalism, Socialism and Democracy*, New York: Harper & Row.

Reserve Bank of India (2009) *Handbook of Statistics on the Indian Economy 2008-2009.*