WHAT LIES BENEATH: A CASE FOR DISAGGREGATED

ANALYSIS IN EVALUATING STRUCTURAL POLICY SHIFTS

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Abstract

Much of the theoretical and empirical research regarding the impact of policy shifts on the economies of developing countries has tended to focus on macro-level aggregates, without adequate attention to sectoral-level dynamics. In the literature where such dynamics are emphasized, the focus has primarily been on the Latin American experience, where macro-economic instability can be attributed to the impact of structural reforms on the sectoral-level dynamics of these economies. What appears to be missing from the present literature is an adequate consideration of scenarios in which seemingly positive trends in macro-level aggregates could sometimes mask problems of concentrated productivity and employment growth that exist at the sectoral level. It is this aspect that this paper seeks to address more closely. By focusing on the Indian manufacturing sector in the pre-and the post-liberalization periods, this paper shows that positive trends in aggregate productivity may sometimes hide problems of structural heterogeneity and concentrated employment growth. This in turn suggests that in developing countries with high open and disguised unemployment, sustainable growth and development requires that liberalization policies be complemented by active industrial and employment generation policies on the part of the State.

1. Introduction

There has been a considerable amount of theoretical and empirical research regarding the impact of policy shifts on the economies of developing countries. However, much of this research has tended to focus on macro level aggregates, without adequate attention to the dynamics that operate at a more disaggregated, or sectoral level.

This paper emphasizes the need for a more disaggregated approach by focusing on the industry-level dynamics underlying the catch-up of productivity levels in developing countries with those in developed countries. If a catch-up observed at the aggregate level is concentrated in a few industries of the economy, and is not accompanied by a relatively uniform generation of employment in different activities, it would exacerbate the employment problem in developing countries that typically have large amounts of surplus labor, with non-negligible (often significant) fractions of the population engaged in precarious forms of self-employment.

For purposes of analysis, this paper focuses on the productivity and employment trends in the Indian manufacturing sector prior to and following the initiation of the liberalization process in 1991.

The rest of this paper is organized as follows. Section two provides a brief preliminary discussion of the need for a disaggregated approach with the help of an illustration. Section three reviews the existing literature on the links between structural shifts in policy, productivity and economic growth. Section four spells out the theoretical framework underlying the analysis presented in this paper. The industrial policy regimes characterizing the pre- and the post-liberalization periods in India are also briefly

discussed. The results of the analysis, along with a discussion of what they appear to suggest are presented in section five. Section six concludes.

2. Need for a Disaggregated Approach

Arguments concerning the impact and desirability of policies, particularly those involving greater liberalization have tended to adopt a more macro approach. For instance, arguments to stress the superiority of an export promotion strategy over import substitution have emphasized the positive impact of this strategy on the rate of investment, on enhancing the efficiency of domestic resource allocation (e.g. Srinivasan and Bhagwati, 1999) and on the balance of payments. While undoubtedly important, macro analysis alone can often lead to misleading conclusions regarding the efficacy of particular policies. For instance, in the case of India, as indicated by the results shown in Table 1, at the macro, or aggregate level, in the post-liberalization period, productivity has been catching up with that of the US[1].

TABLE 1: AVERAGE RATE OF CATCH-UP IN INDIA RELATIVE TO THE US

	Average rate of catch-up
Pre-Liberalization (1977-1990)	0.877163
Post-Liberalization (1991-2002)	1.197067

Source: Madisson, 2001 and author's calculations.

However, this indicates nothing about the dynamics in operation at the sectoral level- whether this catch up has been relatively uniformly spread across different economic activities or concentrated in a few activities; and whether it has been accompanied by

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[1] To calculate the average rate of catch-up, I first calculate the technology gap (or the catch-up) for each year, where the technology gap is the ratio of the productivity index in India to the productivity index in the US, with base year 1990. For details of the procedure used, see the Appendix.

greater employment generation. Furthermore, there is no way to gauge the quality of jobs created, i.e. whether employment is being generated in high-productivity or in low-productivity sectors. If the catch-up has been concentrated in a few sectors, and has not been accompanied by significant employment growth in high-productivity activities, it is a cause for concern since open and disguised unemployment continues to be a central problem in India.

3. Literature Review

When discussing the potential technological benefits that are likely to result from liberalization, particularly with respect to trade, the traditional theoretical literature has emphasized factors such as the minimum efficient size of plant, increasing returns to scale, indivisibilities in the production process, and the necessity for competition (Krueger, 1980). It has also been argued (e.g by Bhagwati (1982) and Bhagwati and Srinivasan (1999)) that policies of export promotion can act as a check against inefficiencies such as directly unproductive profit seeking activities. Not much consideration has been given to the possibility that the structural transformations that result from such policy changes may offset some of these potential benefits.

The importance of structural dynamics in determining the impact of structural policy shifts on aggregate productivity and growth has been emphasized by the Latin American structuralist school e.g. Fanelli and Frenkel (1995), Ocampo and Taylor (1998), Cimoli and Katz (2002), Cimoli and Correa (2002), Ocampo (2003). According to this literature, the ability to inject dynamism, or to propagate technical progress differs across different sectors of an economy. Through the complementarities generated between enterprises and production sectors, and through macroeconomic and distributive effects, structural

changes can either produce virtuous circles of rapid economic growth, or can block the process of growth by giving rise to low growth traps.

Looking at the Latin American scenario in the mid-1990s, Fanelli and Frenkel (1995) emphasize that there exists a two-way interaction between the structural characteristics of an economy (or micro-level factors) and the restrictions of macroeconomic consistency. Whether or not sources of macroeconomic instability can be eliminated through structural reforms depends on the disequilibria that these reforms generate at the aggregate level (primarily with respect to the external sector, fiscal accounts and the balance between savings and investment), and the effects of these disequilibria on the productive base of an economy (through their effects on economic agents' decisions).

Ocampo (2003) identifies the dynamics of production structures to be the outcome of the interaction between three forces, viz. 1) innovations[2]; 2) the complementarities among firms and production activities, including the institutions required for the full development of such complementarities; and 3) elastic factor supplies for innovative activities. With respect to this last force, labor is perhaps the most important elastic factor supply in developing countries[3]. This elastic labor supply plays an important role in the growth process that typically involves reallocating labor towards economic activities involving higher productivity (or activities subject to economies of scale and scope).

Ocampo goes on to develop a theoretical model that captures the dual link between productivity and growth, and shows that structural changes resulting from policies of liberalization could be sufficiently adverse so as to offset the positive microeconomic

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[2] Innovations refer to new activities; new ways of performing previous activities and the learning processes associated with utilizing and diffusing the potentialities of these new activities and methods (Ocampo, 2003).

[3] In developing countries, labor supply tends to be elastic because of the simultaneous existence of both high and low productivity activities- what the structuralist literature refers to as *structural heterogeneity*.

links (the increase in innovation and hence productivity that results from increased competition) of liberalization.[4]

Empirical support for structuralist writings on the dynamics of the economic growth in developing countries is provided by the Latin American experience in the post-liberalization period. According to Cimoli and Katz (2002), in the last two decades, following the adoption of liberalization and market deregulation, the Southern Cone Latin American countries- Argentina, Brazil, Chile and Colombia- have appeared to specialize in natural resource-based industries, with the share of these industries in total manufacturing output increasing by non-negligible amounts[5]. As against this, Mexico has witnessed an increase in the share of the maquila (or assembly)-type industries, including the vehicle industry (which has also received special policy treatment during the liberalization process) .[6] Many of these maquila activities have had a unit import content as high as 98 per cent. All of these specialization activities have been directed towards the world markets. By treating the evolution of labor productivity in the US as the productivity frontier, the authors show it is precisely in these activities that the Latin American countries have managed to narrow the relative productivity gap, reflecting a concentrated rather than a uniform improvement in productivity.

The adverse impact that these structural changes have had is reflected in the poor productivity and economic growth performance of these countries at the aggregate level.

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[4] The adverse structural effects arise when liberalization results in specialization in activities involving weak dynamic economies of scale, which could act to destroy domestic linkages and previous technological capabilities. This has been observed in the case of Latin America, where post-liberalization, specialization (based on factor endowments) has given rise to production activities that involve low domestic value addition, and that significantly rely on external sources of technological change and productivity growth.

[5] As per the evidence provided by the authors, from 1970 to 1996, the share of these industries in total manufacturing output increased from 36.2 per cent to 45.7 per cent for Argentina; 35.8 to 42.4 per cent for Brazil; 43.2 to 56.2 per cent for Chile and from 45.7 to 51.2 per cent for Colombia.

[6] The share of the automotive industry in total manufacturing output of Mexico increased from 5.5 per cent in 1970 to 10.8 per cent in 1996.

As per the evidence presented in Cimoli and Correa (2002), the average rate of GDP growth has declined sharply from the pre-liberalization (1950-80) rate of 5.5 per cent to a rate of around 3.3 per cent during the period 1990-2000. Further, for most of the Latin American countries, although the ratio of domestic productivity growth to the productivity growth of the US (what the authors call, the *technology gap*) has been increasing (i.e. the technology gap has been narrowing) over time, it continues to be less than one, indicating that the productivity convergence in selected sectors has not been translated into productivity convergence at the aggregate level[7].

The above literature suggests that the nature of the dynamics generated at the sectoral level is crucial in determining the observed growth and productivity patterns at the aggregate level. However, most of this literature has been developed to explain the experience of Latin America, where macro-economic instability has been driven by the impact that these reforms have had on the sectoral level dynamics of the Latin American economies. What appears to be missing from this literature is an adequate consideration of the opposite situation in which seemingly positive trends in macro aggregates could sometimes mask problems of concentrated productivity and employment growth that exist at the sectoral level. It is this aspect, which appears to be relevant in the case of India, and its implications that this paper seeks to address more closely.

Also missing from the current literature is a similar kind of disaggregated analysis of the structural dynamics underlying the recent rapid growth of economies in Asia. As discussed in the introduction, this kind of an analysis is relevant to examine whether positive trends in aggregate productivity and growth are likely to help address the problems of underemployment, unemployment and poverty in developing countries that

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[7] A more detailed explanation of the technology gap is provided in the next section.

have a large surplus labor force, with many dependent on precarious forms of self-employment.[8]

4. Analysis Procedure- Time Periods and Theoretical Framework

This paper focuses on the Indian agriculture and manufacturing sectors and analyzes how productivity (or technology) catch-up and employment growth has been changing for agriculture and different manufacturing activities in the post-liberalization period, compared to the pre-liberalization period. The technology catch-up is calculated by treating the US as the technology frontier.[9] Thirteen manufacturing sector categories are considered (see Appendix for the categories considered). The analysis of productivity performance is conducted by comparing the average rate of technological catch-up observed in the pre and the post-liberalization periods. For a detailed discussion of the procedure used to calculate the average rate of technology catch-up and employment growth rate, and for the data sources, see the Appendix.

Time Periods

For both agriculture and manufacturing activities, the period of analysis is divided into two time periods- the pre-liberalization period (1977-90), and the post-liberalization period (1991-2002).

At this stage, it would be a good idea to provide a brief outline of the industrial policy structures characterizing the pre- and post-liberalization periods. Prior to the initiation of the liberalization process in 1991, through policies and objectives spelt out in the five-

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[8] Admittedly, employment generation must be complemented by concrete policy efforts to improve access to health care, food and shelter; the distribution of income; and the access to education.
[9] The author acknowledges that the US may not be the ideal country to treat as the technological frontier for all the manufacturing sector categories. However, the US is used as an approximation since it has been at the forefront when it comes to technical progress, innovation, and the adoption of best practices in production activities.

year plans, the State played a critical role in India's industrialization process. The distinguishing aspects of the pre-liberalization industrial policies involved the licensing of industrial activity; reservation of key economic activities for the state; import substitution strategies aimed at developing industry and self-reliance; controls over the FDI and technology transfer of large domestic firms; interventions in labor markets to protect labor and the promotion of small scale industry to ensure that the poor have access to the benefits of development. These five year plans played a vital role in developing India's self-reliance, allowing the development of basic and heavy industries that are crucial to long-term growth of any economy. However, licensing also fostered a bureaucratic framework that gave rise to corruption. Measures to address this problem began in the late 1970s with some relaxation of the licensing requirements. However, the State continued to play a prominent role in industrial allocation.

It was in the middle of 1991 that there was a major structural shift in policy, with the driving force of resource allocation shifting in favor of the market. The main reason for this structural shift was the foreign exchange crisis of July 1991, with India on the verge of defaulting on its external debt payments. The structural reforms that resulted covered all the major aspects of the Indian economy- finance, the public sector, subsidies, agriculture, banking and manufacturing.

With respect to manufacturing, the reforms signaled the end of the license raj and the reservation of many areas of economic activity for the state. Restrictions on the inflow of foreign capital and technology transfer were relaxed, as were restrictions that had been previously imposed on large industrial houses. The reforms eliminated the quantitative restrictions on the imports of raw materials, intermediate and capital goods. There was

also a sharp reduction in tariff rates, although tariff rates on consumer goods remained high. The exchange controls that had existed prior to 1991 were simplified and the partial convertibility of the Indian rupee was established. [10]

According to the conventional economic arguments favoring liberalization, such measures should act to harness competition, and thereby improve efficiency in manufacturing activities. Undoubtedly, licensing systems are wrought with inefficiencies, and their abolition helps to check the corruption and inefficiencies that these systems foster. But what these arguments miss is that the problem of development is not just one of allocating resources efficiently in the production process. It is also one of being able to improve productivity and generate adequate employment opportunities uniformly across different activities. The concentration of productivity improvements and employment growth in a few activities would limit the positive impacts of liberalization as far as the productive base of the economy, and inclusive growth and development is concerned. And, in the context of a developing country like India that has large surplus manpower, this would re-affirm the need for more active industrial and employment policies. This is why a disaggregated approach is so necessary before drawing conclusions about the efficacy of policies solely based on positive macro-level trends.

Theoretical Framework

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[10] It is important to note that liberalization in India has been much more modest, compared to the liberalization policies adopted in the case of countries in Latin America and South East Asia. This is particularly so in the case of financial liberalization. The fact that complete capital account convertibility has not been introduced, and is unlikely to be introduced in the near future (given the current world financial crisis) is a prime example. The differences in the nature of liberalization adopted, and the different experiences of different countries after liberalization suggest that the question is not so much whether liberalization per se will have positive or negative impacts (and hence whether it is good or bad). Rather, it is a question of how liberalization is adopted, and whether it is complemented by other policies and checks and balances that may also have a crucial part to play in the growth and development process of a country.

The theoretical framework and the assumptions underlying the analysis come from

Kaldor (1966)[11], specifically what has come to be referred to as *Kaldor's first law*- there

exists a strong positive relation between the growth of manufacturing output and the

growth of GDP. Kaldor identifies two main reasons that account for this positive

relationship. *One*, the expansion of industrial production and employment make it

possible to draw labor resources from sectors having open or disguised unemployment

without diminishing the output of these sectors.[12] *Two,* there exist increasing returns of a

static (related to the size and scale of production units) as well as dynamic nature (arising

from learning-by-doing, external economies in production, etc) in industry.

There may be concerns over the exclusion of the financial and the services sector from

the analysis, since both have shown a significant growth in India in the last decade.

However, the exclusion of these two sectors is unlikely to significantly distort the results

of the analysis. For one, it is difficult to measure productivity for the services sector that

comprises a host of different activities ranging from personal services like hair-dressing

to activities like tourism, and, more recently, business process outsourcing (BPO). This

heterogeneity makes it even more difficult to have any meaningful interpretation of

productivity trends. For another, it is again less meaningful to talk of productivity and

catch-up with respect to the financial sector, as is evident from the current financial crisis.

Equally importantly, productivity improvements in both these sectors, e.g. in the methods

adopted with respect to BPO activities, in the provision of credit and other forms of

finance and bank services are more likely the result of productivity improvements in

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[11] For a more recent application, see McCombie and Thirlwall (1994).
[12] As discussed in the previous section when looking at the determinants of structural dynamics, this is a necessary transformation for growth in developing countries like India where both these problems exist. Generally, it is the agricultural sector that has acted as the sector that absorbs surplus manpower in these countries, which is why it is also necessary to account for the dynamics in this sector.

certain manufacturing categories, most notably Information Technology, so that their exclusion does not imply the neglect of important contributors to productivity catch-up.

5. Results

The average rate of technology catch-up in India for 13 manufacturing sector categories is shown in Table 2 for the pre- and post liberalization periods. The sectors where the average rate of catch-up appears to show an increase in the post-liberalization period are indicated in bold.

TABLE 2: AVERAGE RATE OF TECHNOLOGY CATCH –UP IN INDIAN

MANUFACTURING IN THE PRE AND POST LIBERALIZATION PERIODS

	Pre-Liberalization (1977-90)	Post-Liberalization (1991-2002)
Food and beverage and tobacco products	0.060749	0.019819
Textile mills and textile product mills	0.022652	-0.02757
Apparel and leather and allied products	**-0.03089**	**0.577587**
Wood products; Furniture & Fixtures	**0.015233**	**0.058453**
Plastics and rubber products &Petroleum	0.03565	0.004075
Chemical products	0.06068	0.035679
Nonmetallic mineral products	0.067274	0.058174
Paper products &Printing	0.062955	-0.02297
Primary metals	**0.015667**	**0.035701**
Fabricated metal products &Machinery	0.072299	0.024892
Electrical equipment, appliances, and components	0.060079	0.00689
Motor vehicles &Other Transportation	**0.04872**	**0.062625**
Miscellaneous manufacturing	0.101639	0.044778

The results presented in the above table suggest that post-liberalization, the average rate of technology catch-up has shown an increase in only four of the manufacturing sectors, viz. apparel and leather; wood products and furniture; primary metals and motor vehicles. In other words, it is in these four sectors that Indian productivity appears to be increasing more rapidly relative to US productivity.

The greatest surge appears to be in apparel and leather, where the average rate of catch up shows a significant improvement from a negative value of -3.1 per cent in the pre-

liberalization period to an average rate of approximately 57.8 per cent post-liberalization. The next best improvement appears to be in wood products and furniture, where the average rate of catch-up rises from approximately 1.5 per cent in the pre-liberalization period to approximately 5.8 per cent in the post-liberalization period. Primary metals and motor vehicles show more modest (but not insignificant) increases.

For the remaining nine sectors, the average rate of catch-up appears to have slowed down in the post-liberalization period. In the case of textiles and paper products, the rates of catch up have in fact turned negative in the post-liberalization period. The rate of catch-up in electrical equipment, appliances and components has declined particularly sharply from around 6 per cent pre-liberalization to around 0.69 per cent during the post-liberalization period.

Table 3 shows the average growth rate of employment in each of the 13 sub-sectors of the manufacturing sector for the pre and post-liberalization periods.

TABLE 3: AVERAGE RATE OF EMPLOYMENT GROWTH PRE AND POST LIBERALIZATION IN THE MANUFACTURING SECTORS

	Pre-liberalization (1977-90)	Post-liberalization (1991-2002)
Food and beverage and tobacco products	0.012365	0.022962
Textile mills and textile product mills	-0.00048	-0.01548
Apparel and leather and allied products	**0.042299**	**0.030545**
Wood products, Furniture &Fixtures	**0.000528**	**-0.02027**
Plastics and rubber products &Petroleum	0.051049	0.015653
Chemical products	0.014625	0.019338
Nonmetallic mineral products	0.014374	-0.01459
Paper products &Printing	0.011005	-0.00639
Primary metals	**0.022801**	**0.012645**
Fabricated metal products &Machinery	-0.01151	0.002363
Electrical equipment, appliances, and components	0.027939	-0.00431
Motor vehicles& Other Transportation	**0.019246**	**-0.00363**
Miscellaneous manufacturing	-0.01963	0.106728

The above table shows that in the post-liberalization period, the average rate of employment growth has decreased in each of the four sectors where productivity appears to be catching up (indicated in bold). For two of these sectors, viz. wood products, furniture &fixtures; and motor vehicles, the average rate of employment growth has turned negative in the post-liberalization period, suggesting that employment has been slowing down in these sectors.

For the sectors where productivity does not appear to be catching up, the results are mixed. The average growth rate of employment has shown an increase in food, beverage and tobacco products; chemical products; fabricated metal products and machinery and in miscellaneous manufacturing. But in the remaining five sectors where catch-up has not been observed, the average rate of employment growth has been lower in the post-liberalization period. In fact, it has turned negative in three sectors, viz. paper and printing; electrical equipment, appliances and components; and non-metallic mineral products.

Thus overall, in the post-liberalization period, both productivity catch-up and employment growth have been concentrated in a few manufacturing activities, with the latter showing an increase in only five activities that have not shown an improvement in productivity.

To get a clearer picture of what these trends indicate, it is also necessary to consider the average rates of catch-up and employment growth for the agricultural sector. This is in line with Kaldor's argument that the growth of the manufacturing sector makes it possible to employ manpower from sectors with open or disguised unemployment without adversely affecting their output. In the Indian context, disguised unemployment is certainly prevalent in the agricultural sector where a majority of land holdings are small and fragmented. As such, even though employment growth appears to be increasing in low-productivity manufacturing activities, it could still be regarded as a relative improvement if more people are moving from agriculture to manufacturing. Table 4 shows the average rates of catch-up and employment growth for the agricultural sector in the pre- and post-liberalization periods.

TABLE 4: AVERAGE RATE OF TECHNOLOGY CATCH-UP AND

EMPLOYMENT GROWTH IN THE INDIAN AGRICULTURAL SECTOR

	Pre-Liberalization (1977-90)	**Post-Liberalization (1991-2002)**
Average Rate of Catch-Up	-0.008339885	0.00234
Average Rate of Employment Growth	0.013151078	-0.0047

As per the results shown in the above table, the average rate of employment growth in the agricultural sector has slowed down in the post-liberalization period. It is therefore possible that there has been some shift from the agricultural sector to manufacturing activities. Although these may be manufacturing activities which do not appear to be catching up, a comparison of tables 3 and 4 show that the average rate of catch-up for each of these activities is still higher compared to the average rate of catch-up observed in the agricultural sector in the post-liberalization period. As the above table indicates, although the average rate of catch-up in the agricultural sector has turned from negative to positive in the post-liberalization period, indicating an improvement in productivity, it continues to be very low at around 0.234 per cent. Thus, the growth of employment in the low-productivity manufacturing activities may be a partial improvement since it may have facilitated a shift of people from the agricultural sector where productivity performance was very low into manufacturing activities where productivity performance has been relatively better.

Nevertheless, such concentrated improvements in productivity and in the growth of employment should be a cause for concern because their ability to significantly address the problem of open and disguised unemployment is still going to be small. Rather, what is crucial to the process of growth in countries like India is a relatively uniform improvement in productivity performance across different economic activities accompanied by the generation of adequate employment opportunities across these activities. In other words, a crucial element in the process of development is a shift of the population from low-productivity to high-productivity activities. Such a shift is one of the major elements in enabling more people have a greater share in the benefits of aggregate growth and productivity improvements.

This disaggregated analysis also reinforces the need for an adequate consideration of sectoral-level dynamics before drawing inferences from trends observed at the aggregate level. Two main results emerge from the above analysis. The first is that the Indian manufacturing sector appears to be experiencing the problem of structural heterogeneity (the simultaneous existence of low-productivity and high-productivity activities). The second is that employment growth has been concentrated in a few manufacturing activities. Both these aspects would be invisible if one were to confine oneself to productivity performance at the aggregate level. More generally speaking, this analysis reaffirms the argument made at the beginning of this paper- that seemingly positive trends in aggregate variables could sometimes mask problems such as structural heterogeneity and concentrated employment growth that exist at the disaggregated level of an economy.

6. Conclusion

The central message of this paper is that an effective assessment of structural policy shifts requires that enough attention be given to dynamics that operate at a more disaggregated level. Evaluating policies solely on the basis of positive trends in macro aggregates could mask problems of structural heterogeneity or dualism that exist at the sectoral level of an economy.

Concentrated improvements in productivity and in the growth of employment have a limited ability to address the problem of open and disguised unemployment. A crucial element in the process of growth and development is a shift of the population from low-productivity to high-productivity activities. This shift is one of the major elements in enabling more people have a greater share in the benefits of aggregate growth and productivity improvements. The analysis presented in this paper appears to suggest that policies of liberalization alone need not be able to achieve this transformation. While liberalization policies can help to check inefficiencies such as those observed in the case of licensing, the ability to transform the productive structure of the economy and productively absorb surplus manpower also requires that liberalization be complemented by industrial and employment policies. In other words, sustainable growth and development requires that there be a balance between policies of liberalization and active industrial and employment policies.

APPENDIX

Method of Analysis-Variables and Procedure

The method of analysis used in this paper relies partly on the theoretical framework

developed by Cimoli and Correa (2002). In their model, which was developed to explain

the poor productivity performance of Latin America in the post-liberalization period, the

authors incorporate a *technology gap multiplier* into the Harrodian trade multiplier.

The *technology gap* is defined as the ratio of the productivity growth rate in the

developing country to the productivity growth rate in the developed country, or what the

authors call, the *technological frontier*.

So, if π = the productivity growth rate in the developing country;

and π^* = the productivity growth rate in the developed country;

then the technology gap, ψ, is defined as

$$\psi = \frac{\pi}{\pi *}$$

If productivity in the developing country is growing faster than productivity in the

developed country, i.e. $\pi > \pi^*$, the value of ψ would be greater than one.

On the other hand, if productivity in the developing country is growing slower relative to

productivity in the developed country, i.e. $\pi < \pi^*$, the value of ψ would be less than one.

Thus for any sector or manufacturing activity, if the above ratio changes from less than

one to greater than one over time, it would indicate that productivity of the developing

country for that particular sector is catching up with the productivity observed in the

same sector at the technological frontier.

The analysis in this paper departs slightly from the above method by using productivity levels rather than growth rates to construct the productivity indices used to calculate the technology gaps.

The manufacturing activities considered in the analysis are shown in Table I.

TABLE I :MANUFACTURING ACTIVITIES INCLUDED IN ANALYSIS

1. Food and beverage and tobacco products
2. Textile mills and textile product mills
3. Apparel and leather and allied products
4. Wood products, furniture & fixtures, etc.
5. Plastics and rubber products and petroleum
6. Chemical products
7. Nonmetallic mineral products
8. Paper products and Printing
9. Primary metals
10. Fabricated metal products & Machinery
11. Electrical equipment, appliances, and components
12. Motor vehicles and other Transportation
13. Miscellaneous Manufacturing

The calculation of the average rate of catch-up involves four steps.

First, the productivity levels are calculated for the different activities for India and the US for every year.

Second, by treating 1990 as the base year (1990=100), the productivity indices are

constructed.

Letting *PRODY* denote productivity, the productivity indices are calculated as follows:

1) For t ≥ 1991:

Productivity index for year t

$$PI_t = PI_{t-1} \times \left[1 + \frac{PRODY_t - PRODY_{t-1}}{PRODY_{t-1}} \right]$$

2) For t < 1990

Productivity index for year t

$$PI_t = PI_{t+1} \times \left[1 + \frac{PRODY_t - PRODY_{t+1}}{PRODY_{t+1}} \right]$$

Third, the technology gaps, ψ_{it} are calculated as:

$$\psi_{it} = \frac{PI_{it}(India)}{PI_{it}(US)}$$

where PI_{it} (j) = country j's productivity index for activity i in year t; j = India, US;

and ψ_{it} = technology gap for activity i in year t.

Fourth, to analyze relative productivity performances for different activities for the pre-

liberalization and post-liberalization periods, the average rates of technological catch-up

are calculated for the two periods for each activity.

For each activity i, the rate of catch-up for each year is calculated as:

$$g_{\Psi i} = \frac{\psi_{it} - \psi_{i,t-1}}{\psi_{i,t-1}}$$

For the pre-liberalization period (1977-90), the average rate of catch-up for each activity

is then calculated as:

$$\frac{\sum\limits_{t=1978}^{1990} g_{\psi i}}{13}$$

Similarly, for the post-liberalization period (1991-2002), the average rate of catch-up for

each activity is calculated as:

$$\frac{\sum\limits_{t=1991}^{2002} g_{\psi i_i}}{12}$$

To analyze employment trends, the year-wise employment growth rate for each activity is

calculated by using the standard growth rate formula:

For each activity,

The growth rate of employment for year t = $\dfrac{Employment_t - Employment_{t-1}}{Employment_{t-1}}$

Next, these growth rates are used to calculate the average growth rates of employment for

the pre-liberalization and the post-liberalization periods for each category.

Data Sources

1) **Output Data**

For India, the data on output for agriculture and the different manufacturing sector

categories are from the publication brought out by the Central Statistical Organization

(CSO), *National Accounts Statistics Back Series, 1950-51 to 1999-00.* The data for the

years 2001 and 2002 are obtained separately from the CSO publication, *National*

Accounts Statistics 2008. Both these publications are accessible online on the official

website of the Ministry of Statistics, Government of India.

For the US, data on output and employment for the agriculture and different manufacturing sector categories are obtained from the official website of the Bureau of Economic Analysis (BEA). The output data for both India and the US are in 1999-2000 prices.

2) **Employment Data**

Data on Indian employment for the different manufacturing sector categories are obtained from the International Labor Organization (ILO) website . For the US, data on employment for the different manufacturing sector categories is obtained from the official website of the Bureau of Economic Analysis (BEA).

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