INTERNATIONAL TRADE AND PRODUCTIVITY GROWTH: Evidence from the Organised Manufacturing Sector in India

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R. Rijesh*

[***Abstract***: *The present study is an attempt to examine the impact of international trade on manufacturing productivity in India. The literature on international trade suggests that the productivity of domestic manufacturing sector will rise through the effects of economies of scale, reallocation, competition, and spillover channels from trade participation. To study the net impact of these effects on productivity, we constructed trade related variables such as relative import price, import penetration and export intensity for a panel of 17 2-digit organised manufacturing sector industries for the period 1980 to 2013. During this period, the Indian manufacturing sector witnessed considerable liberalisation and openness coupled with an increase in manufacturing growth and productivity, especially in the recent decades. There is evidence of a shift in the composition of sectors—from traditional labour-intensive products such as food, beverages, tobacco, and textiles, to modern-skill and knowledge-intensive industries such as chemicals, machinery, and transport equipment. This is accompanied by a noticeable growth in productivity, both labour productivity and total factor productivity, especially during the 2000s. The panel econometric estimation result, based on random effect modelling, reveals the presence of trade induced productivity gains in manufacturing. The productivity enhancing effects of economies of scale, reallocation and spillover largely operate through imports and become prominent after 1–2 year lag. However, in the short period, there is some evidence of dominance of negative economies of scale induced by import competition. Although we find a positive association between exports and productivity during all selected periods, the relationship is found to be statistically significant only in the current period. Overall, we find trade linked productivity gains being channelled through imports, which persist over time. This reveals that the impact of trade on manufacturing productivity in India is not static but dynamic in nature.*]

Keywords: *India, Productivity Growth, Trade, Manufacturing Sectors, Panel Estimation.*
JEL Classification: *F14, F15, L6, O33, O47*

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1. Introduction

Technological progress is arguably the most fundamental determinant of economic growth. Since the accumulation of physical capital is characterised by diminishing returns, the sustained economic growth requires significant amount of productivity growth, representing an outward shift on the production frontier. However, the conditions for technology generation are often non-existent in low income countries because of lack of sufficient market and resources to undertake risk-bearing investments in production technology. In this context, international trade provides an opportunity to increase market scale and access the wide range of technology in utilising production resources efficiently[1]. According to the standard trade theory, international specialisation provides static as well as dynamic benefits. The traditional trade theory predicts static welfare gains in terms of inter-sectoral specialisation according to comparative advantage while the new trade theory envisages the productivity induced dynamic gains from a combination of economies of scale and expansion of product varieties available to consumers (Bernard *et al*., 2007). Recent theories argue that the removal of trade barriers will induce substantial reallocation within sectors/industries, as less productive import-competing firms exit and the market shares reallocate towards more advanced productive firms, especially to the exporting plants (Melitz and Trefler, 2012; Melitz and Redding, 2014)[2]. Accordingly, the new trade theory predicts substantial sectoral level productivity gain from plant level heterogeneity[3] (see Melitz, 2003; Pavcnik 2002; and, Bernard *et al*., 2003).

The additional gains from participating in international trade are derived from the positive impact of larger markets on innovation (Melitz and Trefler, 2012) as emphasised in the theories of innovation-based welfare gains from trade among homogeneous firms (see Grossman and Helpman, 1991). Trade integration helps expand the choices of manufacturing firms to acquire technology inputs through knowledge-embodied imports or knowledgeable competitors, and protection that discourages this opportunity will limit growth (Grossman and Helpman, 1991). Theories of trade with imperfect competition argue that policies which constrain imports tend to raise market power of the domestic producers (Tybout, 2000). Accordingly, trade encourages adaptation of modern technology and process techniques that raise demand for skilled labour and encourage learning by doing. Empirical evidences do provide substantial presence of

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[1] Tybout (2000) argues that outward oriented development strategy will facilitate long-run growth provided technology diffuses through international transactions.

[2] According to Bernard *et al*. (2007), these welfare gains may be magnified if the increase in product market competition induced by trade liberalisation leads to lower markup price over marginal cost. In this case, the fall in markup and the rise in average productivity both contribute to lower prices and higher real incomes.

[3] Empirical studies for low income countries like Chile (Pavcnik, 2002) and the literature survey of Tybout (2003) finds dominance of "within" industry reallocation pattern since trade liberalisation.

such production gains[4]. The availability of productive and technologically superior factor inputs has been a major source of productivity gains for several countries, including Indonesia (Amiti and Konings, 2007), Chile (Kasahara and Rodiriguez, 2008), China (Ding *et al*., 2016) and India (Goldberg *et al*., 2010; Topalova and Khandelwal, 2011).

In the era of increasing economic integration, understanding the impact of trade orientation on industrial performance is essential, especially for an emerging economy like India. India's case is notably appealing as the policy emphasis in recent decades has shifted away from the relatively heavy protective import-substitution regime to a more liberal and outward oriented industrialisation strategy since the mid-80s. Since the onset of comprehensive economic policy reforms in 1991, the major thrust was to ease barriers to trade and raise the level of openness to improve efficiency and competitiveness of the domestic manufacturing sector. Needless to say, trade openness, measured by merchandise trade-GDP ratio, has increased substantially from 12 per cent in 1980 to 44 per cent in 2008[5]. During 1980–2013, the organised manufacturing sector witnessed a growth rate of 8 per cent per annum with an average share of 16 per cent in GDP[6]. Moreover, there is evidence of considerable productivity surge in recent decades (see Bollard *et al*., 2013; Goldar, 2015).

Although the empirical findings of the trade policy and productivity growth in Indian manufacturing are largely mixed, several recent studies show a positive impact, especially through imports (see, among others, Goldberg *et al*, 2010; Topalova and Khandelwal, 2011). Although studies have examined the issue of productivity and trade, and particularly the policy of trade liberalisation, most of them have not tried to disentangle the effects of trade on productivity growth. Instead of assessing the various channels of trade productivity linkages as per the theoretical propositions, studies have simply attributed causality by association (see Chand and Sen, 2002). That is, if productivity growth has increased in the post-reform period, then it was presumed to be associated with economic reform. Moreover, several authors have used dummy variables, representing a once-for-all type shift in trade policy regime (see, among others, Balakrishnan *et al*., 2000; Milner *et al*., 2007). Others have taken an *ex-ante* approach by taking trade policy instruments such as tariff and non-tariff barriers on manufacturing outcome. In contrast, the present study, based on the theoretical

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[4] See Helpman (2004) for country level evidences. The theoretical and empirical evidences of a positive causal link between market expanding effects of international integration and innovation is given in Lileeva and Trefler (2010).

[5] Trade openness is measured by taking the merchandise trade (Export-Import) share in GDP at current prices. The data is collected from World Development Indicators (WDI), World Bank online database. Since the global economic slowdown, the level of trade openness has reasonably declined and registered 32 per cent in 2015.

[6] The growth rate of manufacturing sector is based on data collected from the Annual Survey of Industries (ASI), CSO. Further details about data sources are given in section 3.2. The manufacturing share is based on value added share in GDP, collected from WDI, World Bank.

propositions, has used an *ex-post* analysis of trade induced impact on productivity growth in the organised segment of Indian manufacturing. The study is based on 17 manufacturing sectors at the 2-digit level for the period 1980–81 to 2013–14.

The rest of the paper is organised as follows. In section 2, a brief review of theoretical and empirical literature on trade and productivity with special focus on Indian manufacturing is given. Section 3 presents the econometric methodology data sources and construction of variables for the empirics. A descriptive analysis of the production, productivity and trade pattern of Indian manufacturing is given in section 4. The econometric model estimation results are given section 5. The final section 6 provides concluding remarks.

2. Literature Review

2.1 Trade and Productivity: Theoretical Propositions

We identify four channels through which international trade impacts manufacturing sector productivity[7]. These are elaborated as follows.

(a) Economies of Scale Effects

In autarky, the size of the domestic market constraints firms from obtaining an efficient scale of production. Trade removes this constraint as additional market opportunities allow firms to produce on a larger scale than otherwise possible. For a relatively small economy, exporting becomes an essential part of achieving economies of scale. According to Hung *et al*. (2004), scale-induced productivity growth can be achieved in two ways. Firstly, moving output to lowest point on the average cost curve through reduction in average fixed cost in the unit cost of output (along the cost curve effect). Secondly, the expectation of higher market opportunities, mainly by the exporting firms, provides additional incentives to undertake fixed-cost investments to boost relative efficiency over time (a downward shift of the average cost curve). While on the one hand, labour productivity improves as exports become the larger part of output, on the other hand, in import-competing firms, it falls as output shrinks[8]. Since trade liberalisation changes the relative prices of exports, productivity expands through increased awareness of best practice technology, production techniques and information which flows from the buyers in the world market (Paus *et al*., 2003).

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[7] For a detailed overview of these arguments, see Edwards (1998) and Tybout (2000). The present classification follows the discussion of Hung *et al*. (2004).

[8] Although theoretically appealing, the empirical studies have noted that scale economies can run both ways (see Rodrik, 1992; Tybout, 1992).

(b) Market Competition Effects

One of the likely effects of trade is that it raises the competitive pressure in the domestic market. Entry of competitive foreign products will force domestic import-competing producers to increase efficiency to maintain their competitive position without cutting profit margins (Weiss, 2002; Hung *et al.*, 2004). As imports create market disciplining effects, especially in import-competing and intra-plant sectoral changes, productivity improves (Pavcnik, 2002; Hay, 2001; Clerides *et al.*, 1998; and Ozler and Yilmaz, 2009) and the price-cost margin decreases because of import penetration (Krishna and Mitra, 1998; and Tybout and Westbrook, 1995). In the neo-classical framework, import competition will lower prices and induce firms to move down the short run cost curve. In the long run, firms will lower costs through investment in new technology and skill development. The implicit "challenge-response" mechanism induced by the competitive pressure will raise the entrepreneurial effort by reducing "managerial slackness" (Nishimizu and Robinson, 1984). This will force firm managers to eliminate agency issues and introduce innovative processes which help eliminate X-inefficiency[9] (Pavcnik, 2002; Tybout, 2000) and increase input efficiency over time (Fernandez, 2007). X-inefficiency can also decrease because of the exit of firms that have not been able to lower costs in line with the new long run prices[10]. This reduces monopoly rents, drives down margins, and reduces the costs for consumer goods. According to Hung *et al.* (2004), low-priced imported products force the import competing firms to improve productivity by investing in R&D, corporate restructuring, learning from foreign competitors through reverse engineering, or through imitating foreign competitors' production processes.

(c) Resource Reallocation Effects

Trade enables countries to specialise, based on comparative advantage, in the manufacture of those products which can be produced most efficiently. Accordingly, the traditional theory suggests reallocation of productive resources among different sectors in line with international opportunity cost and prices (Bhagwati, 1988; Bernard *et al.*, 2007). In contrast, the recent theoretical models predict a large within-sector reallocation where production tends to concentrate on the most efficient and productive firms. This plant level heterogeneity, in terms of larger size, skill and capital intensity, wages and productivity, creates substantial dynamic benefits (see Melitz,

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[9] X-inefficiency refers to intra-firm inefficiency, which can result from such factors as a suboptimal organization of the production process (see Leibenstein, 1966).

[10] In practice, the outcome is not straightforward. According to Tybout (2000), the effects of trade liberalization on the decisions of individual firms depend on industry structure and institutional setting. For instance, exit barriers may slowdown the long-run adjustment process. In addition, import-competing firms may decrease investment if competition reduces market size. In case domestic competition had previously been sufficient to keep inefficiency low, the effect of liberalisation on X-inefficiency would be rather small (see Paus *et al.*, 2003).

2003; Pavcnik 2002; Bernard *et al*., 2003, 2007). As the efficient import-competing firms survive and the less efficient firms exit, the average sectoral productivity increases (Hung *et al*., 2004). According to Melitz (2003), the new profit opportunities from trade exposure enable the most productive firms to raise factor demand, drive the least productive firms out of the market, and help most efficient non-exporters become exporters. Since exporting involves heavy sunk costs, it is expected that only high productive firms will enter foreign markets (self-selection hypothesis). After entry, firms learn and improve productivity through greater technological opportunities (learning-by-exporting hypothesis). As exporting firms expand and sectoral share increases, the overall productivity improves. A large empirical literature using firm level or plant level data documents, on average, a substantial productivity difference between exporters and non-exporters[11], providing sizeable evidence of self-selection but relatively modest evidence for learning-by-exporting firms in manufacturing (see Aw *et al*., 2011; Bernard *et al*., 2007)[12]. Further, the low-priced imports will displace domestic production in lower-productivity sector and release resources which can be reallocated to sectors having better technological opportunities, boosting the average productivity growth over time.

(d) Technology Spillover Effects

The endogenous growth models argue that a firm's internal production capability depends on the aggregate knowledge stock in the economy. International trade augment technology spillovers when domestic firms invest in R&D and skill upgradation, either to compete or to reap economies of scale, raising aggregate knowledge stock and overall productivity (Hung *et al*., 2004). Grossman and Helpman (1991) and Young (1991), while highlighting the sectoral difference in generation of technological progress through R&D, learning-by-doing and human capital accumulation, etc., argued that when trade expands the sectors having higher potential to generate technological progress through any of these sources, the industry can experience and sustain long-run economic growth. Trade provides technological spillovers through imports and exports to the trading partner countries (see Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991). Import of intermediate and capital goods can transmit benefits of new technology from exporting to importing countries. An easier access to low cost and/or high quality imported intermediate and capital

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[11] See Redding (2011) for a survey of theoretical development. For empirical studies based on microeconometric evidence on exporting and productivity performance, see Greenaway and Kneller (2007), Bernard *et al*., (2012) and Wagner (2012) and references therein.

[12] However, Van Biesebroeck (2005) finds some evidence of export induced learning effects on productivity growth in Sub-Saharan African manufacturing firms. This suggests that both effects may be prevailing in the market, as firms in international market may be inherently productive and may improve productivity through international knowledge dissemination and learning (Yasar and Paul, 2007).

goods can help firms to upgrade production technology by learning and adopting from the best practice technologies of foreign competitors (see Ethier, 1982; Hung *et al*., 2004; Amiti and Konings, 2007; Melitz and Trefler, 2012; and, Halpern *et al*., 2015). Similarly, import of final manufactured goods from technologically advanced countries allows low income countries to get familiar with technologically superior and quality products, which induces learning, reverse engineering or imitation. Likewise, exports present an opportunity for firms in developing countries to interact with foreign buyers and to learn new ways to improve products and production process that help in adopting best practice production technology to compete in the world market (Krueger, 1980).

2.2 Empirical Evidences

There exists a large body of literature which has examined the link between trade and productivity using a variety of econometric techniques and data sources[13]. The results are mixed. Generally, empirical studies using cross-country regression tend to support rising average efficiency levels from trade policy reforms (see Edwards, 1993, 1998; Ben-David, 1993; Tybout and Westbrook, 1995; and, Tybout, 2000). However, in general, country specific studies have largely been mixed (Havrylyshyn, 1990; Ozler and Yilmaz, 2009). For instance, Caves and Barton (1990) and MacDonald (1994), using various econometric techniques on U.S data, find a positive association between import penetration and technical efficiency or productivity growth. Some other studies that have reported similar results are Edwards (1998) for 93 advanced and developing countries for the period 1960 to 1990, Benjamin and Ferrantino (2001) for 13 OECD countries from 1980 to 1991, and Andersson (2001) from 1980 to 1995. Alcalá and Ciccone (2004) find an economically significant impact of trade on productivity after controlling for institutional quality, geography and endogeneity of trade policy. Similarly, Fernandes (2007) finds support for a strong impact of trade policy reform on productivity of Colombian manufacturing plants after controlling for unobserved heterogeneity, exchange rates and industry level cyclical factors.

On the other side, few studies have found ambiguous results (See Harrison, 1994; Harrison and Revenga, 1995). The studies that focus explicitly on the impact on productivity growth showed mixed results (see Yean, 1997; Pavcnik, 2002). Lawrence and Weinstein (2001) reported that imports contributed to TFP increases for Japanese, Korean and US manufacturing firms because of competition effects. Kim *et al*. (2009) found that imports, but not exports, make a positive and significant contribution to TFP for Korean manufacturing plants. Productivity enhancement resulted from increased competitive pressure, exposure to foreign final goods and technology embodied in capital goods imported from advanced countries. Plant level studies

[13] For a comprehensive survey of the literature, see Havrylyshyn (1990), Edwards (1998), Tybout (2000), and Singh (2010).

generally find support for trade-induced productivity growth effects but fewer consensuses on specific mechanisms through which this operates.

Empirical studies have tried to determine whether exports cause productivity to increase[14]. While a few studies have found evidence to indicate that causality runs from export growth to productivity growth (*e.g.*, Haddad *et al*., 1996), others suggest that causality runs from productivity to export growth (see Clerides *et al*., 1998; Pavcnik, 2002). Some of the studies that reported positive correlation between exports and productivity are Bonelli (1992), Nishimizu and Robinson (1984) and Weinhold and Rauch (1997). However, these studies did not clarify whether it is due to economies of scale, technological innovation, or other factors. Choudhri and Hakura (2000), for 33 developing countries for the period 1970 to 1993, found that effect of trade openness on productivity growth depends upon sector specific characteristics. Thangavelu and Rajaguru (2004) using a vector error correction model for nine rapidly developing Asian countries, including India, found that imports have a significant impact on labour productivity growth. This suggests that import-led growth is prevalent in Asian countries. They further noted that exports and imports have qualitatively different impacts on labour productivity across different countries.

2.2.1 Case of India

The existing empirical evidences on Indian manufacturing, especially during the initial phase of liberalisation, are not conclusive. The seminal study of Ahluwalia (1991) finds a significant negative relationship between import substitution and total factor productivity growth (TFPG) using the growth accounting and econometric estimation of production function for 63 3-digit industries. The study reported a notable turnaround in TFPG during the first half of the eighties, which the author attributed to the initial liberalisation policy initiatives. However, Balakrishnan and Pushpangadan (1994) challenged this finding based on several methodological issues related to productivity measurement. Das (1998) analysed the effect of output growth, import penetration rate and export growth on TFPG using a panel data of 53 3-digit level industries for the period 1980 to 1993. The results showed that the import penetration rate has a significant negative effect on TFPG in five cases. The export variables (measured by export growth rate and ratio of export to output) were significant only in one case out of 36 regressions estimated. Das (2004), using a panel of 75 3-digit industry product groups, found that an increase in factor accumulation rather than TFPG account for growth in output from 1980 to 2000. However, the study reports a lag effect of trade policy reform on TFP as some of the major industrial sectors such as the capital goods sector TFP improved during the latter half of the 1990s. Srivastava (2001) analysed the issue of trade policy reforms on productivity performance of Indian firms categorised at 17 2-digit level from 1980 to 1997. The panel data estimation for 3100 firms

[14] For a literature survey, see Greenaway and Sapsford (1994) and Wagner (2012).

from RBI revealed that at the aggregate level there was a significant decline in TFPG during the 1990s.

In contrast, some studies have found a positive impact of trade liberalisation on domestic productivity. Goldar and Kumari (2003) examined the effect of Effective Rate of Protection (ERP) and Non-Tariff Barriers (NTB) on TFPG using a panel of 17 2-digit industries for the period 1980 to 1997 and found that the restrictive trade policy retarded TFPG. Chand and Sen (2002), taking a subgroup of 30 3-digit industry groups, observed that a fall in the ratio of domestic to international prices had a significant positive impact on TFPG from 1970 to 1988. Sen (2009), following the methodology adopted by Chand and Sen (2002), reported a positive impact of easing quantitative restrictions on manufacturing TFP. The study used 3-digit ASI data for the period 1973 to 1998. Further, they argued that a reduction in price distortions, increasing intra-industry trade in intermediate and capital goods has had a strong positive impact on productivity. Using simple pre-and post-reform methodology, Milner *et al*. (2007) found improvement in TFP during the reform period. The study covered 159 industries at 3-digit level NIC for the period 1984 to 1998. Recently, Nataraj (2011) documented a large-scale raise in average productivity of small, informal firms from the unilateral reduction in output tariffs. On the other side, the productivity surge of large formal firms is largely driven by reduction in input tariffs. The study uses both ASI and NSSO data sets for the econometric analysis.

Studies at the *firm level* have also provided mixed results, although, several recent studies have documented a noticeable growth in productivity due to trade policy reforms. Krishna and Mitra (1998), using firm level data for 362 firms, noted that returns to scale and price-cost markup have declined in technology-intensive sectors and the increased competition in these industries was associated with an improvement (weaker) in productivity growth since economic reforms. However, Balakrishnan *et al*. (2000), for a panel data of pooled sample of 2300 firms of five industries *viz* electrical machinery, non-electrical machinery, transport equipment, chemicals and textiles, reported that there was no evidence of acceleration in productivity from 1989 to 1998. In both these studies, trade policy changes were proxied by dummy variables.

However, a comprehensive and systematic study by Topalova and Khandelwal (2011) finds significant efficiency improvement in 4000 large formal firms owing to competitive pressure from lower output tariff and the increase in the volume of imported inputs. The study acknowledged that the lower input tariffs have eased the domestic firms' access to cheap and quality imported inputs from the world market. According to Goldberg *et al*. (2010), trade liberalisation widened firms' access to new imported inputs (new input varieties) which lead to substantial increase in product scope and productivity. Similarly, studies by Hasan (2002), Parameswaran (2009) and Rijesh (2015) have documented significant productivity growth in firms that import technology inputs, especially capital goods. Using firm wise panel data from PROWESS, Haidar (2012) provides evidence for export-productivity nexus operating

through self-selection channel for the period 1991 to 2004. However, using the same data set, Sharma and Mishra (2011) could only find a weak statistical evidence for self-selection or learning-by-doing induced productivity growth during the period 1994 to 2004. This implies that the evidence of export-induced productivity expansion is found to be less robust and sensitive to the methodology used in the study.

3. Methodology and Data Sources

3.1 Econometric Methodology

We propose to assess the impact of international trade on organised manufacturing sector productivity using an econometric methodology. We hypothesise that a relatively greater international exposure to trade will lead to greater productivity in Indian manufacturing. The econometric framework[15] relates productivity growth (*P*) in manufacturing to the relative import price (*RP*), import penetration ratio (*IMP*), export intensity (*EXI*), capital intensity (*CI*) and capacity utilisation (*CU*). That is,

$$P_{j,t} = f(RP, IMP, EXI, CI, CU) \; --- (1)$$

where, *j* refers to manufacturing sector and *t* refers to year, 1980–2013. The first three trade-related variables are intended to provide evidences of the theoretical channels outlined in section 2.1. In addition, we include both *CI* and *CU* as additional explanatory (control) variables. The level of capital per worker is an important determinant of productivity growth[16]. The capacity utilisation variable is expected to control the procyclical nature of productivity in manufacturing.[17]

The empirical analysis is based on 17 cross-section manufacturing sectors identified at 2-digit level observed through 1980–81 to 2013–14. The panel is balanced and the statistical inferences are based on standard panel regression estimation methodology. Panel regression provides robust inference of parameters by blending the inter-sectoral differences with intra-sectoral dynamics and helps to control the issue of omitted variable biases arising from unobserved heterogeneity in the regression model (Hsiao, 2003). In our model, two notions of productivity (*P)*, namely labour productivity (LP)

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[15] This is an augmented version of the model adopted by Hung *et al*., (2004). For a similar econometric framework, see Paus *et al*. (2003).

[16] According to Isaksson (2007), both human capital and capital intensity determines the level of absorptive capacity which is required to obtain the benefit of technology transfer through trade.

[17] Basu and Fernald (2001) highlight the following reasons for procyclical nature of productivity. (i) High frequency fluctuations in technology make output to be cyclical. (ii) Due to market imperfections, productivity will increase when input rises. (iii) Resource utilization may vary during the business cycles. (iv) The reported labour and capital figures tend to overstate the true amount of inputs during downtimes.

and Total Factor Productivity (TFP) have been used. The specification of the econometric model is given in equation (2).

$$\Delta ln\, P_t = \alpha_j + \beta_i \Delta RP_{t-i} + \gamma_i \Delta IMP_{t-i} + \delta_i \Delta EXI_{t-i} + \vartheta \Delta CI_t + \theta \Delta CU_t + \mu_t \; --(2)$$

where, α_j = constant representing the trend growth in manufacturing sector, $\Delta lnP_{j,t}$ = the relative change in TFP or LP in sector at time t , $\Delta RP_{j,t}$= the per cent change in relative import price in sector at time t, $\Delta IMP_{j,t}$= the first difference in the import penetration ratio for sector at time t, $\Delta EXI_{j,t}$= the first difference in the export share in sector at time t, $\Delta CI_{j,t}$= the per cent change in capital intensity in sector at time t, $\Delta CU_{j,t}$= the first difference in capacity utilisation in sector at time t, i = lags assumed in the model (see below).

The constant term, α_j is included to control for average productivity trend in sector j. As the coefficient of ΔCU accounts for procyclicality of productivity, we expect θ to be positive[18]. A negative β_i would suggest that decreases in import prices by intensifying competitive pressure help promote productivity. Similarly, we would expect a positive γ_i since the competition effects, reallocation effects and spillover effects all suggest that a rise in import penetration will help promote productivity growth. However, a negative γ_i would imply the dominance of negative economies of scale on import-competing industries having positive competitive effects. A positive δ_i would indicate that productivity growth tends increase when exports constitute a larger share in domestic production. This is consistent with the economies of scale channel, the reallocation channel, and the spillover channel. Finally, a positive ϑ suggests that productivity growth results from increased capital utilisation in manufacturing.

The discussion so far assumes, implicitly, that the impact of trade on productivity is instantaneous. However, in general, the process of resource allocation, spillover channels or technological upgrading may not be immediate as the sectors response to learn, adapt and upgrade technology is likely to realise only after a lag. Therefore, to incorporate the dynamic relationship between trade and productivity growth, we estimate different variants of equation 2. Specifically, we have

(a) i = 0, n = 0 (no lag), (b) i = 1, n = 1 (one year lag) and (c) i = 2, n = 2 (2-year lag)

In the first model (a), we assume instantaneous relationship between trade and productivity growth. In the second model (b), we assume that trade affects productivity growth with 1-year lag. In the last model (c), we expect trade to impact productivity growth after 2-year gap. We estimate equation (2) using fixed effect(s) (FE) and Random

[18] The aim of including α_j and $CU_{j,t}$ in our model is to estimate the effects of international exposure on productivity growth beyond and above what can be accounted by the trend growth and cyclical fluctuations (see Hung *et al.*, 2004 for a similar exposition).

effect(s) (RE) methods. The FE or within transformation model is a pooled OLS to time-demeaned data with the assumption that the unobservable effects has an arbitrarily correlation with the explanatory variables in each period. The RE estimator is a feasible Generalized Least Square (GLS) estimator where the unobserved effect is assumed to be uncorrelated with the explanatory variables in each time period. We use the Hausman Specification test (also known as Durbin-Wu-Hausman test) to select the appropriate estimator for inference.

3.2 Data Sources and Construction of Variables

The study requires statistics on manufacturing production and trade at sectoral level. We have collected the production statistics of organised manufacturing from Annual Survey of Industries (ASI), published annually by the Central Statistical Organisation (CSO), Government of India[19]. We have used Volume 1 of ASI, which contains the summary result of registered factory sector at various classification levels. The ASI classifies manufacturing activities according to the National Industrial Classification (NIC) schedule[20]. The manufacturing sectors are identified at 2-digit level covering broad industry groups. Since the study period is from 1980–81 to 2013–14 and the NIC structure has reshuffled four times during this period, we use several concordance tables of NIC to match the selected sectors accordingly[21]. However, the recent adoption of NIC-2008 has required us to prepare the corresponding table using details drawn from the lower level of industry aggregation. Overall, we were able to build a systematic time series for 17 manufacturing sectors at 2-digit level[22]. The detailed list of the sectors and the corresponding table between NIC-2004 and NIC-2008 is given in *Table 1*.

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[19] ASI reports the survey of registered (or organised) manufacturing sector activities in India. The ASI data consist of two series: (i) the Census sector and (ii) the Factory sector. For a recent account of industrial statistics, strength and weaknesses see Manna (2010) and Nagaraj (1999).

[20] The NIC is based on International Standard Industrial Classification (ISIC) nomenclature of the UN. The NIC-2004 and NIC-2008 follows ISIC rev3.1 and ISIC rev4, respectively.

[21] We have used four-concordance tables provided by the ASI publication, namely NIC-1987, NIC-1998, NIC-2004 and NIC-2008. The concordance is generally provided at disaggregate level which permits us to build the necessary matching at the broad product categories at 2-digiit level. Prior to NIC-2008, the matching of industries does not create much problem. However, the introduction of NIC-2008 has created a great amount of complexity in building correspondence, especially at the disaggregate level.

[22] The study has also made use of ASI concordance series prepared by the EPW-RF for the period 1973 to 2003. This series is available electronically and is based on the concordance scheme of CSO.

Table 1: Concordance of Manufacturing Sectors: NIC-1998/2004 to NIC-2008

SN.	*NIC-98/04*	*Description*	*NIC-08*	*ISIC-rev2*
1	15	Manufacture of food products and beverages	10+11	311+312+313
2	16	Manufacture of tobacco products	12	314
3	17+18	Manufacture of textiles + wearing apparel; dressing and dyeing of fur	13+14	321+322
4	19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	15	323+324
5	20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	16	331
6	21	Manufacture of paper and paper products	17	341
7	22	Publishing, printing and reproduction of recorded media	18	342
8	23	Manufacture of coke, refined petroleum products and nuclear fuel	19	353+354
9	24	Manufacture of chemicals and chemical products	20+21	351+352
10	25	Manufacture of rubber and plastics products	22	355+356
11	26	Manufacture of other non-metallic mineral products	23	361+362+369
12	27	Manufacture of basic metals	24	371+372
13	28	Manufacture of fabricated metal products, except machinery and equipment	25	381
14	29+30	Manufacture of Non-electrical machinery and equipment n.e.c + Office, accounting and Computing machinery	28+2620	382
15	31+32	Manufacture of electrical machinery and apparatus n.e.c. + Radio, television and communication equipment and apparatus	27	383
16	33	Manufacture of medical, precision and optical instruments, watches and clocks	26 (excl. 2620)	385
17	34+35	Manufacture of motor vehicles, trailers and semi-trailers + Other Transport Equipments	29+30	384

Note: The correspondence is prepared by the author using the official concordance table of NIC-2008, prepared by the CSO. We follow the NIC-1998/2004 as the base classification and matched the following series accordingly. The official NIC-2004 concordance is available at 4-digit level of industry classification. Using the detailed information, we build the correspondence at the sectoral level (i.e., 2-digit). The preparation of concordance required us to make several modifications. For instance, in several cases, we clubbed similar 2-digits and adjusted certain 4-digits. We excluded code 36 (manufacture of furniture and other manufacturing n.e.c) and code 37 (recycling) from the final list because of large irregularities.

The primary source of India's foreign trade statistics is the Directorate General of Commercial Intelligence and Statistics (DGCI&S), which compiles and publishes the export and import data on merchandise goods[23]. Before 1987, DGCI&S was following the Indian Trade classification[24] (ITC) system. Since 1988, DGCI&S has adopted the Harmonized Commodity Description and Coding System (Harmonized System, or HS) for commodity classification and provides trade statistics according to HS nomenclature. We use the Standard International Trade classification scheme (SITC), available from United Nations Commodity Trade Statistics Database or COMTRADE online databases of the United Nations Statistical Division (UNSD). SITC is compiled from the HS classification based on UN correspondence scheme[25]. We accessed UN COMTRADE database through World Integrated Trade Solution (WITS)[26]. As trade and industry statistics are reported according to different nomenclatures, the study required industry-trade concordance.

The concordance is done for two periods. For the period 1980 to 1987, we collected trade data according to SITIC rev2[27] and made compatible with ISICrev2. Using the concordance schedule between ISICrev2 and ISICrev3, we derived the required industry groups. The matched series is given in the final column in *Table 1*. To supplement the analysis, we also use the concordance table between NIC 1987 and ITC rev2 of Debroy and Santhanam (1993)[28]. For the remaining period (1988 to 2007), we collected trade data

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[23] The statistics on production covers only the registered or formal manufacturing sectors. However, trade statistics does not make any distinction between registered or unregistered manufacturing. As such, we were not able to distinguish between the two in our study. The problem is assumed to be less severe since the output contribution of organised sector in overall manufacturing sector is substantial. For instance, according to the National Account Statistics (NAS) reports, the gross output contribution of registered manufacturing is 81 per cent in 2012–13. Moreover, the contribution has been relatively stable around 75–80 per cent in the past.

[24] The ITC was designed according to Standard International Trade Classification (SITC rev1 and rev2). For a detailed account of trade and industrial statistics, see the section titled "Commodity classification" in UN (1998).

[25] UN has prepared the product concordance by mapping various nomenclatures. This is available to the public and can be accessed from: http://wits.worldbank.org/product_concordance.html.

[26] WITS is a data consultation and extraction software with simulation capabilities. It is developed by the World Bank in collaboration and consultation with United Nations Conference on Trade and Development (UNCTAD), International Trade Center (ITC), United Nations Statistical Division (UNSD) and World Trade Organisation (WTO).

[27] In WITS, the SITC rev2 data for India is available from 1978 onwards.

[28] Since ITC rev2 follows SITC rev2 structure, we use SITC rev2 trade data till 1987. In some cases, the number of industries at 3-digit NIC 1987 corresponds to 7-digit SITC codes, which is not accessible from COMTRADE. In such cases, we have used the corresponding 5-digit SITC. This is also a reason for us to restrict SITC rev2 data until 1987. For the same period, WITS provides trade flows according to ISIC rev2 nomenclature.

based on SITC Rev3 and use the UN correspondence schedule to match SITC Rev3 and ISIC Rev3[29]. All trade data were extracted from WITS online portal.

All nominal series were converted into real values using appropriate price indices. The Wholesale Price Indices (WPI) series, for the base year 1970–71, 1981–82, 1993–94 and 2004–05, were collected from the Office of the Economic Advisor, Ministry of Commerce & Industry, Government of India. We selected common product groups and spliced the series to construct the price indices with 2004–05 base[30]. The Consumer Price Index (CPI) for Industrial Workers series, obtained from the Labour Bureau, Government of India, is derived by splicing the four available series (i.e., 1960–61=100, 1982–83=100 and 2001–02=100) into a common series (2001–02=100). The series base was shifted to 2004–05=100 to maintain consistency with other price indices. Data on the rupee-dollar (average) exchange rates for the financial year has been collected from the Handbook of Statistics on Indian Economy, Reserve Bank of India.

3.2.1 Construction of Variables

(i) Productivity Growth (P)

We use two notions of productivity growth (*P*), namely Total Factor Productivity (TFP) and Labour Productivity (LP). The standard Growth Accounting (GA) methodology is used to derive TFPG as the residual factor in the value added production framework[31]. The sectoral value added at any year is given by $V_t = f(L_t, K_t)$ where K_t represent the physical capital and L_t is the total amount of labour employed. TFPG is derived from the Tornqvist index formula, which is a discrete approximation to the Divisia index of technical change. Specifically, the TFPG is computed using equation (3).

$$\Delta \ln TFP_t = \Delta \ln V_t - \left((s_{Lt} + s_{Lt-1})/2)\right) \Delta \ln L_t - \left((s_{Kt} + s_{Kt-1})/2)\right) \Delta \ln K_t \quad --- (3)$$

where, V, L and K denote value added, labour input and capital input, respectively. $\Delta \ln V_t = \Delta \ln V_t - \Delta \ln V_{t-1}$ and the rest of the variables are measured accordingly. The share of labour income (total emolument) in value added in period t is s_{Lt} and that of capital is s_{Kt}. The share of capital income in value added in period t is defined as $(1 - s_{lt})$. The share of capital and labour add to unity.

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[29] We use ISIC rev3 because NIC-1998/2004 is based on ISIC rev3 and ISIC rev 3.1, respectively.

[30] In a few cases, the aggregate product group is derived by computing the average of the disaggregate product price series.

[31] Growth accounting is a widely-used technique of measuring TFP for manufacturing sector in India. For instance, see Ahluwalia (1991), Balakrishnan and Pushpangadan (1994), Goldar and Kumari (2003), Das (2004), Bosworth *et al*. (2007), Goldar (2015) among others. For an extensive review, see Kathuria *et al*. (2014).

The sector wise capital stock series is constructed using the perpetual inventory method[32]. The benchmark capital stock is constructed for the year 1973–74 by multiplying the book value of net fixed asset by a factor of two. This is adjusted for 2004–05 prices using WPI for machinery & machine tools. The annual Gross Investment (GI) series is build by taking the yearly difference of fixed asset and adding the reported depreciation value. The real annual gross investment series is derived by deflating the series with an implicit deflator (2004–05) derived from the current and constant values of Gross Fixed Capital Formation (GFCF) series of registered manufacturing sector in the National Account Statistics (NAS). For constructing Net Fixed Capital Stock (NFCS), the rate of depreciation is taken as 5 per cent, which assumes an asset life of 20 years[33]. The real net investment series is created by adjusting the real gross investment by depreciation rate of 5 per cent. The net fixed capital stock series is built by adding the real net investment series to the benchmark fixed capital stock.

Labour Productivity (LP) is defined as the ratio between a volume measure of output (value added) and a measure of input use (total person engaged). Total persons engaged in production measures labour input. LP is derived using equation (4).

$$LP_t = \frac{Q_t^{VA} / L_t}{Q^{VA}{}_{Base\ Year} / L_{Base\ Year}} * 100 \quad ----- (4)$$

where, Q_t^{VA} is the value added volume index in year t, L_t is labour proxied by total person engaged in year t. t denotes time. The volume index of value added is formulated by using the formula given in equation (5).

$$Q_t^{VA} = \frac{VA_t / P_t}{VA_{Base\ Year} / P_{Base\ Year}} * 100 \quad ----- (5)$$

here, VA_t is the value added in current year, P_t is the value added deflator in current year. The nominal VA were converted to real values using appropriate WPI, base 2004–05=100.

(ii) Relative Import Price (RP)

The relative import prices (i.e. import prices relative to domestic prices) are constructed using the unit value index (UVI) of imports and Wholesale Price Index (WPI) of major

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[32] This is the common practice in empirics on Indian manufacturing. The procedure we follow is based on Goldar and Kumari (2003) and Goldar and Sengupta (2016).

[33] This follows from the study by Unel (2003).

industrial groups. The construction of UVI follows Paasche's formula, which uses import quantities in the current period as weights. The UVI calculation is given in equation (6).

$$UVI_{jt} = \frac{\sum_i UV_{jti} Q_{jti}}{\sum_i UV_{j0i} Q_{jti}} \quad --- (6)$$

where, UV_{jt} is unit value of import for sector j in period t, UV_{jo} is the base year import unit value, Q_{jt} is the import quantity for sector j in period t. We calculated unit value of imports[34] (UV_{jt}) by dividing the import value (V_{jt}) by aggregate quantity(Q_{jt}). The relative import price (RP) was derived by dividing the import unit value index (UVI) by the wholesale price index (WPI) for each manufacturing sectors [see equation (7)].

$$RP_{jt} = \frac{UVI_{jt}}{WPI_{jt}} \quad --- (7)$$

(iii) Import Penetration (IMP)

The import penetration rate (IMP) is defined as the ratio of total imports to domestic demand or apparent consumption (the difference between output and exports), as percentage [see equation (8)].

$$IMP_{jt} = \left(\frac{M_{jt}}{(Q_{jt} + M_{jt} - X_{jt})}\right) * 100 \quad --- (8)$$

where, j refers to sectors and t is period, M is the import value, X is export value and Q is the domestic production. All values are in current prices.

(iv) Export Intensity (EXI)

The export intensity (EXI) is the ratio of exports to total production, defined as percentage [see equation (9)].

$$EXI_{jt} = \frac{EX_{jt}}{Q_{jt}} \quad --- (9)$$

where j denotes sector and t time. EX is export value and P is output.

(v) Capital Intensity (CI)

The capital intensity (CI) is computed using the formula (10).

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[34] It has to be noted that for a few sectors we also used the unit value index of imports available from the RBI.

$$CI_{jt} = \frac{K_{jt}}{L_{jt}} --- (10)$$

where, K_{jt} is real capital stock for sector j for period t, L_{jt} is the total number of labour force employed in sector j in period t.

(vi) Capacity Utilisation (CU)

The capacity utilisation (CU) ratio is based on the minimum capital-output ratio method used by Uchikawa (2001) and Goldar and Kumari (2003). The formula for CU is:

$$CU_{jt} = {Q_{jt}}/{\overline{C_{jt}}} ----(11)$$

Q is the actual output represented by gross output and $\bar{C}$ is the estimate of capacity output. The estimated capacity is derived from equation (12).

$$\bar{C}_{jt} = \frac{K_{jt}}{\left(\frac{K_j}{O_j}\right) min} ---- (12)$$

K is the estimated real fixed capital stock and $\frac{K_j}{O_j}$ is the observed lowest capital-output rate for sector j during the reference period.

4. Descriptive Analysis: Manufacturing Production and Trade

4.1 Trend in Manufacturing Production and Trade: Sectoral Level

In this section, we provide a descriptive statistical account of manufacturing production and trade pattern during the reference period. The analysis is based on simple statistical tools such as annual growth rates and average shares. For brevity, the entire period is sub-divided as follows: Period I (1980 to 1990), Period II (1991 to 2000), Period III (2001 to 2007) and Period IV (2008 to 2013). The first period covers the period of initial liberalisation in terms of import deregulations in the 1980s. The second period marks the beginning of the comprehensive liberlaisation regime of the 1990s. The third period covers further expansion of trade liberalisation until the external demand shock from the global economic crisis in 2008. Period IV corresponds to an environment with considerable external uncertainty and demand shock due to the onset of global financial crisis[35].

[35] Incidentally, the period also corresponds to the year in which Government of India changed its industrial classification system from NIC-2004 to NIC-2008. Compared to the earlier NICs, the

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Table 2 provides the growth of India's manufacturing production, in terms of real value added at 2004–05 prices, at sectoral level. Figures in parenthesis are the respective sectoral shares in overall manufacturing for a given period. For the entire period (i.e., 1980 to 2013), the average growth rate of organised manufacturing output is around 8 per cent per annum. The manufacturing production grew at this rate during the 1980s (period I) but declined to 6 per cent per annum during the 1990s (period II). However, production witnessed considerable improvement in the following period as it registered double-digit growth rate of 15 per cent per annum during 2007–08. Thereafter, the growth rate declined to the level witnessed in the nineties.

Table 2: Trend in manufacturing production: by Sectors (1980-2013) % per annum

Description (2digit)	*1980-90*	*1991-00*	*2001-07*	*2008-13*	*1980-2013*
Food products & beverages (15)	11.5 (10.3)	5.8 (10.6)	9.1 (8.8)	7.0 (8.7)	8.4 (9.8)
Tobacco products (16)	13.7 (1.8)	8.9 (2.1)	1.3 (2.1)	3.0 (1.5)	7.7 (1.9)
Textiles, wearing apparel (17+18)	7.4 (14.9)	8.7 (11.7)	8.4 (8.1)	10.4 (7.4)	8.6 (10.5)
Tanning & dressing of leather (19)	14.9 (0.9)	3.4 (0.9)	11.6 (0.7)	14.7 (0.8)	10.7 (0.9)
Wood products (20)	7.6 (0.5)	-2.4 (0.3)	20.8 (0.2)	14.0 (0.2)	8.6 (0.3)
Paper & paper products (21)	9.2 (1.9)	7.1 (1.9)	6.2 (1.6)	9.3 (1.2)	7.9 (1.7)
Publishing & printing (22)	0.6 (1.9)	1.9 (1.7)	11.1 (1.4)	-1.6 (0.9)	2.8 (1.5)
Coke, refined petroleum & nuclear fuel (23)	29.2 (4.2)	13.5 (4.7)	33.1 (11.8)	7.3 (11.9)	21.3 (7.9)
Chemicals & chemical products (24)	10.9 (14.6)	9.5 (19.9)	7.4 (17.1)	10.5 (16.6)	9.7 (17.4)
Rubber & plastics products (25)	13.1 (3.0)	10.7 (3.2)	11.9 (2.9)	18.2 (3.9)	13.1 (3.3)
Non-metallic mineral products (26)	10.8 (4.9)	9.1 (4.7)	17.1 (5.1)	0.0 (6.0)	9.7 (5.1)
Basic metals (27)	8.4 (12.4)	6.4 (11.7)	21.4 (14.8)	2.3 (12.9)	9.4 (12.7)
Fabricated metal products (28)	4.6 (2.9)	8.2 (2.9)	18.1 (3.0)	2.2 (4.1)	8.1 (3.1)
Machinery & equipments (29+30)	6.1 (9.4)	5.7 (7.6)	12.4 (6.5)	8.4 (7.6)	7.7 (7.7)
Electrical machinery & apparatus (31+32)	12.4 (6.8)	7.0 (7.2)	15.7 (5.8)	2.6 (4.8)	9.7 (6.4)
Medical, precision & optical instruments (33)	9.5 (1.2)	18.5 (0.9)	20.1 (1.0)	36.9 (2.5)	19.4 (1.3)
Motor vehicles & trailers (34+35)	9.4 (8.6)	5.1 (7.9)	20.4 (9.0)	9.3 (9.0)	10.4 (8.5)
Manufacturing sector	**8.1 (100)**	**5.9 (100)**	**14.9 (100)**	**5.7 (100)**	**8.4 (100)**

Note: Figures in parenthesis are the average share of individual sector in total manufacturing. The growth rates are the simple average of annual growth over the respective periods. Production data is based on real net value added, base 2004-05=100

Source: Author's calculation based on data collected from ASI (CSO), various issues.

Even though there is considerable variation in sectoral growth rates, the general trend is similar to the pattern observed at the aggregate level. For instance, we can notice that relative to period II, the growth rates of 13 sectors are relatively higher during period I.

present classification registry has made several substantial changes in its product nomenclature at disaggregate level, creating substantial problem in building meaningful correspondence across manufacturing.

During period III, the growth rates improved substantially, as 12 sectors witnessed double-digit growth rates (see *column 4 in Table 2*). However, the growth resurgence did not persist for long as 10 sectors witnessed sharp deceleration in the final period. For the entire period, nine manufacturing sectors registered double-digit growth rates, namely leather (11%), coke & petroleum (21%), chemicals (10%), rubber and plastics (13%), non-metallic minerals (10%), electrical machinery (10%), medical, precision and optical instruments (19%) and transport equipment (10%).

The distribution of manufacturing sector in terms of value added share reveals that the chemicals sector, with 17 per cent share, is the largest contributor followed by machinery, including electrical & non-electrical (14%), basic metals (13%), and textile segments (10%). The share of non-traditional technology-intensive industries such as chemicals, coke & petroleum and transport equipment has witnessed a consistent increase during the reference period. On the other hand, the share of traditional and less-technology-intensive sectors such as food & beverage, tobacco, textiles, wood & paper products and rubber & plastics, has either declined or remained stagnant during the entire period. This indicates the changing nature of sectoral specialisation from traditional segment of manufacturing to more advanced or knowledge-intensive manufacturing activities. Overall, in terms of robust growth rates and size distribution, the chemicals and capital goods segments have been the leading sectors in organised manufacturing in recent decades.

In *Table 3*, the pattern of manufacturing trade by selected industrial sectors is given. In terms of manufacturing exports share, textiles (20%), chemicals (15%), food & beverage (14%), coke & refined petroleum (10%) and machinery (9%), constitute the largest share during the entire period of study. The share of non-traditional export sectors such as chemicals, machinery, coke & petroleum, transport equipment, etc., have expanded and sustained their relative sizes. In contrast, most of the traditional export sectors such as food & beverage, textiles, leather, etc., have witnessed a sustained decline in relative export share during the same period. Similarly, import composition reveals a heavy dependence on technology-intensive products during this period. Some of the major import sectors are coke & petroleum, chemicals, basic metals and machinery equipment (see *Table 3*).

The growth profile of manufacturing exports reveals that most of the sectors have witnessed double-digit growth rates during various sub-periods (see *Table 3*). The growth is relatively less impressive during the 1990s as most of them witnessed considerable deceleration. However, similar to the production case, the exports of almost all sectors have revived during the third period. However, the contraction in world demand in period IV seems to have affected the export prospects, as there was deceleration across sectors, except in food & beverage, textiles, leather and paper products. Overall, manufacturing exports grew at 18 per cent per annum during the entire period. In case of

Table 3: Trend in Manufacturing Trade: by Sectors (1980-2013) % per annum

Description (2-digit)	*Exports*					*Imports*				
	1980-90	*1991-00*	*2001-07*	*2008-13*	*1980-2013*	*1980-90*	*1991-00*	*2001-07*	*2008-13*	*1980-2013*
Food products & Beverages (15)	44.8 (13.5)	10.8 (18.4)	14.7 (10.7)	22.7 (9.0)	24.1 (13.6)	-0.6 (9.7)	38.0 (5.0)	10.9 (4.9)	25.8 (4.3)	18.3 (6.4)
Tobacco Products (16)	13.2 (0.9)	6.3 (0.2)	16.9 (0.1)	12.8 (0.1)	11.8 (0.4)	38.6 (0.0)	23.3 (0.0)	66.0 (0.0)	24.6 (0.0)	37.2 (0.0)
Textiles, wearing Apparel (17+18)	24.0 (24.1)	9.7 (25.7)	7.9 (17.0)	11.0 (8.9)	13.9 (20.4)	55.3 (1.2)	10.1 (2.0)	21.7 (2.3)	9.5 (1.5)	26.2 (1.7)
Tanning & dressing Of leather (19)	25.9 (14.4)	3.0 (7.4)	11.1 (4.2)	11.6 (2.2)	13.2 (8.1)	148.7 (0.2)	8.2 (0.5)	19.1 (0.5)	14.9 (0.4)	54.3 (0.4)
Wood products (20)	3.6 (0.4)	20.3 (0.2)	27.5 (0.1)	15.9 (0.1)	16.0 (0.2)	109.1 (0.1)	17.8 (0.1)	29.5 (0.1)	22.9 (0.2)	48.9 (0.1)
Paper & paper Products (21)	41.1 (0.1)	33.6 (0.4)	15.8 (0.5)	19.7 (0.4)	29.6 (0.3)	16.8 (3.2)	6.3 (2.3)	15.7 (1.6)	15.1 (1.3)	13.1 (2.3)
Publishing & Printing (22)	70.1 (0.3)	27.8 (1.0)	11.3 (0.8)	0.0 (0.3)	32.1 (0.6)	120.6 (0.4)	28.8 (0.9)	20.3 (1.9)	-11.6 (0.3)	47.5 (0.9)
Coke, refined petroleum & nuclear fuel (23)	64.7 (6.6)	12.5 (2.8)	51.2 (13.7)	23.8 2(5.0)	38.6 (10.2)	21.5 (17.4)	1.8 (15.9)	33.4 (7.4)	7.6 (6.1)	15.5 (12.9)
Chemicals & chemical Products (24)	27.7 (11.6)	13.4 (15.2)	21.2 (17.7)	17.1 (16.6)	20.0 (14.8)	152.7 (17.5)	6.7 (24.3)	21.5 (18.5)	16.4 (19.5)	55.8 (20.1)
Rubber & plastics Products (25)	22.7 (2.0)	14.8 (3.1)	20.9 (2.7)	17.8 (2.3)	19.0 (2.5)	70.2 (0.6)	15.0 (1.0)	25.6 (1.3)	14.6 (1.4)	33.9 (1.0)
Non-metallic mineral Products (26)	38.8 (1.0)	21.8 (1.9)	17.0 (2.1)	10.2 (1.3)	23.8 (1.5)	6.4 (1.3)	7.3 (0.7)	28.1 (0.9)	13.7 (0.9)	12.6 (1.0)
Basic metals (27)	34.9 (3.5)	17.2 (6.4)	35.0 (10.1)	14.2 (9.6)	25.8 (6.8)	29.6 (13.7)	16.7 (16.2)	28.4 (21.6)	13.7 (26.0)	22.5 (18.2)
Fabricated metal Products (28)	34.5 (4.0)	12.6 (4.1)	17.6 (4.3)	16.0 (3.2)	20.9 (4.0)	50.0 (1.7)	9.9 (1.3)	32.3 (1.5)	12.1 (1.9)	27.2 (1.6)
Machinery & Equipments (29+30)	26.9 (6.6)	8.2 (4.7)	26.0 (5.7)	14.7 (5.4)	18.8 (5.7)	25.9 (17.5)	8.9 (15.0)	27.4 (15.3)	7.6 (14.1)	17.7 (15.7)
Electrical machinery & apparatus (31+32)	21.2 (3.6)	12.8 (2.8)	27.3 (3.7)	20.0 (5.4)	19.7 (3.7)	35.4 (6.6)	12.5 (6.4)	34.0 (11.9)	10.3 (11.6)	23.6 (8.5)
Medical, precision & Optical instruments (33)	123.4 (0.6)	17.1 (0.7)	18.1 (1.2)	17.3 (1.0)	49.6 (0.8)	42.7 (2.8)	8.2 (3.2)	23.4 (3.5)	10.1 (2.9)	22.2 (3.1)
Motor vehicles & trailers (34+35)	9.8 (6.8)	9.7 (4.9)	29.9 (5.3)	26.7 (9.2)	17.1 (6.3)	55.9 (6.2)	12.9 (5.2)	37.7 (6.6)	19.9 (7.5)	32.5 (6.2)
Manufacturing Sector	**24.4 (100.0)**	**10.3 (100.0)**	**20.5 (100.0)**	**17.1 (100.0)**	**18.0 (100.0)**	**13.0 (100.0)**	**8.1 (100.0)**	**25.9 (100.0)**	**11.3 (100.0)**	**13.9 (100.0)**

Note: Ex= Exports, Im =Imports. The growth is based on simple average annual rates of trade volumes in US $. Figures in parenthesis are the average shares, in percentage, computed yearly.
Source: Author's calculation based on data collected from DGCIS and UN Comtrade.

imports, we find large variation in growth rates compared to exports, particularly during periods I and II[36]. As before, all sectors except food & beverage and printing & publishing have witnessed a rapid rise during period III. Thereafter, imports declined for all except food & beverage. For the manufacturing sector, the growth rate in import exceeded the entire period average of 14 per cent during periods I and II.

4.2 Productivity Growth Profile

The pattern of manufacturing productivity growth, both LP and TFP, is given in *figure 1*. Noticeably, the trend growth rate of both has been extremely cyclical and the pattern has been roughly similar during the entire period. This provides some evidence for our earlier contention of procyclical nature of productivity growth. The similar growth pattern may further reflect the fact that LP growth rate has been largely driven by technical progress rather than by capital accumulation. Relatively, LP growth has been largely higher than TFP growth, except during mid-2000s. For the entire period, the rates of growth of LP and TFP are 6 per cent and 2 per cent, respectively[37]. In *Table 4*, we provide the period-wise break-up of productivity growth for the entire manufacturing sector as well as for the sub-sample sectors. In periods I and III, the rates of growth in LP and TFP have exceeded the growth rates achieved during the entire period. In contrast, there is a sharp deceleration of productivity growth in periods II and IV, which is particularly noticeable in TFP as growth rates become negative during these periods.

The sectoral distribution of organised manufacturing confirms the cyclicality of LP and TFP growth rates observed at the aggregate level (see *Figure A1 in the Appendix*). During the four sub-periods, the trend growth of LP is found to be considerably higher than TFP across all sectors (see *Table 4*). A closer inspection reveals a noticeable reduction in the difference in growth margin in period III. The higher LP growth has been accompanied by considerable increase in capital intensity, which is evident from *Figure A2 in the Appendix*. In general, except for a few[38], the rate of productivity growth for most of the manufacturing sectors has declined during periods II and IV. Apparently, a large number

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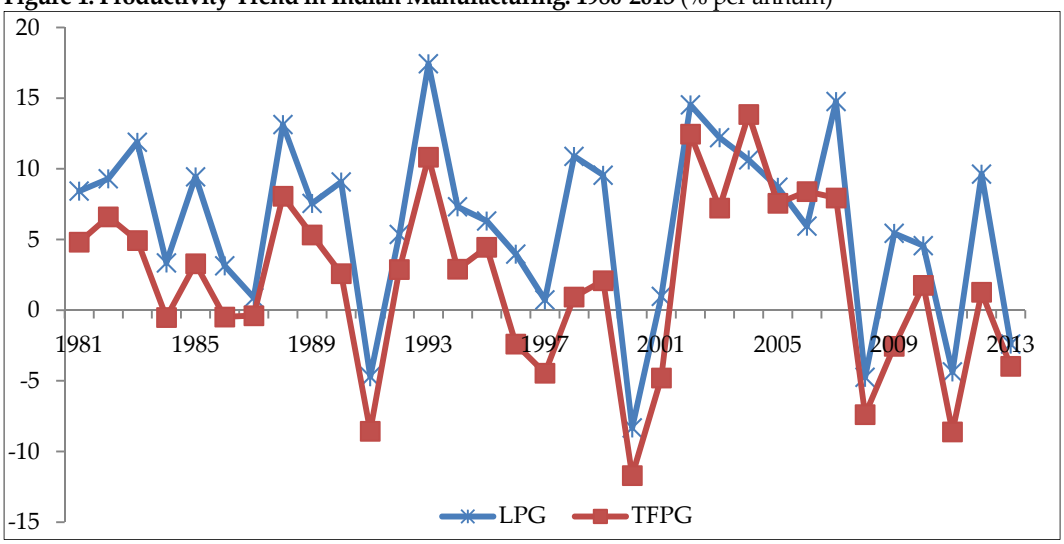
[36] A large part of the expansion of manufacturing imports during the eighties is associated with low base in volume for a number of sectors.

[37] According to Goldar and Sengupta (2016), from 1980 to 2010, the rates of growth of LP and TFP for organised manufacturing is 5.7 and 1.7, respectively, which is quantitatively very similar to our estimates.

[38] Some notable exceptions during period II are the manufacture of publishing printing, fabricated metal products, non-electrical machinery and medical, precision and optical instruments. Similarly, during the global crisis period (IV), the productivity (both LP and TFP) growth rates of textiles, leather, paper and rubber & plastic producing sectors have improved. These sectors are largely less technology-intensive manufacturing groups.

of manufacturing segments reported negative TFP growth rates, especially during this low-growth phase[39].

Figure 1: Productivity Trend in Indian Manufacturing: 1980-2013 (% per annum)



Note: LPG= Labour Productivity Growth, TFPG=Total Factor Productivity Growth. All calculations are based on real net value added (single deflation)

Source: Author's calculation based on data collected from ASI (CSO), various issues.

Table 4: Productivity Profile of Indian manufacturing Sector: Average Annual Growth Rates (% per annum)

Description (2-digit)	*1980-90*		*1991-00*		*2001-07*		*2008-13*		*1980-2013*	
	LPG	*TFPG*	*LPG*	*TFPG*	*LPG*	*TFPG*	*LPG*	*TFPG*	*LPG*	*TFPG*
Food products & beverages (15)	13.9	6.3	4.5	-0.6	7.0	2.8	4.2	-0.7	7.8	2.2
Tobacco Products (16)	10.0	1.5	7.9	0.8	3.6	-2.9	1.5	-5.3	6.5	-0.9
Textiles, Wearing apparel (17+18)	8.6	4.6	7.2	2.7	4.2	1.0	7.6	4.1	7.1	3.2
Tanning & dressing of leather (19)	9.3	1.7	1.9	-2.6	3.9	3.8	8.5	6.6	5.8	1.7
Wood products (20)	9.7	3.3	-0.9	-12.1	14.5	8.5	11.4	3.3	7.8	-0.3
Paper & paper Products (21)	7.9	1.4	4.8	-0.8	0.8	-0.5	8.5	1.8	5.6	0.4
Publishing & Printing (22)	0.8	-2.2	4.4	-2.3	7.5	4.1	-4.8	-10.0	2.3	-2.3
Coke, refined petroleum & nuclear fuel (23)	21.4	2.5	10.3	-6.3	25.1	14.2	9.2	-10.7	16.6	-0.1

[39] Prevalence of negative or abysmal TFP growth rates in Indian manufacturing during the nineties is well-documented. For details, see Das (2004).

Description (2-digit)	*1980-90*		*1991-00*		*2001-07*		*2008-13*		*1980-2013*	
	LPG	*TFPG*	*LPG*	*TFPG*	*LPG*	*TFPG*	*LPG*	*TFPG*	*LPG*	*TFPG*
Chemicals & Chemical products (24)	9.5	5.1	5.9	0.4	5.6	3.1	3.3	3.1	6.5	2.9
Rubber & plastics Products (25)	9.1	3.2	7.1	0.8	6.3	4.3	8.3	4.7	7.8	3.0
Non-metallic mineral Products (26)	8.5	2.5	8.6	0.2	11.1	7.8	-5.5	-9.5	6.5	0.7
Basic metals (27)	7.8	2.7	6.5	-0.7	15.4	11.3	0.2	-9.0	7.6	1.4
Fabricated metal Products (28)	2.3	-0.6	6.0	2.0	8.5	6.9	-2.9	-7.3	3.8	0.5
Machinery & Equipments (29+30)	5.3	1.5	7.9	1.5	7.7	5.5	6.1	1.7	6.7	2.4
Electrical machinery & apparatus (31+32)	7.9	4.4	7.2	-0.1	10.2	8.5	0.4	-2.0	6.8	2.8
Medical, precision & optical instruments (33)	6.7	0.0	13.4	8.4	16.2	12.5	14.9	1.0	12.2	5.4
Motor vehicles & trailers (34+35)	8.1	5.4	6.7	-1.6	13.6	11.4	0.5	-3.2	7.5	3.0
Manufacturing sector	**7.6**	**3.4**	**4.9**	**-0.3**	**9.7**	**7.5**	**1.4**	**-3.2**	**6.1**	**1.9**

Note: LPG= Labour Productivity Growth, TFPG=Total Factor Productivity Growth. All calculations are based on real net value added (single deflation)

Source: Author's calculation based on data collected from ASI (CSO), various issues.

There is evidence of considerable improvement in productivity during period III, which is largely propelled by the growth in engineering sectors such as metals, machinery and transport equipment. For instance, productivity of all of these sectors (both LP and TFP) has improved substantially relative to the growth rates achieved during the eighties. If we exclude the post 2008 period, it is evident that the engineering manufacturing sectors have reported a consistent growth in LP and TFP during all three sub-periods (see *Table 4*). We can see that compared to the eighties, traditional manufacturing sectors such as food & beverages and textiles, with considerable productivity growth, could not sustain productivity momentum from 2001 to 2007. Only coke, petroleum and nuclear fuel sectors were able to maintain a double-digit growth in LP during all sub-periods. In period III, the TFP for fabricated metals, non-metallic minerals, electrical and non-electrical machinery, and medical, precision & optical instruments registered double-digit growth rates. The TFP of textiles, chemicals, rubber & plastics, non-electrical machinery and medical & optical instruments, however, registered a positive rate of growth throughout the period from 1980 to 2013.

To summarise, we clearly see significant improvements in the technical efficiency of the organised manufacturing sector of India in recent period. There is evidence of a notable surge in productivity during the period of increased economic integration since 2000. It is

revealed that the pattern of specialisation has gradually moved away from less technology-intensive traditional sectors to more sophisticated technology-intensive manufacturing. In addition, these technology-intensive sectors have witnessed rapid increase in productive efficiency and technology, especially between 2001 and 2007. There is also evidence of some negative impact of global demand shock on manufacturing as production, trade and productivity growth registered a marked decline during the post-2008 period. This indicates the growing significance of external market conditions in directly shaping the nature of production capability. In the following section, an attempt is made to provide empirical evidences for trade-induced productivity growth in manufacturing using econometric techniques.

5. Trade and Manufacturing Productivity: Estimation Results

To study the trade-productivity growth nexus, we use a panel econometric estimation technique outlined in the methodology section 3.1. We use the standard longitudinal regression tools on 17 cross-section units observed during 33 years. The summary statistics of variables selected for the analysis are given in *Table A1 in the Appendix*. For all variables, the "within" variation is found to be larger than the "between" variation. The relative import price variable has the largest overall variance while the lowest mean deviation is found in export intensity and import penetration variables. The overall trend of relative import prices, import penetration, export intensity and capacity utilisation is given in *Figure A3 in the Appendix*. Since the impact of trade exposure on productivity can last for more than one period, the trade related variables are also assigned a lag structure of one to two periods. The econometric model is estimated using the random effect technique[40], based on Hausman specification tests[41]. Standard errors are calculated using the Huber-White standard errors technique, which is found to be robust in the presence of panel level heteroscedasticity and autocorrelation of the unknown form[42]. The econometric results are discussed in two sub-parts. Part (a) shows the results based on TFP and part (b) the estimation results for LP.

In all estimates, the coefficient of capacity utilisation (ΔCU) is positive and highly significant at 1 per cent level. This confirms our assumption of pro-cyclical nature of productivity in the manufacturing sector. Similarly, the coefficient of capital intensity (ΔCI) is found to have a positive and statistically significant impact on LP—contemporaneously and with lags. For TFP, the coefficient is positive but statistically not

[40] In the random effect(s) model, the individual-specific effect is a random variable that is uncorrelated with explanatory variables.

[41] We found that the estimate results of both fixed effect model and random effect model are similar. This suggests that our inferences are not sensitive to the choice of estimation techniques.

[42] Assuming independently distributed residuals, the standard errors obtained by the Huber-White procedure are consistent even if residuals are heteroskedastic. In STATA, the standard error estimates based on clusters and robust option produces the same results.

significant. The results provide robust evidence for the positive impact of increased mechanisation on labour efficiency.

5.1 Econometric Results of Trade and Productivity Growth: 2-digit Manufacturing Sector Sample

The random panel estimation results for TFP and LP are given in *Table 5 & 6*, respectively. The results are given in three columns corresponding to the lag length. In the first period (no lag), we have 561 observations. In the second period (1-year lag), we have 544 observations and for the last period (2-year lag), we have 527 observations.

Table 5: Panel Regression of productivity growth in Indian manufacturing sector (2-digit industries sample) 1980-2013

Dependent variable: TFPG based value added framework (Random Effects)

Explanatory Variables	*(a) No Lag*	*(b) 1-year Lag*	*(c) 2-Year Lag*
ΔRP	0.006** (0.023)	-0.021*** (0.003)	-0.010*** (0.004)
ΔIMP	-0.175 (0.175)	0.673** (0.273)	-0.486*** (0.014)
ΔEXI	0.050* (0.108)	0.006 (0.263)	0.326 (0.432)
ΔCI	0.063 (0.151)	0.054 (0.136)	0.048 (0.145)
ΔCU	1.089*** (0.0329)	1.090*** (0.321)	1.092*** (0.320)
constant	1.171 (1.00)	0.095 (0.887)	1.047 (0.751)
R^2	0.21	0.23	0.57
Wald test	30.21 (0.0000)***	272.09 (0.0000)***	52.73 (0.0000)***
Hausman	0.13 (0.997)	0.13 (0.997)	0.16 (0.995)
No of observations	561	544	527
No of industry sectors	17	17	17

Notes: (1) Contemporaneous coefficient estimates on ΔCU and ΔCI for all columns. In column (b), coefficient estimates are for 1-year lag; in column (c), coefficient estimates are for 2-year lag. (2) The Huber-White robust standard errors are given in parentheses under estimated coefficients (3) p-values are given in parentheses under chi^2 – statistics for Wald test statistic. (4) Hausman statistic is asymptotically χ^2 distributed with p-values in brackets. (5) * significant at 0.01 level for a two-tailed test, ** at 0.05 level for a two-tailed test, *** significant at 0.1 level for a two-tailed test. (6) RP, relative import price; IMP, import penetration; EXI, exports share in total output; CI, capital intensity in production; and CU, capacity utilization.

Table 6: Panel Regression of productivity growth in Indian manufacturing sector (2-digit industries sample) 1980-2013

Dependent variable Labour productivity growth (Random Effects)

ExplanatoryVariables	*(a) No Lag*	*(b) 1-year Lag*	*(c) 2-Year Lag*
ΔRP	0. 003 (0.003)	-0.021*** (0.005)	-0.011** (0.005)
ΔIMP	-0.291 (0.217)	0.619*** (0.287)	-0.602 (0.264)
ΔEXI	0.079* (0.115)	0.041 (0.271)	0.411 (0.551)
ΔCI	0.734*** (0.130)	0.735*** (0.121)	0.723*** (0.127)
ΔCU	1.119*** (0.373)	1.137*** (0.370)	1.140*** (0.373)
constant	2.728** (1.169)	2.403* (1.033)	2.540* (0.945)
R^2	0.21	0.22	0.21
Wald test	134.47 (0.0000)***	96.69 (0.0000)***	92.96 (0.0000)***
Hausman	4.05 (0.5427)	5.63 (0.344)	4.26. (0.518)
No of observations	561	544	527
No of industry sectors	17	17	17

Notes: (1) Contemporaneous coefficient estimates on ΔCU and ΔCI for all columns. In column (b), coefficient estimates are for 1-year lag; in column (c), coefficient estimates are for 2-year lag. (2) The Huber-White robust standard errors are given in parentheses under estimated coefficients (3) p-values are given in parentheses under chi^2 – statistics for Wald test statistic. (4) Hausman statistic is asymptotically χ^2 distributed with p-values in brackets. (5) * significant at 0.01 level for a two-tailed test, ** at 0.05 level for a two-tailed test, *** significant at 0.1 level for a two-tailed test. (6) RP, relative import price; IMP, import penetration; EXI, exports share in total output; CI, capital intensity in production; and CU, capacity utilization.

(i) Total Factor Productivity Growth

(1) A decline in relative import price (ΔRP), by intensifying competition, improves TFP after 1–2 years. This is evident in *Table 5* as the coefficient estimate is negative and highly significant (5 per cent level) during lag 1 and lag 2 periods. The estimation results suggest that a 1 per cent decline in relative import price increases productivity in the range of -0.01 to -0.02 percentage points. In the short-run, the coefficient is positive and statistically significant. However, since the size of the coefficient is rather small (i.e., 0.006), the economic significance is rather limited.

(2) Contemporaneously, the import penetration $(\Delta \mathrm{IMP})$ coefficient has an insignificant impact on TFP as the coefficient is negative (-0.18) and not statistically significant. Over time, however, the productivity enhancing channels of competition, reallocation and spillover effects becomes dominant as the coefficient is positive (0.67) and highly

significant at 5 per cent level after 1 year. However, this positive effect is not sustained in the second period as the trend reverses and the coefficient becomes negative and statistically significant.

(3) An increase in export share (ΔEXI) enhances TFP of manufacturing contemporaneously as the coefficient is positive (0.05) and statistically significant at 10 per cent level. However, after 1–2 years, the coefficient, though positive, is not statistically significant. This suggests that the export-induced productivity channels such as reallocation, economies of scale and spillover effects operate only in the short-run. It also points out the pervasiveness of self-selection channel rather than export-induced learning effects in manufacturing.

(ii) Labour Productivity Growth

Since the productivity estimates of TFP are suspect of considerable measurement error, the sensitivity of our findings is evaluated in terms of the results based on LP estimates (see *Table 6*). The results are as follows.

(1) A sustained decrease in relative import price (ΔRP) augment LP growth only after 1–2 years. Contemporaneously, the coefficient is not statistically significant. This supports our earlier findings of import-induced competition channels operating after a lag in India.

(2) The increased import penetration (ΔIMP) does not have a significant impact on productivity in the current period. However, the sustained effect becomes prominent after 1 year. For instance, a 1 per cent rise in import penetration increases LP by 0.62 percentage points after 1 year lag. The result is positive and significant—both quantitatively and statistically—at 1 per cent level. This improvements in productivity exhaust in the second period as the coefficient becomes negative and statistically insignificant in period III. The results unambiguously confirm the earlier findings of a positive impact of import-induced competition, economies of scale, and spillover channels on productivity after a lag.

(3) In the current period, the export participation (ΔEXI) boost productivity as the coefficient is positive (0.08) and significant at 10 per cent level. However, as before, the sustained export participation by itself does not seem to advance productivity over time. In periods II and III, the coefficient estimate is positive but not statistically significant.

The results of TFP and LP panel regression reveal that trade stimulated productivity gains are evident in organised manufacturing. To further evaluate the robustness of the results, we use the Flexible Generalised Least Square (FGLS) estimation method, which uses an estimate of the error process in the form of AR(1)[43]. By and large, the results

[43] The GLS estimates assume that we have sufficient knowledge of the error process as it assumes a correct form of autocorrelation [i.e., AR(1)], and group-wise and contemporaneous heterogeneity in

contd…

corroborate the finding of the Random Effect estimation results (see *Table A2 in the Appendix*). There is a clear indication of trade-induced productivity effects channelising through imports, especially during the second period.

Thus, based on the econometric results, the major findings of the study are as follows:

(a) International trade has sizeable impact on organised manufacturing productivity of India. The trade-induced transmission channels, like reallocation effects, economies of scale effects, spillover effects and competitive effects are much more pronounced through imports than exports.

(b) We find that import-induced competition boosts productivity only after a lag. As the lag effect is highly significant after 1 year, it suggests a dynamic relationship between trade and productivity growth.

(c) There is some evidence of negative economies scale dominating the productivity growth in the short run. However, the trend is reversed in the following period.

(d) The trade effects of economies of scale, reallocation and spillover effects on productivity through exports are largely contemporaneous. In the long period, exports *per se*, does not seem to improve productivity.

6. Concluding Remarks

The purpose of the present empirical study is to examine the impact of international trade on productivity growth of the organised manufacturing sector in India. The rationale of the study is based on the various theoretical propositions which predict that participating in international trade could augment productivity growth through competition effects, reallocation effects, economies of scale effects and spillover effects. In contrast to the existing empirical studies on India, we tried to assess the relative merits of these channels thorough several trade related variables such as relative import prices, import penetration and export intensity. The empirical assessment is based on a panel econometric estimation of 17 2-digit sectors during the period 1980 to 2013, a period of considerable trade openness in the economy.

The descriptive analysis reveals that organised manufacturing has witnessed noticeable dynamism in terms of growth in production, productivity and trade pattern. There is evidence of a change in the pattern of specialisation—from less technology-intensive/traditional manufacturing such as food & beverage, tobacco, wood, etc., to highly technology-/skill-intensive modern activities such as chemicals and engineering sectors. The compositional shift is relatively higher in domestic production. The growth in production is accompanied by an expansion in productivity, both TFP and LP,

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the disturbances term. However, in practice, these conditions are difficult to hold, unless we have higher degrees of freedom. Since we have an insufficiently long panel, the results should not be taken as exhaustive.

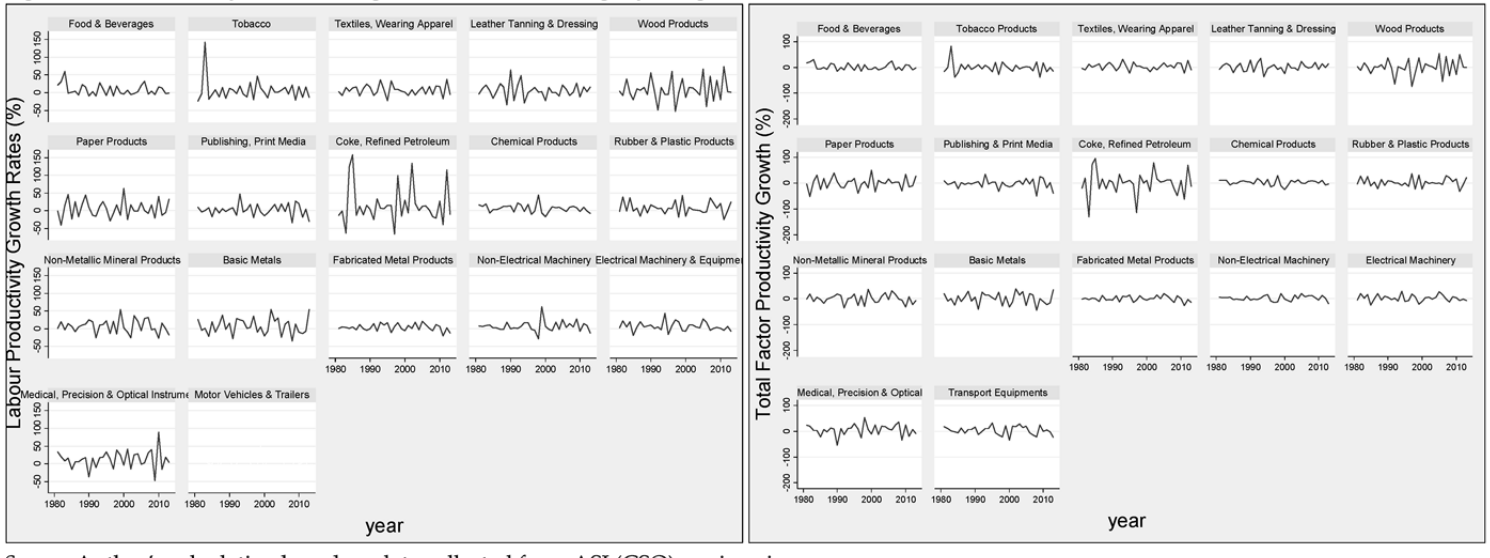
especially during the 2000s. Trade composition has also shifted towards skill-intensive manufacturing, although some traditionally competitive and labour-intensive segments such as textiles still dominate the export basket.

The panel econometric results for both TFP and LP reveal evidences of trade-induced productivity gains in manufacturing. In the short period, there is some evidence of negative economies of scale dominating from increased competition. However, we find strong evidence of trade-induced productivity gains operating through imports, especially by intensifying the competitive channels. Apparently, the positive impact of competition, reallocation and spillover channels from imports is unambiguously robust after 1 year. On the other side, there is less evidence of a sustained productivity improvement from reallocation, economies of scale and spillovers effects through exports as it was found to be significant only during the short period. The contemporaneous correlation may be because of the entry of relatively high productivity firms in the exports business with the expectation of recovering initial sunk costs rather than pure learning effects after entry. Finally, the empirical analysis reveals that the impact of international trade on productivity growth in the Indian manufacturing is not static but dynamic in nature.

The findings of the study suggest considerable scope for further empirical work in this important research area. A natural extension would be to study the impact of trade on productivity at finer disaggregation level, preferably at the 4-digit industry level or at the plant level. Analysis at this level of disaggregation will address the issue of industry/plant level heterogeneity and provide considerable insights into the adaption and learning process of firms from technological shocks. The disaggregate level study is often ideal in addressing several important econometric issues, such as the problem of endogeneity, which is likely to be present in the dynamic trade-productivity relationship. Additionally, we also require some sector-specific studies to explore industry specific issues in further detail. The import-led productivity growth needs further scrutiny, especially at the *ex-ante* level. This is possible by examining the productivity response of industries of changes in input tariff and output tariff since liberalisation. Studying some of these aspects will further enrich our understanding of the dynamic linkage between trade and productivity growth in the Indian manufacturing sector.

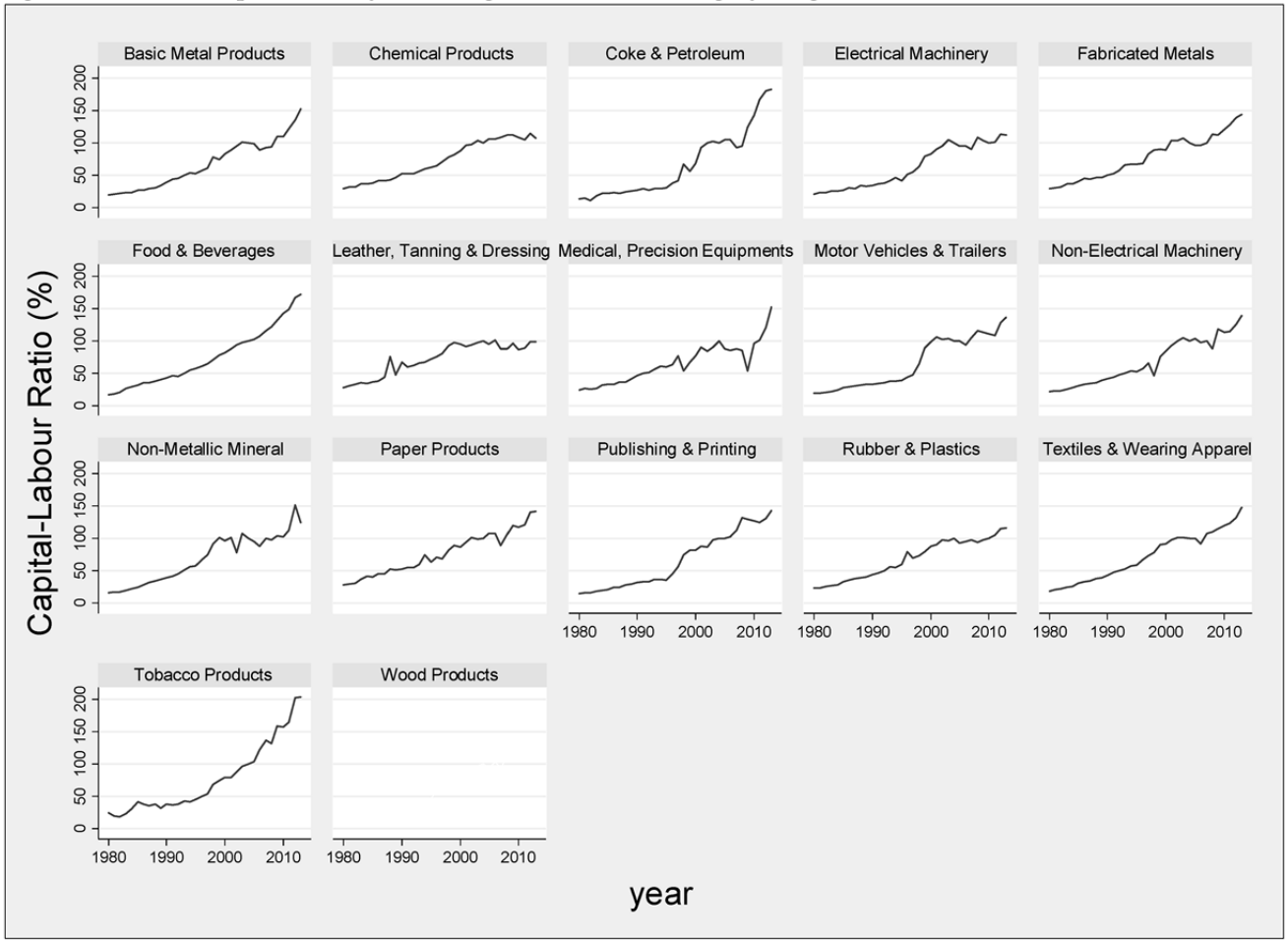
Appendix

Figure A1: Productivity Trend in Organised Manufacturing: By 2-digit Sectors (1980-2013)



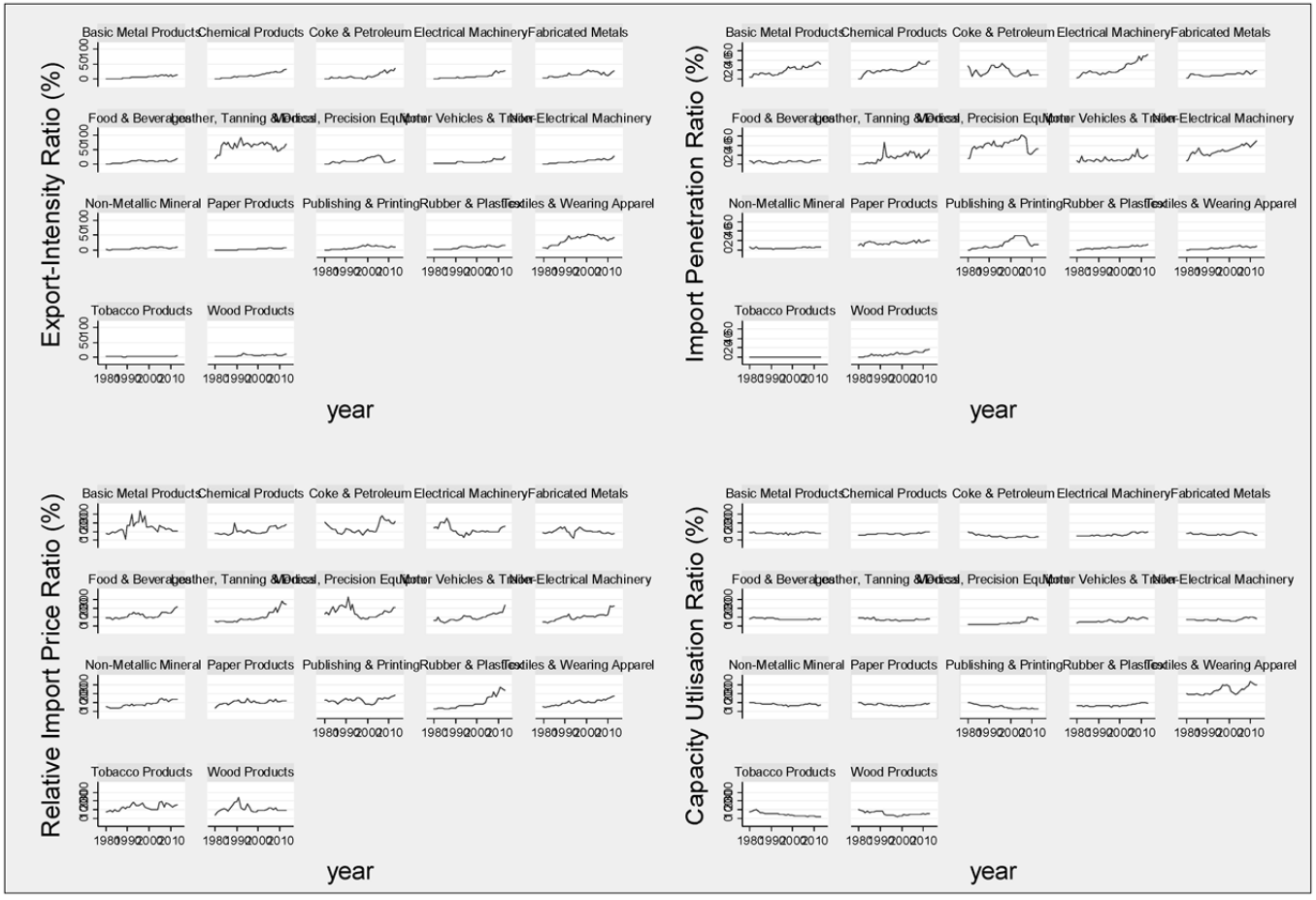
Source: Author's calculation based on data collected from ASI (CSO), various issues.

Figure A2: Trend in Capital Intensity across Organised Manufacturing: by 2-digit Sectors



Source: Author's calculation based on data collected from ASI (CSO), various issues.

Figure A3: Trend in Relative Import Price, Import-Penetration, Export-Intensity and Capacity Utilisation in Organised Manufacturing: by 2-digit Classification (1980-2013)



Source: Author's calculation based on data collected from ASI (CSO), various issues.

Table A1: Summary Statistics

Variable		*Mean*	*Std. Dev.*	*Min*	*Max*	*Observations*
	overall	1.5	20.4	-129.9	94.6	N = 561
ΔTFP	between		1.9	-2.3	5.4	n = 17
	within		20.3	-128.3	96.2	T = 33
	overall	7.3	22.9	-65.4	157.0	N = 561
ΔLP	between		3.1	2.3	16.6	n = 17
	within		22.6	-74.7	147.7	T = 33
	overall	7.7	72.4	-91.3	1600.5	N = 561
ΔRP	between		10.7	2.1	48.8	n = 17
	within		71.6	-132.4	1559.3	T = 33
	overall	0.5	4.2	-30.9	31.5	N = 561
ΔIMP	between		0.5	-0.6	1.5	n = 17
	within		4.2	-31.4	31.0	T = 33
	overall	0.6	3.9	-26.6	34.2	N = 561
ΔEXI	between		0.4	0.1	1.5	n = 17
	within		3.9	-27.5	33.3	T = 33
	overall	0.0	8.7	-54.6	47.6	N = 561
ΔCU	between		1.5	-2.2	3.2	n = 17
	within		8.6	-57.8	45.9	T = 33
	overall	6.5	11.2	-37.8	79.2	N = 561
ΔKL	between		1.3	4.1	9.5	n = 17
	within		11.1	-37.3	78.4	T = 33

Note: ΔTFP = Total Factor Productivity growth, ΔLP=Labour Productivity growth, ΔRP = Per cent change in Relative Import price, ΔIMP = first difference in Import Penetration, ΔEXI = first difference in Export Intensity Ratio, ΔCU = first difference in Capacity Utilisation Ratio, ΔKL = Growth in Capital Intensity. Variation overtime/sector is within variation while variation across sectors is called between variation.

Table A2: Flexible Generalised Least Square(FGLS) Estimate Results for Trade and productivity growth in Indian manufacturing sector: (2-digit industries sample) 1980-2013

Dependent variable: TFPG/LPG

ExplanatoryVariables	*(a) No Lag*		*(b) 1-year Lag*		*(c) 2-Year Lag*	
	TFPG	*LPG*	*TFPG*	*LPG*	*TFPG*	*LPG*
ΔRP	-0. .005 (0.006)	-0.006 (0.006)	-0.013*** (0.006)	-0.013** (0.006)	0.0004*** (0. 006)	-0.000 (0.007)
ΔIMP	0.126 (0.104)	-0.051 (0.102)	0.430*** (0.100)	0.348*** (0.093)	-0.289*** (0. 107)	-0.436** (0.106)
ΔEXI	-0. 098 (0.115)	-0.018 (0. 108)	0.176* (0. 101)	0.202** (0.090)	0. 101 (0. 117)	0.170 (0. 110)
ΔCI	0.074* (0.040)	0. 752*** (0.042)	0. 073* (0. 040)	0. 735*** (0.039)	0. 040 (0. 042)	0.737*** (0. 042)
ΔCU	1.131*** (0.056)	1.178*** (0.061)	1. 070*** (0. 052)	1.122*** (0.056)	1.080*** (0. 053)	1.132*** (0.580)
t	-0.1018* (0.051)	-0.030 (0.057)	-0.090* (0.048)	-0.026*** (0.054)	-0.117** (0.057)	-0.097 (0.062)
constant	204.45* (103.52)	63.28** (113.96)	181.88* (97.04)	54.31* (107.43)	236.59** (114.23)	196.16* (124.80)
Wald test	518.03*** (0.0000)	549.86 *** (0.0000)	536.76*** (0.0000)	583.79 *** (0.0000)	480.08*** (0.0000)	502.20*** (0.0000)
No of observations	561		544		527	
No of industry sectors	17		17		17	

Notes: (1) Contemporaneous coefficient estimates on ΔCU and ΔCI for all columns. In column (b), coefficient estimates are for 1-year lag; in column (c), coefficient estimates are for 2-year lag. (2) standard errors are given in parentheses under estimated coefficients (3) p-values are given in parentheses under chi^2 – statistics for Wald test statistic. (4) * significant at 0.01 level for a two-tailed test, ** at 0.05 level for a two-tailed test, *** significant at 0.1 level for a two-tailed test. (6) TFPG, Total Factor Productivity Growth; LPG ,Labour Productivity Growth; RP, relative import price; IMP, import penetration; EXI, exports share in total output; CI, capital intensity in production; and CU, capacity utilization, t, time.

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