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Exports and Growth in Indian Manufacturing:
An Econometric Analysis

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Exports and Growth in Indian Manufacturing: An Econometric Analysis

Bishwanath Goldar*

Abstract: *The paper investigates econometrically the relationship between the growth in exports and the growth in the manufacturing sector real gross value added (GVA) in India. An analysis of this relationship is undertaken first at the level of aggregate manufacturing using time-series data for 1987-88 to 2019-20 and then at the level of disaggregated three-digit industries using panel data for 2014-15 to 2019-20. The analysis presented in the paper reveals a significant positive relationship between the growth in exports and the growth in real GVA of manufacturing. From the results of the empirical analysis, it appears that for the low-growth and medium-growth industries, increases in exports make an important contribution to their growth, but for the high-growth industries, there are probably other forceful drivers of growth and exports play a relatively less important role. An important finding of the study is that a greater prevalence of R&D activities and foreign equity participation among medium and large industrial enterprises in India enhances the pace of industrial growth in India, and so does the adoption of ISO 14000 series certification and the associated implementation of environmental management systems among such industrial enterprises.*

Keywords: Exports, Growth, Indian manufacturing, R&D, Foreign Direct Investment, ISO 14000
JEL Classifications: F10, F43, O30, Q56

1. Introduction

In the period since the 1980s, the Indian economy has grown at the average rate of about six percent per annum. The average growth rate in the period 1981-82 to 2007-08[1] was slightly lower than six percent per annum, and that in the period since 2008-09, i.e., the

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[1] These are financial years, from April 1st to March 31st next year. Thus, 2007-08 means April 1, 2007, to March 31, 2008. The same practice followed for other financial years.

post-GFC (global financial crisis) period, was slightly higher than six percent per annum. India's manufacturing sector has grown, on average, at the rate of about seven percent per annum. The average growth rate of manufacturing was about 6.7 percent per annum during1981-82 to 2007-08 and about 7.2 percent per annum during 2008-09 to 2018-19.

At the current juncture of her economic development, India needs a significant step up in the rate of economic growth, and this requires the manufacturing sector to take a lead in the economy and the growth rate of manufacturing to accelerate substantially. The need for accelerated growth in manufacturing in India has been recognized by several scholars. To give an example, Mohan and Kapur (2015, p. 34) have observed, based on their analysis of India's economic growth, that a sustained GDP growth rate of 8-9 percent in India in future years is not feasible unless the industrial growth in India is in double digits.[2]

It seems reasonable to argue that accelerated growth in Indian manufacturing needs an accelerated growth in India's manufactured product exports. There have been studies in the past that have dealt with India's export growth potential in the context of India's industrial growth, and the findings of such studies may provide useful guidance on what needs to be done for boosting India's manufactured product exports (see, for example, Anand et al., 2015; and Veeramani and Dhir, 2017; see also Veeramani, et al., 2018; Veeramani and Aerath, 2020; and Banga and Banga, 2020, for a discussion on India's export performance).[3] The object of this paper is to examine the relationship between exports and growth in Indian manufacturing. An attempt is made to quantify the relationship to provide an estimate of the elasticity of manufacturing sector growth with respect to growth in exports (hereafter called export-driven GVA growth elasticity), as also to identify certain other important factors determining manufacturing sector growth.[4]

An analysis of the relationship between the growth in exports and the growth in real GVA of manufacturing is undertaken in the paper first at the level of aggregate manufacturing using time-series data for 1987-88 to 2019-20 and then at the level of disaggregated three-digit industries using panel data for 69 industries for 2014-15 to 2019-20. The second

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[2] An interesting question that arises here is, given that a process of premature de-industrialization has occurred in many emerging economies (Rodrik, 2015), including India, will it be possible to break away from this tendency and attain a rapid growth in Indian manufacturing well above the growth rate of the economy with a rising share of manufacturing in GDP. The answer to this question lies in the underlying reasons for the observed phenomenon of premature de-industrialization in India and the scope of taking remedial action to reverse the process. See, in the context, Kumar (2018). Kumar argues that import liberalization and appreciation in exchange rate are two major reasons for the process of premature de-industrialization in India. He notes that there has been outsourcing of manufacturing activity by Indian firms to other countries because of exchange rate appreciation. Arguably, with appropriate policies in place including a competitive exchange rate, a rapid growth in manufacturing in India, ahead of GDP growth, should be attainable.

[3] For an analysis of India's exports and the potential for growth in exports of network products, see Chapter 5, *Economic Survey*, 2019-20, Volume I, Ministry of Finance, Government of India.

[4] For an earlier study on the relationship between exports and growth in Indian manufacturing, see Banga and Das (2012).

component of the analysis makes use of the recently released provisional results of the *Annual Survey of Industries*[5] for 2019-20.

The analysis presented in the paper bears a connection with the analysis presented in the recent paper of Gupta and Tyagi (2022) dealing with the economic slowdown in India in 2019-20 and a previous study by the present author (Goldar, 2022) which looked into the question of why the growth rate in real GVA of Indian manufacturing declined markedly in 2019-20.

The rest of the paper is organized as follows. The next section discusses the growth performance of Indian manufacturing in recent years, particularly in 2019-20. Section 3 presents a conceptual framework intended to provide a theoretical underpinning for the econometric analysis presented later in the paper. The econometric analysis of the relationship between growth in exports and growth in manufacturing GVA at the aggregate level is presented in Section 4. This is followed by a disaggregated panel-data-based industry-level analysis, presented in Section 5. Finally, Section 6 summarizes and concludes.

The paper has several annexures. Some of them present the results of additional econometric analyses that have been carried out for checking the robustness of the empirical findings presented in the main body of the paper, and some present results of unit-root tests.

2. Recent Trends in Growth Rate of Real GVA of Indian Manufacturing and Exports

Gupta and Tyagi (2022) in their recent paper have observed that there was a deep economic slowdown in India in 2019-20. The growth rate of the Indian economy in 2019-20 was about four percent, the lowest in a decade. They point out that the slowdown in growth was primarily concentrated in the manufacturing sector which contracted by more than two percent in 2019-20. Based on their investigation of the underlying causes of the slowdown, they conclude that the collapse in exports in 2019-20 was one of the reasons for the slowdown in India's economic growth in that year.

In a previous study by the present author, Goldar (2022), it was noted that the average annual growth rate in real GVA of Indian manufacturing was 8.0 percent during 2003-04 to 2018-19 and 7.5 percent during 2012-13 to 2018-19, and by contrast, it was negative at (-)2.9 percent in 2019-20, involving a negative growth turnaround of about 10 percentage points.[6] Based on a preliminary investigation of the reasons for the sharp decline in the growth rate in Indian manufacturing in 2019-20 (which turned negative in that year), the paper concluded that, along with certain other contributory factors, the decline in

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5 Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India.

6 These growth rates were computed by using data on real GVA of manufacturing in *National Accounts Statistics* (NAS), Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India.

manufactured products exports in 2019-20 (as against a seven percent average annual growth in the three preceding years) was probably one of the important causes of the negative growth turnaround in Indian manufacturing in that year. Some empirical evidence linking the export growth performance and the output/GVA growth performance of manufacturing in 2019-20 was presented in the paper, based on industry-level data and firm (company)-level data.

With the recent release of the provisional results of the *Annual Survey of Industries* (ASI) for 2019-20, it has become possible to carry out a detailed analysis of growth in manufacturing industries in 2019-20 at a disaggregated level. Therefore, such an analysis is presented in the paper. The trends and the patterns of the rate of growth in real GVA for manufacturing industries at the three-digit level of NIC (National Industrial Classification), 2008 are analyzed for the years 2014-15 through 2019-20. Also, these data on the GVA growth rate at the industry level are used for the econometric analysis presented later in Section 5 of the paper.

2.1 Trends at the aggregate level

Considering the growth performance of Indian manufacturing, based on *National Accounts Statistics* (NAS),[7] it is found that the average growth rate in real GVA of manufacturing was 7.2 percent during 2008-09 to 2015-16 and 7.0 percent during 2016-17 to 2018-19. The growth rate in 2019-20 was (-)2.9 percent, markedly below the trend prevailing in the recent past.

The ASI data for the organized manufacturing sector[8] show a decline in the real GVA of organized manufacturing in 2019-20 by about 2.7 percent which roughly matches the decline in real GVA by 2.8 percent observed in the NAS data on GVA of the corporate sector of manufacturing though the latter is based on a different data source, namely the MCA-21 database,[9] for its main constituent (organized manufacturing is the main part of the corporate sector of manufacturing in NAS, which also includes a section of unorganized enterprises).

Turning now to exports, during 2016-17 to 2018-19, the average annual growth rate in India's non-oil exports in current US dollars was about seven percent, and the growth rate was negative at minus four percent in 2019-20.[10] Taking data on the exports of 14 important

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[7] Central Statistics Office, Ministry of Statistics and Programme Implementation, Government of India.

[8] Nominal GVA data for manufacturing (defined as NIC-10 to NIC-33, according to National Industrial Classification (NIC), 2008) have been taken from Vol. I of ASI Reports for different years (for 2019-20, the provisional results are used). The nominal GVA has been deflated by the implicit deflator for GVA of manufacturing in NAS.

[9] See CSO (2015), Goldar (2016), and Sapre and Sinha (2016), among others, for a discussion on the use of MCA-21 database for the GVA estimation for Indian manufacturing.

[10] This is based on data taken from the *Handbook of Statistics on Indian Economy*, 2020-21, Reserve Bank of India, Mumbai. The basic data source is the Directorate General of Commercial Intelligence and Statistics (DGCI&S), Ministry of Commerce and Industry, Government of India.

categories of manufactured products (including engineering goods, gems and jewellery, drugs and pharmaceuticals, readymade garments, and organic and inorganic chemicals),[11] at the current value of US dollars, and adding to that the value of exports of petroleum products, the average annual growth rate in exports is found to be about eight percent during 2016-17 to 2018-19 and the growth rate for 2019-20 is found to be minus 5.2 percent (Goldar, 2022). It is thus evident that there was a major negative growth turnaround in India's manufactured goods exports in 2019-20.

These growth trends in exports seen together with the growth trends in manufacturing GVA would lead one to infer that the fall in exports in 2019-20 had adversely affected the growth in output and GVA of Indian manufacturing in that year.

Some doubts, however, arise on whether the decline in the growth rate of manufactured product exports in 2019-20 should be taken as the main factor responsible for the negative growth turnaround in manufacturing in 2019-20. The reason for these doubts is that going by ASI unit-level data, only about seven percent of the organized sector manufacturing plants are engaged in exports (i.e., 93 percent of manufacturing plants do not export) and the average export intensity (exports to output ratio) of organized manufacturing plants is only about four percent (see Goldar, 2022; see also Annexure-A). It is unclear whether the negative growth turnaround in manufactured exports could have caused a major setback to the GVA growth in Indian manufacturing if the domestic market remained intact in 2019-20 and was growing. If exports are viewed merely as a supplementary channel for a small section of the manufacturing firms to sell their products, a large negative effect on the entire manufacturing sector does not, *prima facie*, seem very likely. Yet, a significant adverse effect of the decline in exports on manufacturing sector growth could have occurred because there are possibilities of significant indirect effects through the buyer-supplier linkages between exporting plants and non-exporting plants. Also, it needs to be recognized that ASI captures only the direct exports of manufacturing plants, and there are possibly significant amounts of indirect exports being done by organized sector manufacturing plants through intermediary firms (see, in this context, Ahn, et al., 2011, for a discussion on indirect exports in China). This point is discussed further in Annexure-A.

2.2 Trends in GVA growth at Industry-level

For computing the real GVA growth rates at the three-digit industry level, data on the GVA of 69 three-digit manufacturing industries (excluding NIC-33) have been taken from Vol. I of ASI published reports (provisional results for 2019-20). Deflation of GVA has been done by using price indices at the two-digit industry level. The wholesale price indices have been used.[12] The price index for a two-digit industry has been applied to all constituent three-digit industries.

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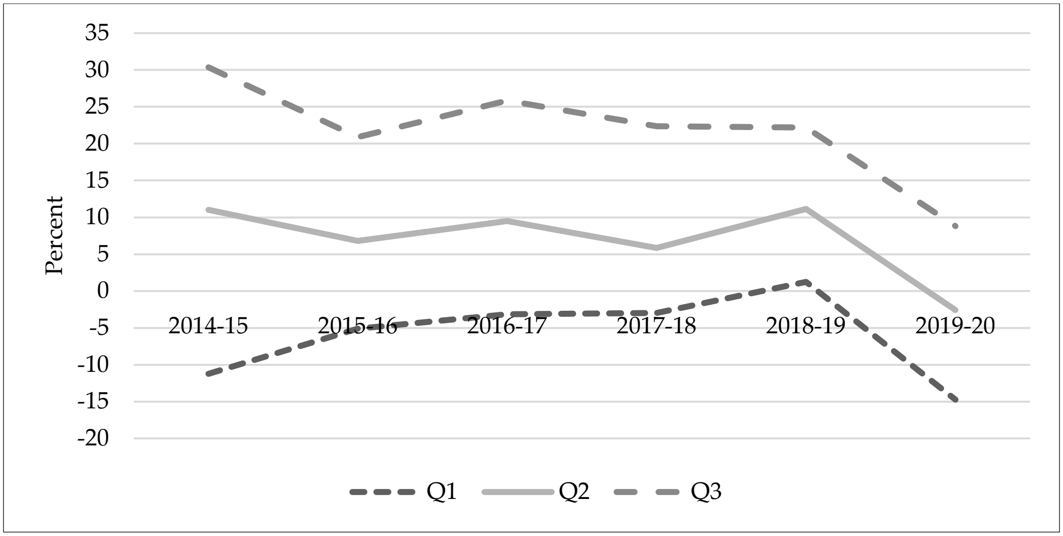
[11] The same data source as mentioned above.

[12] The data source for the wholesale price indices is the Office of the Economic Advisor, Department for

Figure 1 shows the median rate of growth in real GVA across three-digit industries along with the first and third quartiles (Q1 and Q3) for different years during 2014-15 to 2019-20. It is seen that the median growth rate was positive in the years 2014-15 to 2018-19, and it turned negative in 2019-20. There was a decline in both Q1 and Q3. The third quartile of GVA growth rates was in the range of 20 to 30 percent per year during 2014-15 to 2018-19, and it came down to below 10 percent in 2019-20.

Figure 1: Real GVA growth rates of three-digit manufacturing industries, by year, Median(Q2), First Quartile (Q1) and Third Quartile (Q3)



Source: Author's computations based on ASI Data

The median of the industry-wise growth rates in 2019-20 was (-)2.6 percent, and the 10th and 90th percentiles were (-)27.8 percent and 33.6 percent respectively. Interestingly, although the growth rate was negative in 2019-20 in many industries (39 out of 69 industries), some industries achieved high growth rates in that year.

3. Conceptual Framework

To provide a theoretical underpinning for the model specifications adopted in the econometric analysis presented in the next two sections of the paper, a conceptual framework is developed in this section for which certain simplifying assumptions are made regarding the relationship between industrial growth in India and the growth in global industrial goods exports. It is assumed that the relationship between the manufacturing sector's real GVA growth in India and the growth in the global market of manufactured product exports may be expressed in terms of a single parameter, denoted

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by α, that is expected to remain by and large stable over time. This parameter is the elasticity of growth in manufacturing real GVA in India with respect to the growth rate in world exports of manufactured products. The parameter is assumed to remain stagnant, or more or less stagnant, in the medium term. This may be written as (a partial derivative):

$$\alpha = \frac{\partial g_{GVA}}{\partial g_{WMX}} \text{ ... (1)}$$

where, g_{GVA} is the growth rate in real GVA in manufacturing in India and g_{WMX} is the growth rate in global exports of manufactured products. Although the true relationship is complex because it depends on the product-wise growth rates in the world market and the product composition of India's exports, it seems that for empirical analysis in practice it would be useful to think of a single parameter, stable over time and representing broadly the prevailing relationship.

The elasticity of the growth rate in India's manufacturing GVA with respect to the growth rate in global exports of manufactured products may be decomposed into two parts: the elasticity of the growth rate in India's manufacturing GVA with respect to the growth rate in India's exports of manufactured products (denoted by γ) and the elasticity of the growth rate in India's exports of manufactured products with respect to the growth rate in the global exports of manufactured products (denoted by β). Thus, the relationship may be written as

$$\alpha = \frac{\partial g_{GVA}}{\partial g_{WMX}} = \frac{\partial g_{GVA}}{\partial g_{IMX}} . \frac{\partial g_{IMX}}{\partial g_{WMX}} = \gamma \times \beta \text{ ... (2)}$$

In this equation, g_{IMX} denotes the growth rate in India's exports of manufactured products. The parameter α will go up and India will be able to reap more benefits from the growth in the global export market in manufactured products if β goes up or if γ goes up, or both go up. In the paper, the focus is on estimating the export-driven GVA growth elasticity in manufacturing, which is the parameter γ in the equation above.

It is possible to provide a theoretical basis for each of the two parameters β and γ. The parameter β is already in use in the empirical trade literature. It represents the income elasticity of demand for India's exports. Instead of using the world income as an argument in the export demand function, the volume of world exports of the product could be used. To give an example, the logarithm of India's aggregate export volume is regressed on the logarithm of world exports and certain other variables including the real effective exchange rate in a study by Rangarajan and Kannan (2017). According to their estimates at a disaggregate level, the estimate of the elasticity of India's exports with respect to world exports was 2.58 for chemical products, 1.32 for manufacturing goods, 2.21 for machinery and equipment, and 1.92 for miscellaneous manufacturing goods. Thus, overall, the estimate of β for manufactured products appears to be about 2 for Indian manufacturing. The period covered in the study is 2003 to 2013, which could be treated as an estimate relevant to the present.

Turning to the parameter γ, this may be derived from the Leontief input-output model. In this framework, if the export vector changes by ΔX and other final demand vectors do not change, then the change in the gross output vector ΔY may be derived as:

$$\Delta Y = (I - A)^{-1} \Delta X = R . \Delta X \quad \ldots (3)$$

where, A is the input-output coefficients matrix and R is the Leontief inverse. Since in the input-output model framework, the value-added (V) content in gross output for each industry i, given by the coefficient $V_i/Y_i = v_i$, is fixed, the change in gross value added can easily be derived, as shown in the equation below:

$$\Delta V = \Omega . \Delta Y = \Omega . R . \Delta X \quad \ldots (4)$$

where, Ω is a matrix in which the principal diagonal is made of v_i, i.e., the share of value-added in gross output in different industries and zeros in the rest of the matrix.

If exports of all items rise by λ, i.e., $\Delta X = \lambda X$, then the change in the V vector can be computed and thus the change in aggregate V can be computed, which will provide a measure of the elasticity of aggregate GVA in the country to a proportionate change in exports.

In the next step, it may be assumed that the increase in export is confined to manufacturing industries only. Then, on that basis, the increase in the V vector can be computed and the increase in gross value added in manufacturing can be derived. This will yield the elasticity of manufacturing sector value-added for a specific percentage increase in exports of different manufactured products (shown in Annexure-B). This elasticity principally depends on (a) the R matrix, (b) the distribution of manufactured product exports among different industries, i.e., the composition of exports, and (c) the share of different industries in the gross output of manufacturing along with the value-added content in the gross output of each industry which is a fixed parameter in the Leontief framework.

Significance of the export-driven GVA growth elasticity

It is important to draw attention to the significance of the parameter γ. It has been noted above that according to Mohan and Kapur (2015), for attaining a sustained GDP growth rate of 8-9 percent in India, double-digit growth in manufacturing is required. In the past, the average growth rate in the manufacturing sector real GVA has been about 7 percent per annum. If this is to be raised to 10 percent per annum and the value of the parameter γ is equal to one, the required hike in the growth rate in manufactured goods exports is about 3 percentage points. In the recent past, 2016-2018, the growth rate in India's manufactured exports was about 8 percent. For attaining a double-digit growth in the manufacturing sector, this growth rate in manufactured product exports has to be raised to 11 percent or thereabout, which does not appear too difficult. On the other hand, if the value of the parameter γ is 0.2 or less, and the move to a double-digit manufacturing growth is to be achieved only or mainly based on an export-led growth strategy involving faster growth in exports, then the required growth rate in India's manufactured goods exports will probably be more than 20 percent per annum.

The world export market of manufactured goods has grown annually at an average rate of about 2 percent during 2012-2018 and 3.6 percent during 2008-2018.[13] If this pace of growth in the world export market continues, a growth rate of more than 20 percent per annum in India's exports of manufacturing products is undoubtedly very difficult, if not impossible. In this scenario of γ being 0.2 or less, an export-led manufacturing sector growth strategy in India may face considerable problems, and therefore there is a need for appropriate policies directed at swiftly generating domestic demand so that there is faster growth in domestic demand for industrial products supporting rapid industrialization.

4. Relationship between Exports and Growth: Estimation of an ARDL Model

To study the impact of growth in exports on the manufacturing sector GVA growth at the aggregate level, an ARDL (Auto-Regressive Distributed Lag) model has been estimated using time-series data for the period 1987-88 to 2019-20.[14] The growth rate in real GVA of manufacturing has been taken as the dependent variable (data taken from NAS). Five explanatory variables are used.[15] These are:

(i) The growth rate in India's non-oil exports in current US dollars (data taken from *Handbook of Statistics on Indian Economy*, 2020-21, Reserve Bank of India);
(ii) The growth rate in the GDP of OECD member countries (data source: GDP growth, (annual %),[16] Economy and Growth,[17] World Bank Open Data, World Bank);
(iii) The growth rate in the combined real GVA of trade, repair services, transport, and communication sectors (data taken from NAS);
(iv) The growth rate in power generation in utilities (data taken from *Economic Survey*, 2021-22, Ministry of Finance, Government of India – the basic source is the Ministry of Power, Government of India). This variable has been lagged by one year in the estimated model to get around any model estimation issues arising from the possibility of reverse causation that a high rate of growth in manufacturing sector output in a year may impact the growth rate in power generation in the utilities in that year; and
(v) The growth rate in the ratio of the price of crude oil in international markets (annual average, expressed in Indian Rs.) to the wholesale price index of manufactured products in India.

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[13] These growth rates have been computed from trade data available in the databases of the World Bank. https://data.worldbank.org/topic/21

[14] A similar analysis was presented in Goldar (2015) using data for 1981-82 to 2013-14. Datta and Lahiri (2018) have applied an ARDL model to examine the relation between exports, FDI and economic growth in India.

[15] The third and the fourth variable, particularly that related to transport and communication, are expected to capture the impact of improvements in infrastructure facilities on growth.

[16] https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

[17] https://data.worldbank.org/topic/3

The results of the model estimate[18] are presented in Table 1. Estimates of two regression equations are shown – one includes the growth rate in the GDP of OECD member countries, and the other one does not. The results indicate a significant positive effect of the explanatory variables (i)-(iv) above on the growth rate in real GVA of Indian manufacturing and a significant negative effect of hikes in crude oil prices.[19]

Table 1: Explaining the growth rate of real GVA of Indian manufacturing, ARDL model

Dependent variable: Growth rate in real GVA of Indian manufacturing
Period: 1987-88 to 2019-20

Explanatory variables	*Long-run coefficient, Regression-1*	*Long-run coefficient, Regression-2*
Growth rate in India's non-oil exports	0.435*** [0.087] (5.02)	0.166** [0.077] (2.16)
Growth rate in GDP of OECD member countries	1.891** [0.891](2.12)	
Growth rate in real GVA of trade, repair services, transport, and communication	1.421*** [0.481] (2.95)	1.562*** [0.504] (3.10)
Growth rate in power generation in utilities (lagged by one year)	1.795*** [0.539] (3.33)	1.004* [0.477] (2.10)
Growth rate in the price of crude oil in international markets relative to the wholesale price index of manufactured products in India	-7.055** [2.702] (-2.61)	-6.984** [3.061] (-2.28)
Trend term	Included	Not included
No. of observations	33	33
R-squared (of the error correction model)	0.80	0.88
ARDL Lag structure	(1,1,2,2,2,0)	(2,2,3,3,0)
Adjustment coefficient	-1.180*** 0.214(-5.51)	-0.900*** 0.176(-5.12)
Pesaran, Shin, and Smith (2001) bounds test		
F-value	5.65	5.83
t-ratio	-5.51	-5.12

Notes: The critical values for the bounds test at a 5 percent level of significance are 3.8 for F and -3.4 for t for I(0), and 5.5 for F and -4.6 for t for I(1). Inference: the null hypothesis of 'no level relationship' is rejected at a 5 percent level of significance. Standard errors are shown in square brackets and t-ratio in parenthesis. Optimal lag length is determined by the Bayesian information criteria.
* prob. <0.1, **prob.<0.05, *** prob.<0.01
Source: Author's computations

[18] All six variables (one dependent, five explanatory) are found to be integrated of order zero, i.e., they are I(0), based on the Augmented Dickey-Fuller test (see Annexure-C). For the estimated models in Table 1, when the Pesaran, Shin, and Smith (2001) bounds test is applied, the null hypothesis that there is no level relationship is rejected at a 5 percent level. Thus, the results indicate the presence of co-integration.

[19] A negative effect of crude oil prices on India's economic growth has been found in several earlier studies. See, for example, Sarmah and Bal (2021).

Based on the estimates obtained (Regression-1), the long-run coefficients are found to be as follows: growth in non-oil exports, 0.44; growth in GDP of OECD member countries, 1.89; growth in power generation, 1.80; and growth in real GVA of trade, repair services, transport, and communication, 1.42. Thus, the results show a significant positive impact of growth in exports on the manufacturing sector GVA growth with an elasticity of 0.44.

In Regression-2, an alternate estimate has been made after dropping from among the explanatory variables, the growth rate in GDP growth of OECD member countries. The results are qualitatively similar to those in Regression-1. However, in this case, the elasticity of manufacturing GVA growth to export growth is found to be about 0.17. Thus, considering the two estimates of elasticity in Table 1, it may be inferred that the elasticity of manufacturing sector GVA growth with respect to export growth is probably somewhere in the range of 0.2 to 0.4.[20]

Figure 2 shows the growth rate in real GVA in Indian manufacturing in the years 1987-88 to 2019-20 along with the ARDL-model-predicted values for Regression-1. The value of R^2 signifying the explanatory power of the estimated ARDL model is 0.74 (it is 0.80 for the error correction model, Table 1). The estimated model fits the data well. It is interesting to note that the model predicts a lowering of growth rate in 2018-19 compared to 2017-18, followed by a further fall next year and a negative growth rate in real GVA of manufacturing for 2019-20, both of which occurred.

Two concerns may be raised here about the results of the ARDL model presented above. First, data for 33 years have been used for the regression analysis during which major changes occurred in the policy regime, and yet in the method employed for model estimation, these changes in the policy regime have not been explicitly incorporated. Second, the impact of exports on the domestic industry growth depends on the break-up of domestic and foreign value-added components in exports. This has not been taken into account in the analysis.[21]

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20 Some other estimates of the ARDL model presented later also give an elasticity estimate in this range.

21 A third concern that may be raised is that due to trade interventions (import tariff and quantitative restrictions), domestic prices of manufactured products will differ from international prices. In the models estimated, GVA growth is based on domestic prices, but the growth in exports is based on international prices. The ratio of domestic prices to international prices of manufactured products in India has fallen over time in the post-reform period, with the decline in the nominal and effective rates of protection. To incorporate this aspect into the analysis, Regression-2 in Table 1 has been re-estimated after adding the annual changes in the average rate of India's tariff on imports of goods as an additional explanatory variable. The results do not change much. The estimate of the long-run coefficient of export growth is found to be 0.18.

Figure 2: Growth rate in real GVA, Indian Manufacturing Actual and ARDL Model fitted values, 1987–88 to 2019–20

Along x-axis, 1990-91 is written as 1990, 2010-11 as 2010, and similar for other financial years

Source: Author's computations based on NAS and other data sources explained in the text.

Addressing the first concern fully is difficult. One step that has been taken in this direction is to leave out the pre-reform period and estimate the model using data for the period from 1991-92. In addition, Regression-1 in Table 1 has been estimated by the OLS (ordinary least squares) method,[22] and the Cusum and Cusum-squared tests have been carried out. The results do not show any structural break in the post-reform period. It seems that the policy regime changes in the post-reform period in India did not have such a big impact on the model parameters as to render invalid the results of the ARDL model presented in Table 1.

As regards the second concern, a variable representing the domestic value-added (DVA) content in exports of the manufacturing sector has been introduced in the ARDL model. The Trade in Value Added (TiVA) database[23] has been used for this purpose. The database provides DVA content of India's manufactured goods exports for the years 1995 to 2018. To extend/ extrapolate the series backward to 1989, some earlier studies have been used (see Burange, 2001; Bhat et al. 2007; and Goldar, et al. 2020). The estimate of the ARDL model after introducing the DVA content in exports is presented in Annexure-D.

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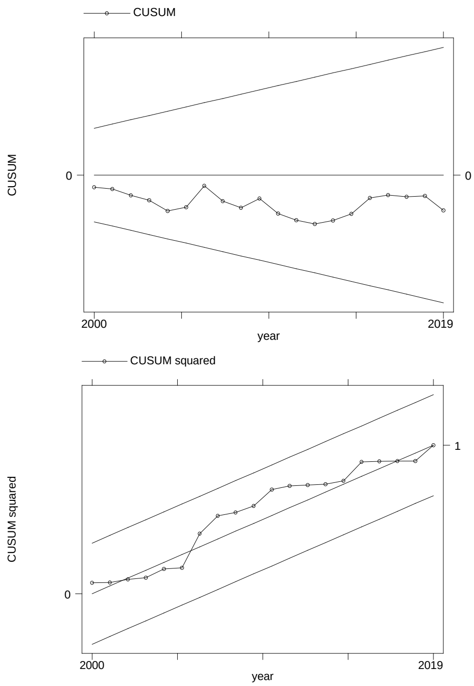
[22] Since all variables in the equation are I(0), the use of the OLS method is justified.

[23] https://www.oecd.org/sti/ind/measuring-trade-in-value-added.htm

Figure 3: Cusum and Cusum-squared test



Source: Author's computations.

In the estimates of the ARDL model obtained after introducing the new variable, DVA (domestic value-added) content in exports, the coefficient of DVA is found to be positive and statistically significant. One may thus infer that *ceteris paribus* an increase in the DVA content in exports tends to enhance the growth rate of the domestic manufacturing sector. It needs to be pointed out, however, that Veeramani and Dhir (2021) have presented empirical evidence which indicates that backward integration into GVCs (global value chains) – use of imported input to produce for exports – leads to a higher absolute value of gross exports, domestic value-added and employment. This is their finding for India, based on an econometric analysis they have carried out using data on India's exports and the Indian economy. They find a positive effect of foreign value-added (FVA) content in exports in the econometric analysis undertaken by them for manufacturing. It needs to be recognized further that in the model specification used in this study, the positive effect of an increase in FVA content in exports is possibility captured by the export growth variable, leading to a positive coefficient of domestic value-added content variable (i.e., a negative coefficient of the FVA content). Thus, there is a need for caution in drawing an inference about the impact of a change in DVA content in exports from the model estimates presented in Annexure-D. Considering the results presented in Annexure-D, keeping also in mind the findings of Veeramani and Dhir (2021), it may be inferred that while the growth in exports has a positive effect on the GVA growth in Indian manufacturing, if the increases in exports are achieved with the help of large increases in the foreign inputs used for exports, the beneficial effect of export growth on manufacturing sector GVA growth may be substantially curtailed.

5. Analysis of Relationship between Exports and Growth -- Three-digit Industries

In the next step of the analysis, econometric models are estimated using disaggregated industry-level panel data. For this purpose, the growth rates in real GVA of manufacturing industries at the three-digit level for the years 2014-15 to 2019-20 are considered. This analysis is confined to NIC 2-digit codes 10 to 32. Industry NIC-33 (Repair and installation of machinery and equipment) is left out, as there is no corresponding data on exports. The total number of observations is 414. In two cases, the estimated GVA for the industry is negative and the growth rate in real GVA cannot be computed. Hence, the growth rate in real output has been used in place of the growth rate in real GVA. This impacts four observations. As mentioned earlier, nominal GVA has been deflated by the wholesale price indices at the two-digit industry level, i.e., the price index for a two-digit industry has been applied to all constituent three-digit industries.

Figure 4: Kernel density estimate, growth rate in real GVA, three-digit Indian manufacturing industries, 2014-15 to 2019-20

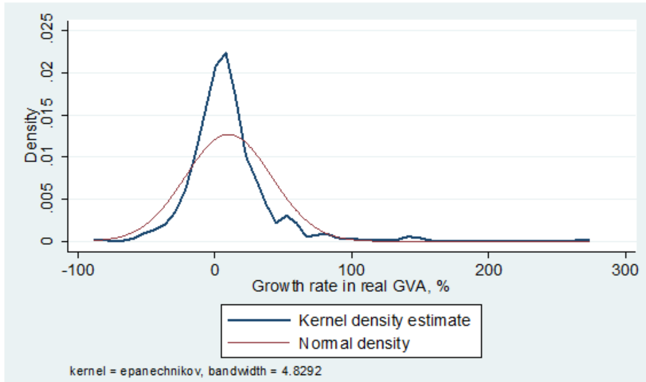
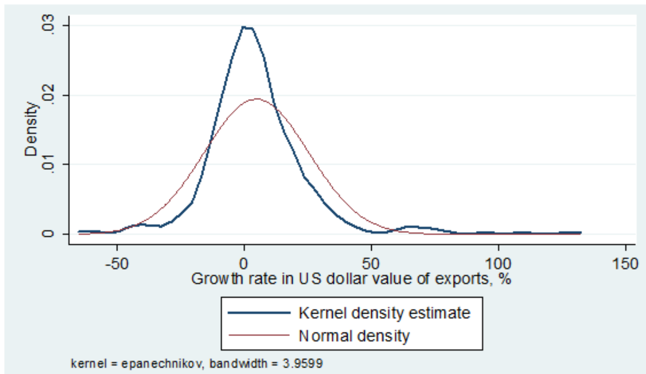


Figure 5: Kernel density estimate, growth rate in exports, three-digit Indian manufacturing industries, 2014-15 to 2019-20



Source: Author's computations based on ASI and trade data.

For getting the corresponding growth rates in exports (in current US dollars), data on exports have been drawn from the UN-COMTRADE database with the help of the WITS (World Integrated Trade Solutions) software of the World Bank. Export data (for calendar years) at ISIC (International Standard Industrial Classification), Rev.3 have been taken at three and four-digit levels. The ISIC Rev.3 at three- and four-digit levels have been mapped into the NIC-2008 to get for each three-digit NIC industry the growth rate in exports. For three industries, namely petroleum products, pharmaceutical products, and gems and jewellery, instead of using the abovementioned source, the data on exports (in current US dollars) have been taken from the *Handbook of Statistics on Indian Economy*, 2020-21, Reserve Bank of India (basic source DGCI&S). For three other industries (NIC-182, NIC-243, and NIC-268), data on exports (in current US dollars) have been taken from the *Export Import Data Bank*, Department of Commerce, Ministry of Commerce and Industry, Government of India.

Examining the distribution of the GVA growth rates, it is found that there is wide variation, and the same applies to the export growth rates. The kernel density functions of the GVA growth rates and the export growth rates are shown in Figures 4 and 5 respectively, with a comparison made with the normal density function. For these graphs, the industries whose share in aggregate GVA of organized manufacturing in 2019-20 was less than 0.05 percent have been left out. Also, all observations in which the growth rate in GVA was more than 300 percent have been left out; for exports, the cut-off used is 150 percent (after applying the above GVA share cutoff, there are no cases of above 150 percent growth).

5.1 Quantile Regression

To study the relationship between GVA growth and export growth, the quantile regression method has been applied. The dependent variable is the growth rate in real GVA (for various three-digit industries for each of the six years). The main explanatory variable is the growth rate in the US dollar value of exports. For both these variables, the observations in which the growth rate is more than 200 percent or the rate of fall of more than 90 percent have been left out. Also, the analysis is confined to those industries whose share in the aggregate GVA of organized manufacturing in 2019-20 was at least 0.05 percent (reducing the sample to 61 industries).

Another explanatory variable considered is profitability or profit margin. This is measured by taking the ratio of net profits to output (both at current prices). This variable has been winsorized at the 5th and 95th percentile, i.e., the values below the 5th percentile have been raised to this lower limit and the values above the 95th percentile have been capped at the level of the 95th percentile. This has been done so that very high or very low (negative) values of the explanatory variable do not affect the regression results.

In addition to the above, an explanatory variable representing the export orientation of the industry has been introduced. For this purpose, the average export intensity (share of exports in value of products and by-products produced) among plants with 50 or more workers has been computed for each industry for each year. These have been estimated from the unit-level data of ASI after applying sample weights. In the model estimated, this variable is lagged by one year. Thus, the growth rate in real GVA in year *t* over the year *t*-1 is taken as a function of (i) the growth rate in exports in year *t*, (ii) profitability in year *t*, and (iii) the level of export orientation in year *t*-1.[24] In addition, dummy variables for years are used in the regression to capture the year-specific effects.

The regression results are shown in Table 2. In the regression equation estimated for the median of the distribution of GVA growth, the coefficients of the growth rate in exports, the profitability margin, and the degree of export orientation (in the previous year) are

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[24] For the GVA growth rate variable and the three explanatory variables, panel unit root tests have been carried out. The results of the panel unit-root test are presented in Annexure-E. From the results of the panel unit root tests, it may be inferred that all the variables used for the analysis are integrated of order zero, i.e., these are I(0).

found to be positive and statistically significant. The implication is that these variables have a positive effect on industrial growth. The coefficient of the growth rate in exports (representing the export-driven GVA growth elasticity) is found to be about 0.22 which is within the range of the elasticity estimate (0.2 to 0.4) indicated by the results of the analysis of time-series data presented earlier.

Table 2: Factors influencing GVA growth in industries, regression results, quantile regression

Dependent variable: Growth rate in real GVA (percent per annum)
Data: 61 three-digit industries for 6 years, 2014-15 to 2019-20

Explanatory variables	*20th percentile*	*25th percentile*	*50th percentile (median)*	*75th percentile*	*80th percentile*
Growth rate in exports	0.187 (2.79)***	0.141 (2.06)**	0.216 (3.89)***	0.210 (1.72)*	0.150 (1.92)*
Average export intensity of the medium and large plants in the industry (lagged by one year)	0.256 (1.80)*	0.300 (2.56)**	0.256 (2.69)***	0.192 (1.36)	0.131 (1.16)
Ratio of Profits to output	1.068 (3.63)***	0.821 (3.07)***	0.800 (2.09)**	0.904 (1.96)*	0.816 (1.88)*
Year dummies	Included	Included	Included	Included	Included
No. of observations	364	364	364	364	364
Pseudo-R-squared	0.086	0.085	0.059	0.041	0.044

Note: Observations in which the growth rate in GVA or exports is more than 200 percent or less than (-)90 percent have been excluded. Also, the industries whose share in the aggregate GVA of organized manufacturing was below 0.05 percent in 2019-20 are excluded. The standard errors are robust to intra-cluster (i.e., three-digit industries) correlation and valid under heteroskedasticity.
t-ratios in parentheses. * prob. <0.1, **prob.<0.05, *** prob.<0.01
Source: Author's computations

The regression equation has been estimated for five different percentiles of the GVA growth rate distribution, as may be seen in Table 2. It is seen from the results that the profitability variable has a significant positive effect on GVA growth in all five regressions. This result probably reflects the fact that there is a favourable impact of high profitability on growth through internal resource generation for investment and the enhanced ability of the enterprises to raise external funds for investment thanks to the relatively high rate of return.

Similarly, the coefficient of the growth rate in exports is positive and statistically significant in the regression equations estimated for different percentiles of the distribution. However, in the estimates for the 75th and 80th percentile, the coefficient is found to be statistically significant at a 10 percent level of significance. This suggests that for high-growth manufacturing industries, the impact of exports on GVA growth is relatively smaller.

The effect of export orientation is found to be positive and statistically significant in the middle and lower range of the growth rate distribution (say, -20 to +10 percent annual growth), but not in the upper range of the growth rate distribution (over 20 percent annual growth; see Box 1 for information such industries). It may be inferred that while the export orientation of firms plays an important role in boosting growth in low-growth industries and medium-growth industries, there are certain other forceful drivers of growth in high-growth industries, and in these cases, exports play a relatively smaller role in boosting growth than the other major, forceful drivers of such growth.

Box 1: High-growth industries

Out the 61 industries considered for the econometric analysis (having a share of 0.05% or more in aggregate GVA in 2019-20), 28 industries exceeded 20% GVA growth rate only once during the six-year period under study (2014-15 to 2019-20), and 11 industries did not cross it even once. On the other hand, seven industries exceeded 20% GVA growth rate thrice and four industries, four times in the six-year period. Among these 11 industries, seven industries had an average growth rate of 15% p.a. or more. These may be regarded as high-growth industries. Some information on these industries is given in the table below:

NIC	*Description*	*Median growth rate in real GVA during 2014-15 to 2019-20*	*Number of times, growth rate exceeded 20 percent in six- year period*	*Share in aggregate org. manufac-turing GVA (%), 2019-20*	*GVA to output ratio (%), 2019-20*	*Export to output ratio (%), plants with 50+ workers, 2018-19*
102	Processing and preserving of fish, crustaceans and mollusks	15.2	3	3.6	11	39.5
292	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	21.1	3	1.7	19	0.9
303	Manufacture of air and spacecraft and related machinery	23.6	3	0.7	34	17.9
325	Manufacture of medical and dental instruments and supplies	27.1	4	1.2	34	10.3
329	Other manufacturing n.e.c.	27.2	4	1.7	25	51.0
302	Manufacture of railway locomotives and rolling stock	36.3	4	3.5	23	1.0
301	Building of ships and boats	39.5	4	0.4	37	0.7
	All manufacturing			100	16	8.0

Source: Prepared by the author from ASI data.

5.2 Panel Quantile Regression

In the regression results presented in Table 2 above, the panel character of the dataset was not recognized – it was treated merely as a pool of six cross-sections for six years. Hence, a new set of regression results have been obtained by applying the panel quantile regression. The advantage is that by recognizing the panel character of the data, this estimation method takes account of the unobserved heterogeneity among different industries. In this case, the analysis is confined to those observations in which the growth rate in real GVA or exports does not exceed 150 percent or the rate of decline does not cross 50 percent. Also, the industries whose share in aggregate organized manufacturing GVA in 2019-20 was less than 0.05 percent have been excluded (as in Table 2). The results are shown in Table 3.

Table 3: Factors influencing GVA growth in industries, regression results, panel quantile regression

Dependent variable: Growth rate in real GVA (percent per annum)
Data: 61 three-digit industries for 6 years, 2014-15 to 2019-20

Explanatory variables	*20th percentile*	*25th percentile*	*30th percentile*	*50th percentile (median)*	*70th percentile*	*75th percentile*	*80th percentile*
Growth rate in exports	0.179 (3.07)***	0.168 (2.78)***	0.164 (3.43)***	0.177 (3.64)***	0.092 (1.42)	0.045 (0.72)	0.087 (1.21)
Average export intensity of the medium and large plants in the industry (lagged by one year)	-1.237 (-0.83)	-0.930 (-0.44)	-0.328 (-0.41)	-0.341 (-1.38)	-0.135 (-1.11)	-0.140 (-0.55)	0.937 (1.00)
Ratio of Profits to output	2.071 (6.37)***	2.262 (4.13)***	2.322 (5.26)***	3.246 (9.88)***	3.990 (4.10)***	4.691 (5.06)***	5.042 (4.64)***
Year dummies	Included	Included	Included	Included	Included	Included	Included
Combined test of three parameters, Chi-squared, and probability	45.6 (0.0000)	26.4 (0.0000)	46.1 (0.0000)	319.4 (0.0000)	29.3 (0.0000)	32.4 (0.0000)	29.7 (0.0000)
No. of observations	358	358	358	358	358	358	358

Note: Observations in which the growth rate in GVA or exports is more than 150 percent or less than (-)50 percent have been excluded. Also, the industries whose share in aggregate GVA of organized manufacturing was below 0.05 percent in 2019-20 are excluded. The null hypothesis in the combined test is that all three parameters are zero, against the alternative hypothesis that at least one of them is not zero.
t-ratios of coefficients in parentheses. * prob. <0.1, **prob.<0.05, *** prob.<0.01
Source: Author's computations

The results obtained by applying the panel quantile regression are mostly similar to those presented in Table 2. Profitability is found to be an important factor impacting growth positively. The results in Table 2 presented earlier also indicated a significant positive effect of profitability on growth.

Growth in exports has a positive effect on GVA growth in the regression for the median of the distribution. Also, it is found that growth in exports has a significant positive effect on GVA growth in the middle and lower end of the distribution, but not at the upper end of the distribution. This implies that growth in exports has contributed to GVA growth in the low-growth and medium-growth industries, but not as much in the high-growth industries.

Interestingly, the export intensity does not have a statistically significant coefficient in any of the regressions. Also, the coefficient is found to be negative in most regression equations estimated. Thus, unlike the results in Table 2, the results based on panel quantile regression suggest that export intensity does not have a strong positive relationship with GVA growth achieved by industries. However, for drawing an inference about the impact of export intensity on growth, the results in the two tables must be considered together.

Making a comparison of the coefficients of export growth and profitability in the estimated regressions for different percentiles, a pattern is observed. This is depicted in Figures 6 and 7, the former showing the coefficient of the export growth variable and the latter showing the coefficient of the profitability variable. The point estimate of the parameter and the 95 percent confidence intervals are shown in the two figures. The parameter estimates are for different percentiles, from the 20th percentile to the 80th percentile (the estimates for the 40th and 60th percentile have been used for the figures though not shown in Table 3).

In Figure 7, a clear upward trend in the estimated parameter capturing the impact of profitability on real GVA growth is seen at the progressively higher end of the GVA growth rate distribution. The coefficient increases from about 2 at the 20th percentile to about 5 at the 80th percentile. As regards the estimated parameter capturing the effect of export growth on GVA growth, depicted in Figure 6, it is stable at a value slightly lower than 0.2 in the estimates from the 20th percentile to the 50th percentile and falls beyond the 50th percentile. It may be thus inferred that for high-growth industries, the contribution of export growth to GVA growth is relatively small, whereas the contribution of profitability is substantially larger.

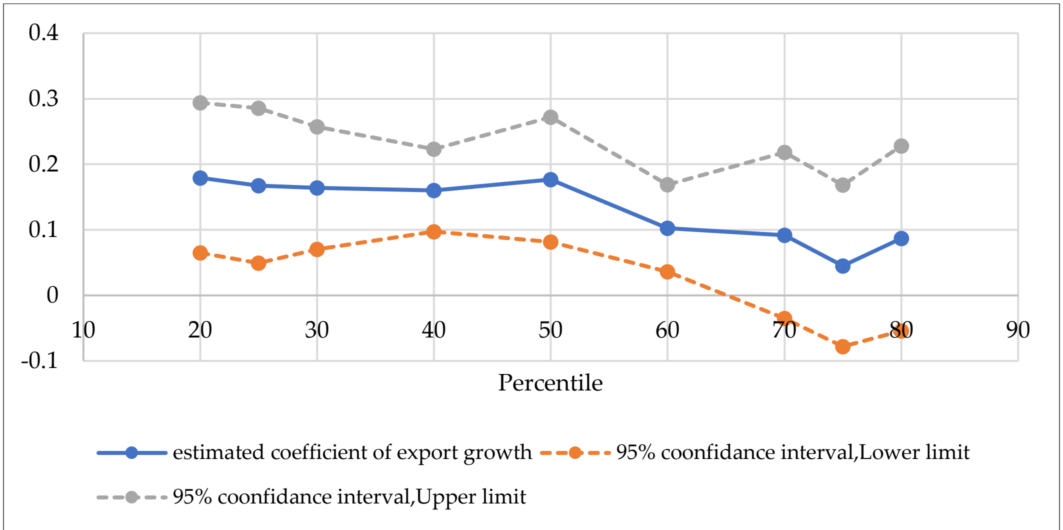
Since a significant positive relationship is found between profitability (profits to output ratio) and growth rate in the regression analysis presented above (Tables 2 and 3, and Figure 7), it would be instructive to examine the inter-temporal trends in the growth rate in real GVA and profitability (profit margin) in India's organized manufacturing. This is depicted in Figure 8 for the period 2000-01 to 2019-20. Three-year moving averages are shown against the mid-point.

The graph is based on the ASI Factory Sector total estimates for each year. This aggregate of the factory sector considered for the graph is predominantly manufacturing (about 95 percent or so in terms of GVA), but also includes some non-manufacturing industries (e.g., cotton ginning, cleaning, and bailing; publishing of books, newspapers, journals, and software; and a section of electricity generation units). As seen from Figure 8, the series on growth rate in real GVA[25] and that on profitability margin show a good deal of similarity in the direction of movement. In the first half of the 2000s, the profitability had an upward trend, and this was accompanied by an acceleration in manufacturing sector growth. From the late 2000s to the initial part of the 2010s, the GVA growth rate had been coming down and this was accompanied by a fall in profitability. In the more recent period, post-2015,

[25] Nominal GVA of ASI factory sector has been deflated by the implicit deflator for the manufacturing sector GVA in NAS.

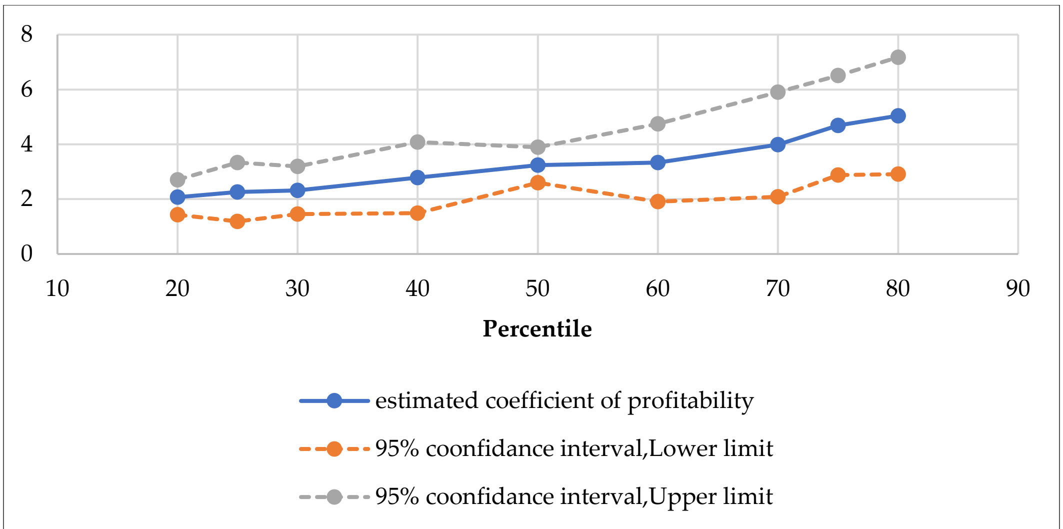
there was a slight fall in the profit margin, and there was a downward trend in the GVA growth rate of the manufacturing sector.

Figure 6: Coefficient of export growth, panel quantile regression, at different percentile, estimate and confidence interval



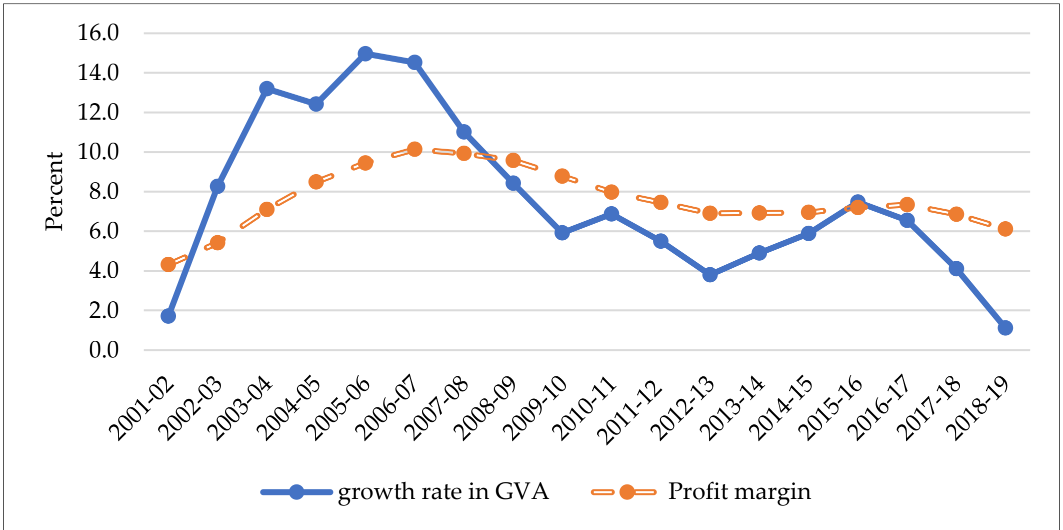
Source: Author's computations

Figure 7: Coefficient of profitability, panel quantile regression, at different percentile, estimate and confidence interval



Source: Author's computations.

Figure 8: Three-year moving average of the real GVA growth rate and the ratio of profits to output, 2000-01 to 2019-20, organized manufacturing



Source: Author's computations based on ASI data.

The key empirical findings from the estimates of quantile regression and panel quantile regression presented above have been subjected to some robustness checks. This is presented in Annexure-F. One issue considered is the model specification. In the model specification used above, a linear from the equation has been used. It may be argued that the impact of export growth on GVA growth will be influenced by the level of export intensity of the industry, and therefore an interaction variable involving export growth and export intensity should be included in the equation. This has been done and quantile regression estimates have been made. The results indicate that there is no substantial gain in adding an interaction variable.

Another interesting exercise undertaken in Annexure-F is to change the export growth rate variable. In the analysis above and in the analysis that follows, the growth rate in exports has been computed from the value of exports in current US dollars. An alternate measure that has been tried is to take the value of exports in Indian Rupees, deflate it by the export unit-value index,[26] and then compute the growth rate in exports. There are considerable difficulties in matching the export unit-value indices with NIC, and this affects the estimates of the real export growth rate obtained. Nonetheless, even with this altered measure of export growth rate, a significant positive effect of export growth on real GVA growth is found, confirming the findings from Tables 2 and 3.

[26] The export unit-value indices have been taken from the *Handbook of Statistics on Indian Economy*, 2020-21, Reserve Bank of India, Mumbai. The basic data source is the Directorate General of Commercial Intelligence and Statistics (DGCI&S), Ministry of Commerce and Industry, Government of India.

5.3 Application of the System GMM Estimator

For checking the robustness of the core results of the econometric analysis presented above and expanding the analysis by bringing in additional explanatory variables, an alternate econometric modeling exercise has been done in which the parameters are estimated by applying the system Generalized Method of Moments (GMM) estimator.

In the analysis above, the profitability ratio was found to be an important determinant of growth. However, there may be an issue of endogeneity with this variable giving rise to problems in estimation.[27] Hopefully, the estimation issues connected with the possible endogeneity of this explanatory variable or other explanatory variables[28] would probably be taken care of (to a large extent) by the application of the system GMM estimation procedure. Also, this method of estimation recognizes the panel character of data and thus has the advantage of taking into account the unobserved heterogeneity among industries.

The results obtained by applying the GMM estimator are presented in Table 4. The estimation has been made by the two-step method. The analysis is confined to those industries whose share in aggregate organized manufacturing GVA in 2019-20 was at least 0.1 percent. Besides the three explanatory variables used in the analysis above, four more explanatory variables have been added. These are:

(a) The proportion of plants that were engaged in R&D (Research and Development) or had foreign equity participation in the firm to which they belong (or both). This is considered for each industry in respect of the plants with 50 or more workers. A dummy variable is constructed which takes the value of one for a plant if there is foreign equity participation in the firm to which the plant belongs, or if the plant has an R&D unit within the factory premises, or if the plant does not have an R&D unit within factory premises but is spending at least 0.1 percent of its value of output on R&D. The dummy variable takes the value of zero otherwise. This dummy variable has been constructed for each plant for each year for the years 2015-16 to 2018-19[29] using unit-level data of ASI, and a weighted average has been computed at the industry level (applying sample weights in the unit-level data) for each three-digit industry for each year. Then, for each industry, an average of the estimates for four years (2015-16 to 2018-19) has been taken. Constructed in this manner, the variable represents the proportion of medium and large plants in an industry that is engaged in R&D or has foreign direct investment (FDI) or both. This variable has been introduced into the regression equation in an interaction

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[27] The estimation problem is that while profitability impacts growth, growth might be impacting profitability as well, or both growth and profitability may be impacted by a third variable.

[28] The issue of endogeneity can be raised also for the export growth rate variable. Questions may be raised about the direction of causality. See, in this context, Chow (1987) and Dadoro (1993), among others. See also, Banga and Das (2012) and Datta and Lahiri (2018), among others, for the analyses of causality between exports and economic growth undertaken for India.

[29] The data on R&D and the presence of foreign equity are available from 2015-16 onwards. Hence, data for the years 2015-16 to 2018-19 have been taken. Plant-level data for 2019-20 had not been released yet (at the time of writing of this paper).

form, after multiplying it by the variable on export intensity mentioned earlier. The object is to assess the growth-enhancing impact of R&D and FDI in conjunction with export orientation among medium and large manufacturing plants in the industry.

(b) A variable representing the adoption of ISO 14000 is constructed like that representing R&D and FDI. A dummy variable is constructed at the plant level, and a weighted average is computed for each year using sample weights. Computations have been for the years 2013-14 to 2018-19, and then an average across years has been taken. This variable measures for each industry the proportion of medium and large plants that have adopted ISO 14000 (which involves the implementation of environmental management systems).

(c) The proportion of plants that are located in urban areas among the plants with 50 or more workers. This variable has been constructed using data for 2013-14 to 2018-19 and used as a regressor in the model. This is used in the model with one year lag.

(d) The proportion of plants that were 15 years old or younger (judged by the year of initial production) in 2018-19[30] in different industries, among plants employing 50 or more workers. This is taken as an indicator of the rate of entry of new plants in different industries.

The results presented in Table 4 indicate that profitability is a major factor positively impacting GVA growth in manufacturing. For the export growth variable, a positive and statistically significant coefficient is found indicating a positive effect of export growth on real GVA growth in manufacturing industries. These results are consistent with the results reported earlier in Tables 2 and 3.

Another interesting finding is that ceteris paribus the real GVA growth rate tends to be higher in industries in which there is greater export orientation accompanied by R&D activities or FDI or both. The coefficient of this composite, interaction variable is found to be positive and statistically significant.

The variable representing the pace of setting up of new medium and large plants in different industries has a positive and statistically significant coefficient. It shows that the growth rate of an industry tends to be higher if the increase in production is more due to the new plants being set up rather than increased production of existing plants.

For the variable representing urban versus the rural location of plants, the coefficient is positive but statistically insignificant. It is thus difficult to say if the growth of an industry is facilitated, or does it get hindered, if a greater portion of plants of the industry is in urban locations.

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[30] Unit-level data for 2019-20 have not been released yet (at the time of writing of this paper). Hence, variable (a) has been constructed by using data for 2015-16 to 2018-19, variable (b) by using data for 2013-14 to 2018-19, and variable (d) by using data for 2018-19. It is possible to construct variable (d) for each year, except 2019-20. There would probably be not much gain, and hence this has not been done.

Table 4: Factors influencing GVA growth in industries, regression results, GMM estimator

Dependent variable: Growth rate in real GVA (percent per annum)
Data: 57 three-digit industries for 6 years, 2014-15 to 2019-20
Estimation method: System GMM

Explanatory variables	*Regression-1*	*Regression-2*	*Regression-3*	*Regression-4*
Growth rate in real GVA (t-1)	-0.128 (-2.87)***	-0.123 (-2.97)***	-0.129 (-3.07)***	-0.155 (-4.02)***
Growth rate in exports	0.126 (2.40)**	0.167 (3.00)***	0.130 (2.39)**	0.111 (2.06)**
Ratio of Profits to output	1.79 (3.63)***	1.65 (3.83)***	1.47 (3.34)***	1.74 (3.77)***
Proportion of medium and large plants located in urban areas (lagged by one year)	11.92 (0.61)			2.38 (0.12)
RDFE (representing the level of R&D and FDI in the industry) multiplied by the average export intensity of the medium and large plants in the industry (lagged by one year)	7.13 (1.99)**	4.22 (2.06)**		
ISO14000(representing the level of implementation of comprehensive EMS in the industry)(in percentage)			2.67 (1.37)	
ISO14000 multiplied by the average export intensity of the medium and large plants in the industry (lagged by one year)			8.08 (2.95)***	11.22 (3.44)***
The proportion of plants of age 15 years or younger in 2018-19 in the industry among medium and large plants	283.0 (1.75)*			187.1 (1.52)
Year dummies	Included	Included	Included	Included
No. of observations	281	281	281	281
Wald chi-square and prob.	85.5(0.000)	114.5(0.000)	93.2(0.000)	107.76(0.000)
AR(1)	-2.82(0.005)	-2.70(0.007)	-3.07(0.002)	-2.92(0.003)
AR(2)	0.49(0.63)	0.45(0.65)	0.62(0.53)	0.62(0.43)
Sargan test of overidentifying restrictions, Chi-sqr and prob.	10.95 (0.53)	14.78 (0.32)	12.35 (0.42)	11.13 (0.52)

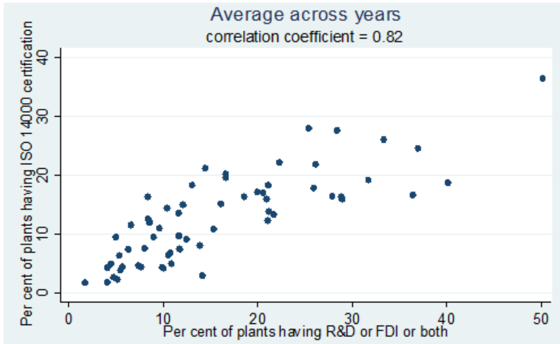
Note: Observations in the growth rate in GVA or exports is more than 150 percent or less than (-)50 percent have excluded. Also, the industries whose share in aggregate GVA of organized manufacturing was below 0.1 percent in 2019-20 are excluded. RDFE=Proportion of medium and large plants having R&D activity or foreign equity participation or both; an average is taken for each industry across four years. ISO 14000 variable is similar, showing the proportion of medium and large plants that adopted ISO 14000. An average taken for each industry across six years.

t-ratios of coefficients in parentheses. * prob. <0.1, **prob.<0.05, *** prob.<0.01

Source: Author's computations.

When the ISO 14000 variable is multiplied by export intensity, the coefficient is found to be positive and statistically significant at a one percent level. Thus, the regression results indicate that the adoption of ISO 14000 has a positive effect on GVA growth in industries, particularly when it is combined with a relatively greater export intensity of the industry. It is known from the literature that the adoption of ISO 14000 helps in augmenting the exports of firms. Thus, the finding of a positive relationship between the adoption of ISO 14000 and GVA growth could be rooted in the favourable effect of ISO 14000 on export growth.

Figure 9: Three-digit industries plotted according to R&D/FDI and ISO 14000



Note: Industries whose share in aggregate GVA in 2019-20 was less than 0.5 percent have been left out.
Source: Author's computations

While the variable representing R&D/FDI and that representing the adoption of ISO 14000 are found to have positive and statistically significant coefficients, these variables could not be included in the same regression because of the high positive inter-correlation between them (see Figure 9). This gives rise to the possibility that the coefficient of the ISO 14000 variable may be picking up the effect of R&D and FDI on growth. To get over this difficulty, the R&D/FDI and ISO 14000 variables have been re-constructed. This has been done for 2018-19 using output weights, and the estimated model based on these changed variables is presented in Table 5.[31] Measured in this manner, the R&D/FDI variable and ISO 14000 variables reflect the proportion of medium and large plants that have these characteristics with greater weight being given to larger plants. In this case, the correlation coefficient between the R&D/FDI and ISO 14000 variables is 0.66. Although the problem of multi-collinearly is not completely over, with the aforesaid change in the measures of the R&D/FDI variable and ISO 14000 variable, it becomes possible to include both the R&D/FDI and ISO 14000 variables in the same regression equation and get statistically significant coefficients for both of them.

The results presented in Table 5 indicate that both technological advances represented by the R&D/FDI variable, and the adoption of ISO 14000 representing the implementation of EMSs have a positive effect on the growth of industries. This is brought out by the fact that the coefficients of both variables are found to be positive and statistically significant when both are present in the same regression. The coefficient of the R&D/FDI variable was found to be positive and statistically significant in regressions (1) and (2) in Table 4, and similarly, the coefficient of the ISO 14000 variable was found to be positive and statistically significant in regressions (3) and (4). In the regression results in Table 5, both variables are included in the same regression equations and the coefficients are found to be positive and statistically significant, thus providing empirical evidence to infer that both variables have a significant positive effect on the growth of industries.

While the finding of a positive effect of R&D and FDI on industrial growth will most likely be readily accepted, the finding of a positive effect of the adoption of ISO 14000 on industrial

[31] A change has been introduced in the modelling methodology by allowing two-period lags in the dependent variable and some of the explanatory variables.

growth might not get that level of acceptance. To strengthen the empirical basis of the finding of a positive effect of the adoption of ISO 14000 on industrial growth, an analysis of the determinants of output growth has been undertaken at the plant level, the results of which are presented in Annexure-G. Data on about 15,500 plants for 2010-11 and 2015-16 have been used. The results indicate a positive effect of R&D and FDI on the growth of output of industrial plants, as well as a similar positive effect of the adoption of ISO 14000.

Table 5: Factors influencing GVA growth in industries, regression results, GMM estimator

Dependent variable: Growth rate in real GVA (percent per annum)
Data: 57 three-digit industries for 6 years, 2014-15 to 2019-20
Estimation method: System GMM

Explanatory variables	*Regression-5*	*Regression-6*	*Regression-7*	*Regression-8*
Growth rate in real GVA (t-1)	-0.143 (-3.01)***	-0.156 (-3.53)***	-0.189 (-1.99)**	-0.084 (-1.99)**
Growth rate in real GVA (t-2)	-0.163*** (-2.83)	-0.144 (-2.47)**	-0.144 (-2.37)**	
Growth rate in exports (t)	0.120 (1.86)*	0.106 (1.67)*	0.087 (1.44)	0.091 (1.64)#
Growth rate in exports (t-1)	0.077 (1.25)	0.019 (0.28)	0.019 (0.30)	
Ratio of Profits to output	2.05 (3.93)***	2.28 (4.38)***	2.33 (4.47)***	1.86 (4.49)***
RDFE (representing the level of R&D and FDI in the industry) multiplied by the average export intensity of the medium and large plants in the industry (**lagged by one year**)	2.29 (1.63)#	2.27 (1.81)*	3.69 (3.75)***	2.67 (2.74)***
RDFE multiplied by the average export intensity of the medium and large plants in the industry (**lagged by two years**)		3.44 (3.76)***		
ISO14000(representing the level of implementation of comprehensive EMS in the industry)(in percentage)	1.70 (3.59)***	1.38 (2.94)***	1.23 (2.89)***	1.27 (2.88)***
ISO14000 multiplied by the average export intensity of the medium and large plants in the industry (lagged by one year)			3.05 (3.50)***	
Year dummies	Included	Included	Included	Included
No. of observations	225	225	225	281
Wald chi-square and prob.	76.92 (0.000)	93.54(0.000)	135.22(0.000)	96.22(0.000)
AR(1)	-3.25 (0.001)	-3.06(0.002)	-2.98(0.003)	-3.27(0.001)
AR(2)	1.38 (0.17)	1.38(0.17)	1.29(0.20)	0.78(0.44)
Sargan test of overidentifying restrictions, Chi-sqr and prob.	7.92 (0.64)	4.29 (0.93)	4.33 (0.93)	12.81 (0.38)

Note: Observations in the growth rate in GVA or exports is more than 150 percent or less than (-)50 percent have excluded. Also, the industries whose share in aggregate GVA was below 0.1 percent in 2019-20 are excluded. RDFE and ISO 14000 variables have been constructed for 2018-19 using output weights. These are based on dummy variables constructed using the information on R&D and FDI, and the adoption of ISO 14000 as explained in the text.

t-ratios of coefficients in parentheses. # prob.<0.11, * prob. <0.1, **prob.<0.05, *** prob.<0.01

Source: Author's computations.

6. Conclusion

In this paper, the relationship between the growth in exports and the growth in the manufacturing sector real GVA in India was investigated econometrically, first at the level of aggregate manufacturing using time-series data for 1987-88 to 2019-20, and then at the disaggregated industry-level using panel data for 69 three-digit (organized sector) industries for 2014-15 to 2019-20. For the analysis at the aggregate level, an ARDL model was estimated. For the disaggregated industry-level econometric analysis of determinants of industrial growth, different methods of model estimation were applied, including methods that take into account unobserved cross-industry heterogeneity and can address, at least to some extent, the issue of possible endogeneity of explanatory variables. The following points emerge from the analysis presented in the paper:

- There is a significant positive relationship between the growth in manufactured product exports and the growth in GVA of Indian manufacturing. In other words, growth in exports has made a significant contribution to the manufacturing sector growth in India in the past. This interpretation of the econometric results obtained in the study is in harmony with the assertion made by Chatterjee and Subramanian (2020) that contrary to perception, India has been an exemplar of the export-led growth model. They point out that in terms of the growth rate in the overall exports and manufactured product exports India's performance has been one of the best and this has played a critical role in India's economic growth.
- The finding of a positive relationship between growth in exports and growth in manufacturing GVA provides a basis to argue that for significantly raising the growth rate of Indian manufacturing in the coming years, the growth rate in manufactured products exports needs to be raised substantially. It should be recognized, however, that the growth rate in global merchandise trade has come down considerably from the levels prevailing in the 2000s. While the average annual growth rate in global merchandise exports (in US $ value) was about 13 percent per year during 2003-2011, it was only about one percent per year during 2013-2018.[32] India's share in global merchandise exports grew at the average annual rate of about 8.4 percent during 2003-2010, which came down to 3.7 percent during 2011-2017 (Banga and Banga, 2020, p. 153). In a situation of slow growth in global trade in manufactured products, how to raise substantially the growth rate of India's exports of manufactured products is a challenge. Nonetheless, this is not impossible, and appropriate policy action would help in raising the growth rate of India's manufactured product exports. It seems this will require a continuing increase in India's share in global markets in several types of manufactured products.[33]

[32] These growth rate computations are based on World Bank data on exports, World Development Indicators.

[33] See, in this context, Chapter 5, *Economic Survey, 2019-20*, Volume I, Ministry of Finance, Government

- Growth in exports makes a significant contribution to the growth in real GVA in low-growth and medium-growth manufacturing industries in India. But, for high-growth industries, there are perhaps other forceful drivers of growth, and the contribution of exports is relatively less as compared to the contribution of those factors. Some of the high-growth industries (e.g., NIC-102, Processing and preserving of fish, crustaceans, and mollusks) have a significant share of exports in production, but some others (e.g., NIC-301, Building of ships and boats; and NIC-302, Manufacture of railway locomotives and rolling stock) sell almost all their output in the domestic markets. The key point is that the high-growth industries are heterogeneous, and some of them are not driven by exports.
- Profitability is found to be an important factor impacting growth, particularly the high-growth industries. This possibly indicates that high-growth industries need a bigger flow of finance for growth. Arguably, appropriate tax and credit policies that help the high-growth industries earn a high rate of profit and facilitate the mobilization of financial resources for growth will help in enhancing the growth rate of Indian manufacturing.
- The empirical results obtained in this study underscore the importance of technological advances in promoting growth. The econometric results presented in the study indicate that the rate of growth is higher for those industries which have greater export orientation accompanied by R&D or foreign equity participation or both among many plants (FDI being a conduit for the flow of technology from abroad). The importance of enhancing the level of R&D in India's industrial enterprises for boosting productivity and growth is well recognized. *Economic Survey,* 2020-21 (Ministry of Finance, Government of India) notes (p. 238) that India must significantly raise investment in R&D to achieve its aspiration to emerge as the third-largest economy in terms of GDP current US$. According to *Economic Survey*, 2020-21, India's gross expenditure on R&D is 0.65 percent of GDP which is much lower than that of the top ten economies, which range from 1.5 to 3 percent of GDP. In India, the private sector is not spending sufficiently on R&D. The share of the government in gross R&D expenditure is about 56 percent, which is three times the average contributed by the government in the top ten economies. It is therefore important that the private sector industrial enterprise make larger investments in R&D and this will help in raising the growth rate of Indian manufacturing.
- Several studies have shown that the implementation of comprehensive environmental management systems associated with the adoption of ISO 14001

of India. It is observed in the *Economic Survey*, 2019-20 (p.125) that the current situation presents India an opportunity to chart a China-like, labour intensive, export trajectory. It is noted in the *Economic Survey* that focus should be placed on enabling assembly operations at a mammoth scale in network products. According to the assessment made, this will help India raise its export market share in network products.

has a positive effect on the financial performance of firms.[34] For Indian firms, such finding of a positive effect of a comprehensive EMS has been reported by Goldar (2011), Kumar and Shetty (2018b), and Kumar and Dua (2021). That the adoption of ISO 14001 raises the export performance of firms has been found in several studies for other countries, and a positive effect of ISO 14000 on export performance among Indian industrial plants has been reported in Goldar (2021). The results of the econometric analysis presented in this paper indicate that the adoption of ISO 14000 has a favourble impact on industrial growth. This calls for policies that will help promote the adoption of ISO 14000 among industrial firms.

[34] What factors motivate Indian industrial plants to adopt ISO 14000 has been studied in Goldar and Majumder (2022). Also see, Kumar and Shetty (2018a).

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Annexure A: Direct and Indirect Exports of India's Organized Manufacturing Plants

Veeramani *et al*. (2016) have made an estimate of manufactured product exports of India's organized manufacturing plants for 2008-09 to 2012-13 based on the unit-level data of ASI and compared this with the aggregate exports of manufacturing products from India derived from COMTRADE-WITS (making use of the WITS software of the World Bank to access international trade data, UN-COMTRADE). The estimate of aggregate manufactured exports of organized manufacturing plants based on ASI data is found to be substantially less than India's aggregate manufactured exports obtained from the COMTRADE-WITS data. The ratio of ASI-based estimate to the actual aggregate exports of manufactured products is found to be less than 50 percent (42.3 percent for 2012-13).

A similar estimate of manufactured product exports has been made for 2018-19 in this study based on ASI unit-level data. The estimate of the value of exports is found to be about 30 percent of the value of manufactured exports according to the DCCI&S data. A part of the observed gap could be attributed to exports of unorganized sector manufacturing enterprises, which do not get covered under ASI. This is, however, not likely to be large. Thus, one interpretation of this finding of a significant gap between (a) the ASI-based estimate of exports of manufacturing plants and (b) the level of manufactured product exports indicated by the trade data is that the Indian manufacturing plants are also exporting indirectly through intermediary firms. Probably, the extent of such indirect exports is substantial.

In this context, it should be mentioned that according to the data of the World Bank Enterprises Survey for India (survey for 2014),[35] 6.9 percent of the firms export directly at least 10 percent of their sales, and 8.8 percent of the firms export directly or indirectly at least 10 percent of their sales. This indicates that significant amounts of exports are being done indirectly by manufacturing firms. According to these data, the proportion of total sales that is exported directly is 3.7 percent and the percentage of exporting firms is 9.6. This is broadly in line with the corresponding figures derived from ASI unit-level data (see Goldar, 2021).

[35] https://www.enterprisesurveys.org/en/data/exploretopics/trade, accessed June 1, 2022.

Annexure B: Conceptual Framework – Derivation of the relationship between growth in exports and growth in GVA from an input-output model

The Leontief input-output model is used for this analysis. There are *n* sectors in the economy. Let X be the export vector. It is assumed without any loss of generalization that the first *r* elements belong to manufacturing, and the remaining *n-r* elements are for other sectors of the economy. Define a matrix Ψ which has the value one in the main diagonal up to the first *r* elements and zero value elsewhere in the matrix. Then, assuming that only manufacturing exports change, and the change is proportionate given by λ, i.e., $\Delta X_i=\lambda X_i$, for i=1,2, ..r, the vector ΔV may be derived as (see eq. 3 and eq. 4 in Section 3):

$$\Delta V = \Omega.R.\Delta X = \Omega.R.\lambda\Psi X \;\; ...(B.1)$$

In this equation, Ω is a matrix in which the principal diagonal is made of v_i, i.e., the share of value-added in gross output in different industries and zeros in the rest of the matrix.

Define V* as the total value added in manufacturing and let θ' be a row vector that has the value of one in the first r elements and zero elsewhere. Then, the increase in aggregate value-added of manufacturing because of the proportionate increase in exports of manufactured products may be derived as:

$$\Delta V^* = \theta'\Delta V = \theta'\Omega.R.\Delta X = \theta'\Omega.R.\lambda\Psi X \;\; ...(B.2)$$

Defining now X* as the aggregate value of manufactured product exports and Y* as the aggregate value of manufacturing sector gross output, the following equation may be derived by dividing both sides of equation (B.2) by V* and λ.

$$\left[\frac{\Delta V^*}{V^*}\right]\frac{1}{\lambda} = \frac{\theta'\Omega.R.\Psi X}{V^*} = \theta'\Omega.R.\frac{\Psi X}{V^*} = \theta'\Omega.R.\frac{\Psi X}{X^*}\frac{X^*}{Y^*}\frac{Y^*}{V^*} \;...(B.3)$$

It would be realized that the left-hand side term of the equation is the proportionate increase in the aggregate value-added of manufacturing caused by a proportionate increase in manufactured goods exports (by λ). This is the elasticity of manufacturing sector value-added with respect to manufacturing sector exports, which is the parameter γ in equation (2) in Section 3. It depends on (i) the matrix R, the Leontief inverse matrix, (ii) the term ΨX/X* which may be interpreted as the share of different manufacturing industries in the aggregate level of manufactured product exports (structure of exports), (iii) the term X*/Y* which is the share of exports in production, i.e. export intensity, in manufacturing at the aggregate level, and (iv) the term Y*/V* which is the inverse of the value-added content of gross output of manufacturing at the aggregate level. Since the value-added content of output is a fixed parameter in the Leontief framework, the ratio of V* to Y* at the aggregate level is determined by the industrial structure.

From equation (B.3), it is seen that the higher the export intensity of manufacturing, the bigger the elasticity of GVA growth with respect to export growth. This is understandable. It is interesting to note that the parameter γ is inversely related to the share of value-added in gross output at the aggregate manufacturing level. This requires an explanation. Consider two countries, A and B. In Country-A, the output structure of manufacturing is tilted toward the industries in which the value-added content is high. In Country-B, the output structure of manufacturing is tilted towards the industries in which the value-added content is low and the industries, therefore, have greater backward linkages. If k% increase in manufactured product exports in Country-A leads to s% increase in value-added in manufacturing, and in Country-B, the same percentage increase in exports causes an increase in value-added is m%, then m% is expected to be higher than s% (i.e., the parameter γ is bigger) because of stronger backward linkage. It should not be difficult to prove this mathematically.

Further insight into the relationship between exports and the growth of the domestic industry can be obtained by splitting the elements [a_{ij}] of the input-output coefficients matrix [A] according to domestic sourcing and foreign sourcing. This is not attempted here. However, it seems, that such an analysis will bring out how the impact of an increase in exports on the growth of value-added of domestic industry is conditioned by the extent of foreign sourcing of inputs.

Annexure C: Unit root tests, time-series data

Table C1: Augmented Dickey-Fuller tests

Variables	*Levels*	*First difference*
Growth rate in the real GVA of Indian manufacturing	-3.55**	-5.54***
Growth rate in India's non-oil exports	-4.24***	-7.87***
Growth rate in the GDP of OECD member countries	-3.97***	-7.65***
Growth rate in the real GVA of trade, repair services, transport, and communication	-4.32***	-8.22***
Growth rate in power generation in utilities	-4.30***	-11.01***
Growth rate in the ratio of international crude oil price to the domestic price index for manufacturing	-6.51***	-9.11***
1% critical value	-3.70	-3.70
5% critical value	-2.98	-2.98

Notes: (1) Data for the period 1987-88 to 2019-20 have been used. (2) Inference: All six variables are found to be I(0). (3) A similar test has been carried out for the annual rate of change in domestic value-added (DVA) content in exports using data for 1991 to 2018; this variable is used in the model estimates in Annexure-D. The statistic is found to be -3.9 at levels and -6.9 in the first difference. This indicates that the variable is integrated of order zero, i.e., it is I(0).

prob.<0.05, * prob.<0.01

Source: Author's computations

Annexure D: ARDL model, alternate estimate

Table D1: Explaining the growth rate of real GVA of Indian manufacturing, ARDL model

Dependent variable: Growth rate in real GVA of Indian manufacturing
Period: 1991-92 to 2018-19

Explanatory variables	*Long-run coefficients*		
	Regression D.1	Regression D.2	Regression D.3
Growth rate in India's non-oil exports	0.305** [0.109] (2.79)	0.274** [0.108](2.54)	0.275** [0.109](2.53)
Growth rate in real GVA of trade, repair services, transport, and communication	0.609* [0.340] (1.79)	0.699* [0.344] (2.03)	0.698* [0.351] (1.99)
Growth rate in power generation in utilities (lagged by one year)		0.160 [0.411] (0.39)	
Growth rate in the price of crude oil in international markets relative to the wholesale price index of manufactured products in India	-0.749 [5.305] (-0.14)		
Annual rate of change in domestic value-added (DVA) content in exports	140.29** [55.53] (2.53)	106.3** [44.08] (2.41)	103.8** [44.0] (2.36)
Trend term	Not included	Not included	Included
No. of observations	28	28	28
R-squared (error correction model)	0.63	0.60	0.60
Adjustment coefficient	-1.005*** [0.190] (-5.29)	-0.983*** [0.193] (-5.10)	-0.980*** [0.194] (-5.05)
ARDL Lag structure	(1,1,0,1,0)	(1,1,0,0,0)	(1,1,0,0)
Pesaran, Shin, and Smith (2001) bounds test			
F-value	6.70	6.30	7.85
t-ratio	-5.29	-5.10	-5.05
Prob. value for I(0), for F/ and t	0.003/0.000	0.003/0.001	0.005/0.002
Prob. value for I(1), for F /and t	0.014/0.007	0.018/0.009	0.017/0.015

Notes: (1) Inference based on Pesaran, Shin, and Smith (2001) bounds test: the null hypothesis of 'no level relationship' is rejected at a 5 percent level of significance. (2) Data on the DVA content of exports are available for 1995-2018 in the TiVA database. Hence, the model estimates are confined to data up to 2018-19. The DVA content series taken from the TiVA database has been extended/extrapolated backward to 1989-90 using some earlier studies on the import intensity of exports in Indian manufacturing (see Goldar, et al. 2020). (3) Optimal lag length is determined by the Bayesian information criteria.

* prob. <0.1, **prob.<0.05, *** prob.<0.01

Source: Author's computations

Annexure E: Panel data unit root tests, three-digit industries

Table E1: Panel data unit root tests

Variables	*Levin-Lin-Chu (2002) test Statistic: adjusted t* (Prob. in parentheses)*	*Im-Pesaran-Shin (2003) test Statistic: Z-t-tilde-bar (Prob. in parentheses)*	*Hadri (2000) test Statistic: z (Prob. in parentheses)*
Growth rate in real GVA	-22.5 (0.000)	-5.4(0.000)	-0.72 (0.77)
Growth rate in exports	-50.8 (0.000)	-5.9 (0.000)	-0.72(0.76)
Average export intensity of the medium and large plants in the industry	-13.9 (0.000)	-2.6(0.005)	2.66 (0.004)
The ratio of Profits to output	-6.6×10^{2} (0.000)	-2.8 (0.003)	-1.21 (0.89)
Proportion of medium and large plants located in urban areas	-53.2 (0.000)	-3.6(0.000)	1.49 (0.07)

Notes: (1) The null hypothesis and alternate hypothesis are reversed in the Hadri test. (2) Data for various industries for the years 2014-15 to 2019-20 have been used. The industries whose share in 2019-20 was less than 0.05 percent are left out. (3) The profitability margin variable without winsorization is used for these tests. The results do not change qualitatively if the variable with winsorization is used.

Inference: The results indicate that all variables are I(0). It should be noted that for the export intensity variable, the results do not match – the Hadri test rejects the hypothesis that the variable is I(0). Hence, the Breitung test has been applied. The test statistic is found to be (-)4.86 with the corresponding probability of 0.000. Thus, in this case, support is found for the hypothesis that the variable is I(0).

Source: Computed by the author.

Annexure F: Robustness Check – Results of Quantile Regression and Panel Quantile Regression

The results of two exercises are presented in this Annexure. In the first exercise, the model specification is changed to include an interaction term involving the growth rate in exports and the level of export intensity – because the impact of export growth in an industry on its output growth should be influenced by its export intensity. In the second exercise, the export growth variable has been changed. Instead of taking the export growth computed from the value in current US dollars, the value of exports has been converted to Indian Rupees and then deflated by the export unit-value index to express it at constant 2012-13 prices (the export unit values have been taken from the Handbook of Statistics on Indian Economy, Reserve Bank of India, basic source DGCI&S). The results of these two exercises are presented in Tables F.1 (quantile regression) and F.2 (quantile regression and panel quantile regression) respectively.

Table F1: Quantile Regression, Alternate Specifications

Explanatory variables	*Reg.-F.1*	*Reg.-F.2*	*Reg.-F.3*	*Reg.-F.4*
Growth rate in exports	0.216 (3.89)***	0.150 (2.18)**	0.194 (2.35)**	
Average export intensity of the medium and large plants in the industry (lagged by one year)	0.256 (2.69)***		0.201 (1.88)*	
Growth rate in exports multiplied by one period lagged average export intensity		0.008 (1.14)	0.005 (0.41)	0.019 (3.83)***
Ratio of Profits to output	0.800 (2.09)**	0.620 (1.94)*	0.787 (2.16)**	0.650 (2.13)**
Year dummies	Included	Included	Included	Included
No. of observations	364	364	364	364
Pseudo R-squared	0.059	0.050	0.059	0.046
Elasticity of GVA growth with respect to export growth at the sample mean	0.216	0.225	0.241	0.169

Note: Observations in which the growth rate in GVA is more than 200 percent or less than (-)90 percent have been excluded. Also, the industries whose share in the aggregate GVA of manufacturing was below 0.05 percent in 2019-20 are excluded. The standard errors are robust to intra-cluster (i.e., three-digit industries) correlation and valid under heteroskedasticity.
Source: Author's computations.

From the results presented in Table F.1, it is seen that the inclusion of an interaction term involving the growth rate in exports and the level of export intensity does not make any marked improvement in the explanatory power of the model as indicated by pseudo-R^2. Nor does it lead to any significant change in the estimate of the elasticity of GVA growth with respect to export growth. The results in Table F.2 show that even after changing the export growth variable, the coefficient of this variable is found to be positive and statistically significant supporting the results reported in Tables 2 and 3.

Table F2: Quantile Regression and Panel Quantile Regression, Alternate Measure of Growth Rate in Exports

Explanatory variables	Quantile Regression		Panel Quantile Regression	
	Regression-F.5	Regression-F.6	Regression-F.7	Regression-F.8
Growth rate in exports (in current US dollars)	0.234 (3.25)***		0.160 (6.22)**	
Growth rate in exports (in Indian Rupees, deflated by export unit-value index)		0.120 (2.17)**		0.090 (6.95)***
Average export intensity of the medium and large plants in the industry (lagged by one year)	0.257 (2.64)***	0.244 (2.30)**	-0.215 (-0.58)	0.115 (0.41)
Ratio of Profits to output	0.639 (2.39)**	0.711 (2.44)**	3.085 (7.66)***	3.306 (10.03)**
Year dummies	Included	Included	Included	Included
No. of observations	338	338	338	338
Pseudo-R^2	0.068	0.055		
Combined test of three parameters, Chi-squared and probability	11.99 (0.000)	8.18 (0.000)	301.5 (0.000)	156.5 (0.000)

Note: Observations in which the growth rate in GVA is more than 150 percent or less than (-)50 percent have been excluded. Also, the industries whose share in the aggregate GVA of manufacturing was below 0.1 percent in 2019-20 are excluded. For the estimates of quantile regression, the standard errors are robust to intra-cluster (i.e., three-digit industries) correlation and valid under heteroskedasticity.
Source: Author's computations.

Annexure G: Impact of R&D, FDI, and adoption of ISO 14000 on growth in manufacturing – plant-level analysis

The regression results presented in Section 5.3 indicated that the growth of manufacturing industries is significantly positively impacted by R&D activities and foreign equity participation (FDI) in the medium and large plants and by their adoption of ISO 14000 (involving implementation of environmental management systems). This annexure provides a robustness check of these empirical findings by carrying out a plant-level analysis.

For the plant-level analysis, a cross-section of about 17,000 plants has been formed from the unit-level data of ASI. The period of the analysis is 2010-11 to 2015-16 – data for these two years have been taken. Those plants have been chosen for the study which were covered in the ASI survey for both 2010-11 and 2015-16 (operating status "open" in 2015-16). The annual (compound) growth rate in real output has been computed by using data on output for 2010-11 and 2015-16. Deflation has been done by using the wholesale price indices at the two-digit level. Thus, the price index for a two-digit industry has been applied to all constituent three-four and four-digit industries. The mean growth rate in real GVA is found to be about six percent per annum and the median growth rate is found to be about three percent per annum (after leaving out very high and very low growth rates).

Econometric models have been estimated to explain the real output growth rate (per year) at the plant level. The explanatory variables used are (1) size in 2010-11 (logarithm of real output), (2) export intensity (share of exports in production, in 2015-16), (3) a dummy variable for R&D and FDI for 2015-16 (it takes the value of one if the plant had foreign equity participation, or had an R&D unit within factory premises, or was spending at least 0.1 percent of its value of output on R&D; zero otherwise), and (4) a dummy variable representing the adoption of ISO 14000 for 2015-16 (it takes the value of one if the plant had a certificate in the ISO 14000 series; zero otherwise).[36] Another explanatory variable used is a dummy variable for making a distinction between old plants and newly set up plants. It takes the value of one, if the plant was last up during the last ten years (i.e., ten years from 2015-16), and zero otherwise.

The model has been estimated by the Ordinary Least-Squares (OLS) method and the quantile regression method. In the estimated models, industry dummies at the two-digit level and state dummies have been included to capture the industry-specific and state-specific effects. This improves the specification by incorporating inter-industry heterogeneity and difference among states. The results are shown in regressions R-1 and R-2 in Table G.1.

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[36] The correlation coefficient between the ISO dummy variable and the dummy variable for R&D and FDI is about 0.3.

Table G1: Factors influencing growth in real output in manufacturing plants, regression results, OLS, quantile regression, and instrumental variable method

Dependent variable: Growth rate in real output (percent per annum)
Data: cross-section data on 15,613 plants for 2015-16 (compared to 2010-11)

Explanatory variables	*OLS (R-1)*	*Quantile regression (R-2)*	*OLS (R-3)*	*Instr. Variable (R-4)*	*Instr. Variable (R-5)*
Export intensity (in percent)	0.055 (8.85)***	0.047 (9.18)***	0.056 (8.93)***	0.056 (8.87)***	0.046 (8.38)***
Size in base year (logarithm of real output in 2010-11)	-1.52 (-19.45)***	-0.70 (-11.76)***	-1.47 (-18.31)***	-1.48 (-18.68)***	-1.06 (-15.86)***
R&D and FDI dummy (2015-16)	2.54 (6.64)***	1.61 (4.79)***	3.03 (8.05)***	2.71 (6.91)***	1.86 (5.59)***
ISO14000 adoption dummy (2015-16)	2.93 (7.83)***	1.38 (4.09)***		2.11 (3.94)***	1.05 (2.25)**
ISO14000 adoption dummy (2008-2010)			1.09 (3.44)***		
Dummy variable for plants of age 10 years or younger in 2015-16	6.52 (14.56)***	5.24 (16.38)***	6.61 (14.70)***	6.52 (14.56)***	6.16 (16.06)***
Industry dummies	Included	Included	Included	Included	Included
State dummies	Included	Included	Included	Included	Included
No. of obs.	15,613	15,613	15,613	15,613	14,991
R^2/ Pseudo-R^2 /Centered-R^2	0.073	0.031	0.070	0.073	0.073
Underidentification test (Kleibergen-Paap rk LM statistic), prob.				0.000	0.000
Hensen J-statistics (over-identification test), prob.				0.001	0.018

Note: Observations in which the (annual)growth rate in GVA is more than 100 percent or less than (-)50 percent have been excluded. For the last column (R-5), the cut-offs are 75 and (-)25 percent. Robust standard errors for the OSL estimates.
t-ratios in parentheses. * prob. <0.1, **prob.<0.05, *** prob.<0.01
Source: Author's computations.

It is seen from regressions R-1 and R-2 in Table G.1 that all coefficients have the expected sign. A positive effect of export orientation on growth is found, as expected. The positive coefficient of the age-related variable (new plants) and the negative coefficient of the base-period size variables are as expected. There is a clear indication that R&D and FDI and the adoption of ISO 14000 have a positive effect on growth, supporting the results based on industry-level data (in Section 5.3).

The results obtained for the ISO 14000 dummy variable need a critical examination because of the issue of the possible endogeneity of this variable. One cannot rule out the possibility that whether or not a plant had ISO 14000 certification in 2015-16 was influenced by the growth rate experienced by the plant in the preceding five years. To address this issue, the ISO dummy variable for the based period has been used in regression R-3. The ISO dummy variable has been constructed for the base period by considering the status in 2008-09, 2009-10, and 2010-11. If a plant had an ISO 14000 series certificate in any of these three years, the dummy variable is assigned the value of one, otherwise zero. The estimate obtained after using the base-period ISO 14000 dummy variable is quite similar to that before the change. This may be seen by comparing R-1 and R-3. The coefficient of the base-period ISO 14000 dummy variable is positive and statistically significant.

To investigate the above issue further, the instrumental variable method has been applied. Since there are difficulties in finding suitable instruments for the ISO 14000 dummy variable in a cross-section dataset with variables confined to those available in the ASI unit-level data, the method suggested by Lewbel (2012, 2018) has been applied in which heteroskedasticity-based instruments are used. The results are shown in R-4 and R-5 in Table G.1. The coefficient of the ISO 14000 dummy variable is found to be positive and statistically significant supporting the results in R-1 to R-3.

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