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Article

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Effects of dynamic variables on industrial output in one of the world's fastest-growing countries: case evidence from India

A. Sankaran[1*], A. Vadivel[2] and M. Abdul Jamal[3]

Abstract

Increase in industrial output is an important indicator to identify the socio-economic development of a nation. India is one of the fastest-growing economies in the world; using its comparative advantage and capitalizing its educated youths, it tries to be as a hub of manufacturing in the world map. Under these circumstances, the present study attempts to identify the effects of dynamic macroeconomic variables on manufacturing output in India using secondary data from 1990Q1 to 2017Q4 sourced from the World Bank, and IMF, RBI, ASI and published materials are other source of information. This study considered variables such as industrial production, population, agricultural output, exchange rate, export, oil price, and gross fixed capital formation. We employed ADF and PP unit root tests, Johansen co-integration test, and error correction model based on Granger causality test. This study found that manufacturing output was driven by agricultural output, export and population. The chief role played by the agricultural output in affecting the manufacturing output suggested that the agricultural sector is still serving as engine of economic development in general and manufacturing output in particular in the case of fast-growing Indian economy. Further, investment on education, health, trainings and other capacity building in the form of human capital on population will lead the industrial sector to get strengthened through observing entrepreneurial spirit, high skilled labours, technicians, and managers. Finally, it is suggested that the superior focus on tapping the potential market on the planet, research and development, mechanization, proper quality control, skill development, better management, and effective marketing will give a new life to the manufacturing sector of the fast-growing Indian economy.

Keywords: Causality, Indian industries, Long-run relationship, Manufacturing output, New industrial policy

JEL Classification: O11, E20 C220, E220, F430

Introduction

Industrial sector is the driving force for sustainable and paramount economic development of a nation; industrialization is also viewed as synonymous with development [71, 75]. The momentous role played by this sector over the course of development was well documented by Kuznets [45], Chenery [15], Hoffman [28], Clark [17], and Taylor [70] in their world-famous research publications. In the latter study, Kaldor [40] and Cornwall [18] offered empirical supports for this view. It can be understood from the World Bank [74] and Verdoorn [72] studies that the spectacular growth achieved in the second half of the twentieth century by East Asia was underpinned by amazing performance of manufacturing industries. This conclusion was also corroborated with Jesus [35], Kim and Park [44] and Szirmai [67]. In an analytical research work, Ltot [50] identified the manufacturing as dynamic benefit offering sector, which is very essential for the transformation of an economy. Further, the effective forward and backward linkages are additional merits of this sector.

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India is one of the fast-growing and fourth largest economies in this world. By capitalizing educated youths particularly in advanced and service oriented industries, it became a leading supplier of human capital in the world [63]. Recently, India emerged as a home to globally recognized companies, predominantly in pharmaceuticals, steel, information and space technology industries [76]. Modernization and industrialization (with special focus on manufacturing process) are the unique qualities of the fast-growing Indian economy. Right from the second five-year plan, Indian government has been making several efforts to reshape and enhance the manufacturing output, introduction of new economic policy being one among them.

India, after independence in 1947, adopted a centrally planned development strategy. The industrial economy of India was highly controlled and regulated through its tight licensing mechanism. The fundamental reform, what Kohli [42] called as '*pro-business*' in orientation, was introduced in 1980s, which included the following key features: (i) liberalizing the import of capital and intermediate inputs through expansion of goods' range and number, and through a reduction of canalization, (ii) prolonging the incentives for exports through tax system and moderate access to foreign exchange and credit, (iii) the noteworthy relaxation of industrial licensing-direct 'delicensing' of some industries and through 'broad banding' and (iv) removal of control of administered prices of some important intermediate inputs [9]. Due to the establishment of the basic industrial layers, it attained a fluctuating growth, which stimulated to liberalize the economic base further. In the words of Kohli [42], the '*License and Permit Raj*' over the past three decades failed to offer an expected rate of growth in the Indian manufacturing economy. Hence, a comprehensive and concrete shift in the developmental policies has been introduced in 1990—the industrial policy has been radically altered to *outward looking* export policy from *inward-looking* import substitution.

The new economic reform considered '*pro-market*' in orientation includes the following key dimensions: (i) the industrial licensing abolition packed by minimizing the scope of public sector, (ii) foremost financial reform—the removal of capital controls, free approval to establish private banks (both domestic and foreign) (iii) free flow of foreign direct and portfolio investment; (iv) trade liberalization with special reference to the removal of import licensing and reducing the non-tariff barriers and (v) unleashed rules in investment and trade in important services [9, 62, 63]. In addition to this, recently, the government of India has fixed its target to contribute 25% from manufacturing output to overall GDP in 2025. To reach this goal, several steps have been introduced, as a part of this exercise Prime Minister Mr. Narendra Modi had initiated the '*Make in India*' program to put India in the world map as a manufacturing hub and give worldwide gratitude to the economy of India. But on the other side, the existing economic environment revealed that the growth rate in agriculture and unorganized sectors has slowed down in recent years resulting insignificant employment generation. Hence, the attention of the economic policies has been redirected towards the promotion of manufacturing sector, as it has the capacity to accomplish the social goals of employment and income generation in the economy. Therefore, the study attempts to answer the question that what factors determine the growth of manufacturing out and how to sustain it. In toto, using advanced econometric tools on World Bank, IMF and RBI database, the study adds a piece of information with the existing body of knowledge and enhances the understanding of academicians about the determinants of industrial output in the contemporary world.

Previous studies

Development of manufacturing sector is a necessary condition for attaining rapid, paramount and sustained development particularly in developing countries. Hence, many studies are still focusing on the different dimensions of the industrial economy. In world-famous research work Verdoorn [72] captured the causal relationship between manufacturing output and partial (labour) productivity in industrial economy, Chenery [14] in his scholarly work acknowledged trade as an important determinant of growth in industrial output. Moreover, among the available international level studies, Gollin et al. [23] assessed the relationship between the outputs of industrial and agricultural sectors in 62 developing countries. They concluded that the industrial output has been accelerated with the support of the yield of agriculture. Whereas, Kim and Lau [43] underlined that there is a positive relationship between major inputs and output in the newly industrialized East Asian countries. In the manufacturing economy of USA, Tassey [68, 69] captured a positive impact of R&D on industrial output; he provided the statistical evidence that 8.6% enhancement in R&D supported to increase 38% of manufacturing output. In the recent decades of financial and infrastructural development influencing the industrial output, the research conclusion of McGrath [52] identified a positive impact due to financial deregulation in the industrial output in the Czech Republic, Hungary and Poland, but David et al. [19] mentioned that the currency depreciation created a negative impact in Nigeria's manufacturing output. Few studies such as Zegeye [77] and Hulten et al. [29] examined the impact of infrastructural development in the industrial sector, and they highlighted a

positive impact on the industrial output during the study periods. In a macro-level approach, Bilgin and Sahbaz [10] reported a high correlation between GDP and industrial production. Even in a seminal work, Causland and Theodossiou [12] found a close association between the growth of manufacturing output and gross domestic product.

International trade can influence the industrial output in different directions, a study pursued by Al Mamun and Nath [6] in Bangladesh opined that there was a long-run positive causality running from export to industrial production over the period. In another study, Akpan et al. [5] assessed the relationship between non-oil export and industrial output in Nigerian economy and found that there was a positive unidirectional causality escalating from industrial output to non-oil export.

Whereas international oil price is also one of the variables, its effect on the industrial output may turn positive or negative. A research work conducted by Jiranyakul [38] in Thailand found that there was a positive relationship between oil price and industrial production, while Mehrara and Sarem [51] estimated the impact of oil price shocks on industrial output, and they found that there is a strong causal relationship moving from the primary to latter variable in Iran and Saudi Arabia during the period taken for study. But this outcome is to some extent, differing from Lee and Ni's [48] findings. They observed that oil price shocks created a negative effect particularly in the oil-intensive industries.

Scholars around the world used different types of techniques to estimate the factors determining the industrial growth in general and industrial output in particular. Among the available research contributions, Kathuria et al. [39] on India's data and Islam and Syed Shazali [32] on Bangladesh's data used the conventional Cobb–Doglous' production function to find out the relationship among manufacturing productivity, growth of human capital and expenditure. The total factor productivity approach of Cingano and Schivardi [16], Sola et al. [66] and Sankaran and Samantaraya Amaresh [63] yielded a considerable positive impact on the productivity in Italian and Nigeria manufacturing industries, respectively. Mustafa and Yavuz [53] reached the conclusion from their vector autoregressive estimation that the manufacturing output of Turkey was mainly depended on total investment and demand factors. Moreover, Sertic et al. [64] estimated the determinants of manufacturing growth in European Union by applying the generalized method of moments (GMM). In an analytical research, Heshmati and Rashidghalam [25] examined the determinants of the performance of manufacturing and service sectors in one of the largest economies in East Africa, such as Kenya, by administrating the ordinary least square and Cobb–Doglous production estimations for the World Bank's Enterprise Survey's database. Moreover, recent studies by Burger et al. [11] in Central and Eastern European countries and Ajmair and Hussain [4] in Pakistan have used VAR system for different periods to find the determinants of manufacturing growth. But the present study adds value by using the appropriate econometric tools such Johansen Co-integration and Granger Causality to understand the long-run relationship among these dynamic variables and the direction of causality among those variables.

Among the available studies in India, Gujarati [24] provided an empirical finding that capital played as a major source of output growth in the manufacturing economy of India, while Ahmad [3] and Jaleel [34] endowed with a statistical evidence that import substitution facilitated for 23% of the total output growth during the study period from 1950–1951 to 1965–1966. A leading economist Ahluwalia [1] in her comprehensive research work portraits that inadequate infrastructure investment due to slowdown in the public investment, underprivileged management of infrastructure, slow growth in demand for industrial products, and restricted trade and industrial policies were negatively influenced the industrial output in the mid-60s and mid-70s. In the same way, Patnaik and Rao [56], Balakrishnan and Babu [8] and Rangarajan [58] mentioned that lackadaisical trend of public investment and infrastructural bottleneck were negatively affected the industrial output. Using time series data, Chakravarty [13] in his research works concluded that the agricultural income is the main source of demand for the industrial output, which positively influenced the industrial economy of this nation. In the latter study, this conclusion was supported by Lahiri et al. [46] and Jacob [33] through their econometric estimation administered to explore the impact of government policies and international trade in determining industrial output and its prices.

At the time of introducing new economic reform, Ray [60] conducted a multidimensional study in India covering the data from 1951 to 1984 to identify the determinants of industrial output. He presented that increase in the availability of food ingredients motivated the growth of manufacturing output. Further, he mentioned that the industrial output had positively affected by agricultural income and negatively affected by severe shortage of power supply. In a dual economy framework, Rao [59] pursued a research to understand the determinants of industrial output over the period of four decades from 1951 to 1990. Rao computed the results separately for different industrial groups such as (a) consumer goods group, (b) capital goods group and (c) intermediate goods. This study concluded that a reasonable satisfactory explanation was provided by variables such as public

expenditure, and agricultural income towards industrial output. Using sophisticated tools, Balakrishnan and Pushpangadhan [7] ascertained the factors influenced the manufacturing output in India during the period from 1952 to 1980, and found that rigid industrial policy downsized the industrial output. By applying advanced econometric tools, Kanwar [41] reached that, during the study period from 1950 to 1992, the agricultural output determines the industrial output in India. Further, the study underlined that domestic terms of trade, investment by the government and agricultural output influencing the industrial output over the study period.

From the theoretical background, it is well understood that the industrial sector plays an imperative role in the socio-economic development of an economy. Further, as the development of manufacturing sector generates employment opportunity, enhances the quality of life and triggers economic growth, the research on determinants of manufacturing output has been drawing attention of academicians and policy makers not only in the industrialized nations but also in emerging countries. While many social scientists [1, 2, 22, 54–56, 58] have scrutinized the different dimensions of industrial sector, studies on the effect of dynamic macroeconomic variables such as agricultural output, exchange rate, export, oil price; foreign direct investment and size of population on industrial output of a fastest-growing nation in the present context have not published in the global dais. With this contemporary significance, the present study is a value addition to the existing literature body on the industrial development scenario, by administrating Johansen Co-integration and Granger Causality techniques on Indian's data soused from IMF, World Bank, and RBI.

Methods

Industrial development is the prerequisite for economic development of a nation. Further, the increase in industrial output is one of the best indicators to understand the rate of socio-economic development in an economy. Hence, the present study is confined to find out the effect of macroeconomic variables on manufacturing output in the industrial economy of India. The time series quarterly data have been sourced from IMF database, World Bank database, and RBI publication—Hand book of statistics on Indian Economy from 1990Q1 to 2017Q4. The study considered six explanatory variables such as agricultural output (AO), population (POP), exchange rate (EX), export (E), oil price (OP), and gross fixed capital formation (GFCF) of industrial sector to identify the determinants of manufacturing output. Out of these variables, agricultural output, industrial output, export, and gross fixed capital formation are observed in terms of USD at constant 2010 prices; oil price is USD per barrel and population in numerical term in lakhs. Hence, except population, all other variables are in terms of USD; these variables are transformed into log (logIO, logAO, logPOP, logEX, logE, logOP, and logGFCF). In order to attain a meaningful result, the variables considered in this study should not have unit root [53]. Hence, at first, the stationarity of the variables has been estimated based on the Phillips–Perron (PP) test, and the Augmented Dickey–Fuller (AFT) test [20, 57].

The maximum likelihood-based Johansen [36] test and Johansen–Juselius [37] test are the most extensively applied methods to explore the existence of long-run equilibrium relationship among the considered variables. Hence, the study applied co-integration test [37] to understand the equilibrium among the considered variables. "Johansen's methodology takes its starting points in the vector regression (VAR) p given by

$$y_t = \mu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t$$

where y_t is an $n \times 1$ vector of variables that are integrated of order one—commonly denoted $I(1)$ —and ε_t is an $n \times 1$ vector of innovation. This VAR can be rewritten as

$$\Delta y_t = \mu + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma \Delta y_{t-1} + \varepsilon_t$$

where

$$\Pi = \sum_{i=1}^{p} A_i - I \quad \text{and} \quad \Gamma_i = -\sum_{j=i+1}^{p} A_j$$

If the coefficients matrix Π has reduced rank $r \prec n$, then there exist $n \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta' y_t$ and $y_{t\text{-}1}$ are stationary; r is the number of co-integrating relationship. The elements of α are known as the adjustment parameters in the vectors error correction model, and each column of β is a co-integrating vectors. It can be shown that for a given r the maximum likelihood estimators of β define the combinations of $y_{t\ -\ 1}$ that yields the r largest canonical correlation of Δy_t with $\Delta y_{t\ -\ 1}$ after correcting for lagged differences and deterministic variables" Hjalmarsson and Österholm [27].

Moreover, the error correction model based on causality has been applied to estimate the relationship among these variables. The study has used industrial output as a function (IO) of gross fixed capital formation (GFCF), export (EX), agricultural output (AO) etc., industrial output 'causes' the gross capital formation (IO → GCF) or is it the gross fixed capital formation that causes (GCF → M). The granger causality test assumes that the information relevant to the predication of the respective

variables, IO and GFCF, is contained solely in the time series data in these variables. The test involves estimating the following pair of regressions:

$$\mathrm{IO}_t = \sum_{i=1}^{n} \alpha_i \mathrm{GCF}_{t-i} + \sum_{j=1}^{n} \beta_i \mathrm{IO}_{t-j} + \mu_{1t}$$

$$\mathrm{GCF}_t = \sum_{i=1}^{n} \lambda_i \mathrm{GCF}_{t-i} + \sum_{j=1}^{n} \delta_i \mathrm{IO}_{t-j} + \mu_{2t}$$

where it is assumed that the disturbances μ_{1t} and μ_{2t} are uncorrelated

Econometric results and discussion

Industrial sector is a significant component in an economy, Rodrik [61] uttered that this sector is an *engine of economic growth*, in another comprehensive work covering 92 sample countries during 1960–2010, Lavopa and Szirmais [47] concluded the same as manufacturing is the engine of economic growth. This sector has been influenced by a group of variables in the contemporary world. In order to identify the impacts of macroeconomic variables on the industrial output of India, at first, the Augmented Dickey–Fuller and Phillip and Perron tests have been executed. The results of this analysis at level and first difference are presented in Table 1 to understand whether these variables have unit root or not at 1%, 5% and 10%. The computed result conformed that all these variables are stationary in the first difference.

Since all these variables are stationary at first difference, the Johnson co-integration test is appropriate to capture the equilibrium or long-run relationship among these variables. Before executing the Johnson co-integration test, it is mandatory to run the VAR model to fix the optimal lag length based on Akaike information criterion (AIC). The lag length criterion directed us to select 5 lags.

The result of multivariate Johnson co-integration test presented in Table 2 revealed that there are five co-integration equations at 1% level, and 2 at 5% level based on the trace statistics. At the same time, the co-integration equation rooted in max-eigenstatistics offered a mixed form of result that there are three co-integration equations at 1% and 5% levels, respectively, and 1 at 10% level. The quintessence of this multivariate Johansen co-integration test showed the existence of more than one long-run relationship in the composition of logIO, logAO, logPOP, logEX, logE, logOP, and logGFCF.

Since the major focus of this study is to estimate the influence of macroeconomic variables on industrial

Table 2 Result of Johansen co-integration test

No. of EC(s)	Trace statistics	Prob.	Max-eigenstatistics	Prob.
$r = 0$	0.600	0.00***	0.600	0.00***
$r \leq 1$	0.466	0.00***	0.466	0.00***
$r \leq 2$	0.396	0.00***	0.396	0.00***
$r \leq 3$	0.263	0.00***	0.263	0.02**
$r \leq 4$	0.185	0.00***	0.185	0.07*
$r \leq 5$	0.154	0.01**	0.154	0.02**
$r \leq 6$	0.050	0.03**	0.050	0.02**

***Denotes significance at the 1% level, **at the 5% level, and *at the 10% level

Table 1 Result of unit root test *Source*: Computed from secondary data

Variables	Level		First difference	
	ADF	PP	ADF	PP
	Trend and intercept	Trend and intercept	Trend and intercept	Trend and intercept
LIO	− 1.795	− 1.795	− 3.929	− 3.930
	(0.701)	(0.699)	(0.014)	(0.013)
LGFCF	− 2.461	− 2.460	− 4.357	− 4.357
	(0.346)	(0.346)	(0.003)	(0.003)
LOP	− 2.427	− 2.427	− 8.616	− 8.616
	(0.363)	(0.363)	(0.000)	(0.000)
LE	− 2.111	− 2.111	− 3.978	− 3.978
	(0.532)	(0.532)	(0.012)	(0.012)
LEX	− 3.252	− 3.098	− 7.848	− 8.001
	(0.080)	(0.112)	(0.000)	(0.000)
LPOP	− 1.032	− 3.318	− 17.188	− 12.577
	(0.934)	(0.069)	(0.000)	(0.000)
LAO	− 2.267	− 2.419	− 9.924	− 9.830
	(0.447)	(0.367)	(0.000)	(0.000)

output, the VECM-based Granger causality test has been administered. The result of the estimation revealed the short-run and long-run casual relationship among the variables. The composition of the VECM-based Granger causality test offered forty-nine results. Out of these results, there are twenty Granger causes escalating across these variables. As the core objective of this study is to discover the influence of macroeconomic variables on the industrial output in the fast-growing Indian economy, that causality was highlighted accordingly.

As Singer [65], Hwa [30] and Vogel [73] pointed out that there is a close association between agriculture and industrial sectors even in India. At first, there is a unidirectional causality escalating from logAO to logIO. This result coincides with the world-famous literature established by Lewis [49], Hirschman [26], and Fei and Ranis [21]. Further, the result implies that the agricultural sector is the mainstay of Indian economy and key source of raw materials for various industries including textiles (one of the well-established segments in the Indian industrial sector) and food processing industries. Moreover, the connection between these major sectors can be traced that when increase in industrial output increases the demand for raw materials that motivates agriculturalists to increase agricultural production (Table 3).

Whereas the bidirectional causality running from logGFCF to logIO entails that capital formation in the industrial sector facilitates producers to buy advanced industrial equipment, employ skilled labours and managerial capacity, which resulted in the change in industrial output. The computed result also indicates that there is a unidirectional Granger cause running from logEX and logIO. The implication of this causality may be the devaluation of the exchange rate affects the industrial output through import of machines; technology and equipments. Besides, it is found that there is a bidirectional causality also escalating from logPOP to logIO revealed that the explosion of population in India and the effort of international and national level organizations to enhance the human capital lad to supply a huge amount of labour force to industrial sector and eventually improved the industrial output in India.

The industrial expansion and increase in per capita income coupled with other factors increased the size of the population. Automobile is one of the largest industries in India, which offers around 7.1% to the overall GDP of the nation [31]. Particularly due to growing trend of middle class and young population, the two wheelers segment is in the dominant place in the automobile sector with 81% of the market share. As a result of the expansion of automobile and oil refinery industries, the oil price has increased through upward trend in the consumption of oil barrels.

Table 3 Result of Granger causality test

Null hypothesis	*F*-Stat.	Prob.
GFCF does not Granger cause AO	3.976	0.07*
E does not Granger cause AO	11.210	0.00***
AO does not Granger cause EX	6.064	0.02**
IO does not Granger cause AO	7.247	0.01**
AO does not Granger cause IO	5.483	0.02**
OP does not Granger cause AO	4.899	0.03**
POP does not Granger cause AO	9.294	0.00***
AO does not Granger cause POP	5.235	0.02**
E does not Granger cause GFCF	24.57	0.00***
GFCF does not Granger cause EX	3.912	0.05**
IO does not Granger cause GFCF	11.61	0.00***
GFCF does not Granger cause IO	7.056	0.01**
OP does not Granger cause GFCF	10.101	0.00***
GFCF does not Granger cause POP	8.683	0.00***
E does not Granger cause OP	2.783	0.09*
E does not Granger cause EX	3.045	0.08*
POP does not Granger cause E	2.785	0.09*
E does not Granger cause POP	4.876	0.03**
EX does not Granger cause IO	4.143	0.04**
POP does not Granger cause EX	4.082	0.05**
OP does not Granger cause EX	1.663	0.02**
IO does not Granger cause OP	4.615	0.03**
POP does not Granger cause IO	10.76	0.00***
IO does not Granger cause POP	4.020	0.05**
OP does not Granger cause POP	3.328	0.07*

***Denotes significance at the 1% level, **at the 5% level, and *at the 10% level

Conclusion

India is one of the fast-growing economies in the world; using its comparative advantage and capitalizing its educated youths, it tries to be as a hub of manufacturing in the world map. In the light of this aspect, the present work attempted to capture the impact of macroeconomic factor on the industrial output in India. In order to do the same, this study considered seven variables such as industrial production (IO), agricultural output (AO), population (POP), exchange rate (EX), export (E), oil price (OP), and gross fixed capital formation (GFCF). Secondary data on these above-mentioned variables have been sourced from the World Bank, IMF, RBI and ASI for the period from 1990Q1 to 2017Q4. Appropriate econometric techniques are used to obtain some meaningful results. The outcome of ADF and PP unit root tests revealed that all these variables are $I(1)$. The Johansen co-integration test was administered, and its result exposed that there are five co-integration

equations at 1% level, and 2 at 5% level based on the trace statistics. At the same time, the co-integration equation rooted in max-eigenstatistics offered a mixed form of result that there are three co-integration equations at 1% and 5% levels, respectively, and 1 at 10% level. Hence, VECM-based Granger causality test has been applied, which depicts that there are twenty causalities (pertinent) escalating among the variables, and there are bidirectional causalities running between agricultural output and industrial output, gross fixed capital formation and industrial output, and population and industrial output. Finally, out of this exercise, the study found that manufacturing output was driven by agricultural output, exchange rate and population. The chief role played by the agricultural output in affecting the manufacturing output suggested that the agricultural sector is still serving as engine of economic development in general and manufacturing output in particular, in the case of fast-growing Indian economy.

In the light of the findings of present study, it is suggested that Indian government may take immediate step to protect the slowly fading agricultural sector, its result will positively reflect in the industrial output, and these sectors will attain the win–win situation in future. As the fixed capital formation is causing the industrial output, it is suggested that the central and state government should properly invest in the industrial sector, which will lead the nation to become an effective player in the global market by attaining the comparative advantage, economics of scale and enhanced quality. Further, investment on education, health, trainings and other capacity building (in the form of human capital on population) will lead the industrial sector to get strengthened through observing entrepreneurial spirit, high skilled labours, technicians, and managers. At last, it is suggested that the superior focus on tapping the potential market on the planet, research and development, modernization, proper quality control, skill development, better management, and effective marketing will give a new life to the manufacturing sector of the fast-growing Indian economy.

Abbreviations

ADF: Augmented Dickey–Fuller; ASI: Annual Survey of Industries; GDP: gross domestic product; GMM: generalized method of moments; IBEF: India Brand Equity Foundation; IMF: International Monetary Fund; PP: Phillips and Perron; RBI: Reserve Bank of India; R&D: research and development; VAR: vector autoregression; VECM: vector error correction model.

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Authors' contributions

The authors contribute in ratio 60, 20 and 20%: the corresponding author (AS 60%); second author (AV 20%) and the third author (MAJ 20%). AS framed the research issue, collected data and prepared the theoretical part and interpretation. AV estimated the result and provided suggestions for the preparation of interpretation. While the third author MAJ collected source materials, contributed to the review of literature and edited the document. All authors read and approved the final version of the manuscript.

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Availability of data and materials

The data set is available on request.

Competing interests

The authors declare that they have no competing interests.

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