Determinants of Manufacturing Output in India: Panel Data Analysis

Krati Jain, Research Scholar,
Department of Economics,
(IIS Deemed to be) University, Jaipur.
Mob: 7597071690
Mail id- Kratijain157@gmail.com

Dr. J.N. Sharma Professor,
Department of Economics.
(IIS deemed to be) University, Jaipur.
Mob- 9414378663
Mail id- jn.sharma@iisuniv.ac.in

Abstract

This study investigates the determinants of manufacturing output in India for the period 2000 to 2019 considering 25 states of India. The study employed panel data regression analysis on secondary data extracted from EPWRF. Traditional panel data models of POLS, FEM and REM have been estimated along with the long-run FMOLS and DOLS models. As per the result, variables of total persons engaged, fixed capital, working capital, fuel consumed and output of service sector have positive and significant influence on output of the manufacturing sector in India but agriculture production have negative and significant impact on manufacturing output in long-run. Among the three models, the study found out that Fixed Effect model is the most appropriate model and as per the FMOLS and DOLS model there exist a long-term association between the variables.

==========

Section-I

1.1 Introduction

The manufacturing sector plays a crucial role in economic development, reflecting a country's level of progress through its modernity and performance. Both developed and developing nations focus on improving manufacturing through heavy investment, policies, and attracting FDI, which is believed to bring innovation, create jobs, and boost production in both consumer and capital sectors. Manufacturing is a key driver of wealth, job creation, and reduces disguised unemployment, particularly in countries like India, where it also helps bridge regional disparities, increase exports, and improve foreign currency reserves. India's manufacturing sector has grown rapidly due to favorable policies, rising consumer demand, skilled labor availability, and increased FDI.

However, the critical question remains: what factors determine manufacturing output across India's states? This study aims to identify these factors by analyzing 25 states with varying income levels, providing a comprehensive understanding of what influences manufacturing performance.

Present study aimed to determine various factors which affects manufacturing output in the sample of 25 states in India. Namely, we selected the economic variables which are elicited and are assumed to have a direct control over the dependent variable. We targeted a heterogenous country which compromises of all income group states, developed and developing states which will give an accurate picture of determinants which affect manufacturing output.

Section 2

2.1 Literature Review

Attention may be drawn on the fact which explains the factors determine the economic output has been remarkable. Much of the number of studies has attempted to pursue the relationship between factors that determine manufacturing output.

Studies by *Farhad Hussain, Sun Jianfu and Muhammad Kamran (2023), Nahaian Bin Abdullah (2022), Aragaw Eshetie Aguade (2022), Larrisa Batrancea, Malar Mozhi Rathnaswamy and Ioan Batrancea (2021), Sazan Taher Saeed (2017), Reenu Kumari and Anil Kumar Sharma (2015)* used econometric models including POLS, fixed effect, random effect and Hausman test to analyze the effect of macroeconomic variables on the growth of manufacturing industries. These studies have also applied panel data regression models by using panel data for different time period, and also used several variables like the study of Farhad Hussain used corporate tax, and interest rate, exchange rate, stock market development and a public debt while the study of Aragaw Eshetie Aguade (2022) used Ownership, firm-size, advertising intensity and import intensity, firm size, government and advertising intensity as independent variables. Study of Reenu Kumari and Anil Kumar Sharma (2015) used several explanatory variables like market size, trade openness, infrastructure, inflation, interest rate, human capital and research and development. All these studies have revealed that manufacturing sector growth rate was substantially influenced by economic indicators such as imports, exports, gross capital formation. Labour force participation rate negatively impacts manufacturing economic growth while institutional, capital formation and advancement of technology has a positive relation with manufacturing economic growth. All the above studies used POLS, fixed effect model and random effect model to check the association between the variables and to check the appropriateness of the models the studies applied Hausman Test.

This study is divided into four sections: the first section is related with introduction, second sections deal with review of literature, third section consist data and data source, econometric modelling and the last section which is fourth sections is related with results and conclusion.

Section 3

3.1 Data Nature and Source

In this study, panel data has been used for 25 states of India for the period 2000 to 2019. The data was extracted from EPWRF (Economic and Political Weekly Research Foundation). These 25 states are Andhra Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu Kashmir, Jharkhand, Karnataka, Kerela, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Orrisa, Punjab, Rajasthan, Tripura, Tamil Nadu, Uttar Pradesh, Uttarakhand and West Bengal.

The present study considers Manufacturing Output as dependent variable and Total Persons Engaged, Working Capital, Fixed Capital, Fuel Consumed, Agriculture Production and Service Sector output as the independent variables. For this purpose, panel data has been used because it

contains numerous advantages in terms of accuracy and measurability compared to time series or cross section data and moreover it includes more variables and more information as compared to pure time series or cross section data.

3.2 Model Specification

The panel data regression model is expressed as below:

$Y_{it} = \alpha + \beta X_{it} + \mu_{it}$

Where i= 1, 2,…N for cross-section and t= 1,2,…..T for years. Y is the dependent variable and X is the independent variable.

Considering the dependent and independent variable, the model is specified as:

GVO= f (TPE, WC, FIC, FC, AP, SS)

Where, GVO – gross value added of manufacturing output, TPE- total persons engaged, WC- working capital, FIC- fixed capital, FC- fuel consumed, AP- agriculture production and SS- output of service sector.

Taking ln (natural logarithm) the model becomes:

$\ln GVO_{it} = \beta_1 + \beta_2 \ln TPE_{it} + \beta_3 \ln WC_{it} + \beta_4 \ln FIC_{it} + \beta_5 \ln FC_{it} + \beta_6 \ln AP_{it} + \beta_7 \ln SS_{it} + \mu_{it}$

This specified model has been considered for estimation the traditional panel data models as described below:

Pooled Ordinary Least Squares Model, Fixed Effect Model and Random Effect Model.

3.3 Description of variables used in the study-

In this study, the dependent variable is the Gross Value of Output (GVO), which includes the ex-factory value of products, by-products, semi-finished goods, work-in-process, receipts for industrial and non-industrial services, and the sale value of electricity generated. The independent variables include:

1. **Total Persons Engaged (TPE)**: Refers to all individuals engaged in work related to the manufacturing process, including administrative, technical, and clerical staff.
2. **Working Capital (WC)**: Represents the physical inventory held by the factory, including lubricants, fuel, and other items on the closing day of the financial year.
3. **Fixed Capital (FIC)**: Depreciated value of fixed assets like land, plant, machinery, buildings, and transport equipment owned by the factory.
4. **Fuel Consumed (FC)**: The total purchase value of fuel products such as lubricants, electricity, and water consumed during the accounting year.
5. **Agriculture Production (AP)**: The total output from primary sector activities such as farming, mining, and forestry, including crops, livestock, and other agricultural products.
6. **Output of Service Sector (SS)**: Represents the tertiary sector, which focuses on services such as hospitality, tourism, healthcare, transport, and finance.

Pooled Ordinary Least Square Method (POLS)

It assumes that the data set is homogenous. The intercept is assumed to be same for all the states.

Static pool OLS model can be shown as follows-

$$lnGVO_{it} = \beta_1 + \beta_2\, lnTPE_{it} + \beta_3\, lnWC_{it} + \beta_4\, lnFIC_{it} + \beta_5\, lnFC_{it} + \beta_6\, lnAP_{it} + \beta_7\, lnSS_{it} + \mu_{it}$$

i= 1, 2, 3…...25, stands for 25 states
t=1,2,3…., stands for time period 2000 to 2019
the constant intercept assumption assumes that all 25 states are same and there is no substantial state specific and temporal effect. However, Pooled OLS should be used when fixed effect is not appropriate.

Fixed Effect Model

Fixed effect least square dummy variable model because it allows for heterogeneity among the subject as it allows different intercept for each entity. In the below model α_i is the intercept term which represent cross section state effect.

$$lnGVO_{it} = \alpha_i + \beta_1\, lnTPE_{it} + \beta_2\, lnWC_{it} + \beta_3\, lnFIC_{it} + \beta_4\, lnFC_{it} + \beta_5\, lnAP_{it} + \beta_6\, lnSS_{it} + \varepsilon_{it}$$

There is no constant term in the fixed effect model, instead of constant term now we have an individual-specific component α_i that determines a unique intercept for each state.

Random Effect Model

It is also known as error components model, in this method the individual effects are randomly distributed across cross-sectional units, and in order to capture individual effect, the regression model is specified with an intercept term representing am over all constant term.

$$lnGVO_{it} = \mu_i + \beta_2\, lnTPE_{it} + \beta_3\, lnWC_{it} + \beta_4\, lnFIC_{it} + \beta_5\, lnFC_{it} + \beta_6\, lnAP_{it} + \beta_7\, lnSS_{it} + u_{it}$$

In random effect model the individual specific model α_i is not used parameter and even its not being estimated but it is considered as random variable as μ.
To test the appropriateness of the estimated models, different test has been applied.

Section 4

4.1 Estimation and Analysis of Results

Panel Ordinary Least Square Model (POLS)

Table1

Dependent variable: lnGVO

Method: Panel least square

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	0.127793	0.156606	0.816019	0.4149
LnTPE	0.239675	0.022592	10.60866	0.0000
LnWC	0.213071	0.017447	12.21252	0.0000
LnFIC	0.386571	0.027338	14.14021	0.0000
LnFC	0.149964	0.027310	5.491212	0.0000
LnAP	-0.218761	0.025240	-8.667073	0.0000
LnSS	0.343752	0.028333	12.13270	0.0000
R-squared	0.988275		F-statistic	6714.925
Adj. R-squared	0.988128		Prob. (F-stat)	0.000000

Source: Authors estimation

Table 1 represents the result of panel ordinary least square method; table revealed the linkage between all the explanatory variables and manufacturing output is significant. Independent variables have positive and significant impact on

manufacturing output. On the other hand, variable like agriculture production have negative and significant influence on

manufacturing output.

Only a variable fuel consumed have negative and insignificant impact on net value added. Value of R-squared depicts that 98% of the variation in dependent variable can be explained by selected independent variables in dataset. The prob F stat value which is 0.0000 suggest that model is good fit.

Fixed Effect Model

Table 2

Dependent variable: lnGVO

Method: Fixed effect model

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	2.337318	1.096992	2.130660	0.0337
LnTPE	0.383821	0.038926	9.860173	0.0000
LnWC	0.067745	0.012752	5.312297	0.0000
LnFIC	0.252070	0.027532	9.155624	0.0000
LnFC	0.155649	0.033024	4.713233	0.0000
LnAP	-0.069385	0.047757	-1.452872	0.1470
LnSS	0.188743	0.058313	3.236734	0.0013
R-squared	0.996766		F-statistic	2736.131
Adj. R-squared	0.996402		Prob (F-stat)	0.000000

Source: Authors estimation

The table shows results of fixed panel data which resembles with that of POLS, because all the explanatory variables have linked with dependent variables. All the variables like total persons engaged, working capital, fixed capital, fuel consumed and output of service sector have positive and significant impact on manufacturing sector. 1% increase in total person engaged, working capital, fixed capital, material consumed, fuel consumed and service sector will increase the manufacturing output by 38%, 6.0%, 25.2%, 15.5% and 18.8% respectively.

On the other hand, independent variable like agricultural production have negative and insignificant impact on manufacturing output. An increase of 1% in agriculture output will decrease the manufacturing output by 14.7% but it will not affect significantly.

Value of R-squared depicts that 99% of the variation in dependent variable can be explained by selected independent variables in dataset. The prob F stat value which is 0.0000 suggest that model is good fit.

Redundant Fixed Effect Test

Table 3

Effect Test	Stat	Prob.
Cross-section F	43.4415	0.0000
Cross-section Chi-square	593.07051	0.0000

Source: Authors estimation

The results of redundant fixed effect test which measures the best appropriate test out of POLS and FEM. The hypotheses to

measure the appropriate test are as followed –

H0: Pooled ordinary least square method is appropriate

H1: Fixed effect model is appropriate

The results and interpretation are based on most appropriate model which is determined on the basis of F and Chi-square test. As per the table, the prob value (0.0000) which is less then 0.05, therefore we reject the null hypotheses and conclude that fixed effect model is appropriate than POLS model.

Random Effect Model

Table 4

Dependent variable: lnGVO

Method: Random effect model

Variable	**Coefficient**	**Std. Error**	**t-stat.**	**Prob.**
C	-0.423	0.277	-1.527	0.127
LnTPE	0.22006	0.030	7.306	0.000
LnWC	0.10974	0.0131	8.3535	0.000
LnFIC	0.29563	0.0263	11.250	0.000
LnFC	0.31124	0.0298	10.435	0.000
LnAP	-0.22952	0.0320	-7.164	0.000
LnSS	0.44692	0.034612	12.91210	0.000
R-squa	0.972303		F-stat	2796.693
Adj. R-squa	0.971955		Prob (F-stat)	0.000

Source: Authors estimation

Table 4 represents the outcomes of random effect method which indicates that gross value of output of manufacturing sector is positively and significantly influenced by total persons engaged, working capital, fixed capital, material consumed, fuel consumed and output of service sector as similar to fixed effect model.

A 1 % increase in total persons engaged, working capital, fixed capital, fuel consumed and service sector will increase the manufacturing output by 22.0%, 10.9%, 29.5%, 31.1% and 44.69% respectively. Furthermore, just one variable like agricultural production have negative and significant impact on gross value of output of manufacturing sector.

Value of R-squared depicts that 97% of the variation in dependent variable can be explained by selected independent variables in dataset. The prob F stat value which is 0.0000 suggest that model is good fit.

Hausman Test

Table 5

Hausman Test

Test Summary	Chi-sq Statistic	Prob.
Hausman test	19.782693	0.0030

Source: Authors estimation

Hausman test was performed to choose between random and fixed effect method which is appropriate method. The null hypotheses is framed as random effect is more appropriate and consistent then fixed effect method. If p value is less than 0.05, then we reject the null hypotheses and say fixed effect method is appropriate at 5% level of significance.

As per the table 5, the p value (0.0030) is less than 0.05, therefore we reject the null hypotheses and say fixed effect model is more appropriate and consistent than random effect model at 5% level of significance.

Robustness of the Model

1. **FMOLS (Fully-Modified Ordinary Least Square Model)**

Table 6

Dependent Variable: lnGVO

Long-run covariance estimation

Method: FOLS (Fully Ordinary Least Square Method)

Variable	Coefficient	Std. Error	t-statistic	Prob.
LnTPE	0.24391	0.0534	4.5692	0.000
LnWC	0.11564	0.0179	6.4735	0.000
LnFIC	0.27125	0.0375	7.2393	0.000
LnFC	0.32784	0.0445	7.3736	0.000
LnAP	-0.19919	0.0499	-3.991	0.000
LnSS	0.43188	0.0560	7.7083	0.000
R-squar	0.996039			
Adj. R-squared	0.995757			

Source: Authors estimation

The above table shows the result of FOLS (Fully modified least square method) which depicts the long-term association between explanatory variables and gross value of output of manufacturing sector. It was done by applying long-run covariance estimates: Bartlett Kernel, Newey-West fixed bandwidth).

The result depicts short run panel data regression, as all the independent variables except agriculture production have influenced manufacturing output in positive and significantly. This denotes that there is long run cointegration between the dependent variables and manufacturing output.

The only variable agricultural production has negative and significant impact dependent variable. Value of R-squared depicts that 97% of the variation in dependent variable can be explained by selected independent variables in dataset.

2. DOLS (Dynamic Ordinary Least Square Model)

Table 7

Dependent variable: lnGVO

Long Run Covariance Estimation

Method: DOLS (Dynamic Ordinary Least Square Method)

Variable	Coefficient	Std. Error	t-statistic	Prob.
LnTPE	0.23874	0.0589	4.0465	0.000
LnWC	0.14186	0.0225	6.3047	0.000
LnFIC	0.32801	0.0479	6.8435	0.000
LnFC	0.30166	0.0605	4.9883	0.000
LnAP	-0.18686	0.0576	-3.246	0.001
LnSS	0.35247	0.064	5.5072	0.000
R-squa.	0.997775			
Adj. R-squared	0.996328			

Source: Authors Estimation

The above table shows the result of DOLS (Dynamic Ordinary Least Square method) which depicts the long-term relationship between dependent and independent variable.

the table shows long run covariance estimation done through Bartlett kernel, Newey -West bandwidth test used for covariance estimation.

The result of DOLS (Dynamic Ordinary Least Square Method) is similar to FMOLS method in which independent variables like total persons engaged, working capital, fixed capital, fuel consumed and output of service sector have a positive and significant impact on output of manufacturing sector.

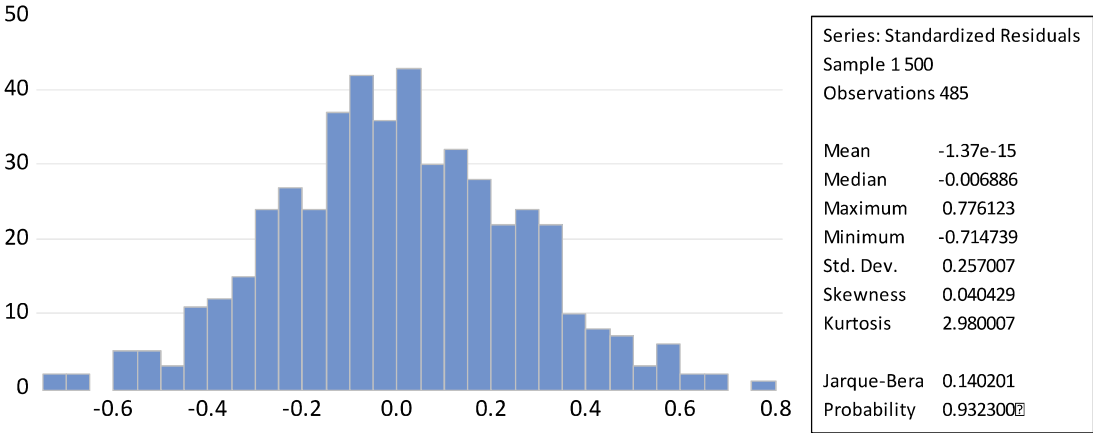
On the other hand, agriculture production has a negative and significant impact on manufacturing sector.

Value of R-squared depicts that 99% of the variation in dependent variable can be explained by selected independent variables in dataset.

Diagnostic Test

1. Normality test

Fig. 1



Source: Authors estimation

We have estimated Normality of the residuals through Jarque Bera test, the hypotheses for normality are as under follows-

H0: Residuals are normally distributed

H1: Residuals are not normally distributed

In the above fig. 1 the p value (0.932300) which is greater than 0.05, therefore we failed to reject the null hypotheses which means we accept the null hypotheses and conclude that the residuals are normally distributed.

2. Cross-sectional dependence test

Several tests have been proposed to check the cross-sectional dependence test however it is the LM test which is commonly used among these tests, the following hypotheses is followed as under-

H0: There is no cross-sectional dependence

H1: There is cross-sectional dependence

The result of test indicates that we reject the null hypotheses as p value is less than 0.05, and it has been determined that is cross-sectional dependency in the series.

Table 6
Residual cross-section dependence test

Test	Statistic	Prob.
Breusch-Pagan LM	759.5066	0.0000
Pesaran scaled LM	18.75928	0.0000
Bias-corrected scaled LM	18.10139	0.0000
Pesaran CD	-2.48393	0.0130

Source: Authors estimation

This result can be explained as a shock that occurs in any state participating in the test will affect other state as well.

Section 5

5.1 Discussion and conclusion

This study analyzes the short-term and long-term relationships between the dependent variable (gross value of manufacturing output) and several independent variables across 25 states of India from 2000 to 2019. Data was sourced from the EPWRF website. The states included are Andhra Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Odisha, Punjab,

Rajasthan, Tripura, Tamil Nadu, Uttar Pradesh, Uttarakhand, and West Bengal.

The study uses panel data regression analysis with three methods: Panel Ordinary Least Squares (POLS), Fixed Effect, and Random Effect models. The independent variables include total persons engaged, working capital, fixed capital, fuel consumed, agricultural production, and output of the service sector. Fixed effect redundant and Hausman tests were applied to determine the best model.

The results indicate that all independent variables positively and significantly affect the gross value of manufacturing output. However, agricultural production negatively impacts manufacturing output in the Random Effect and POLS models, while its effect is negative but insignificant in the Fixed Effect model.

After applying the Hausman test, the Fixed Effect method was identified as the most appropriate and consistent model. Diagnostic tests, including the Jarque-Bera normality test, confirmed that residuals were normally distributed, and LM tests revealed cross-sectional dependency, meaning changes in one state affect others.

References:

1. Abdullah, B., N. (2022) A panel data approach of determining factors of economic growth for different income groups of countries. Dissertation submitted in the Sodertom University, school of economics.
2. Ajmair, M., Hussain, K. (2017) Determinants of Industrial Sector Growth in Pakistan. *Journal of Poverty, Investment and Development.* **Vol (34).**
3. Aguade, E., A., Ayanaw, D., Derso, A., E. (2022) Panel data analysis of profitability and employment growth of medium and large size industries in Ethiopia. Open access article at *Heliyon 8.* **Pp. 2405-8440.** https://doi.org/10.1016/j.heliyon.2022.e10859
4. Batrancea, L., Rathnaswamy, M., M, Batrancea, L. (2021) A panel data analysis of Economic growth determinants in 34 African industries. *Journal of Risk and Financial Management.* **14. 260**. https://doi.org/10.3390/jrfm14060260
5. Egyu, H. (2022) Panel data analysis in Investigation The Economic Growth of Turkic States. *International Journal of New Approaches in Social Studies*. **6(1). 36-46.** DOI: 10.38015/sbyy.1075022

   Hiestand, T. (2005) Using Pooled Method, Random Model And Fixed Model Multiple Regression To Measure Foreign Direct Investment In Taiwan. *International Business & Economics Research Journal*. **Vol. 4. No. 12**.

   Hussain, F., Jianfu, S., Kamran, M. (2023) Examining macroeconomic factors & capital structure choices in Pakistan's manufacturing industry: An empirical analysis. *Journal Of Social Research Development.* **2788-8320.** https://doi.org/10.53664/JSRD/04-02-2023-02-252-261
6. Ismail, R., Sulaiman, N., Norsi'ee, R., S. (2017) Total factor productivity and its contribution to Malaysia palm oil-based industry output growth. *Review Of Integrative Business And Economics Research.* **Vol. 6. Issue. 4**.
7. Jawaid, T. S., Saleem, M. S. (2017) Foreign capital inflows and economic growth of Pakistan. *Journal of*

Transnational Management. **Vol 22(121-149). Issue 2.**

8. Kumari, R. (2017) Determinants of foreign direct investment in developing countries : A panel data study. *International Journal Of Emerging Markets.* **Vol. 12 Issue 4. Pp. 658-682.** https://doi.org/10.1108/IJoEM-10-2014-0169
9. Malik, A. M., Masood, T., Sheikh, A. M. (2021) Econometric analysis of total factor productivity in India. *The Indian Economic Journal*. **69(1).88-104**.
10. Mohsen, A.S., Chua, S.Y. & Sab, C.N.C (2015) Determinants of industrial output in Syria. *Journal of Economic Structures.* **4(19).** DOI: 10.1186/s40008-015-0030-7
11. Ogunwole, O. C., Abalaba, P. B., Aderemi, A. T., Olasupo, F. S., Aransiola, J. I. (2022) Determinants of industrial development in developing countries: The case of Nigeria. *Journal of Business Administration and Business Economics*. **Vol 18. Pp (39-52). No.6.**
12. Saeed. S., Hatef Abdul kadheem Altaee, H. (2017) Export and economic nexus in the GCC countries: A panel data approach. *International Journal Of Business And Social Research*. **Vol. 07 Issue. 12 01-09.** http://dx.doi.org/10.18533/ijbsr.v7i12.1084
13. Susandi, E., A. (2020) Manufacturing industry growth patterns and analysis of variables affecting value added (Case study: China, Malaysia, Thailand, Inodnesia, and England 1998-2005). *International Journal Of Applied Finance And Business Studies*. **Vol. 8. Issue. 3. Pp. 112-119.**

***