PAPER • OPEN ACCESS

Impact of Manufacturing Value Added on Environmental Degradation: empirical evidence from India

To cite this article: C Sulaiman *et al* 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1102** 012035

Impact of Manufacturing Value Added on Environmental Degradation: empirical evidence from India

C Sulaiman[1,*], A S Abdul-Rahim[2,6], N S A Samad[3], I Muhammad-Jawad[4], N S Zainal Abidin[5] and N F Shaari[7]

[1]Department of Natural Resources and Sustainability, Faculty of Earth Science, Universiti Malaysia Kelantan, Kelantan, Malaysia
[2]School of Business and Economics, Universiti Putra Malaysia, UPM Serdang, 43400 Selangor, Malaysia
[3]Faculty of Entrepreneurship and Business, Universiti Malaysia Kelantan, Kelantan, Malaysia
[4]Assistant Manager (CS), Shahkot Division, Lahore Electric Supply Company (LESCO), District Nankana, Pakistan
[5]Tadika Komputer Cerdik 629, Jalan Merak 6, Taman Thivy Jaya, 70300 Seremban, Malaysia
[6]Institute of Tropical Agriculture & Food Security (ITAFoS), Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[7]Department of Economics, Faculty of Business and Management, Universiti Teknologi MARA Cawangan Johor Kampus Segamat, Johor, Malaysia
*E-mail : sulaiman.c@umk.edu.my

Abstract. In recent years, the manufacturing sector in India has been witnessing a continuous growth in output production due to increase in investment in the sector and the government's commitment to reduce reliance on imports and boost exports considering the country's huge domestic market. However, this development is not environmentally friendly as increase in production entails increase in energy consumption, which result in an increased carbon emission that damage the environment. In view of the foregoing situation, this study is set out to investigate the impact of manufacturing value-added on environmental degradation in India over the 1965-2016 period. The study used autoregressive and distributed lag (ARDL) model to achieve its objective. Carbon dioxide emission was used to proxy environmental degradation in the model. In order to serve as control variables in the model, some selected relevant macroeconomic variables such as energy use, trade openness, and economic growth were employed. The estimated result showed that manufacturing value added has positive impact on environmental degradation in India. It infers that the increasing production in the manufacturing sector is degrading the environment through carbon emission. This suggests that an increase in manufacturing sector value added contributes to reducing the quality of environmental in India. Also, the environmental Kuznets curve (EKC) hypothesis was tested and found to be invalid and non-existent. Since the manufacturing sector consumes a lot of energy in its productive activities, the result does not come as a surprise. Thus, we suggest that policymakers in India should apply appropriate measures to improve the quality of the environment through adoption of new technology that will ensure energy efficiency and reduce carbon emission from the country's manufacturing sector.

1. Introduction

The economic reform in India has made the country to become one of the world's quickest emerging economies, where in 2020 the service sector contributed 54.13% to India's economic development, the manufacturing sector contributed 18.32% and agriculture contributed 14.39% [1]. However, economists in India argued that 18.32% of manufacturing contribution is not a healthy sign for India as the country has a large domestic market with a population of over 1 billion. They maintained that the lack of percentage contribution from the manufacturing sector is the reason why India's economy is not comparable to developed countries. Therefore, India is now being propelled through a "Make in India" movement under the leadership of the Narendra Modi government to improve economic growth and build job opportunities [2].

Since India has highly skilled and unskilled labour, the government believes that foreign investors might find India as a suitable country for them to invest in the manufacturing sector. In addition, the government has been spending more than 1 billion dollars to provide adequate infrastructures like electricity and well-built railways for transportation and also enact legislation that would attract and give foreign investors the flexibility to start their business in India. Other than that, the India government also encourage local companies to further boost the manufacturing sector. This is because a strong manufacturing industry would allow India to reduce its reliance on imports and increase its exports to other countries, while paving way for large-scale Indian jobs. Unfortunately, the quick development of the manufacturing industry is not an environment friendly.

Over the last two decades, air pollution especially carbon dioxide emission has increased globally. Since the emissions increased by 49% between 1990 and 2011. The largest contributors are from developed and less developed countries and they need to cooperate to mitigate these emissions. Realizing the need to participate in reducing carbon dioxide emission, India made a pledge in 2009 to lessen its emission intensity by 20 – 25%. Similarly, in 2011 India committed to a legally binding agreement to cut its carbon emissions by 2015 and would enter into force by 2020 [3]. However, India's ambitious plan to grow its manufacturing sector is likely to be interrupted by this new agreement as it imposes more stringent restrictions on India's carbon emissions. It is because the existence of many factories in India would make it difficult for the country to reduce its carbon emission.

In addition, the global shift in manufacturing from advanced economies to the developing economy such as India according to the report from Chartered Institute of Management Accountants [4] has made it difficult to reduce the manufacturing's pollution. Based on a report from the United Nations Environment Programme [5], the pollution from the manufacturing sector would be influencing India's air quality. Other than that, the absence of a centralized database for easy access into the emission records and no regulatory inspection on the manufacturing plants according to India Policy Forum 2017 might impact on environmental degradation. By considering the contribution of manufacturing value-added on environmental degradation in India, this study aims to examine the impact of manufacturing value-added on India's environmental degradation for the 1965 – 2016. India has been selected based on a list of G20 countries which are the largest greenhouse gas producers based on Emission Gap Report 2018 and the top eight largest emitting countries in 2015. It is worthwhile to examine the aftermath of manufacturing value-added on environmental degradation in India because it will contribute a lot to parties such as policymakers, manufacturers and government.

There are few related literature in this area. [6], [7], and [8] reported that manufacturing sector has a significant positive impact on carbon dioxide emissions. A study by [9] found that the manufacturing sector actually improves people lifestyle through provision of employment opportunities. This finding supports [10], who reported that manufacturing provides millions of employment opportunities. However, environmentalists argued that it can cause damage to the environment because carbon dioxide is released from the manufacturing activities [11]. [12], [13], and [14] equally showed that industrial activities have significant positive impact on carbon dioxide emissions. Other related studies include [15] – [16].

The rest of the paper is organized as follows. Section two discusses the methodology and data utilized in the study. Section three presents and analyses the results of the study. While conclusion and recommendation are contained in section four.

2. Methodology and Data

2.1. Theoretical modelling and Data Sources

The model specification for this study follows environmental Kuznets curve theory. This theory proposes an inverted U-shaped relationship between income and environmental degradation. All the data used in this study were obtained from World Development Indicators except for energy consumption that was obtained from BP Statistical Review of World Energy and Shift Energy Data Portal. The data cover from 1965 to 2016 for India. The variables denoted with '$\boldsymbol{l}$' at their initial signifies that they have been pre-converted into logarithm form to eradicate the biases in the model formulation. The description of the modelled variables is given in Table 1.

Table 1. Description of variables.

Variable	Variable type	Symbol	Measure
Carbon dioxide	Dependent	lCO2	Metric tons per capita
Gross domestic product	Independent	lY	Constant 2010 US$
Manufacturing value added	Independent	lMAN	Constant 2010 US$
Trade openness	Independent	lTRD	% of GDP
Energy consumption	Independent	lEC	kWh

2.2. Method of Estimation

This study applies autoregressive and distributed lag (ARDL) model to achieve the objective of this research. The major advantage of this method is that it allows both short- and long-run relationships between dependent and independent variables to be evaluated. This is in contrast to ordinary least Squared (OLS) regression estimator. The estimation steps of this method include; unit root tests, ARDL bounds test, ARDL long-run coefficients, ARDL short-run coefficients, and diagnostic tests.

2.2.1. Unit Root Test

The analytical work presumes that based on time-series results; the underlying data are stationary. In general, the series of data are deemed to be stationary when its mean and variance are constant over time. Furthermore, the covariance value between two periods of time depends only on the distance or lag between the two periods of time and not on the actual time at which the covariance is measured. Therefore, this study applies unit roots test to verify the stationary nature of the time series data employed. To examine the stationary property of the time series involved, augmented Dicker-Fuller and the Phillip-Perron tests are used.

2.2.2. The ARDL and Bound Testing Approach

The ARDL test of cointegration proposed by [17] is utilized to establish long-run cointegration relationship among the underlying variables. The selection of the ARDL model for this study is motivated by the fact that it has an advantageous position over other cointegration strategies such as Johansen test suggested by Johansen and Engle-Granger, which assumes that all variables are integrated of order of I(1), which may lead to incorrect conclusions on variables integrated of different orders. On the other hand, the ARDL model permits the variables employed in the model to be either I(0), I(1) or a mixture of both stationary properties. However, the pre-testing of the integration order of the variables cannot be avoided in order to ensure there is no I(2) integration order. Because, the presence of I(2) in the model would invalidate the method.

Another strength of ARDL is its ability to be beneficial in small samples. Since this study consists of 52 observations and uses a single equation modelling, this makes ARDL relatively clear and easy to apply. ARDL makes the analysis relatively straightforward and simple since it uses single equation modelling. The ARDL model for this study is specified in Equation 1 in an unrestricted error correction form with null hypothesis of no cointegration.

$$\Delta lCO_{2t} = \beta_0 + \sum_{i=1}^{\rho} \beta_1 \Delta lCO_{2t-i} + \sum_{i=0}^{\rho} \beta_2 \Delta lGDP_{t-i} + \sum_{i=0}^{\rho} \beta_3 \Delta lMAN_{t-i} + \sum_{i=0}^{\rho} \beta_4 \Delta lEC_{t-i} + \sum_{i=0}^{\rho} \beta_5 \Delta lTRD_{t-i}$$
$$+\theta_1 lCO_{2t-1} + \theta_2 lGDP_{t-1} + \theta_3 lMAN_{t-1} + \theta_4 lEC_{t-1} + \theta_5 lTRD_{t-1} + \varepsilon_t \quad (1)$$

If the calculated F-statistic is higher than the critical value of the upper bound of the ARDL bounds test, we can reject the null hypothesis of no cointegration. This implies that long-run relationship exists among the variables. In contrast, if the computed F-statistic falls below the lower critical bound, the null hypothesis is accepted, confirming that there is no long-run relationship among the variables. However, if the F-statistic lies between the two bounds, the result is classified as inconclusive. If evidence of long-run relationship is established among the variables, the following long-run (Equation 2) and short-run (Equation 3) models would be estimated simultaneously:

$$lCO_{2t} = \beta_0 + \sum_{i=0}^{\rho} \beta_1 lGDP_{t-i} + \sum_{i=0}^{\rho} \beta_2 lGDP(lGDP)_{t-i} + \sum_{i=0}^{\rho} \beta_3 lMAN_{t-i} + \sum_{i=0}^{\rho} \beta_4 lEC_{t-i}$$
$$+\sum_{i=0}^{\rho} \beta_5 lTRD_{t-i} + \varepsilon_t \quad (2)$$
$$\Delta lCO_{2t} = \beta_0 + \sum_{i=1}^{\rho} \beta_1 \Delta lCO_{2t-i} + \sum_{i=0}^{\rho} \beta_2 \Delta lGDP_{t-i} + \sum_{i=0}^{\rho} \beta_3 \Delta(lGDP(lGDP))_{t-i}$$
$$+\sum_{i=0}^{\rho} \beta_4 \Delta lMAN_{t-i} + \sum_{i=0}^{\rho} \beta_5 \Delta lEC_{t-i} + \sum_{i=0}^{\rho} \beta_6 \Delta lTRD_{t-i} + \varphi ECM_{t-1} + \varepsilon_t \quad (3)$$

The ECM model in the Equation 3 depicts the speed of adjustment from a short-run shock back to a long-run state of equilibrium. Where the speed of adjustment is denoted by the symbol, φ. ECM_{t-1} is the residual value and ε_t is defined as the error term.

3. Results and Discussions

Table 2 presents descriptive statistics of the analysed variables over the 1965 – 2016 period. The summary of common statistics comprising of mean, median, maximum and minimum for each series before the transformation into logarithm forms are given in the table. According to the summary statistic results, the highest carbon dioxide emission is 1.817783 metrics ton per capita. While, the lowest is 0.330974 metrics ton per capita. The highest consumption of energy is 6305.748 kilowatts per hour. Whereas, the lowest consumption of energy is 1234.199 kilowatts per hour. The results also show that the highest output of manufacturing value added is US$ 429 000 000 000 and the lowest output is US$ 22 700 000 000. For trade openness, the highest level is 55.79% and the lowest level is 7.66% in India. For gross domestic product, its highest value is US$ 1875.73 and its lowest value is US$ 345.42. Also, since the Jarque-Bera probability value is significant 5% level of significance, it indicates that the series are normally distributed. Thus, we can proceed with our estimation.

Table 2. Descriptive Statistics.

Variables	CO2	EC	MAN	TRD	Y
Mean	0.804188	2925.644	119000000000	23.61776	742.8569
Median	0.723742	2663.469	73400000000	16.24699	578.3599
Maximum	1.817783	6305.748	429000000000	55.79372	1875.732
Minimum	0.330974	1234.199	22700000000	7.661769	345.4216
Standard Deviation	0.432363	1480.12	109000000000	15.18806	415.4718
Skewness	0.814845	0.750603	1.276568	0.887477	1.150106
Kurtosis	2.635171	2.461333	3.595883	2.374464	3.249169
Jarque-Bera	6.042811	5.511532	14.89276	7.673808	11.5983
Probability	0.048733	0.06356	0.000584	0.02156	0.00303

Note: CO2 is carbon dioxide emissions, EC is energy consumption, MAN is manufacturing value-added, TRD is trade openness and Y is logarithm of economic growth.

Using a time series model, unit root test is conducted to test the stationarity of the variables in order to avoid having spurious regression. ADF and PP tests are conducted. The results of both tests are displayed in Table 3. The results show that LCO2, LY, LMAN, LTRD and LEC are significant at first difference as revealed by both ADF and PP tests. This implies that the variables are stationary at first difference, i.e., I (1). As such, the ARDL method is suitable for this study. Next, we use ARDL bound test to test the long-run relationship among the variables modelled.

Table 3. Unit Root Test.

	ADF		PP	
	Level I(0)			
Variable	Constant Without Trend	Constant With Trend	Constant Without Trend	Constant With Trend
LCO2	1.5488	-2.3903	1.5531	-2.4238
	(0)	(0)	(3)	(3)
LY	4.0590	-0.4698	7.4163	0.2400
	(0)	(0)	(6)	(7)
LMAN	-2.2208	-2.0728	-2.3023	-2.2318
	(0)	(0)	(3)	(2)
LTRD	-0.7281	-1.6706	-0.7988	-2.1009
	(0)	(0)	(2)	(2)
LEC	1.3313	-2.3154	1.5240	-2.3148
	(0)	(0)	(2)	(3)
	First Difference I(1)			
LCO2	-6.9603	-7.3223	-7.0079	-7.3204
	(0)***	(0)***	(4)***	(3)***
LY	-6.4108	-6.3098	-6.5565	-10.0403
	(0)***	(3)***	(4)***	(6)***
LMAN	-6.7372	-6.7819	-6.7801	-7.50130
	(0)***	(0)***	(6)***	(9)***
LTRD	-5.6522	-5.5943	-5.7692	-5.7163

	(0)***	(0)***	(2)***	(2)***
LEC	-7.8982	-8.1779	-7.8501	-8.1362
	(0)***	(0)***	(3)***	(3)***

Notes: *** , **, and * denote significance at 1%, 5%, and 10% levels, respectively. The figure in parenthesis (…) represents optimum lag length selected based on Akaike info criterion. LCO2 is logarithm of carbon dioxide emissions, LY is logarithm of economic growth, LMAN is logarithm of manufacturing value-added, LTRD is logarithm of trade openness and LEC is logarithm of energy consumption.

Table 4 shows the results of the cointegration test. The rule of thumb suggests that the F-statistics should be greater than the critical value of the upper bound at 5% significance level. The existence of cointegration is tested by using the ARDL Bound test with a maximum lag of two. The result shows that the computed F-statistics is 3.9273, which is higher than the critical value of the upper bound of 3.79 at 5% significance level. Hence, the null hypothesis of no long-run relationship can be rejected. Therefore, we can safely conclude that the variables have long-run equilibrium relationship.

Table 4. Cointegration test (ARDL Bound Test)

F-statistic:	3.9273	
k	4	
Bound critical values (unrestricted intercept and no trend)		
Significance level	I(0)	I(1)
1%	3.41	4.68
5%	2.62	3.79
10%	2.26	3.35

Table 5 shows the estimated long-run coefficients. Manufacturing value-added has a significant positive impact on environmental degradation in the long-run. The finding is supported by [2] and [7]. The result indicates that when manufacturing value-added is increased by 1%, environmental degradation would be increased by 0.40 % in India at 5% significant level. The result also reveals that economic growth has an insignificant relationship with environmental degradation. The squared economic growth is equally insignificant. This confirms that the EKC hypothesis is not valid in this study. This finding can be substantiated by [18], [19] and [20]. Trade openness shows a statistically significant negative impact on environmental degradation. The finding can be supported by [21], [22] and [23]. This suggests that the trade openness is increasing environmental quality in India. Energy consumption yields statistically significant positive impact on environmental degradation. The finding is supported by the research of [24], [25] and [26]. This means that consumption of energy is decreasing the quality of the environment in the country.

Table 5. Long-run ARDL regression result

Variable	Coefficient	Standard Error	t-Statistic	Probability
Constant	-10.5239	0.7797	-13.4973	0.0000***
LY	0.0419	0.2299	0.1824	0.8567
LY^2	0.1893	0.2260	0.8376	0.4099
LMAN	0.3992	0.2078	2.2206	0.0358**
LTRD	-0.1807	0.0676	-2.6718	0.0128**
LEC	1.0306	0.1171	8.8033	0.0000***

Note: ***significant at 1%, **significant at 5%,*significant at 10%, LY is the logarithm of economic growth, LY^2 is the logarithm of economic growth squared, LMAN is the logarithm of manufacturing value-added, LTRD is the logarithm of trade openness and LEC is the logarithm of energy consumption.

Table 6 shows the short-run coefficients from the ARDL short-run model. The result reveals that the coefficient of error correction term is -0.6385 and significant at 1% level, which is in line with the theory as it is negative and statistically significant. The results further reveal that trade openness has a statistically significant negative impact on environmental degradation in the short-run. This finding can be supported by [27]. Energy consumption yields significant positive impact on environmental degradation, which supports the finding of [28]. Finally, economic growth and manufacturing value-added show insignificant impact on environmental degradation.

Table 6. Short-run ARDL result

Variable	Coefficient	Standard Error	t-Statistic	Probability
D(LY)	0.0349	0.1591	0.2193	0.8281
D(LY^2)	0.1019	0.1665	0.6122	0.5457
D(LMAN)	0.1217	0.1145	1.0623	0.2976
D(LTRD)	-0.1472	0.0515	-2.8567	0.0083***
D(LEC)	0.5273	0.1610	3.2741	0.0030***
CointEq(-1)	-0.6385	0.1840	-3.4706	0.0018***

Notes. ***significant at 1%, **significant at 5%,*significant at 10%, D(LY) is the logarithm of economic growth, D(LY^2) is the logarithm of economic growth squared, D(LMAN) is the logarithm of manufacturing value-added, D(LTRD) is the logarithm of trade openness, D(LEC) is the logarithm of energy consumption and CointEq(-1) is coefficient value.

4. Conclusion and policy recommendation

This study examined the impact of manufacturing value-added on environmental degradation in India using ARDL over the 1965–2016 period. The result revealed that manufacturing value added increases environmental degradation in India. Put differently, an increase in manufacturing activities results in the reduction of environmental quality in the country. The estimated result further indicated that EKC hypothesis is not valid in this study. Since the manufacturing sector consumes a lot of energy in its production, which lead to generation of carbon emission, the finding does not come as a surprise. The deterioration of the environment can be linked to the manufacturing activities in India.

Thus, we suggest that policymakers should take corrective measures to improve the quality of the environment. The study also recommends that the authorities should enforce some environmentally friendly policies to promote the greening of manufacturing sector. Additionally, there is a need to advance green innovation in the manufacturing sector of India. Government and policymakers should increase investment in the manufacturing sector with a specific emphasis on research and development in order to foster innovation in environment friendly technologies. Improving technology could simultaneously increase economic development, speed up energy production and decrease carbon intensity per output unit. Coal has been the largest source of energy in India's industries. Replacing coal with renewable energy would significantly lower CO_2 emissions. Lastly, cooperation among various stakeholders should be promoted to increase the environmental consciousness of managers, workers, distributors and traders involved in manufacturing production chain in order to amplify the development of the country as well as the sustainability of the environment.

References

[1] Narwal M S and Bhool R 2014 *International Journal of Research in Engineering and Technology* **3** 2 91.
[2] Alam J 2015 *World Review of Business Research* 2015 **5** 39-59.
[3] Bhandari D and Garg R K 2015 *Global Journal of Research Analysis* 2015 **4** 281-2.
[4] Nandi A, Ashok A, Guindon G E, Chaloupka F J and Jha P 2015 *Tobacco Control* **24** 369-75.
[5] Zhu Z, Liu Y, Tian X, Wang Y and Zhang Y 2017 *Journal of Cleaner Production* 2017 **168** 867-75.
[6] Liu J, Yang Q, Zhang Y, Sun W and Xu Y 2019 *Sustainability* **11** 226.
[7] Haseeb M, Haouas I, Nasih M, Mihardjo LW and Jermsittiparsert K 2020 *Energy* **196** 117094.
[8] Mehta Y and Rajan A J 2017 *Procedia engineering* **174** 90-104.

[9] Sulaiman C and Abdul-Rahim A S 2020 *Sustainability* **12** 3280.
[10] Sulaiman C, Abdul-Rahim A S, Mohd-Shahwahid H O and Chin L 2017 *Ecological Indicat*ors **74** 414-9.
[11] Sulaiman C, Abdul-Rahim A S, Chin L and Mohd-Shahwahid H O 2017 *Chemosphere* **177** 224-31.
[12] Sulaiman C and Abdul-Rahim A S 2020 *Environmental Science and Pollution Research* **30** 37699-708.
[13] Sulaiman C, Abdul-Rahim A S and Ofozor C A 2020 *Journal of Cleaner Production* **253** 119996.
[14] Sulaiman C and Abdul-Rahim A S 2018 *Sage Open* **2** 2158244018765916.
[15] Sulaiman C and Abdul-Rahim A S 2017 *Environmental Science and Pollution Research* **32** 25204-20.
[16] Chindo S, Abdulrahim A, Waziri S I, Huong W M and Ahmad A A 2015 *GeoJournal* **3** 315-22.
[17] Pesaran M H, Shin Y and Smith R J 2001 *Journal of Applied Econometrics* **16** 289-326.
[18] Chandran V G and Tang C F 2013 *Renewable and Sustainable Energy Reviews* **24** 445-53.
[19] Al-Mulali U, Saboori B and Ozturk I 2015 *Energy policy* **76** 123-31.
[20] Govindaraju V C and Tang C F 2013 *Applied Energy* 2013 **104** 310-8.
[21] Zhang S, Liu X and Bae J 2017 *Environmental Science and Pollution Research* **24** 17616-25.
[22] Sulaiman J, Azman A and Saboori B 2013 *American Journal of Environmental Sciences* **9** 103.
[23] Kais S and Sami H 2016 *Renewable and Sustainable Energy Reviews* **59** 1101-10.
[24] Keho Y 2017 *International Journal of Energy Economics and Policy* **7** 356-63.
[25] Pao H T and Tsai C M 2010 *Energy policy* **38** 7850-60.
[26] Shahbaz M, Ozturk I, Afza T and Ali A 2013 *Renewable and Sustainable Energy Reviews* **25** 494-502.
[27] Hossain M S 2011 *Energy policy* **39** 6991-9.
[28] Khan M K, Teng J Z and Khan M I 2019 *Environmental Science and Pollution Research* **26** 23480-90.