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RESEARCH ARTICLE

AN ERROR CORRECTION MODEL TO EXPLAIN THE RELATIONSHIP BETWEEN INDEX OF INDUSTRIAL PRODUCTION AND S&P BSE SENSEX

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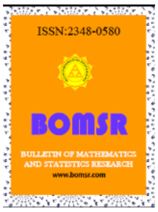

ABSTRACT

The correspondence between stock market and Index of Industrial Production (IIP) has always been a subject of considerable debate and raises an empirical question whether the industrial production have an effect on stock market or whether it is a consequence of development in stock market. Industrial production measures the economic activity in the economy and affects stock prices through its impact on expected future cash flows and expected that an increase in industrial production is positively related to the stock price as increased in industrial production results in increase in output growth and hence leads to increase in the profit of corporate sectors. This study attempts to investigate the both long run & short run dynamics and the direction of causality between stock price index and industrial production or vice versa using unit root and stationarity tests (ADF, PP and KPSS), Engle-Granger cointegration test (EGC), Error Correction Model (ECM) and Granger causality test (GCT). It can be concluded from the result that stock market return is uniquely dependent on the level of industrial production.

Keywords: Spurious Regression, Serial Correlation, Unit Root, Engle-Granger Cointegration, Error Correction and Granger Causality.

1. INTRODUCTION

Stock markets have an important role in international economy and their effects on economic growth can be transmitted to the various sectors through their specific channels. The stock market opens policies to boost economic growth by allocating funds to corporate sector. The level of development of the stock market is necessary for increased industrial production as it provides a specific opportunity to firms for gaining capital quickly, due to the ease with which securities are traded. The industrial sector remains a powerful and glassy sector of the economy and an integral part of development; playing a vital role in the economic growth and development of a nation.

Fluctuations in stock market are to some extent associated with variation in industrial production, which constitute the three broad sectors: Mining, Manufacturing and Electricity. A relatively average demand of stock market instruments by investors increases the amount of fund available for industrial production. High industrial production increases corporate sales and profits, which directly results in trading activities in the stock exchange and reflected by the market index. The ability of the stock market to efficiently provide mechanisms to trade, pool and diversify investor's risk would translate to better effect and development. This is because the operation of firms listed on the exchange will be increased due to access to required fund. According to Levine (1991), in a well developed stock market, investment risks were decreased by offering good times for portfolio assortment. Better allocation of resources with greater efficiency is achieved in a well developed stock market which amplifies productivity level and a greater rate of output growth (Levine, 1997).Despite the fact, many scholars believe that industrial activities / production stimulate the stock market index.

2. REVIEW OF LITERATURE

There is a copious of literature surrounding the association between stock market and index of industrial production; however, there is still a lot of debate on it. Gangaraju and Keshava (2014), analysed the impact of stock market on growth of industries in India for 21 years from 1991 to 2012 using statistical techniques and revealed that 93.90% of variance of the industrial production was explained by the regressor of market capitalisation, gross turnover and Sensex. Zbigniew (2003), evaluated the collision of stock market on industrial development and the Granger causality test (GCT) and revealed that there is a negative effect of stock market on industrial growth.

Positive impact of industrial production on stock market was studied by Benaković and Posedel (2010), whereas, negative impact by Büyükşalvarcı (2010), and both analyse the strength of association of independence between stock market and index of industrial production by Arbitrage Pricing Theory (APT). Ponce et al., (2015), used cointegration and common cycle test procedure to assess the positive relationship between stock market and the aggregate economy for both the long run and the short run period.

For Indian context, Bhattacharya and Mukherjee (2002), found the causal relationship between stock market index and index of industrial production by Toda and Yamamoto method and identified a significant affect of industrial production on stock prices. Similar result was also obtained by Chakravarty (2005). Augmented Dickey Fuller (ADF) unit root test, Johansen-Juselius multivariate cointegration (J-JMC) and Vector Error Correction Model (VECM) techniques were used by Hosseini (2011), to explore the long run as well as short run relationships and evidenced both the long run and short run linkages. Similar result was found by Patel (2012), while analyzing the Sensex and Nifty, but Naik (2012), found the positive and bidirectional causality between industrial production and stock prices.

Singh (2010), used correlation and Granger causality test (GCT) to investigate the causal linkages between stock market index (BSE Sensex) and industrial production and found a reciprocal causal relationship between stock market index (BSE Sensex) and industrial production, whereas Pethe and Karnik (2000), reported weak causality and directed from industrial production to share price indices. Ahmed (2008), investigated the quarterly data to find the relationship between stock index and industrial production using Johansen cointegration (JC) and Toda and Yamamoto Granger causality test (TY-GCT) whereas, Singh (2010), attempted to delve the causal relationship between the BSE Sensex and industrial production and found that industrial production having bilateral causal relationship with BSE Sensex by using correlation, unit root stationarity tests and Granger causality test (GCT).

Johansen cointegration test (JCT) and Vector Error Correction mechanism (VECM) were used by Naka et al., (2001), to demonstrate the effect of industrial production on the Indian stock market in long run equilibrium. Patel (2012), investigated the effect of industrial production on the performance of the Indian stock market by applying Augmented Dickey–Fuller (ADF) unit root test, Johansen cointegration test (JCT), Granger causality test (GCT) and Vector Error Correction model (VECM) and found that stock market development indicator (all share index) Granger cause on index of industrial production, whereas, Singh (2014), found a negative result while applying the Pearson's correlation and multivariate stepwise regression.

Nandini and Yuan (2008), gauged the impact of stock market liberalisation on industrial growth in materializing markets using multiple regressions with ordinary least square (OLS) data and found a significant positive relationship between industry index and stock market liberalization whereas, Li (2010), explored the equity market liberalisation facilitates on economic growth at the industry level and found a uniform increase in the growth rate across industries following liberalisation in transpire markets.

3. RESEARCH METHODOLOGY

In this paper, monthly index of industrial production and S&P BSE Sensex are used for the time period of April, 2014 to March, 2020. The independent variable; industrial production index and dependent variable S&P BSE Sensex were collected from official website of Ministry of Statistics and Programme Implementation, Government of India (https://www.mospi.gov.in) and Bombay Stock Exchange Ltd. (https://www.bseindia.com) respectively. In order to establishing the algorithm, following steps are followed.

- The data used in this study are in logged form and transformation was done in order to increase its interpretability and subsequently for the statistical analysis (Rezina, Jahan and Mustafi, 2017). The log transformation is plausibly the most popular among other to transform skewed data into approximately conform to normality.
- Stationarity of a data series is an important phenomenon because of its influential behaviour. If two series are non stationary random processes (integrated), then modelling with these variables creates spurious regression. In order to keep away from the trend, unit roots and stationarity test is performed to obtain stationarity using the ADF (Augmented Dickey Fuller), PP (Phillips-Perron) and KPSS (Kwiatkowski, Phillips, Schmidt and Shin) unit root test procedure.
- The Engle-Granger cointegration (EGC) test procedure assumes that, the variables should all be stationary at the same level of difference because, non stationary data are unpredictable

and cannot be forecasted. Furthermore, it is usually used single equation model as there are two variables. In this method, OLS equation was constructed to find the spurious regression.

- Error correction model (ECM) set out the short run as well as long run dynamics and adjustments of the cointegrated variables towards their long run equilibrium.
- The Granger causality test investigates the direction of influence between stock market index and index of industrial production and decides whether the two variables can predict each other or not.

4. MATHEMATICAL STRUCTURE OF THE MODEL

The identified model is two variable models which hypothesize that S&P BSE Sensex as a function of index of industrial production. Symbolically,

$$(\mathrm{Sensex}) = \mathrm{f}(\mathrm{IIP})$$

Statistically,

$$(Sensex)_{i,t} = \beta_0 + \beta_1 (IIP)_{i,t} + \varepsilon_{i,t}$$

Where, Sensex = Dependent Variable,

IIP = Independent Variable,

β_0 = Intercept,

β_1 = Slope and

ε = Regression residual.

4.1. Stationarity Test

Stationarity test was conducted to find out the nature of the time series data. According to Box and Pierce, (1970), short term differencing is used to check stationarity in the mean and long term differencing (log or power transformation) for stationarity in the variance. At the experimental level, there is no such method, which can increase the post sample forecasting efficiency (Granger and Nelson, 1978). But can rectify through differencing or linear detrending.

If the mean of a series is increasing over period of time, the desire way of finding a unit root is to examine the mean and covariance of a series and such type of test is called Dickey-Fuller (DF) unit root test, introduced by, Dickey and Fuller (1979). The possible approach to examine the t-value on coefficients, but F-test is conducted when the a.c.f for the variable approach zero as the lag length increases. If a.c.f attend to zero speedily, then the variable is stationary; otherwise non stationary.

Hence, build up the test using lags of the dependent variable it would be necessary to use Augmented Dickey-Fuller (ADF) test, proposed by Said and Dickey (1984). For stable size of the test and minimal power loss, first to set an upper bound lag difference and estimate the ADF test regression with upper bound = lag difference. For testing the significance, if, I t-statistic I > 1.6, then upper bound = lag difference and unit root test is performed (Kumar, 2011). Otherwise, the lag length is decreased by 1 and the process is repeated (Ng and Perron, 1995).

The "Phillips and Perron unit root test", named after Phillips and Perron (1988), difference from the ADF test in terms of "serial correlation and heteroskedasticity in the errors". In particular, where the ADF test approximate the ARMA structure of the errors by using a parametric autoregression, the PP test ignores any serial correlation and heteroskedasticity in the test regression.

The KPSS test (Kwiatkowski et al, 1992), model

$$y_t = \beta' D_t + \varphi_t + \varepsilon_t$$

$$\varphi_t = \varphi_{t-1} + \epsilon_t, \quad \epsilon_t \sim WN\,(0, \sigma_\epsilon^2)$$

where, D_t contains preordain components (constant or constant + time trend) andε_t is integrated of order zero and may be heteroskedastic. The KPSS test statistic for testing H_0: σ_ϵ^2 = 0, againstH_1: σ_ϵ^2> 0 is given by

$$KPSS = \left(T^{-2}\sum_{t=1}^{T}\hat{S}_t^2\right)/\hat{\lambda}^2$$

where, $\hat{S}_t = \sum_{j=1}^{t}\hat{\varepsilon}_j$, $\hat{\varepsilon}_j$ is the residual of a regression of y_t on D_t and $\hat{\lambda}^2$ is a consistent estimate of the long run variance of ε_t using $\hat{\varepsilon}_t$.

4.2. Engle-Granger Cointegration Test

If there is an interrelationship between two integrated non stationary time series in the long term and they cannot deviate from equilibrium and also identifies the structures, then an Engle-Granger cointegration (ECG) test is used to establish. Consider the static regression after first having verified that both the dependent variable y_t and independent variable x_t are integrated of order one:

$$y_t = \theta' x_t + \varepsilon_t$$

The test suggested by Engel-Granger was to estimate $\hat{\theta}$ by OLS and the test for unit roots in

$$\hat{\varepsilon}_t = y_t - \hat{\theta}' x_t$$

The limiting distribution does not have the limiting distribution tabulated by Dickey and Fuller. The limiting distribution does, however, resemble the Dickey-Fuller distribution even though need a separate table for each dimension of the regressor. Typically, it will allow for dynamics in the residual and perform the equivalent of the ADF test (using the slightly different critical values in this case).

4.3. Error Correction Model

Testing for Engle-Granger cointegration (EGC) methodology is otherwise known as testing for the stationarity of the residual series (Agunloye, et al., 2014).Two non stationary time series, say x and y are said to be cointegrated of order one if there exists a long run equilibrium relationship such that, the residuals of the estimated regression are stationary (Engle and Granger, 1987). According to Hall (1986), it is important to identify the lag stracture in the error correction model (ECM), as few lags may create serial correlation problem. But, Li et al. (2009), pointed out that, appropriate specification of lag length is important decisions about implementation of the error correction process.

Consider the following regression models:

$$y_t = \alpha_0 + \alpha_1 x_t + w_t$$

$$x_t = \beta_0 + \beta_1 y_t + v_t$$

where,

x and y are integrated of order one,

$\alpha_0, \alpha_1, \beta_0$and β_1 are cointegrating parameters,

w_t and $v_t$are OLS residuals which capture divergences between the variables from an assumed equilibrium in long run relationship.

For capturing long run equilibrium relationship using the Engle-Granger cointegration (EGC) methodology, it is required pair-wise comparison of two cointegrating regressions because the Engle Granger method produces only one cointegrating vector and sensitive to the choice of dependent variable (Dickey et al., 1991).

4.4. Granger Causality

For a simple bivariate model, the Granger causality exists, if x is a cause of y, if it is functional (x is able to increase the accuracy of the prediction of y w.r.t. a forecast, considering only past values of y) in forecasting y (Hojati and Ghaderi, 2010).

For our study purpose, S&P BSE Sensex is used as an indicator of stock price and index of industrial production is used as an independent variable. According to Mahdavi and Sohrabian (1991), the following two equations can be specified.

$$(IIP)_t = \theta + \sum_{i=1}^{m} A_i\,(IIP)_{t-i} + \sum_{j=1}^{n} B_j\,(Sensex)_{t-j} + \mu_t$$

$$(Sensex)_t = \vartheta + \sum_{i=1}^{p} X_i\,(Sensex)_{t-i} + \sum_{j=1}^{q} Y_j\,(IIP)_{t-j} + \varepsilon_t$$

Based on the estimated OLS coefficients, four different hypothesis can be formulated from the above two equations.

<table>
<tr><td colspan="2">Casualty</td><td>Formula</td><td>Decisions</td></tr>
<tr><td rowspan="2">Unidirectional Granger Causality</td><td>Sensex to IIP</td><td>$\sum_{j=1}^{n} B_j \neq 0 \,\&\, \sum_{j=1}^{q} Y_j = 0$</td><td>Sensex increase the prediction of IIP but not vice versa.</td></tr>
<tr><td>IIP to Sensex</td><td>$\sum_{j=1}^{n} B_j = 0 \,\&\, \sum_{j=1}^{q} Y_j \neq 0$</td><td>IIP increase the prediction of Sensex but not vice versa.</td></tr>
<tr><td rowspan="2">Bidirectional Granger Casualty</td><td>Sensex to IIP</td><td rowspan="2">$\sum_{j=1}^{n} B_j \neq 0 \,\&\, \sum_{j=1}^{q} Y_j \neq 0$</td><td rowspan="2">IIP increase the prediction of Sensex and vice versa.</td></tr>
<tr><td>IIP to Sensex</td></tr>
<tr><td rowspan="2">No Granger Causality</td><td>Sensex to IIP</td><td rowspan="2">$\sum_{j=1}^{n} B_j = 0 \,\&\, \sum_{j=1}^{q} Y_j = 0$</td><td rowspan="2">Two variables are independent</td></tr>
<tr><td>IIP to Sensex</td></tr>
</table>

It seems possible to detect the Granger casualty between S&P BSE Sensex and index of industrial production by obtaining any one of the result from the above table.

5. OUTPUT AND DISCUSSION

Monthly S&P BSE Sensex and index of industrial production having a total number of 72 observations are used in this study and was taken from their official website. Closed stock price is chosen for this study because it reflects all the activities of the index.

5.1. Stationarity

The first step is to determine the order of differencing to find out a unit root and make the series stationary. Over a long period of time, a stationary series has constant mean and variance. The unit root and stationarity test could be identified according to the t-statistic and LM-statistic values in ADF, PP and KPSS test.

Table – 1: Summary of ADF, PP and KPSS unit root and stationarity test

Variables	ADF Test (1st Difference)					PP Test (1st Difference)				
	t-stat.	Prob*	Level of Significance			t-stat.	Prob*	Level of Significance		
			1%	5%	10%			1%	5%	10%
Sensex	-5.274	0.000	-3.527	-2.904	-2.589	-5.274	0.000	-3.527	-2.904	-2.589
IIP	-9.205	0.000	-3.529	-2.904	-2.590	-18.393	0.000	-3.527	-2.904	-2.589

Variables	KPSS Test (1st Difference)			
	LM-stat.	Level of Significance		
		1%	5%	10%
Sensex	0.258282	0.379000	0.463000	0.347000
IIP	0.171614	0.739000	0.463000	0.347000

Based on the Akaike's Information Criteria (AIC), the optimal lag for ADF test is selected from the above table. For fixing the truncation lag for PP and KPSS test Bartlett kernel and Newey - West method are selected for spectral estimation and Bandwidth respectively (Mishra et al., 2018). The calculated values of ADF, PP and KPSS test statistic for S&P BSE Sensex and index of industrial production is less as compared to tabulated t-statistic at 1%, 5% and 10% level of significance (los) and conforms the existence of unit root and stationarity after the first difference and avoid the problems of spurious regression.

5.2. Cointegration

From the above stationarity test, it is seen that both the dependent variable S&P BSE Sensex and independent variable industrial production index are stationary at first difference. From the table - 2, it is seen that the coefficient of the constant 2.039284 ~ 2.04 suggests that if value of production index is constant, S&P BSE Sensex will increase by 2.04. Similarly, the industrial production index coefficient 1.729698 ~ 1.73 indicates that a percentage increase in the value of industrial production would increase the S&P BSE Sensex by a factor of 1.73.Probability of both the constant and independent variable has less than 5% level of significance. Also, value of R-squared is less than

Durbin-Watson statistic (0.599823<0.893676) and conforms that, there is no spurious regression (Phillips, 1986).

Table – 2: Summary of OLS and Regression Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.	R-squared	D-W stat.
C	2.039284	0.810432	2.516292	0.0142	0.599823	0.893676
IIP	1.729698	0.168864	10.24317	0.0000		

Note - Dependent Variable: SENSEX

From the table – 3, the ADF test of residuals reject the null hypothesis of non-stationarity at 1%, 5 % and 10% level of significance since absolute value of Engel-Granger critical values are less than the absolute value of t-statistic and provides an evidence that there is a long run cointegration relationship between S&P Sensex and index of industrial production (MacKinnon, 2010).

Table – 3: Residual Unit Root Test (ADF Test)

R-squared	D-W stat.	t-stat.	Prob.*	Level of Significance		
				1%	5%	10%
0.775299	1.942242	-8.926647	0.0000	-3.528515	-2.904198	-2.589562

Note - Null Hypothesis: D(U) has a unit root, Exogenous: Constant, Lag Length: 1

(Automatic - based on AIC, max lag=4) *MacKinnon (1996) one-sided p-values.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(U(-1))	-1.864318	0.208849	-8.926647	0.0000
D(U(-1),2)	0.223108	0.119615	1.865210	0.0666
C	0.002206	0.010083	0.218824	0.8275

Note - Dependent Variable: D(U,2), Sample (adjusted): 4 72, Included observations: 69 after adjustments.

5.3. Error Correction Model

Since the two variables S&P BSE Sensex and index of industrial production are cointegrated of order one and there exist a long run equilibrium relationship, the ECM method is tested (Panagiotou, 2005).

From Table – 4, the negative sign of coefficient of error term possesses a disequilibrium position. Four lag for the explanatory variable was found to be sufficient for estimating the Error Correction Model, to fade the residuals. In the Engle-Granger cointegration methodology, the coefficient of the lagged residual shown in table represents the speed of adjustment as well as stability of the system (Alogoskoufis and Smith, 1991). The absolute value of the coefficient is 0.0148350 which is quite small and less than 1 indicating that the system is stable and about 14.83% of any deviation from the long run path is corrected within a month by index of industrial production.

Table – 4: Error Correction Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001229	0.005639	0.217868	0.8282
D(IIP)	0.215704	0.099492	2.168043	0.0338
U(-4)	-0.148350	0.054183	-2.737959	0.0080
Statistic	R-squared	0.149336	Mean dependent var	0.001901
	Adjusted R-squared	0.123162	S.D. dependent var	0.049628
	S.E. of regression	0.046472	Akaike info criterion	-3.256830
	Sum squared resid	0.140375	Schwarz criterion	-3.158911
	Log likelihood	113.7322	Hannan-Quinn criter.	-3.218031
	F-statistic	5.705455	Durbin-Watson stat	1.658248
	Prob(F-statistic)	0.005214	**Note - Sample (adjusted): 5 72**	

Table – 5: Serial Correlation of Error Correction Model

F-statistic	1.946003	Prob. F(2,66)	0.1135	D-W stat	1.717046
Obs *R-Sqr.	7.698997	Prob. Chi Sqr.(2)	0.1032	R-Sqr.	0.108437
Note - Null hypothesis: No serial correlation at up to 4 lags					

Note - Dependent Variable: RESID, Pre sample missing value lagged residuals set to zero

From table – 5, the null hypothesis from, Breusch-Godfrey Serial Correlation LM test is that, there is no serial correlation upto lag order 4(Breusch, 1978 and Godfrey, 1978). Consequently, the model is also free from autocorrelation.

5.4. Granger Causality

The table - 6 and 7, signify appropriate lag length and Granger causality test results on monthly data series. The estimations are carried out and based on the Akaike's Information Criterion (ACF)for appropriate lag length is selected (Liew, 2004).

The granger causality performed with a maximum lag of 4 in table – 7, shows that, there is a unidirectional relationship between stock market and index of industrial production at 10% level of significance.

Table – 6: Optimum Lag Selection (VAR Lag Order Selection Criteria)

Lag	Log (L)	LR	FPE	AIC	SC	HQ
0	138.4024	NA	5.49e-05	-4.133406	-4.067053	-4.107187
1	217.0947	150.2307	5.71e-06	-6.396809	-6.197749	-6.318151
2	226.7546	17.85623	4.82e-06	-6.568322	-6.236556*	-6.437225
3	231.6927	8.828635	4.69e-06	-6.596747	-6.132275	-6.413212
4	238.3692	11.53212*	4.33e-06*	-6.677853*	-6.080675	-6.441880*
5	242.2795	6.517219	4.35e-06	-6.675136	-5.945251	-6.386724

Note - * indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion.

Table – 7: Pair wise Granger Causality Test (Lag – 4)

Null Hypothesis:	Observation	F-Statistic	Prob.
IIP does not Granger Cause SENSEX	68	1.21251	0.3152
SENSEX does not Granger Cause IIP		2.27350	0.0720

6. CONCLUSION

This study investigated empirically that, the causal relationship between index of industrial production and S&P BSE Sensex. The experimental analysis was carried out on monthly series for the time period from April, 2014 to March, 2020. The observed variables are integrated of order one and are non-stationary (unit root) at their levels and then stationary after first difference and was tested by ADF, PP and KPSS tests.

Engle-Granger cointegration test investigate the long as well as short run relationship between the independent variable and dependent variable. Based on cointegration method, ADF test was applied on generated residuals from the estimated regression on non stationary data to see whether the series is stationary or not at their levels. Error correction model was employed to rectify the long run disequilibrium and adjusts to restore equilibrium in the short run. The monthly results of error correction model signify that once the S&P BSE Sensex deviates away from the long run equilibrium, then index of industrial production makes adjustment to restore the long run equilibrium by correcting disequilibrium about 14.83% on each month.

Findings of the study suggest that the index of industrial production and stock prices are positively related because increase in production of industrial sector that leads to increase in corporate sales and profits, which directly results in the stock market and reflected by the market index. The ability of the stock market to efficiently provide mechanisms to trade, pool and diversify investor's risk would translate to better performance and development of the market. On the other way, increase in production of industrial sector that leads to increase in financial sector and stimulates economic growth.

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