Evaluating Causal Relationships and Impact of commodity prices and macro-economic variables on Indian Automobile industry using Granger causality

Maddi Manoj Kumar
Amrita School of Business, Coimbatore
Amrita Vishwa Vidyapeetham
Amrita University
Coimbatore, India
maddimanojkumar26@gmail.com

Dr. Balasubramanian P
Amrita School of Business, Coimbatore
Amrita Vishwa Vidyapeetham
Amrita University
Coimbatore, India
bala@amrita.edu

Deepti Mohan
Amrita School of Business, Coimbatore
Amrita Vishwa Vidyapeetham
Amrita University
Coimbatore, India
deepti.eee@gmail.com

***Abstract* — This paper explores the causal relationships among global prices of crude oil, aluminum, iron and rubber, USD-INR exchange rate, US stock market Index (S&P 500) and Nifty index of automobile industry (NIFTY AUTO). Granger causality tests were conducted to determine bi-directional causal linkages among the variables for a ten-year period from 2007 to 2016. The study found that, during the period, Crude Oil Prices causes Aluminum Price, Iron ore prices causes Crude Oil Prices, and there is also a bi-directional causality between S&P Index and Crude Oil Prices. Identification of the relationships would help investors, automobile companies and policy makers in making informed decisions.**

Keywords—Oil prices, Aluminium prices, Iron ore prices, Exchange rate, Rubber prices, Nifty Auto Index, US stock market index(S&P 500), Granger Causality.

I. INTRODUCTION

In 2016, India is the six largest producer of Automobiles in the world [10]. This industry is main pillar for Indian economy contributing to around 7.1 % of Country's Gross Domestic Product (GDP) [11]. India is the fifth largest exporter of Passenger cars in Asia for the FY2015-16 [12].

Automobile Industry is very important for metal companies. Because the raw materials used in Automobile industry are iron ore, Aluminum and rubber. Iron ore is the raw material for producing steel. India is the third largest producer of steel & fourth largest producer of aluminum. Many automobile companies use either steel or aluminum for car body making. Rubber is used for making tires, gaskets, hoses and seals in cars. There were no much studies done on automobile industry with macroeconomic variables so I want to explore more on how these macro-economic variables impact automobile industry.

Oil price movements is one of the indicator for studying the future prospects of Automobile sales and also oil prices have been considered as an important indicator for determining world economy. Because the transactions are largely done through US dollars, so the demand and supply of dollars leads to either currency depreciation or appreciation. So the price movements of iron ore and rubber will allow automobile companies to protect from the raw material costs by entering in to hedging contracts. Therefore, examining relationship between the variables of oil, iron ore, rubber prices and exchange rate, would help the investors, automobile companies and policy makers in making decisions.

II. LITERATURE REVIEW

Reference [1] explained that the upward and downward movement of oil prices had a large spillover effect on metal prices. Metal prices have been taken from London stock exchange for the period 2000 to 2015. So the upward and downward movements of Oil prices had a spillover effect on metals before and after financial crisis. This will help investors to manage their risk in order to protect their portfolios and manufacturers should consider these oil price movements impact on metals used in production process.

Reference [2] investigated the relationship between oil prices and 25 other commodities over the period 1900 to 2011 using annual data and found that decrease in oil prices leads to decrease in commodity prices in short run for 13 commodities out of 25 commodities, by using asymmetric Granger causality test.

Reference [3] studied about the causal relationship between the commodities (WTI crude oil, Brent crude oil, gold, and copper) and exchange rate of countries, Canada, Australia, Norway and Chile. Causality is stronger in short horizons and it becomes weaker as horizon increases. Causal relationship is very strong from commodity prices to exchange rates than vice-versa.

Reference [4] explores the dynamic factors that drives the commodity prices (agricultural products, chemicals, energy, metals and precious metals) Data was collected from August 1995 to June 2015. The major factors are inflation rate, industrial production, stock index and crude oil price. A generalized dynamic factor model has been used to find out the factors, which drives commodity prices. The variance proportion explained by these four factors is high for all the metals.

Reference [5] explained about the comparison of oil prices changes with those of other nine commodities (aluminum, nickel, zinc, copper, lead, tin, silver, gold, wheat).

Reference [6] analyzed the dynamic relationship between oil prices exchange rate, oil prices and US stock prices by using vector auto regression model and found that increase in emerging market stock prices leads to increase in oil prices and also positive shock of oil prices tend to move downward of emerging market stock prices.

Reference [7] focused on the granger causality relationship between the stock prices and trading volume, taking minute by minute data of NIFTY 50 companies traded in National stock exchange by using Toda-Yamamoto methodology. Out of 50 companies 29 had bi directional causal relationship, 15 had uni-directional causal relationship and 6 had no causal relationship.

Reference [8] This paper studies about the relationship between price and volume between two time series by using Granger causality test. Twenty shares were taken in to consideration out of which only 17 shares were found to have leading and lagging relationship.

Reference [9] explained about the oil price shock on agricultural commodities (wheat, corn, soybean, bean pulp, cotton and natural rubber) in china. Out of these commodities only natural rubber was influenced by jump intensity of oil price.

III. RESEARCH METHODOLOGY

From the RBI data source Exchange rate of USD/INR data was taken and from NSE India website NIFTY AUTO INDEX data was taken. Nifty Auto is a benchmark to measure the behavior and performance of automobile sector in India, maintained by the National Stock Exchange and also US stock market Index(S&P 500).

Global Commodity prices	Unit
Aluminum spot price	USD/ton
Brent Crude spot price	USD/barrel
Rubber spot price	US cents per pound
Iron ore spot price	USD/Dry Metric Ton

The global commodity prices data are taken from World Bank website. Monthly data was collected for the span of ten years from 2007 to 2016. After collecting the data, it is tested with Augmented Dicker-Fuller Unit root test to find whether my data is stationary or not. So the data is found non stationary for all the variables so I have converted my data in to stationary by taking log returns of all the variables. The variables are IOPR (Iron Ore prices Return), COPR (Crude Oil Prices Return), APR (Aluminum Prices Return), RPR (Rubber Prices Return), RER (Return on Exchange Rate),Nifty Auto Index Return(NAIR),Return on S&P 500 Index(RSPI).The above stationary data is tested with Granger-Causality test to find out the causal relationship among the variables. This test is useful in determining whether one time series of the data is useful in forecasting another or not.

Unit Root Method

This method is used to find whether dataset is stationary or not.

- Yt=B1+ZYt-1+αi+et →Intercept Only
- Yt=B1+B2t+ZYt-1+αi+et →Trend and Intercept Only
- Yt= ZYt-1+αi+et → No trend, No Intercept

There are three steps to check the stationarity of the data namely, Intercept, Trend and Intercept, No trend and no intercept- these are the levels on which stationarity is to be checked.

Granger Causality Test

It is conducted in order to find out whether one time series data set can predict another time series dataset.

$$RER_t = \sum_{i=0}^{2} \alpha_i \, RPR_{t-i} + \sum_{j=0}^{2} \beta_j \, RER_{t-j} + \varepsilon_{1t}$$

$$RPR_t = \sum_{i=0}^{2} \alpha_I \, RER_{t-1} + \sum_{j=0}^{2} \beta_j \, RPR_{t-1} + \varepsilon_{1t}$$

Where,

RER = Return on Exchange rate
RPR = Rubber prices Return

α_I, β_J = coefficients of the model (i.e., the contributions of each lagged observation)
ε_{1t} = residuals (prediction errors) for each time series.

If the coefficients of the lagged terms of RPR are found to be significant then we can say that past values of RPR is causing future values of RER, only when p-value is less

than 5% which means we are rejecting the granger causality of null hypothesis.

Hypothesis:

For studying the causal relationship among the variables, following hypotheses have been developed**:**

H01a: Iron ore Prices Return (IOPR) is not caused by its Crude Oil Prices Return (COPR)

H01b: Crude Oil Prices Return (COPR) is not caused by its Iron ore Prices Return (IOPR)

H02a: Return on Exchange Rate (RER) is not caused by its Crude Oil Prices Return (COPR).

H02b: Crude Oil Prices Return (COPR) is not caused by its Return on Exchange Rate (RER).

H03a: Aluminum Prices Return (APR) is not caused by its Crude Oil Prices Return (COPR).

H03b: Crude Oil Prices Return (COPR) is not caused by its Aluminum Prices Return (APR).

H04a: Nifty Auto Index Return (NAIR) is not caused by its Crude Oil Prices Return (COPR).

H04b: Crude Oil Prices Return (COPR) is not caused by its Nifty Auto Index Return (NAIR)

H05a: Return on S&P Index (RSPI) is not caused by its Crude Oil Prices Return (COPR).

H05b: Crude Oil Prices Return (COPR) is not caused by its Return on S&P Index (RSPI).

H06a: Rubber Prices Return (RPR) is not caused by its Crude Oil Prices Return (COPR).

H06b: Crude Oil Prices Return (COPR) is not caused by its Rubber Prices Return (RPR).

H07a: Nifty Auto Index Return (NAIR) is not caused by its Aluminum Prices Return (APR).

H07b: Aluminum Prices Return (APR) is not caused by its Nifty Auto Index Return (NAIR).

H08a: Return on S&P Index (RSPI) is not caused by its Aluminum Prices Return (APR).

H08b: Aluminum Prices Return (APR) is not caused by its Return on S&P Index (RSPI).

H09a: Return on Exchange Rate (RER) is not caused by its Aluminum Prices Return (APR).

H09b: Aluminum Prices Return (APR) is not caused by its Return on Exchange Rate (RER).

H10a: Rubber Prices Return (RPR) is not caused by its Aluminum Prices Return (APR).

H10b: Aluminum Prices Return (APR) is not caused by its Rubber Prices Return (RPR).

H11a: Return on S&P Index (RSPI) is not caused by its Nifty Auto Index Return (NAIR).

H11b: Nifty Auto Index Return (NAIR) is not caused by its Return on S&P Index (RSPI).

H12a: Return on Exchange Rate (RER) is not caused by its Nifty Auto Index Return (NAIR).

H12b: Nifty Auto Index Return (NAIR) is not caused by its Return on Exchange Rate (RER).

H13a: Nifty Auto Index Return (NAIR) is not caused by its Rubber Prices Return (RPR).

H13b: Rubber Prices Return (RPR) is not caused by its Nifty Auto Index Return (NAIR).

H14a: Return on S&P Index (RSPI) is not caused by its Return on Exchange Rate (RER).

H14b: Return on Exchange Rate (RER) is not caused by its Return on S&P Index (RSPI).

H15a: Return on S&P Index (RSPI) is not caused by its Rubber Prices Return (RPR).

H15b: Rubber Prices Return (RPR) is not caused by its Return on S&P Index (RSPI).

H16a: Rubber Prices Return (RPR) is not caused by its Return on Exchange Rate (RER).

H16b: Return on Exchange Rate (RER) is not caused by its Rubber Prices Return (RPR).

H17a: Iron ore Prices Return (IOPR) is not caused by its Rubber Prices Return (RPR).

H17b: Rubber Prices Return (RPR) is not caused by its Iron ore Prices Return (IOPR)

H18a: Iron ore Prices Return (IOPR) is not caused by its Return on Exchange Rate (RER)

H18b: Return on Exchange Rate (RER) is not caused by its Iron ore Prices Return (IOPR)

H19a: Iron ore Prices Return (IOPR) is not caused by its Nifty Auto Index Return (NAIR).

H19b: Nifty Auto Index Return (NAIR) is not caused by its Iron ore Prices Return (IOPR)

H20a: Iron ore Prices Return (IOPR) is not caused by its Aluminum Prices Return (APR).

H20b: Aluminum Prices Return (APR) is not caused by its Iron ore Prices Return (IOPR)

H21a: Iron ore Prices Return (IOPR) is not caused by its Return on S&P Index (RSPI).

H21b: Return on S&P Index (RSPI) is not caused by its Iron ore Prices Return (IOPR)

IV. EMPIRICAL RESULTS AND ANALYSIS

The results of the Granger Causality test are summarized in table 1 and 2 below

Table No: 1

Null Hypothesis:	F-Statistic	Prob.
NAIR does not Granger Cause RPR	1.80775	0.1687
RPR does not Granger Cause NAIR	0.2674	0.7658
RER does not Granger Cause RPR	5.38046	0.0059
RPR does not Granger Cause RER	1.78535	0.1724
COPR does not Granger Cause RPR	5.3862	0.0058
RPR does not Granger Cause COPR	1.28277	0.2813
RSPI does not Granger Cause RPR	10.9872	4.00E-05
RPR does not Granger Cause RSPI	5.06741	0.0078
IOPR does not Granger Cause RPR	9.14631	0.0002
RPR does not Granger Cause IOPR	1.0917	0.3392
APR does not Granger Cause RPR	11.3083	3.00E-05
RPR does not Granger Cause APR	1.11497	0.3315
RER does not Granger Cause NAIR	0.7597	0.4702
NAIR does not Granger Cause RER	1.45628	0.2374
COPR does not Granger Cause NAIR	2.07566	0.1302
NAIR does not Granger Cause COPR	4.12924	0.0186
APR does not Granger Cause COPR	0.88878	0.414
COPR does not Granger Cause APR	4.68491	0.0111
IOPR does not Granger Cause RSPI	2.56432	0.0814
RSPI does not Granger Cause IOPR	5.06305	0.0078
APR does not Granger Cause RSPI	8.28164	0.0004
RSPI does not Granger Cause APR	4.62588	0.0117
APR does not Granger Cause IOPR	3.63969	0.0294
IOPR does not Granger Cause APR	0.78826	0.4571
RSPI does not Granger Cause NAIR	0.22592	0.7981
NAIR does not Granger Cause RSPI	0.15363	0.8578
IOPR does not Granger Cause NAIR	2.87704	0.0604
NAIR does not Granger Cause IOPR	1.40494	0.2496
APR does not Granger Cause NAIR	1.55434	0.2158
NAIR does not Granger Cause APR	4.17117	0.0179
COPR does not Granger Cause RER	0.37924	0.6852
RER does not Granger Cause COPR	3.04726	0.0514
RSPI does not Granger Cause RER	0.68966	0.5038
RER does not Granger Cause RSPI	0.34065	0.712
IOPR does not Granger Cause RER	0.63975	0.5293
RER does not Granger Cause IOPR	5.27211	0.0065
APR does not Granger Cause RER	1.02895	0.3607
RER does not Granger Cause APR	3.32109	0.0397
RSPI does not Granger Cause COPR	3.2958	0.0406
COPR does not Granger Cause RSPI	4.36627	0.0149
IOPR does not Granger Cause COPR	7.27196	0.0011
COPR does not Granger Cause IOPR	2.6507	0.075

Table No: 2

Variable 1	Variable 2	Granger Cause(Yes/No)
IOPR	COPR	Yes
COPR	IOPR	No
RER	COPR	No
COPR	RER	No
APR	COPR	No
COPR	APR	Yes
NAIR	COPR	Yes
COPR	NAIR	No
RSPI	COPR	Yes
COPR	RSPI	Yes
RPR	COPR	No
COPR	RPR	Yes
NAIR	APR	Yes
APR	NAIR	No
RSPI	APR	Yes
APR	RSPI	Yes
RER	APR	Yes
APR	RER	No
RPR	APR	No
APR	RPR	Yes
RSPI	NAIR	No
NAIR	RSPI	No
RER	NAIR	No
NAIR	RER	No
NAIR	RPR	No
RPR	NAIR	No
RSPI	RER	No
RER	RSPI	No

RSPI	RPR	Yes
RPR	RSPI	Yes
RPR	RER	No
RER	RPR	Yes
IOPR	RPR	Yes
RPR	IOPR	No
IOPR	RER	Yes
RER	IOPR	No
IOPR	NAIR	No
NAIR	IOPR	No
IOPR	APR	No
APR	IOPR	Yes
IOPR	RSPI	No
RSPI	IOPR	Yes

From the results of Granger causality we can infer that Iron Ore Prices Return granger causes Crude Oil Prices Return,Crude Oil Prices Return Granger causes Aluminium Price Return,Nifty Auto Index Return granger causes Crude Oil Prices Return,there is also a bi-directional granger causality between Return on S&P 500 index and Crude Oil Prices Return,Crude Oil Prices Return granger causes Rubber Prices Return,Nifty Auto Index Return granger causes Aluminium Prices Return,there is a bi-directional granger causality between Return on S&P 500 Index & Aluminium Prices Return,Return on Exchange rate granger causes Aluminium Prices Return,Aluminium Prices Retrun granger causes Rubber Prices Return,there is a bi-directional between Rubber Prices Return and Return on S&P 500 Index, Return On Exchange Rate granger causes Rubber Prices Return,Iron Ore Prices Return granger causes Return on Exchange rate,Aluminium Prices Return garnger causes Iron ore Prices Return,Return on S&P 500 Index garnger causes Iron Ore Prices Return

V. Conclusion

This paper identified variables which affect the automobile industry in India and examined the causal linkages among them. Commodity prices of Aluminium, Iron ore and Rubber, macro-economic variables viz crude-oil prices, India-US exchange rate and US stock market return, and Nifty Auto index were found to have certain causal relationships among them. The study would help investors in making trading decisions regarding automobile stocks, automobile companies in designing hedging strategies, and policy makers in making policy decisions regarding automobile industry.

The study is confined to a ten-year period and does not take into consideration the effect of global financial crisis of 2007-2008 on commodity prices and other economic variables which may have affected the results.

VI. References

[1] Reboredo, J. C., & Ugolini, A. (2016). The impact of downward/upward oil price movements on metal prices. *Resources Policy*, *49*, 129-141.

[2] Rafiq, S., & Bloch, H. (2016). Explaining commodity prices through asymmetric oil shocks: Evidence from nonlinear models. *Resources Policy*, *50*, 34-48.

[3] Zhang, H. J., Dufour, J. M., & Galbraith, J. W. (2016). Exchange rates and commodity prices: measuring causality at multiple horizons. *Journal of Empirical Finance*, *36*, 100-120.

[4] Kagraoka, Y. (2016). Common dynamic factors in driving commodity prices: Implications of a generalized dynamic factor model. *Economic Modelling*, *52*, 609-617.

[5] Plourde, A., & Watkins, G. C. (1998). Crude oil prices between 1985 and 1994: how volatile in relation to other commodities?. *Resource and Energy Economics*, *20*(3), 245-262.

[6] Basher, S. A., Haug, A. A., & Sadorsky, P. (2012). Oil prices, exchange rates and emerging stock markets. *Energy Economics*, *34*(1), 227-240.

[7] Abinaya, P., Kumar, V. S., Balasubramanian, P., & Menon, V. K. (2016, September). Measuring stock price and trading volume causality among Nifty50 stocks: The Toda Yamamoto method. In *Advances in Computing, Communications and Informatics (ICACCI), 2016 International Conference on* (pp. 1886-1890). IEEE.

[8] Singh, D., & Balasubramanian, P. (2000). Price-Volume Relationship: Some Evidence from the Indian Stock Market. *Vision*, *4*(1), 17-28.

[9] Zhang, C., & Qu, X. (2015). The effect of global oil price shocks on China's agricultural commodities. *Energy Economics*, *51*, 354-364.

[10]Production Statistics. (n.d.). Retrieved March 14, 2017, from http://www.oica.net/category/production-statistics/

[11]Brand India. (n.d.). Retrieved March 14, 2017, from http://www.ibef.org/industry/india-automobiles.aspx

[12]India surpasses China in passenger car exports. (n.d.). Retrieved March 14, 2017, from http://www.autocarpro.in/analysis-reports/india-surpasses-china-passenger-car-exports-20224