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A Data Science View on Effects of Agriculture & Industry Sector on the GDP of India

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Abstract*: Gross Domestic Product is the measure of the market value of all finished goods and services produced annually (often). It is one of the important measures of growth in country's economy. The agriculture and industry sectors have played a major role in Indian economic growth since its establishment as an independent country. For an industry sector to be successful the raw material should be available at a viable price range which is not the case if there is a decline in agriculture production, the major supplier of raw materials to industry. We'll be analyzing the effect of changes in the industry and agriculture sector on the GDP of India with the help of data science and machine learning methodologies. We'll also look at the trends of GDP and industry shares with changing agriculture contribution. The knowledge of data science is implemented to bring out the hidden patterns that provide insights about future enhancements. This work helps in determining the major changes in the agriculture and industry sector that hinder GDP growth.

***Index Terms*: Accuracy, Agriculture, Economy, Gross Domestic Product – GDP, Industry, Variance score.**

I. INTRODUCTION

Data science is the most important tool in the present-day world that is helping develop the living standards of people around the globe. The collection of data from different sources has helped many corporate companies to draw insights which helped them in improving their firms going further in the market. It has provided many solutions in the fields of Healthcare, Digital marketing, Customer services sectors etc. The way this form of science has brought changes in various fields around the world, there is scope in the future that this still evolves to help us lead a better life.

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There are two methods in which a data is studied and analyzed based on its structure. Our data is continuous; hence Regression techniques are applied to analyze the data. A regression is a measure of relation between one variable with the average of another variable. Various Regression algorithms are used to predict the target class. Linear, Polynomial, Logistic, Lasso, Ridge etc. are the various kinds of regression algorithms used commonly. Various regression models such as linear, lasso and ridge are used to analyze the data and make a comparative study.

A. Agriculture sector in India

Agriculture has been the backbone of Indian Economy for years from its independence. It accounts for around 18 percent of India's GDP at present and provides employment to around 50 percent of its population. It provides food and raw materials to non-agricultural sectors of the economy. It is the main source of raw materials for industries. As India is a developing country its main goal is to improve its agriculture sector which is the common sector that took predominant role in the developed countries at their initial stages of development. 28 percent of national income still comes from agriculture for India. This sector requires less capital for development thus minimizes growth problem for foreign capital. The major problem with Indian agriculture is, even though 50% (nearly 55 crores) of its population work their sweat out on agriculture, the yield produced is very low due to usage of old and conventional methods. The lack of use of advanced technology in Indian agriculture hampers a great deal of production statistics. The below table depicts change in the average share and average growth rate of agriculture sector towards GDP.

Period	Share (Avg)	Growth (Avg)
1951-60	41.050	3.408
1961-70	34.535	2.536
1971-80	31.009	2.107
1981-90	27.256	3.654
1991-00	21.921	2.803
2001-13	13.617	3.422

The above data unveils the fact that growth rate of agriculture sector is a very important factor for improving GDP of a developing country. The fall in growth rate directly corresponds to decrease in the share provided towards GDP.

B. Industry sector in India

Industry sector is one of the major contributors of Indian economy and contributes 31.46% to the country's economy at present.

It provides employment opportunities and also enhances the growth of produced goods and services there by contributing to the increase in GDP. Industry produces goods that improves foreign exchange and generates revenue which boosts the national income.

For a developing economy, industry sector is the second most important factor for its monotonic growth. It majorly improves living standards of society. It is the biggest market place for agriculture commodities. The below table depicts change in the average share and average growth rate of agriculture sector towards GDP.

Period	Share (Avg)	Growth (Avg)
1951-60	17.898	6.242
1961-70	23.380	5.419
1971-80	24.850	3.990
1981-90	26.415	6.181
1991-00	27.414	5.605
2001-13	27.803	7.323

From the above numbers we can argue that industry has played a significant role and has developed at a good pace. But further in this article we'll prove why it is not a good amount of improvement and will try to prove the fact how this is affected by the changing agriculture production.

II. LITERATURE SURVEY

Afroz Alam, Aqeel Hasan Rizvi et al [1]: The Changing Scenario in Indian Agriculture - A Review**.** An economical study on the trends of agriculture growth across India.

Dr. Y. Jeevan Nagendra Kumar et al [2] (2017): Projected that Map centered spatial analysis of rainfall data of AP and TS states is made using Hybrid machine learning methods.

Dr. Y. Jeevan Nagendra Kumar et al [3] (2016): For supervision of knowledge discretion and get reasonable grain access control.

Limbore Nilesh V and Killare Shrirang K [4]: An Analytical Study of Indian Agriculture Crop Production and Export with Reference to Wheat. Study on major agricultural crop production, export and import of agriculture crop wheat.

Dr. Y. Jeevan Nagendra Kumar et al [5] (2014): Proposed a new symbol-based tree traverse searching scheme.

Dhiraj Jain, K. Sanal Nair and Vaishali Jain [6]: Factors Affecting GDP (Manufacturing, Services and Industry) - An Indian Perspective. An economic point of view on how the manufacturing, services and industry sectors effect the GDP

Dr. Y. Jeevan Nagendra Kumar et al [7] (2018): Medical Disease Prediction using Grey Wolf optimization and Auto Encoder based Recurrent Neural Network

Renu Khndelwal [8]: L1 and L2 Regularization Math.

Dr. Y. Jeevan Nagendra Kumar et al [9] (2018): The main idea in designing marketing policies is to identify the influencers in the communication

Lasso and Ridge Regression in Python [10] from Official documentation (scikit-learn)

Dr. Y. Jeevan Nagendra Kumar et al [11] (2013): developed a greedy method in minimizing number of points and spatial mining is used to recognise solution for it.

Saptashwa [12]: Ridge and Lasso Regression, A Complete Guide with Python Scikit-Learn.

Dr. Y. Jeevan Nagendra Kumar et al [13] (2013): Provided a thorough information of the exertions of this area and our world is advancing with a lot of concerns on bio-diversity, science and technology and many more.

III. METHODOLOGY

A. *Datasets:*

There are three different factors considered to analyse in depth how the agriculture and industry sectors depend on each other and how they affect the GDP of an economy. The datasets have been obtained from the Reserve Bank of India's data bank website. The dataset is split into three different files with following features

B. *Contribution (in Rs. Cr)*

This dataset is used to predict how the contribution of agriculture and industry sectors have varied with respect to each other and their effect on GDP. It has four features financial year, Gross Domestic Product (in Rs. Cr), Agriculture (in Rs. Cr.) and Industry (in Rs. Cr.). From this data following patterns have been observed

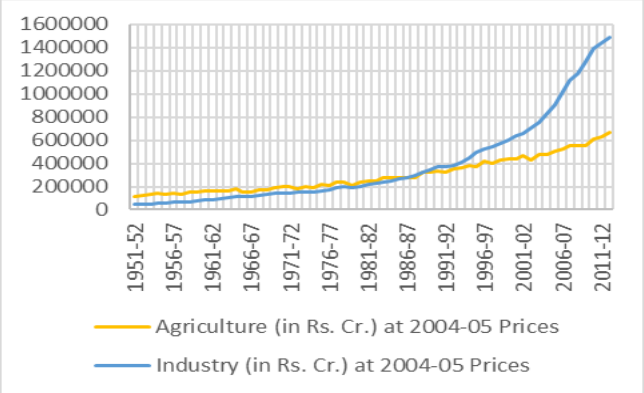


Fig. 1: Contributions (in Rs. Cr) of industry vs agriculture sectors towards GDP from 1951-2013

The Fig. 1 indicates that there is giant leap in industry sector with not much increase in agriculture. The adverse effects of such leap can be seen on a long run which is discussed further in our study. To make a point the industry sector took over agriculture during the financial year 1990 and from then it has been the better of the lot but the agriculture sector remained at the same rate.

The contribution by agriculture to the GDP has started at a higher point then contribution by industry which is expected from a country like India during the initial years of independence. There has been significant growth in agriculture contribution which in turn improved industry contribution as we can see. As mentioned above the contribution by agriculture has not shown any significant increase though the industry sector has developed a lot and is presently contributing around 31.46% of GDP whereas the agriculture sector still holds down to 14.39%, which is not a good sign for a developing country like India.

C. *% Growth Rate*

This dataset is used to predict how the growth of agriculture and industry sectors have varied with respect to each other and their effect on GDP.

It has four features financial year, Gross Domestic Product - % Growth Rate (YoY), Agriculture - % Growth Rate (YoY) and Industry - % Growth Rate (YoY). From this data following patterns have been observed

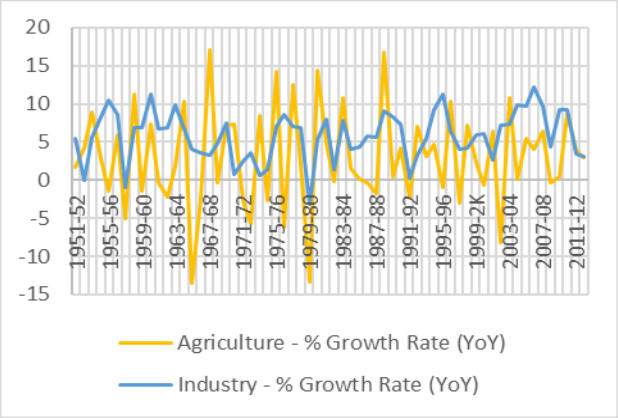


Fig. 2: % Growth Rate (YoY) of industry vs agriculture *sectors towards GDP from 1951-2013*

From Fig. 2 it can be deduced that growth rate in industry increased with increase in the agriculture sector but going further we'll be looking at some graphs that point out the disadvantage in depreciating growth rate of agriculture is to GDP.

Though there was a considerable amount of increase in agriculture contribution towards GDP (few years) due to under developed industry sector there was no considerable boost in India's GDP.

The increase in agriculture growth in 1953-54 boosted industry growth in that year and next year due to high availability of raw materials. There was further decrease in agriculture growth for the next two years (1955-56 and 1957-58) which hampered the growth of industry sector due to low availability of raw materials.

Though there was a huge decrement in the growth of agriculture in the year 1965-66, the industry sector was able to sustain a positive growth due to good percentile increase in growth of agriculture in the previous year i.e. 1963-64 and the coming years 1967-68 and so on up to 1977-78.

D. *Share to Total GDP*

This dataset is used to predict how the agriculture and industry sectors have varied with respect to each other. It has three features financial year, Agriculture - Share to Total GDP and Industry - Share to Total GDP. From this data following patterns have been observed

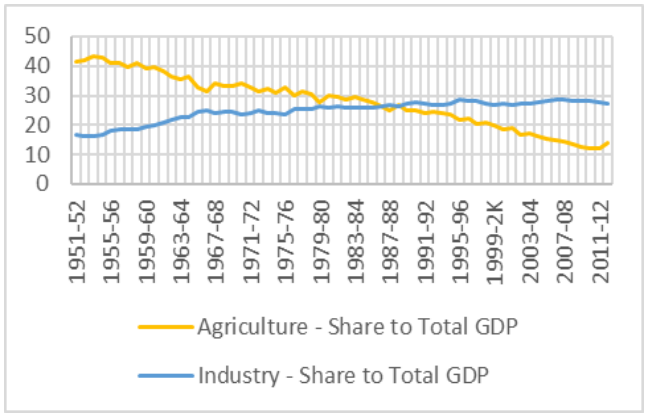


Fig. 3: Share to Total GDP of industry vs agriculture sectors from 1951-2013

The Fig. 3 depicts the clear fact that decrease in agriculture share proportionally effects the industry share due to decrease in agricultural products which in turn reduces the raw materials for industry which depreciates the count of finished goods and services thus affecting the GDP. The share to GDP by these sectors is much dependent on agriculture sector for a developing country. Though the industry has been developing at a war phase the depreciating agriculture share has limited the share provide by industry sector due to unavailability of raw materials for production of goods and services. The industry sector has overtaken the agriculture sector during 1989-90 and has not improved since then due to decrease in the share by agriculture (decreasing agriculture production).

IV. EFFECT OF AGRICULTURE AND INDUSTRY ON GDP

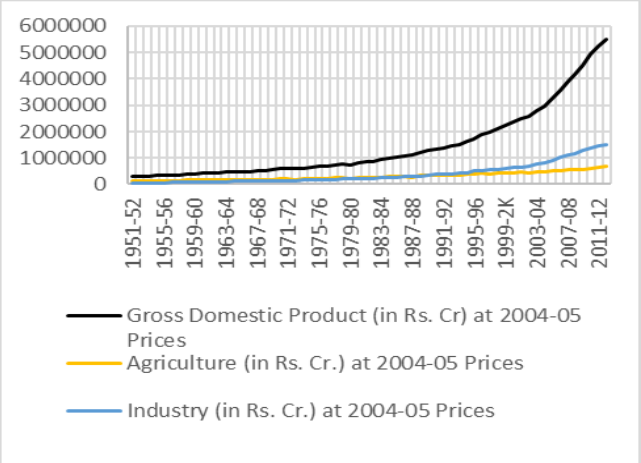


Fig. 4: Relation between contribution (in Crores) of industry and agriculture sectors towards GDP and GDP from *1951-2013*

From the Fig. 4 effects of Agriculture and Industry on GDP can be figured out. The graph is plotted on the basis of data from 1951 – 2013. As we can see the GDP has grown at a slow pace during the early stages due to less contribution from the industry sector. There is a giant leap in the GDP with the dawn of industry sector at a high scale. Though there was increase in the agriculture sector it only contributed to a little boost in improving the GDP.

The GDP took a giant leap when the raw materials produced by Agriculture where used extensively by the industry sector for producing goods and services rather than importing.
We can also observe that the improvement in agriculture sector has only boosted GDP at a normal pace, from the year 1989-90 with industry sector taking giant leap the GDP has increased at pace that is four times the previous decade.
Thus, we can clearly conclude that though there is a minute increase in agriculture production, without proper use of its produces, there would no effect on the GDP of a developing nation like India.
Note: Usage of produces in the above phrase means encouraging industrialization, providing those raw materials to industries and producing goods.

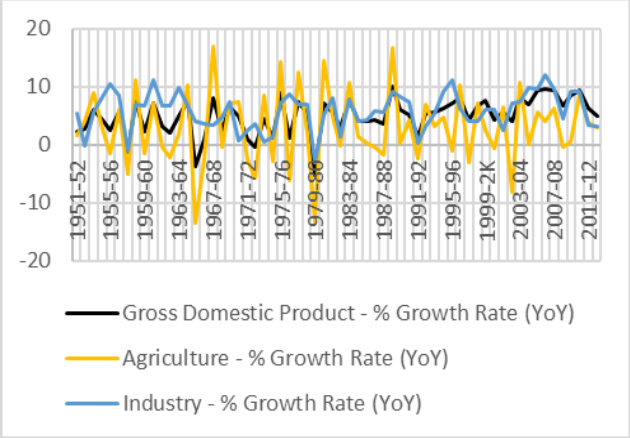


Fig. 5: Relation of growth rate of industry, agriculture sectors vs GDP growth rate from 1951-2012

The Fig. 5 indicates even though there is an increase in industry sector, if there is a decline in agriculture sector the GDP of the nation gets depreciated as more amount of raw materials required for the production have to be imported from other countries.
Thus, the growth rate remains the same or even decreases in such case.
We can draw following insights:

- During the year 1955-56 even though there is an increase in growth rate of industry the GDP had a sharp decline due to drop in growth rate of agriculture.
- 1964-65, although there is a sharp decline in both industry and agriculture the GDP had no effect as there was good growth percent in both industry and agriculture sector in the previous financial year and the next year.
- From then the GDP had never seen a sharp fall leaving 1979-80, the industry always kept good growth rate aiding GDP.

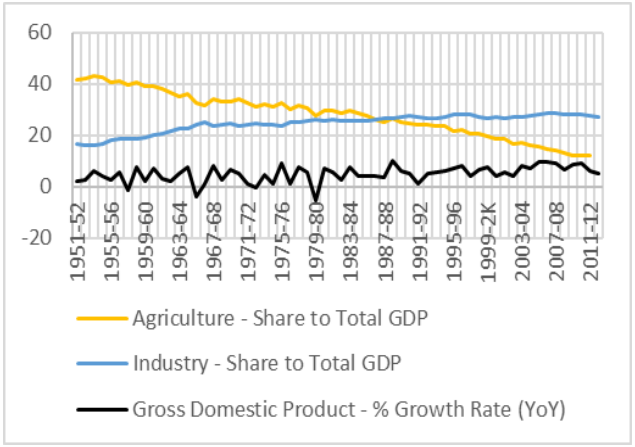


Fig. 6: Relation between shares provided by industry, agriculture sectors towards GDP and growth rate of GDP from 1951-2012

From Fig. 6 it can be observed that even though there is an increase in share of industry sector it doesn't have any effect to the growth rate of GDP due to decrease in the share by agriculture sector
It shows that the growth of GDP remained at the same rate due to decrease in the share by agriculture sector when compared to increasing share of industry sector.

V. DATA PRE-PROCESSING

The data has been collected from the official website of Reserve Bank of India. Therefore, there was no need for processing the data to check for outliers and also the data has no missing values helping the model to be more specific. The correlation among the data was verified using correlation matrix plots.

A. *Correlation Matrix Plot*

Correlation is a statistical tool that helps in understanding how two variables are correlated and effect of one over the other, which is whether they are positively or negatively correlated.

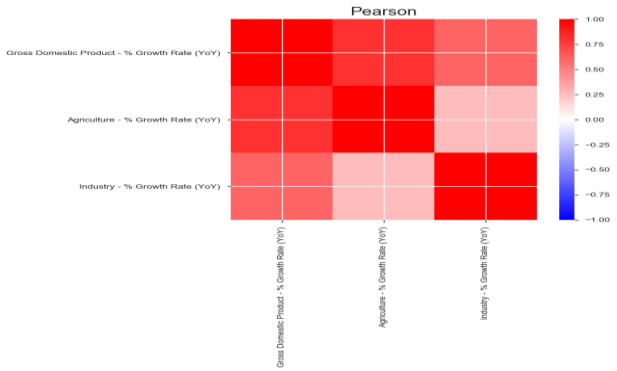


Fig.-7: Example Correlation Matrix

B. *Min Max Scalar Method:*

It is a Min-max normalization strategy. This method uses linearly transformation technique such as

x to y= (x-m)/(M-m)
Where, m=min, M=max

C. *Algorithms:*

i) *Linear Regression:*

This a simplest form of regression which involves fitting of a best possible straight line to the given data points. The equation of the line is of the form

Y = M x + B, where
Y is the dependent variable we are trying to predict
B is the y-intercept of the best fit line
M is the slope

The following formulas are used to derive the above co-efficient

$$m = \frac{\sum_{i=1}^{n}(x_i-\overline{X})(y_i-\overline{Y})}{\sum_{i=1}^{n}(x_i-\overline{X})^2} \qquad b = \overline{Y} - m\overline{X}$$

This model always tries to optimize values of m and b to minimize the cost function.

The cost function is given as

$$\sum_{i=1}^{M}(y_i-\hat{y}_i)^2 = \sum_{i=1}^{M}\left(y_i - \sum_{j=0}^{p} w_j \times x_{ij}\right)^2$$

We've not tuned any metrics for this particular model.

ii) Lasso Regression / L1 Regularization / L1 Norm:

This model is used to reduce model complexity and over fitting that is the main drawback for linear regression. It is basically updated version of the linear regression model. The cost function for this model is given by

$$\sum_{i=1}^{M}(y_i-\hat{y}_i)^2 = \sum_{i=1}^{M}\left(y_i - \sum_{j=0}^{p} w_j \times x_{ij}\right)^2 + \lambda \sum_{j=0}^{p} |w_j|$$

Cost function for Lasso regression

$$\text{For some } t > 0,\ \sum_{j=0}^{p} |w_j| < t$$

This model does feature selection by assigning insignificant input features with weight as zero and the remaining with non-zero weights. L1 regularization is given mathematically as

$$L(x,y) \equiv \sum_{i=1}^{n}(y_i - h_\theta(x_i))^2 + \lambda \sum_{i=1}^{n} |\theta_i|$$

The optimization objective for lasso is
- (1 / (2 * n_samples)) * ||y – Xw||^2_2 + alpha * ||w||_1
- The value of alpha is a constant term that multiplies the L1 term.

iii) L2 Regularization / Ridge Regression / L2 Norm:

This model also serves the same purpose as of lasso but uses L2 regularization for fitting the data. The cost function for this model is given by

$$\sum_{i=1}^{M}(y_i-\hat{y}_i)^2 = \sum_{i=1}^{M}\left(y_i - \sum_{j=0}^{p} w_j \times x_{ij}\right)^2 + \lambda \sum_{j=0}^{p} w_j^2$$

Cost function for ridge regression

$$\text{For some } c > 0,\ \sum_{j=0}^{p} w_j^2 < c$$

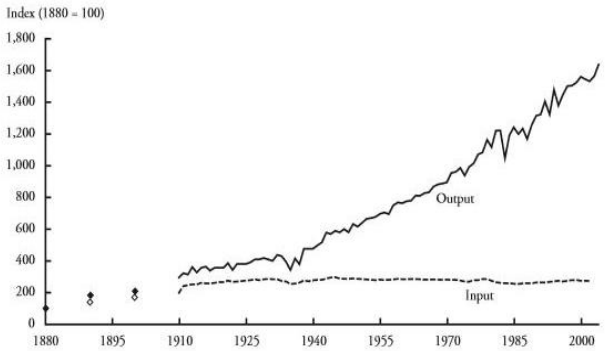
This model forces the weights to be small but does not make them zero. L2 regularization is mathematically given as

$$L(x,y) \equiv \sum_{i=1}^{n}(y_i - h_\theta(x_i))^2 + \lambda \sum_{i=1}^{n} \theta_i^2$$

This model minimizes the objective function to
- ||y – Xw||^2_2 + alpha * ||w||^2_2
- The value of alpha here is the regularization strength. Improves conditioning of the problem and reduces the variance of estimates. Larger value specifies larger regularization.

VI. A COMPARATIVE STUDY

We've chosen a developed country (USA) to compare and contrast. The production rate of USA with a limited input is very high then what is produced in India. Now, question arises about climatic conditions. Yet, the major factor that affects Indian agriculture is unawareness of development in technology fields.



Sources: Indexes of the quantity of output and input are from USDA ERS (1984) for 1880–1938; from USDA ERS (1986) for 1939–1948; and from InSTePP for 1949–2004 (for output), 1949–2002 (for input).

Fig 8: Aggregate Agricultural Output an Input Quantity Trends, 1880 – 2004

For example, look at the Fig 8. The input remained the same from decades yet there is a high amount of growth in produced output which helps industries within the country to be self-sustaining without depending on the exports from other countries. In India the input has increased, even then there is no significant rise in the produced output affecting the industry's ability to self-sustain and increasing dependency on exports from foreign countries. The technological advancement in agriculture sector is the main step that helps developing countries like India improve their GDP without any extra efforts. In the year 2016-17 Indian agriculture showed 4% increase in growth rate. The graphs depicted above show us that the produce and share of agriculture has not shown any significant improvement over the past few decades.

VII. RESULTS AND DISCUSSIONS

Jupyter Notebook was used for analytical and scientific processing of data. The models used are verified using following metrics

a. *Mean Squared Error:* It stands for the average of the difference between the estimated values and the actual values. It is the most important metric in raking a regression algorithms performance. It is mathematically given as

$$\text{MSE} = \frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^2$$

b. *Variance:* It stands for the squared deviation of a random variable from its mean. It is mathematically given as

$$\sigma^2 = \frac{\sum(X-\mu)^2}{N}$$

c. *Score:* It predicts how well the model predicts in future for unseen data. It can be positive and negative as well. It is mathematically given as

$$R^2(y,\hat{y}) = 1 - \frac{\sum_{i=0}^{n_{\text{samples}}-1}(y_i - \hat{y}_i)^2}{\sum_{i=0}^{n_{\text{samples}}-1}(y_i - \bar{y})^2}$$

d. *Classification report:* On processing and analysing the data we've come up with the following mathematical equations to represent the relation of Agriculture sector and Industry sector with respect to the year.

- Contribution in Rupees (Crores) at 2004-05 prices

Industry: y = 18760 x + 202784
Agriculture: y = 7699 x + 53407

- Share to Total GDP

Industry: y = 0.1741 x + 19.246
Agriculture: y = -0.4923 x + 43.474

- % Growth Rate

Industry: y = 0.0272 x + 4.988
Agriculture: y = 0.0159 x + 2.5096

The regression of fit for this particular data has been derived using different metrics of Lasso and Ridge Regression (L1 and L2 Regularization)

e: Contribution in Rupees (Crores) at 2004-05 prices:

The data under evaluation included four columns (Financial Year, GDP, Agriculture and Industry – Contribution in Crores) from the year 1951-2013. The data other than Financial Year has been

The best fit for the data is found at alpha=1 with Lasso Regression with following metrics

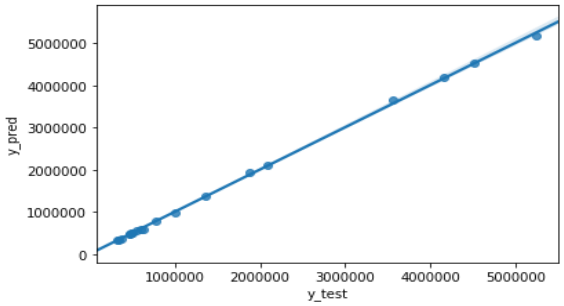
Mean Squared Error (Testing) – 1148704786.43
Mean Squared Error (Training) – 1678167413.02
Variance Score – 1.00
Score – 99.93 %

The best fit line has the following co-efficient

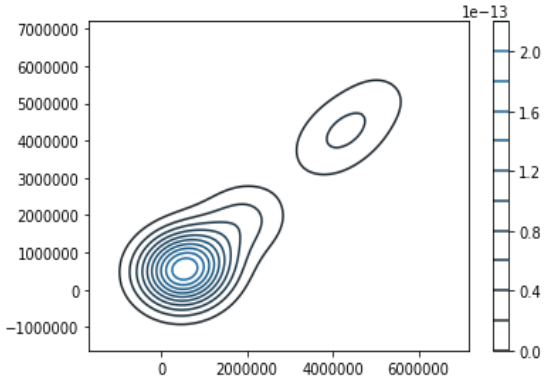
Slope (m) = 0.9861173
Intercept (c) = 9100.1998
Std Error = 0.0047183

The equation thus can be concluded as y = 0.986x + 9100.1998

The following are the Regression and KDE plots with testing data as X-axis and predicted data as Y-axis



Regression Plot



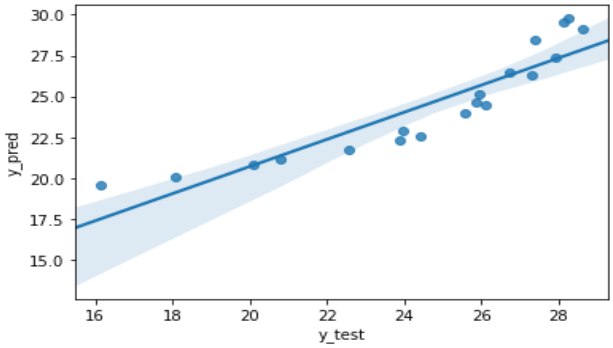
KDE Plot

f. Share to Total GDP:

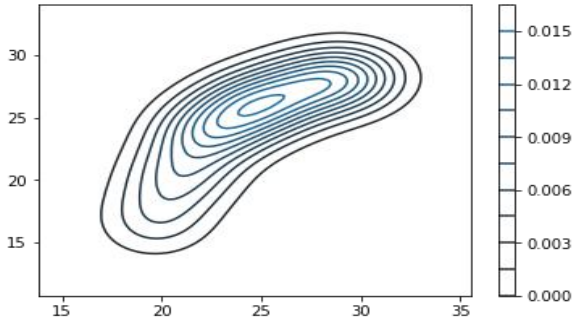
The data under evaluation included three columns (Financial Year, Agriculture and Industry – Share to Total GDP) from the year 1951-2013. Change in industry share with respect to agriculture share is analysed.The best fit for the data is found at alpha=1 with Lasso Regression with following metrics

Mean Squared Error (Testing) – 2.42
Mean Squared Error (Training) – 2.44
Variance Score – 0.82
Score – 82.04 %

The best fit line has the following co-efficient
Slope (m) = 0.7131211
Intercept (c) = 7.0201504
Std Error = 0.0766946
The equation thus can be concluded as y = 0.713x + 7.020
The following are the Regression and KDE plots with testing data as X-axis and predicted data as Y-axis



Regression Plot



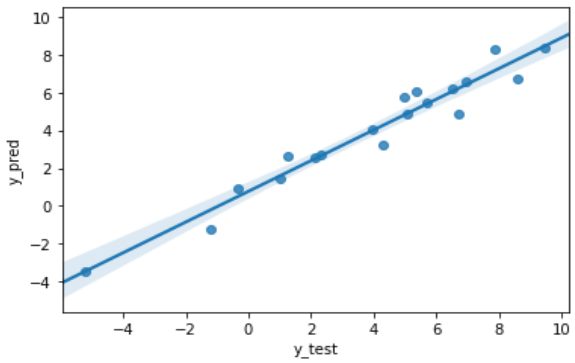
KDE Plot

g: % Growth Rate:

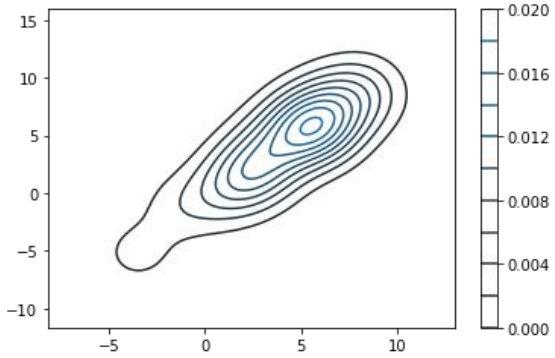
The data under evaluation included four columns (Financial Year, GDP, Agriculture and Industry - % Growth Rate) from the year 1951-2013.
The best fit for the data is found at alpha=0 with both Lasso and Ridge Regression (which is essentially Linear Regression), so we opted for Linear regression since the lasso and ridge models do not converge well for alpha=0.
The following metrics were obtained
Mean Squared Error (Testing) – 0.82
Mean Squared Error (Training) – 0.61
Variance Score – 0.93
Score – 92.88 %
The best fit line has the following co-efficient
Slope (m) = 0.8591675
Intercept (c) = 0.6669400
Std Error = 0.0550525

The equation thus can be concluded as
y = 0.859x + 0.666

The following are the Regression and KDE plots with testing data as X-axis and predicted data as Y-axis



Regression Plot



KDE Plot

VIII. CONCLUSION

For a developing country to be self-sustaining and improve its economy at a good pace the first and foremost priority should be given to the agriculture sector until the other sectors develop to a level where they draw customers and investors from other countries. This doesn't mean entire workforce to be employed in this sector but using of modern technologies to improve productivity and reduce work burden. The agriculture, "The Backbone of Indian Economy" is the perfect phrase to describe its role in the current scenario. The farmers should be updated with advancement in technology related to agriculture and efforts should be put in to help them practice these methods. The industry sector should be able to encourage the outcomes of agriculture by offering them good prices and improve living standards of farming society. Industry and agriculture sectors should both complement each other for a good period of time to be able to sustain independently.

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