Exploring the Association between Debt Ratio and Economic Development: A Developing Country Level Study

Team: COGNOS

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Problem Statement

- Is there any association between debt ratio and GDP growth rate?
- Analyzing data related to debt and economic indexes.
- Try to find the associations between debt ratio and economic development of countries

Importance

- High debt model of development transfers the risk to the financial industry
- Healthy debt ratio prevent financial crisis and regulate the fiscal policy and interest rate.
- Governments can make adjustment according to their current situation.

Hypotheses

- The hypothesis is that there is an appropriate debt ratio range that is most conducive to economic development.
- Appropriate debt ratio (40%-60%) of corporates [2]
- Deduce some important aspects to adjust debt ratio in country level.

Dependent & Independent Variables

Independent Variables	Type	Scale
Concessional debt (% of total external debt)	Numeric	Ratio
Debt service on external debt, total (TDS)	Numeric	Interval
Exports & Imports of goods, services and primary income	Numeric	Interval
Short-term debt (% of total external debt)	Numeric	Ratio
Total debt service (% of exports of goods, services and primary income)	Numeric	Interval
Total reserves (% of total external debt)	Numeric	Ratio

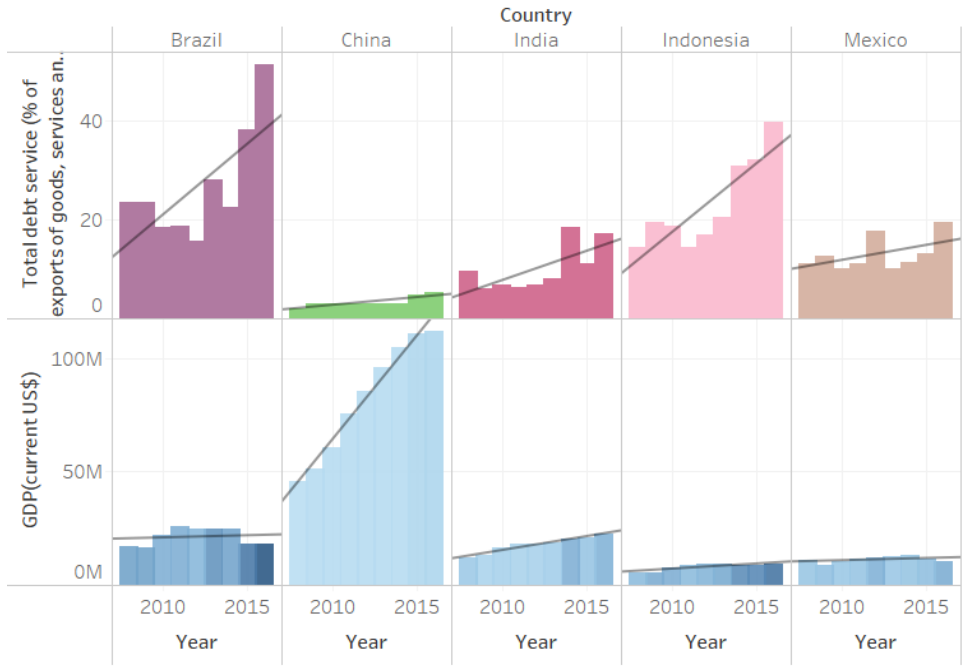
Dependent Variables	Type	Scale
Current account balance	Numeric	Interval
Gross National Income (GNI)	Numeric	Interval
Primary income on FDI	Numeric	Interval
GDP	Numeric	Interval

# of years data, period:
9 years (2008-2016)

Data size:
129 countries*9 years*14 variables = 16,254

Data source:
http://data.worldbank.org/data-catalog/international-debt-statistics
http://data.worldbank.org/data-catalog/world-development-indicators

Barchart plot



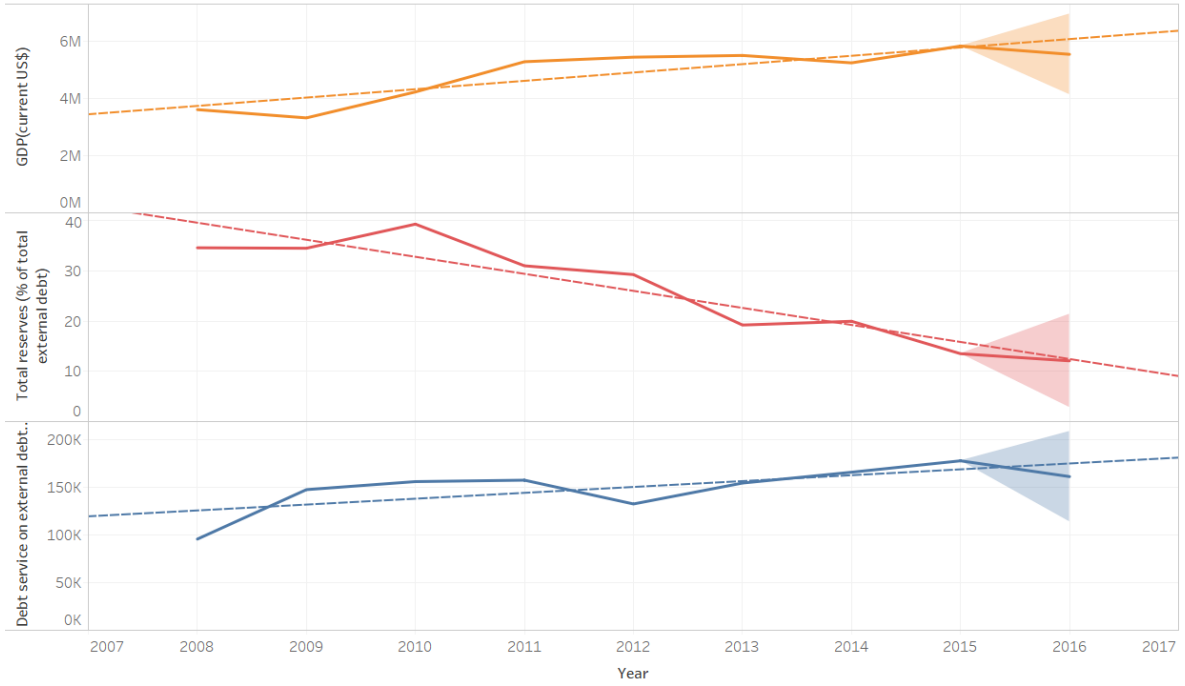
The plots of sum of Total debt service (% of exports of goods, services and primary income) and sum of GDP(current US$) for Year broken down by Country. For pane Sum of Total debt service (% of exports of goods, services and primary income): Color shows details about Country. For pane Sum of GDP(current US$): Color shows sum of Total debt service (% of exports of goods, services and primary income). The view is filtered on Country, which keeps Brazil, China, India, Indonesia and Mexico.

Country
- Brazil
- China
- India
- Indonesia
- Mexico

Total debt service ..
2.07 51.25

- The bar-chart shows 5 countries' sum of GDP and Total Debt Service as well as their trend lines between 2008 and 2016.
- Maintaining lower and stable Total Debt Service might accelerate the growth rate of GDP.
- For those countries with relatively high volume of GDP, lowering Total Debt Service is one solution to accelerate the GDP growth.

Forecasting plot



The trends of GDP(current US$), Total reserves (% of total external debt) and Debt service on external debt, total (TDS, current US$) for Year. Color shows details about GDP(current US$), Total reserves (% of total external debt) and Debt service on external debt, total (TDS, current US$). The data is filtered on Country, which keeps Argentina.

Measure Names
- Debt service on external debt, total (TDS, current US$)
- GDP(current US$)
- Total reserves (% of total external debt)

- The Forecast plot uses Argentina's 2008-2015 data (GDP, Total reserves, and Debt service on external debt) to predict 2016's.
- Total Reserves and Debt Services on external debt have lower forecasting data than actual data. Total Reserves has negative relationship with GDP, but Debt Service on external Debt has positive relationship with GDP.
- Total Reserves is an important and valuable factors to study. Focus on the variation of Total Reserves on other countries' situation is a reasonable direction.

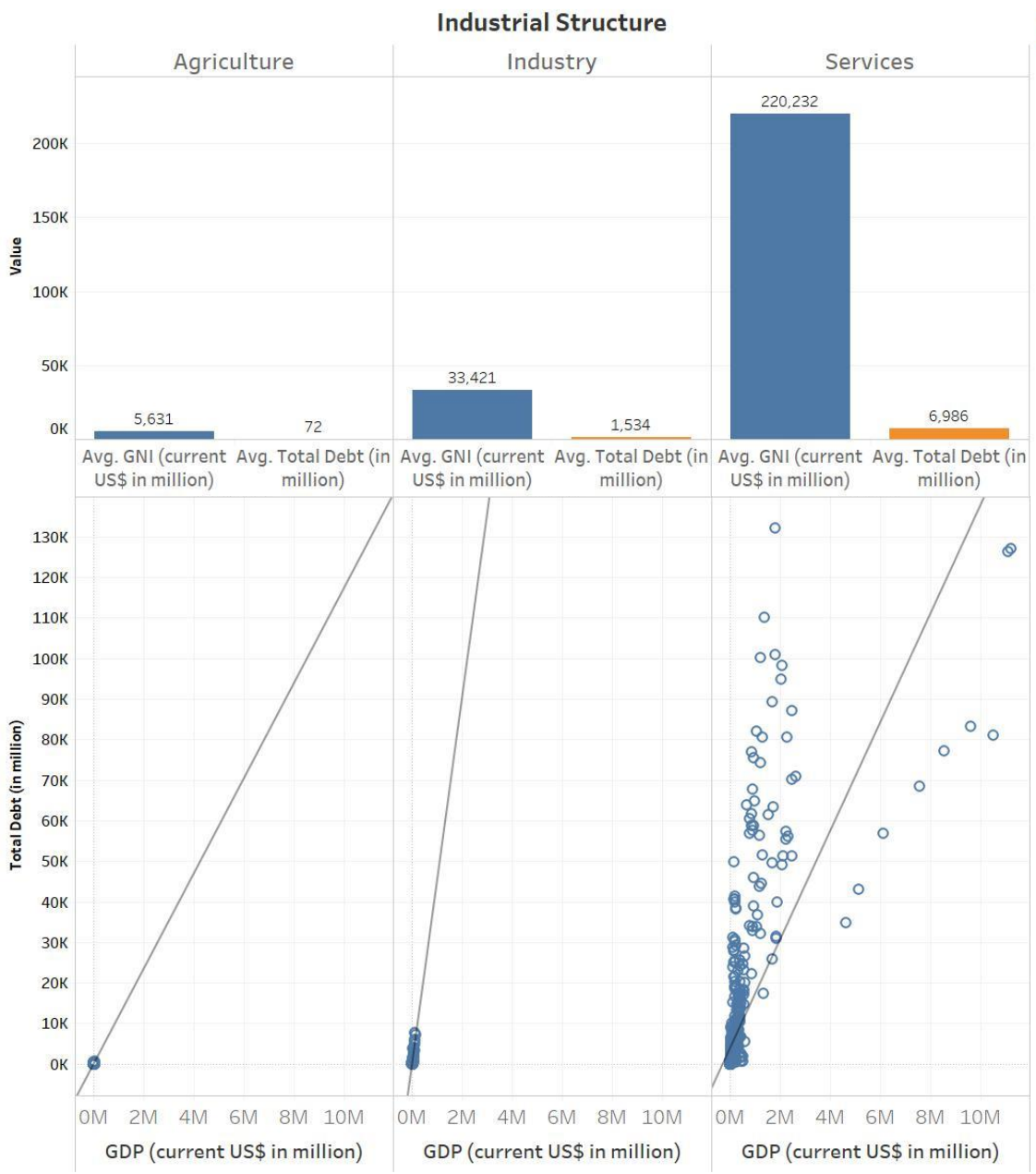
Industry comparison

The plots of average of GDP growth (annual %), average of Debt Ratio and average of Total reserves (% of total external debt) for Year broken down by Industrial Structure. Color shows details about Industrial Structure. The view is filtered on Industrial Structure, which keeps Agriculture, Industry and Services.

Industrial Structure
- Agriculture
- Industry
- Services

- The chart shows the Avg GDP growth rate, Avg Debt Ration, and Avg Total reserves from each industry within 9 years.
- Different relationship between GDP growth and Debt Ratio (Total reserves) in Agriculture and other two industries.
- Development pattern in agriculture countries is different from other 2 types. Development of industrial countries are easier to be influenced by Debt ratio and Total reserves.

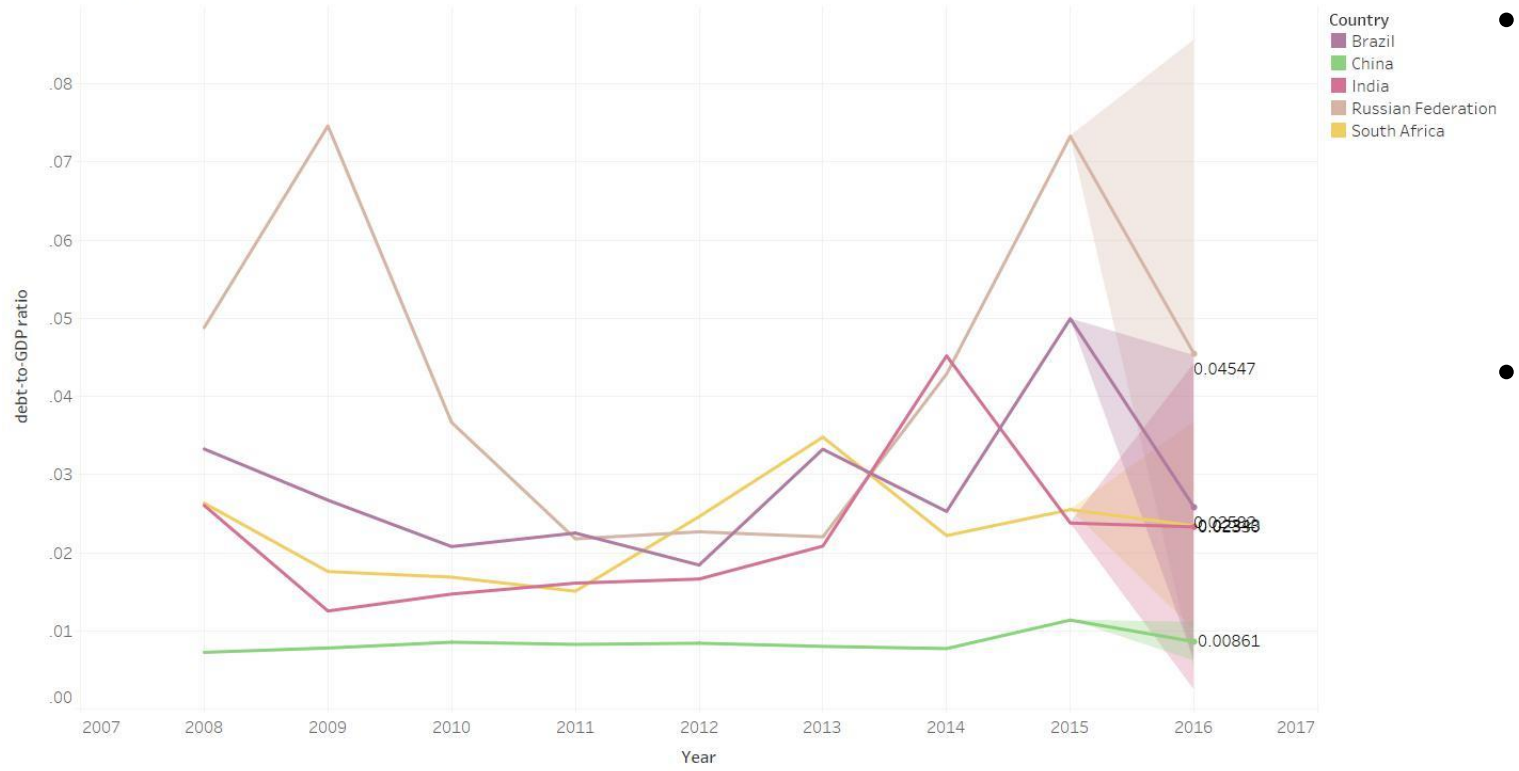
Bar and Scatter Plot



GDP (current US$ in million) vs. Total Debt (in million) broken down by Industrial Structure. The view is filtered on Industrial Structure, which keeps Agriculture, Industry and Services.

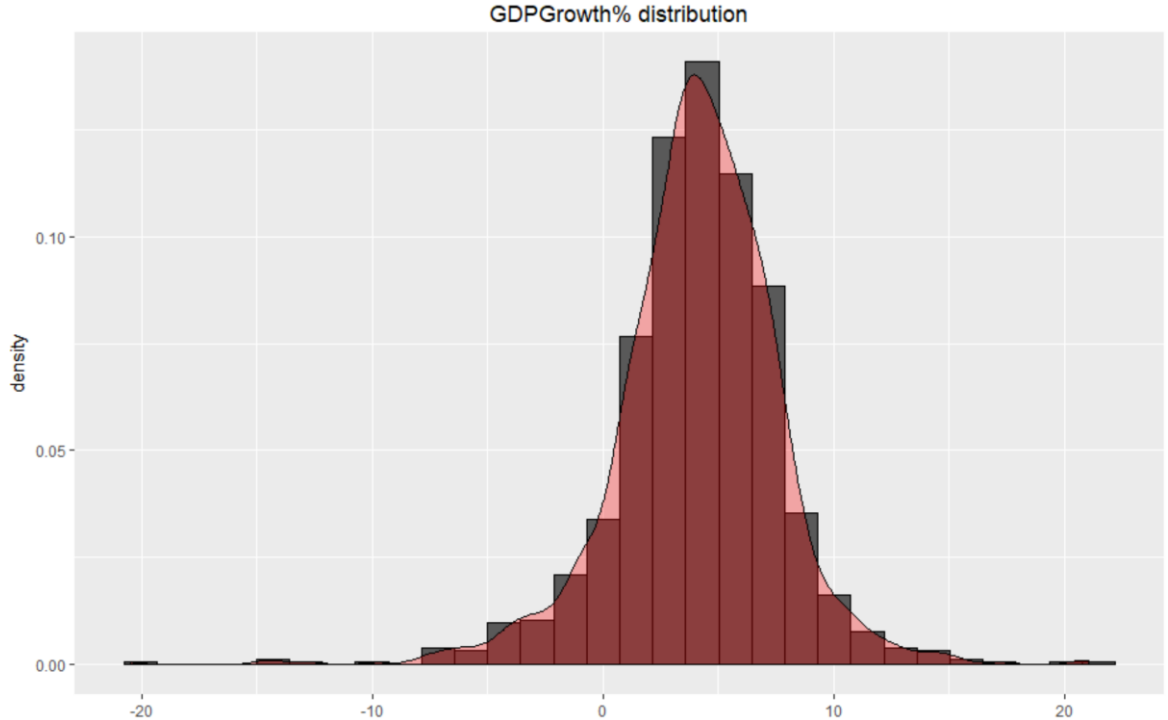
- The bar chart shows the comparison of average total debt and average GNI of countries in different industrial structures. The scatter plot shows the trend of debt-to-GDP ratios.
- The countries in tertiary industrial sector have highest gross national income and relatively high total debt as well; countries in secondary sector have the highest debt ratio.
- Generally, the countries with relatively high GNI tend to have great debt-paying ability. Thus, for economies of scale reasons, they are likely to have high debt.

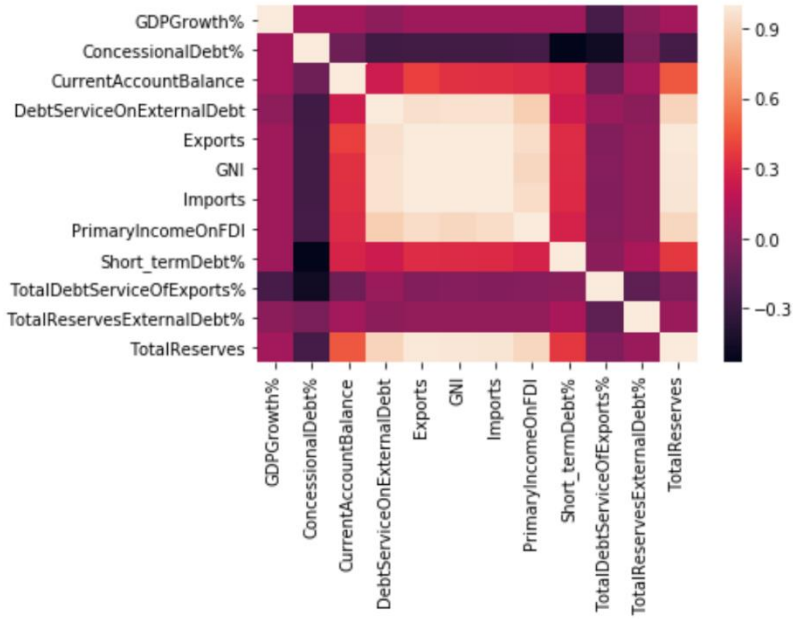
Predicting Line Plot

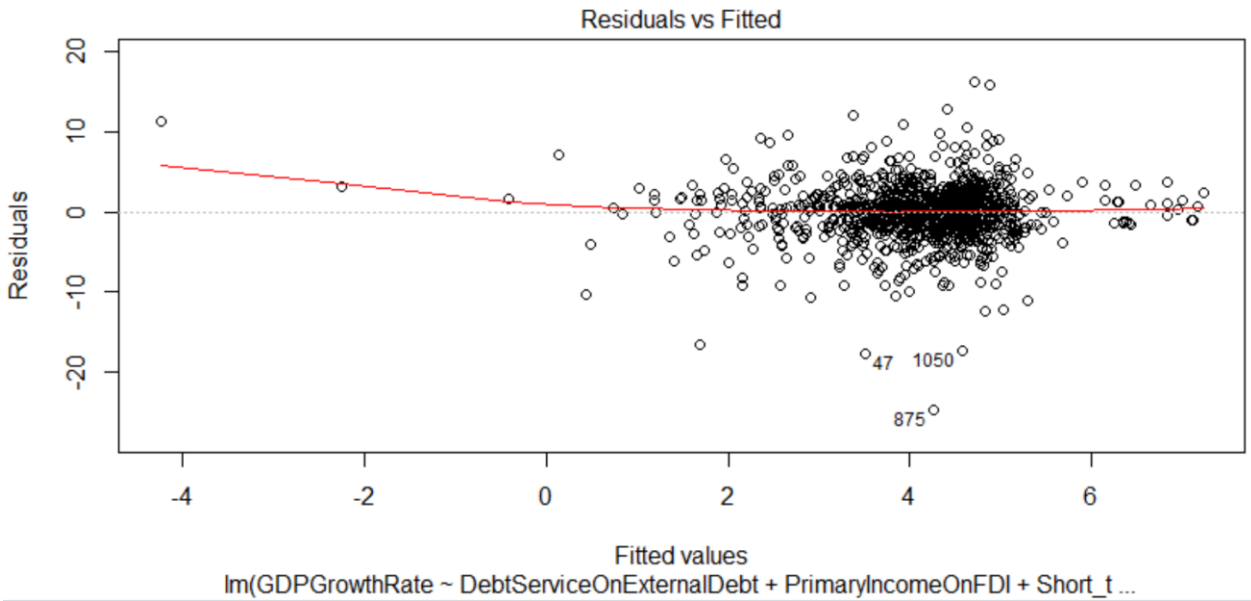


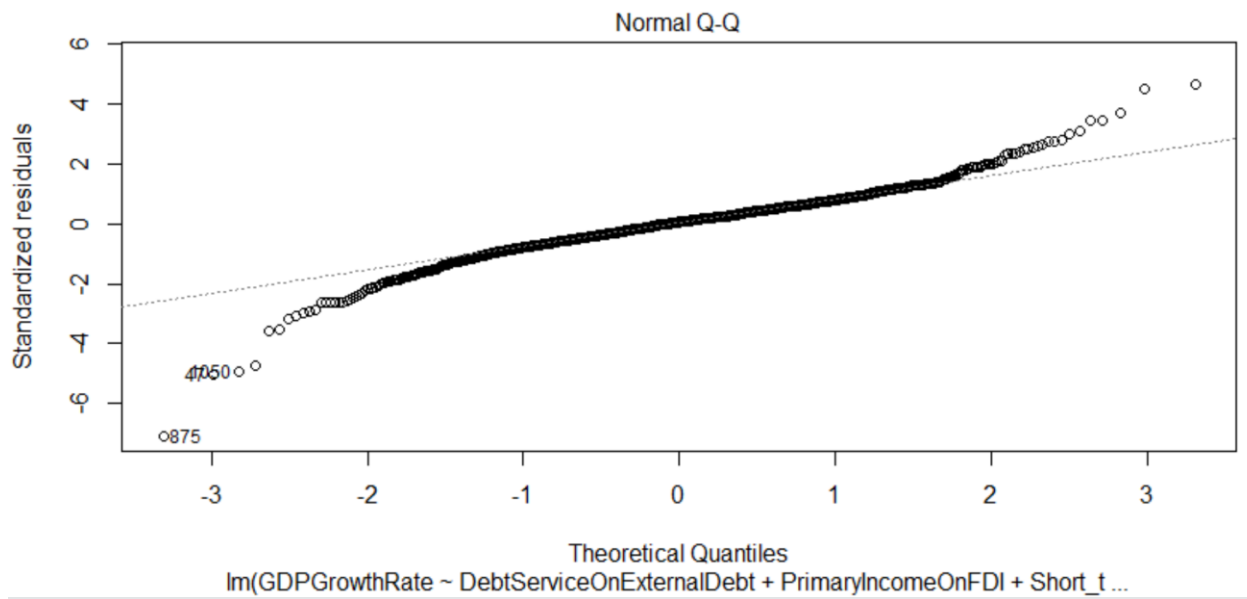
The trend of sum of debt-to-GDP ratio (actual & forecast) for Year. Color shows details about Country. The view is filtered on Country, which keeps Brazil, China, India, Russian Federation and South Africa.

- The line forecast chart shows the debt-to-GDP ratio of 5 countries from 2008 to 2015 and the estimated prediction value of 2016.
- The chart depicts that the ratio fluctuates during the first years and the ratio of all five countries has different degrees of decline in 2016.
- The decrease of debt-to-GDP ratio indicates that an economy produces and sells more goods and services to have the ability to pay back debts, instead of having further debt.


GDPGrowth% distribution
density
0.10
0.05
0.00
-20
-10
0
10
20


GDPGrowth%
ConcessionalDebt%
CurrentAccountBalance
DebtServiceOnExternalDebt
Exports
GNI
Imports
PrimaryIncomeOnFDI
Short_termDebt%
TotalDebtServiceOfExports%
TotalReservesExternalDebt%
TotalReserves
0.9
0.6
0.3
0.0
−0.3


Residuals vs Fitted
Residuals
20
10
0
-10
-20
-4
-2
0
2
4
6
47
1050
875
Fitted values
lm(GDPGrowthRate ~ DebtServiceOnExternalDebt + PrimaryIncomeOnFDI + Short_t ...

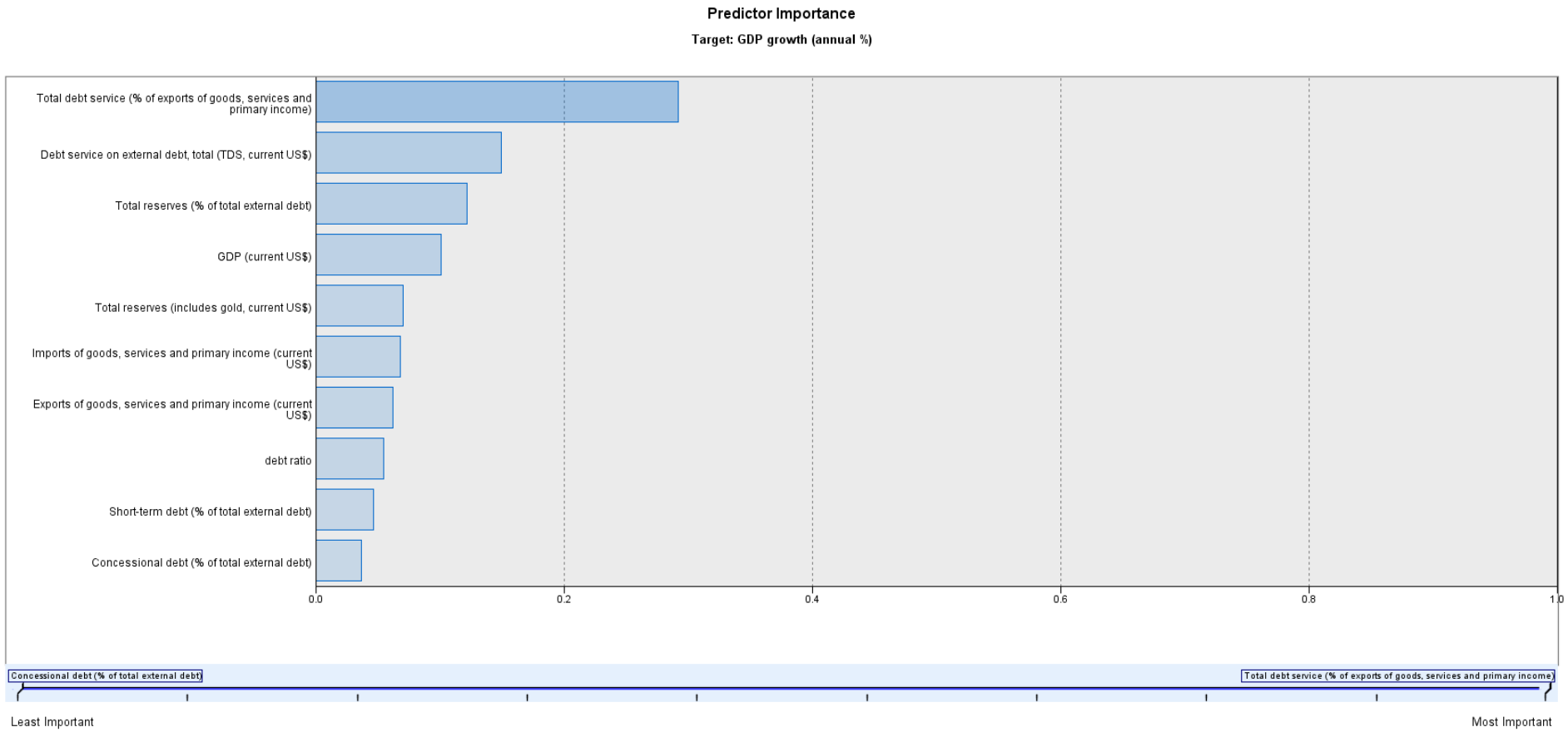

Normal Q-Q
Standardized residuals
6
4
2
0
-2
-4
-6
-3
-2
-1
0
1
2
3
47
1050
875
Theoretical Quantiles
lm(GDPGrowthRate ~ DebtServiceOnExternalDebt + PrimaryIncomeOnFDI + Short_t ...

```
Call:
lm(formula = GDPGrowthRate ~ DebtServiceOnExternalDebt + PrimaryIncomeOnFDI +
    Short_termDebtRate + TotalDebtServiceOfExportsRate, data = Gdp)

Residuals:
     Min       1Q   Median       3Q      Max
-24.7435  -1.7774   0.2054   1.9515  16.3044

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                  4.740e+00  1.984e-01  23.891  < 2e-16 ***
DebtServiceOnExternalDebt   -4.370e-12  2.220e-12  -1.969   0.0493 *
PrimaryIncomeOnFDI           8.448e-12  3.384e-12   2.496   0.0127 *
Short_termDebtRate           1.723e-02  8.601e-03   2.003   0.0454 *
TotalDebtServiceOfExportsRate -8.143e-02  1.052e-02  -7.743 2.26e-14 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 3.508 on 1063 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.06989,   Adjusted R-squared:  0.06639
F-statistic: 19.97 on 4 and 1063 DF,  p-value: 7.2e-16
```

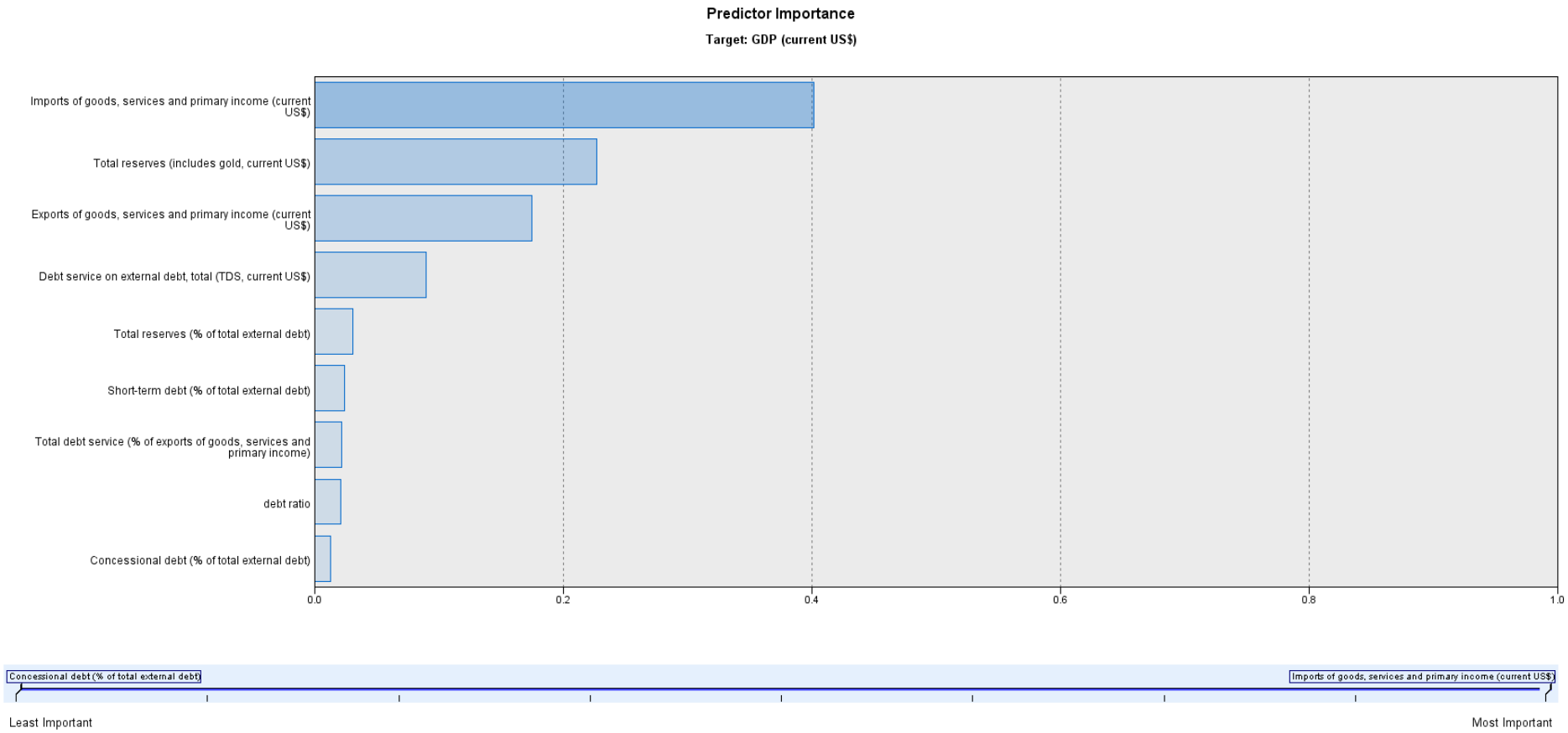
The results of our linear regression model is

GDPGrowthRate = 4.74 – 4.37e-12Debt Service On External Debt + 8.448e-12 PrimaryIncomeOnFDI + 1.723e-02 Short_termDebtRate – 8.143e-02 Total Debt Service of ExportsRate

Neural Network for GDP Growth Rate



Neural Network for GDP



Scope & Limitations

- The study only researches the debts and economic data of developing countries, not worldwide.
- The period of study is 9 years, which may cause great fluctuations on exchange rate.
- This is just an economic study which considered without politic factors.

Conclusions & Future Research

- Conclusion:

  Although there isn’t a strong association between debt ratio and economic development measurement parameters. National governments should still pay close attention to their debt ratio since total debt service showed a 1st position influential effect.

- Future Research:

  In order to make further advanced studies on correlation between debt ratio and GDP growth rate, we are supposed to take exchange rate, currency liquidity and trade dependency into consideration.

Managerial Implications

- Study result of debt ratio can be used as a threshold to remind countries that they are in high debt risk. And the result can also be used by commercial banks or financial organizations.

- Government could take the result into consideration while evaluating issuing treasury bonds.

- Credit rating companies could evaluate countries based on different structures according to the study.

References

- [1] Wade, Robert, and Frank Veneroso. "The Asian crisis: the high debt model versus the Wall Street-Treasury-IMF complex." *New Left Review* 228 (1998): 3.
- [2] *Corporate Finance: European Edition*, by D. Hillier, S. Ross, R. Westerfield, J. Jaffe, and B. Jordan. McGraw-Hill, 1st Edition, 2010.
- [3] Caner, Mehmet, Thomas J. Grennes, and Friederike Fritzi N. Köhler-Geib. *"Finding the tipping point-when sovereign debt turns bad."* (2010).
- [4] Kimberly Amadeo, *Debt-to-GDP Ratio: How to Calculate and Use It*, January 27, 2018
- [5] https://data.worldbank.org/data-catalog/international-debt-statistics

Sample data for analysis

	A	B	C	D	E	F	G	H	
1	ID	Country	Year	GDP growth (annual %)	GDP (current US$)	Concessional debt (% of total external debt)	Current account balance (current US$)	Debt service on external debt, total (TDS, current US$)	Exports of
2	1	Afghanistan	2008	3.611368392	10190529882	87.8653	-1753947190	8031000	
3	2	Afghanistan	2009	21.02064874	12486943506	80.4039	-850071623.5	10739000	
4	3	Afghanistan	2010	8.433290482	15936800636	76.5153	-1672929475	9735000	
5	4	Afghanistan	2011	6.113685169	17930239400	73.074	-2776293429	10328000	
6	5	Afghanistan	2012	14.43474129	20536542737	72.085	-5759690616	14772000	
7	6	Afghanistan	2013	1.959122893	20046334304	77.0884	-5051131726	25131000	
8	7	Afghanistan	2014	1.312530908	20050189882	73.1908	-3050102164	38241000	
9	8	Afghanistan	2015	1.112557528	19215562179	74.275	-5040237517	44622000	
10	9	Afghanistan	2016	2.232271759	19469022208	75.3339	-3781140537	43670000	
11	10	Albania	2008	3.760853683	12881352688	36.3185	-2018680000	202455000	
12	11	Albania	2009	3.352610243	12044212904	37.3308	-1849620000	243465000	
13	12	Albania	2010	3.710057793	11926953259	32.73	-1353550000	379702000	
14	13	Albania	2011	2.55016086	12890867539	28.7831	-1668840000	479965000	
15	14	Albania	2012	1.419967541	12319784787	27.5834	-1257970000	540035000	
16	15	Albania	2013	1.0007546	12776277515	23.7964	-1395210000	552513000	
17	16	Albania	2014	1.774368743	13228244357	23.727	-1702750000	695807000	
18	17	Albania	2015	2.226581414	11335264967	24.6009	-1222040000	914710000	
19	18	Albania	2016	3.369988612	11863865978	23.7668	-1142450000	553938000	
20	19	Algeria	2008	2.360134861	1.71E+11	32.4781	33954307487	1251623000	
21	20	Algeria	2009	1.632243838	1.37E+11	27.5633	431665235.5	1055375000	
22	21	Algeria	2010	3.634145353	1.61E+11	25.5518	12220267767	676201000	
23	22	Algeria	2011	2.891865995	2.00E+11	26.8247	17673868500	639343000	
24	23	Algeria	2012	3.374768651	2.09E+11	21.6222	12092476753	864809000	
25	24	Algeria	2013	2.767638867	2.10E+11	21.2624	1187894323	538986000	
26	25	Algeria	2014	3.789121212	2.14E+11	15.9859	-9506888927	294769000	
27	26	Algeria	2015	3.763466958	1.66E+11	14.9821	-27229373551	691081000	