IOSR Journal of Economics and Finance (IOSR-JEF)
e-ISSN: 2321-5933, p-ISSN: 2321-5925.Volume 12, Issue 5 Ser. VI (Sep. – Oct. 2021), PP 21-29
www.iosrjournals.org

Extrapolating equations that emanate the quantitative effect of a change in the Repo Rate on GDP growth rate and unemployment rate on the Indian economy.

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Abstract
The Repo Rate is the rate at which the commercial banks borrow money by selling their securities to the central bank of a country, often during the occurrence of a shortage of funds, but also due to statutory measures. Despite being used mainly as a monetary policy to control inflation, its effects are quite significant on two macroeconomic indicators; GDP, and unemployment rate in a country. As the repo rate's main objective does not directly focus on these two macroeconomic indicators, the effect of its change is often underestimated and not taken into consideration when the repo rate is deduced. Hence, we have developed a regression model that portrays the quantitative spill-over effects of a change in the repo rate.
In today's world, major decisions such as a change in the repo rate claim a big role in a country's future and must be established with respect to its holistic effects. Our model. is based with the intention of assisting economists and advisors when devising a repo rate with a specific focus on its effects on GDP and unemployment rate.
Our model used Autoregressive-Distributed Lag (ARDL) to find the relationship between the repo rate and the two variables, GDP and unemployment . We further checked using unit root tests whether the data is stationary or not over the time frame taken into consideration, while the implementation of correlation coefficient analysis portrayed to us the correlation of the two variables. This helped us identify
the prospective numerical values of the GDP and unemployment after a change in the repo rate. Quarterly data taken from the government of India over the last ten years served as training data for our model.
Overall, this paper sheds light on the importance of the repo rate and how governments must carefully go about changing the repo rate due to its adverse effects.
Keywords: *Repo Rate, Unemployment, GDP, ARDL Model, Correlation Coefficient Analysis, Unit root tests.*

Date of Submission: 01-10-2021 Date of Acceptance: 15-10-2021

I. Introduction

The repo rate is defined as the rate at which a central bank of a country lends money to commercial banks that operate in that given economy. This lending occurs when commercial banks face a shortage of funds. The rate decided by the Central Bank is crucial as it affects various macroeconomic aims. The rate is mainly used to control inflation but can have spillover effects on the Gross Domestic Product growth rate

(GDP-GR), as well as the unemployment rate to a certain extent. Over the last 2 decades, repo rates in various countries have been of paramount significance, tackling various economic crises. Especially incidents such as the 2008 mortgage crisis in the United States of America. At that point in time, the federal bank helped bail out large financial institutions by handing out a total sum of $16.8 trillion with $4.6 trillion already paid out according to the Special Inspector General for TARP. This sum influenced the choices made by the treasury board when deciding the repo rate 2009 onwards to mitigate the dreadful effects of 2008. As economic uncertainty in various nations across the world have increased, the repo markets are crucial to the financial sector of an economy helping them stay afloat. The 2008 bailout is one such example where repo rates assisted in stabilising the economy while also restoring the faith of citizens in the banking system. We noticed how there

was a relation between various macroeconomic objectives and the repo rate and we wanted to examine this in further detail. \ The Repo markets are an important source for securing funding for banks and various financial institutions, and a key tool for the implementation of a monetary policy. A repo, also considered a purchase and repurchase agreement, refers to the sale of a security as well as an agreement to repurchase the identical security

at a specified price at the tip of the contract. Repo markets have doubled in size since 2002, with gross amounts outstanding at year-end 2007 near the $10 trillion figure, in each of the US and euro repo markets, with another $1 trillion within the UK repo market alone. Despite the presence of collateral, repo markets were quickly full of the financial turmoil in mid-2007. Concerns about the creditworthiness of counter-parties and therefore the ability to grasp the worth of the collateral in an exceedingly sale meant that repo transactions were increasingly restricted to short maturities and against only the highest-quality securities during this era. As financing in unsecured markets became more expensive or unavailable, financial institutions with funding requirements bid more aggressively in repo markets to secure financing. Meanwhile, traditional repo investors that lend cash pulled back from the market, reducing the amount of financing available. At the identical time, the flight to government securities and also the hoarding folks Treasuries by investors led to a general scarcity of top- quality collateral, with repo rates for US Treasury securities falling to levels near zero. Overall, the US repo market experienced significantly more disruptions than either the euro area or the United Kingdom repo market.

1.1 Research Questions

- Is there a direct relationship between a change in the repo rate and i) the GDP Growth rate, ii) Rate of unemployment?
- If yes, can this relation lead to finding a quantitative equation that can portray the effect of a change in Repo rate on i) GDP Growth rate and ii) Rate of unemployment?

1.2 Aim

Our aim was to extrapolate an equation that would find the relation between the macroeconomic objectives of GDP-GR, Unemployment and the repo rate in the Indian economy. The intention of an equation was to help economists and various economic bodies choose a repo rate with specific attention towards the effect of a change in a repo rate on these macroeconomic objectives. The vision we had was to base our equation on repo rates over the last 20 years and see whether a trend surfaced relating delta repo rate with GDP-GR or Unemployment. Essentially, we aim to use a linear regression model to create the two equations: one for gdp-gr and repo rate and the other for the rate of unemployment and the repo rate. We also used null hypothesis testing and this resulted in the equation consisting of a p value. In null hypothesis testing the p value is the probability of obtaining test results at least as extreme as the results actually observe. If the p value was less than 0.05, the variables had a significant correlation, but if the p value was greater than 0.05, the variables were said to have a very weak correlation.

1.3 Hypothesis

We predict that there will be a strong correlation between the GDP-GR and repo rate. This is because of the direct impact a cut or rise in the repo rate has on the GDP-GR. If the government wants to boost economic activity, it will simply lower the repo rate.

This means that it would cost commercial banks less to borrow from the central bank which will hence allow the commercial banks to lend at a lower price without compromising on their profit margins. The lower lending rate would provoke businesses to borrow and invest without hesitation, thus boosting economic activity. The opposite is possible when the repo rate is increased. The cost to commercial banks when borrowing from the central bank will be higher so the commercial banks will lend at a higher price to maintain their profit margins. This will see fewer businesses borrowing as the lending rate is higher. This decreases economic activity but helps control inflation. Hence, we firmly believe that the repo rate and GDP-GR have a strong correlation

We also forecast that the unemployment and repo rate will have a p value greater than 0.05 and therefore show no correlation. Although the effect of a cut or rise of the repo rate on inflation rate and GDP-GR can have underlying effects on the unemployment rate, there is no direct relationship between the repo rate and the unemploymentrate.

There are many unquantifiable factors that play a role in affecting the unemployment rate and the change in repo rate has a minimalistic effect.

II. Method And Results

Since the repo rate has been changed numerous times in India in a year, we have decided to take the average weighted repo rate of each year.

Weighted Repo Rate =

$$\frac{\sum \text{no.of days repo rate was affective x Repo rate during that time period}}{365}$$

We did this by taking the weighted average repo rate, according to the number of days that the repo rate, by multiplying each repo rate into the number of days it was effective, adding all of the values for all the repo rates that year, then dividing the number we get by 365.

The table below shows the average repo rate and the GDP growth rate of each year.

Year	GDP Growth rate(%)	Weighted Average Repo Rate(%)
2001	3.841	8.87
2002	4.824	8.05
2003	3.804	7.09
2004	7.86	6.25
2005	7.923	6.05
2006	8.061	6.78
2007	7.661	7.67
2008	3.087	8.02
2009	7.862	4.91
2010	8.498	5.47
2011	5.241	7.49
2012	5.456	8.15
2013	6.386	7.52
2014	7.41	7.98
2015	7.996	7.28
2016	8.256	6.5
2017	7.044	6.15
2018	6.12	6.25
2019	5.024	5.8

(RR= repo rate, GDPGR=GDP growth rate)
To plot the relationship between the variables, we decided to use linear regression. Initially, we plotted the GDP Growth rate against the repo rate of each year.
The linear regression came out like below :

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.55320597
R Square	0.30603685
Adjusted R S	0.26521549
Standard Err	1.4804376
Observations	19

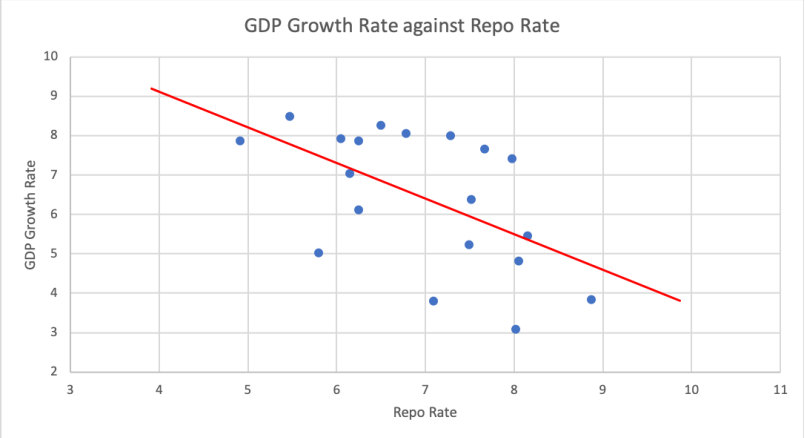
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	16.4310927	16.4310927	7.49697794	0.01401421
Residual	17	37.2588234	2.19169549		
Total	18	53.6899161			

	Coefficients	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	12.7283414	2.32173194	5.4822614	4.0473E-05	7.8299152	17.6267676	7.8299152	17.6267676
X Variable 1	-0.9032695	0.32989385	-2.738061	0.01401421	-1.5992847	-0.2072543	-1.5992847	-0.2072543

This regression model gave us the general equation of
DPGR RR

The graph of these variables and the line of best fit looks like this.



Since the P-value of this regression is less than 0.05, we can say that these two variables have a significant negative relationship in the short run.
To also test the long run relationship between these variables, we used ARDL. First, we tested the relationship between RR and GDPGR 1 year later. The regression model came out like below.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.30114462
R Square	0.09068808
Adjusted R S	0.03385609
Standard Err	1.62671064
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4.22258059	4.22258059	1.59572236	0.22460863
Residual	16	42.3390004	2.64618752		
Total	17	46.5615809			

	Coefficients	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	9.92188619	2.66999484	3.71606943	0.00187756	4.26174998	15.5820224	4.26174998	15.5820224
X Variable 1	-0.4750233	0.37604194	-1.263219	0.22460863	-1.2721966	0.32214996	-1.2721966	0.32214996

Here, the P-value is extremely large, which means that the repo rate does not affect the GDP growth rate after 1 year.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.17614812
R Square	0.03102816
Adjusted R S	-0.0259702
Standard Err	0.14599856
Observations	19

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.01160355	0.01160355	0.54436953	0.47069022
Residual	17	0.36236487	0.02131558		
Total	18	0.37396842			

	Coefficients	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	5.38025159	0.22896577	23.4980613	2.1162E-14	4.89717605	5.86332713	4.89717605	5.86332713
X Variable 1	0.02400378	0.03253364	0.73781402	0.47069022	-0.0446362	0.09264376	-0.0446362	0.09264376

Also, we did the same for unemployment. However, the regression model below showed that unemployment rate and repo rate had no significant correlation to each other, since the P-value was significantly greater than 0.05.

2.1 Economic events

The equation we got above is the line of best fit. However, many economic events occurred in real life which affected the equation. For example, the 2008 economic crisis and the demonetisation of 500 and 1000 rupee notes in 2016 will have affected the economy. So, we decided to create equations from 2001 to 2008, from 2009 to 2016, and 2001 to 2016. Hence, we will get four equations, and we can take the average of the equations to get a final equation.

From 2001 to 2008, we got the regression model below.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.71667324
R Square	0.51362054
Adjusted R S	0.43255729
Standard Err	1.64560468
Observations	8

ANOVA

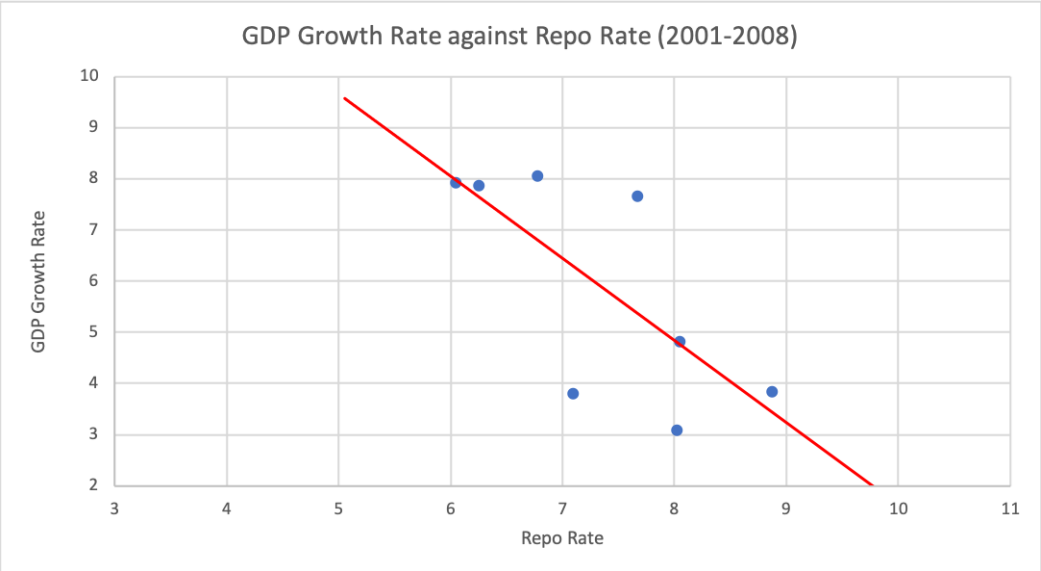
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	17.1581093	17.1581093	6.33604715	0.04546176
Residual	6	16.2480886	2.70801477		
Total	7	33.4061979			

	Coefficients	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	17.6900337	4.72672744	3.74255421	0.00959355	6.12414828	29.2559191	6.12414828	29.2559191
X Variable 1	-1.6069968	0.63841899	-2.5171506	0.04546176	-3.1691518	-0.0448418	-3.1691518	-0.0448418

Hence, we get the equation of

DPGR RR.

The graph of the data and the best fit line looks like below.



From 2009 to 2016, we got the regression model down below.

SUMMARY OUTPUT

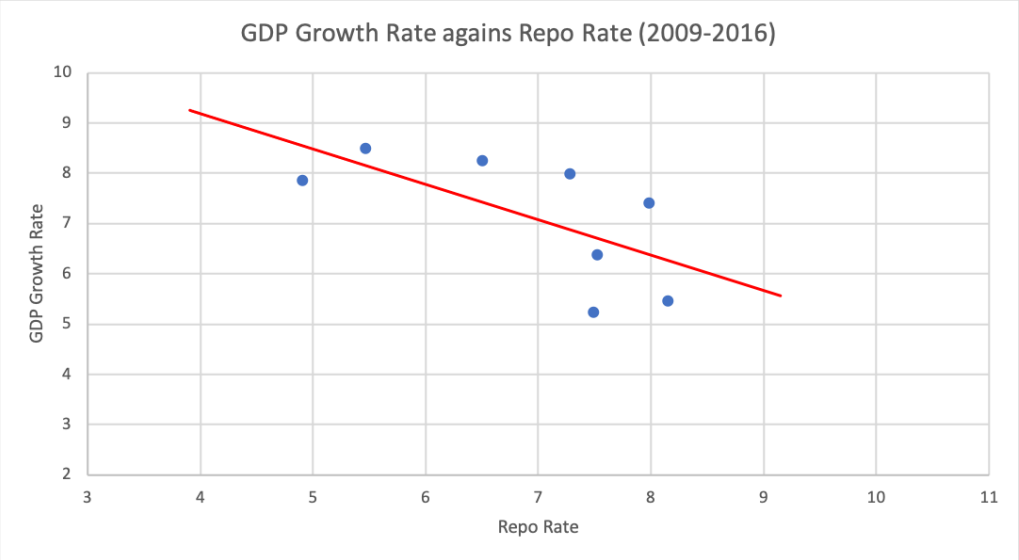
Regression Statistics	
Multiple R	0.65313567
R Square	0.4265862
Adjusted R S	0.33101724
Standard Err	1.04502377
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4.87463674	4.87463674	4.46364776	0.07907337
Residual	6	6.55244813	1.09207469		
Total	7	11.4270849			

	Coefficients	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	12.0209256	2.34047492	5.1361053	0.00214416	6.29398982	17.7478615	6.29398982	17.7478615
X Variable 1	-0.7063726	0.33434043	-2.1127347	0.07907337	-1.5244742	0.11172894	-1.5244742	0.11172894

This gives the equation of
DPGR RR.
The graph of the data and the best fit line looks like below.



From 2001 to 2016, we got the regression model down below.

SUMMARY OUTPUT

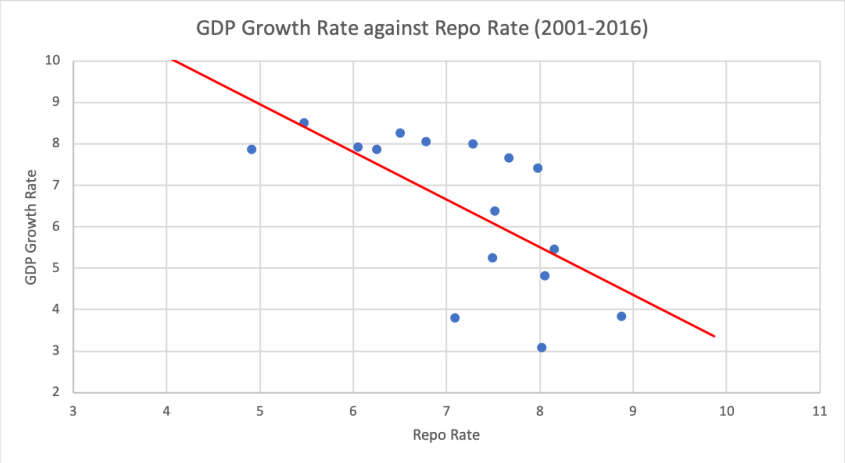
Regression Statistics	
Multiple R	0.66692752
R Square	0.44479232
Adjusted R S	0.40513463
Standard Err	1.42408955
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	22.7459693	22.7459693	11.2157895	0.00477347
Residual	14	28.3924345	2.02803104		
Total	15	51.1384038			

	Coefficients	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	14.7167058	2.47611231	5.94347265	3.5878E-05	9.40597306	20.0274385	9.40597306	20.0274385
X Variable 1	-1.150958	0.34367233	-3.3489983	0.00477347	-1.8880619	-0.4138542	-1.8880619	-0.4138542

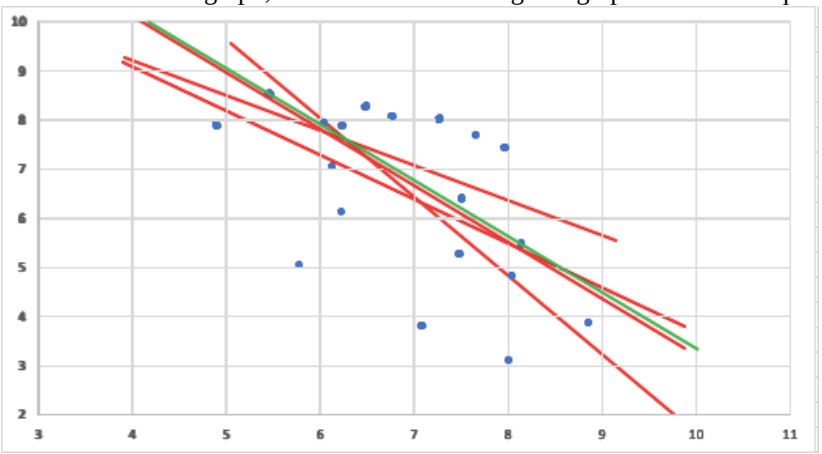
This gives us the equation *DPGR RR*



And by taking the average of the four equations, we get the final equation of

*DPGR RR***.**

Now if we plot all the lines onto one graph, it looks like this. The green graph is the final equation.



III. Discussion

As shown in the results above, we can see how a change in the repo rate has a significant impact on the GDP Growth Rate. The results also provide evidence for how a decrease in the RR would lead to an increase in the GDP-GR. This trend is justified as true by following a basic macroeconomic aspect in which the lower the rate of borrowing is in a country, the greater the quantity being borrowed, and in this case a lower repo rate would incentivise banks to borrow more and increase spending, affecting GDP.

When viewing our choices made with regards to the aspects in the methodology, we have used certain tools that we felt would lead to the most accurate equation derived.

We decided to use a linear regression model to form our equations because of its various advantages. One advantage includes how linear regression models help with an easier estimation procedure of future values. This was of vital importance to us as one of our aims included predicting the effect of a change in the repo rate on the GDP-GR in the future. In addition, linear regression helps in modelling a relationship at a greater pace compared to other models which can be implemented. The implementation of a linear regression model can be seen as best suited over here due the variables being examined having a direct relation.

We decided to use an Auto Regressive Distributive Lag (ARDL) because it is more robust and performs better for smaller sample sizes of data, and is hence most suitable for this financial model due to sample size being only 20 years. Furthermore, an ARDL Model addresses the issue of collinearity by allowing the lag of the dependent variable in the model with the independent variable and its lag.

Our results give the final equation: **GDP GR= 14.29 - 1.092RR**

In this equation we can see that the value of the gradient is -1.092 indicating how for every 1% increase in the repo rate the GDP growth rate decreases by 1.092%. We can also see that the GDP-GR is 14.29% when the repo rate is 0%. In reality, the repo rate can't be 0% as a repo rate of 0% would mean there is no cost on the commercial bank when borrowing from the central bank. Thus, demand pull inflation occurs and the value of the currency destructs. The importance of the repo rate can be seen clearly here as a repo rate that is too low would lead to very high rates of inflation and a repo rate that is too high would lead to minimal economic growth. We made this equation by taking into account two major events of the last twenty years (our data time frame) which included the economic crisis in 2008 and demonisation in India in 2016.

We initially formed a base equation which was based on how the GDP-GR reacted over the last 20 years on a change in Repo Rate. This equation was **GRD-GR= 12.73 - 0.903RR,** this equation served as a basis with which we compared the other equations which were formed. A basic principal we used over her was how the GDP-GR would react in a similar way in the future as it has in the past.

The second equation being formed was considered during the time period 2001 to 2008, **GRD-GR= 17.69 - 1.607RR** was this equation. We considered time from as it is the time frame between our base year and the financial crisis occurred. In this equation we can see that the value of the gradient is the highest amongst the four equations, portraying how the Repo rate had the greatest impact on GDP before the financial crisis. After the financial crisis, this was not the case due to a change in the economic situation in every country. The impact of the change in the repo rate on GDP can be seen from the third equation which is post the economic crisis and what our third equation reflects.

The third equation is **GRP-GR=12.02-0.706RR** with the time period 2009 to 2016 to see the effects of the economic crisis on the decision of the repo rate.

This time period is highly significant as global debt soared to amounts where large financial bodies had to bail countries out. This can be seen by the mass payments and lending of money by major financial institutions to those banks that lit the first match that would go on to destabilise numerous economies. However, what can also be visible here is how in previous years the rate of repurchasing was minimum and was a time period where spending and borrowing were highly promoted in an economy. Here is where the main problem emanates itself. In theory, the repo rate is a great policy that can be used to control various macroeconomic objectives. In many cases where the repo rate and an aim can be linked together as direct, the data shown gives us a weak correlation in relating unemployment to the repo rate. This can be viewed in our report where we tried to extrapolate a direct link in the form **y=mx+c** for unemployment**,** we could not get an equation of this sort due to a vast majority of other factors affecting unemployment. This is a classic example of where two factors, the repo rate and rate of unemployment are related to each other but have an indirect relationship. It can be said that the effect of a change in the repo rate on the rate of unemployment is minimal.

Many companies picked up the slack post the financial crisis, by taking advantage of rock-bottom interest rates to take on increasingly high amounts of leverage to boost profits. After nearly $27 trillion of borrowing later, the organisations are almost as large as the world's GDP.

In the equations we devised which took into account the economic situations, we made a bold assumption in which we took into consideration the repo rates that were prevalent for the following years. This is a big assumption as one can not say that the financial body will keep the repo rate the same after a grave

economic situation. This however is an assumption without which equations 2,3 and 4 could not be devised. We understand this as a potential error but feel it is vital and must be acknowledged on our part.

Another statistical error that may have occurred could be where an increase in GDP- GR in comparison to the previous year may be greater but the amount by which the increase was, may not necessarily be. We have looked past this as we want our equation to focus in particular on the growth rate and its reaction to a change in the repo rate.

IV. Conclusion

Our idea behind devising this equation was simply forming an equation in which the affect of a change in the Repo rate can be can be quantified with regards to the GDP- GR. Although our equation is India specific, we want other countries to implement our methodology by which they can also form equations that would be assist economists of their country. We also hope to enhance our equation as much as possible by taking into account more number of economic situations and factors, only after we have backtested the trends we find with other countries in the near future.

Our final formula is in a form where GDP-GR = M x RR + C, we however want this equation to be used when comparing repo rates of two consecutive years. In this scenario we want GDP-GR 2 - GDPGR 1 which would show the change in the GDP- GR based on a change in the Repo rate. We want this change to be considered the cost, if GDP-GR goes down, or the benefit if GDP GR goes up, based on the change in the repo rate.

We also hope that in future years, our final formulae can be further developed by other economists and researchers through implementing more economic events that will happen in the future.

In conclusion, we can see how there is a direct relation between the repo rate and the GDP-GR, and one that can be quantified to show the effect of a change in the repo rate, numerically on the GDP.

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Kushagra Goenka. "Extrapolating equations that emanate the quantitative effect of a change in the Repo Rate on GDP growth rate and unemployment rate on the Indian economy." *IOSR Journal of Economics and Finance (IOSR-JEF)*, 12(05), 2021, pp. 21-29.