AIJR Preprints
Section: Coronavirus
Article Id: 101, Version: 1, 2020
URL:https://preprints.aijr.org/index.php/ap/preprint/view/101
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Version 1: Received: 01 June 2020 / Approved: 02 June 2020 / Online: 03 June 2020

COVID-19 – Role of Government Intervention

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ABSTRACT

The ravage of COVID-19 has remained unprecedented in the history of human civilization. The pandemic has bewildered the governments across the nations amidst the twin edge blade of economic stringency or unabated growth of the disease. The study has attempted to find the efficacy of Government Intervention (GI) in combating the forces of the pandemic. It has pooled historical data of victims of 13 most affected countries after smoothening the data with ARIMA (p,q,r) technique to formulate an exponential model for its spread. The model considers six explanatory variables including GI to understand the dynamics of the disease. The historical data of the countries pooled across continents to have six groups. While variance inflation factor used for detecting multicollinearity, multivariate regression model adopted to determine the association between the explanatory variables and COVID-19 growth. The study pivoted on finding the role of GI, looking at its association with COVID-19 spread. Comparability analysis of the coefficient of GI conducted across the models to find the intensity across the continents. The study finds GI an effective instrument in the continents of America (North), America (South) and Asia, conducive for buying time for herd immunity and invention of vaccine and/or medicine.

Keywords: COVID-19, ARIMA (p, q, r), Exponential, Multicillinearity, Regression.

1. INTRODUCTION:

Global civilization has pulled through many pandemics and crises including two world wars, however, COVID-19 remained unique, affecting all facets of human life, including economics, education, psychology, culture and religion. In addition to threat to life, COVID-19 has left billions of marginalized people of the globe out of livelihood pushing them to casualty out of starvation. Government intervention across the globe has thus fumbled between saving economies and combating the spread of the disease [1]. The issue is more pronounced with governments of developing countries having a tight rope walk between

How to Cite:

Sandip Chatterjee "COVID -19- Role of Government Intervention". *AIJR Preprints*, 101, version 1, 2020.

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two choices, bereavement out of disease or starvation. This study has looked into the issues of Government Intervention (GI) in combating the forces of the pandemic from historical data of 13 major affected countries, across the globe.

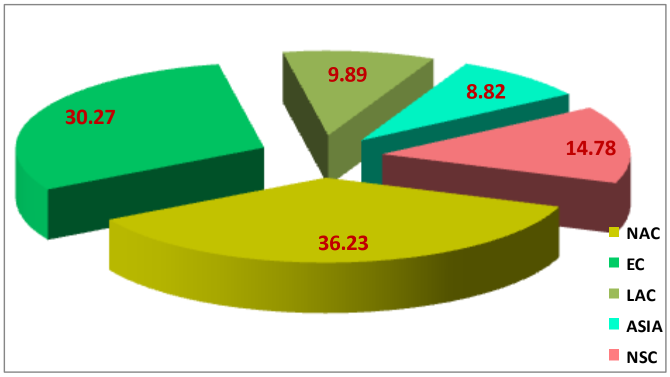
GI in resisting spread of COVID-19 has remained varied across the countries. The significant GIs may be summed up as slamming lock down, invigorating tests for the virus, governing social distancing, arranging quarantine and isolation, accentuating public awareness, caring lock down affected daily bread earners, strengthening Public Distribution System (PDS) and ruling strict the evils of hoarding and black marketing. The early bird countries of COVID-19 brazen out bolt from the blue and got devastated, keeping government a mute spectator at the early stage of the break out. In these GI efforts, the role and efficacy of local governments has also emerged crucial even bringing about debates like dilution of federalism to fight COVID-19 [2]. GI has attracted disparagements across the nations almost without exception [1] [3]. The issues being, lock down affected livelihood of one and all, social distancing intruded public education and culture, caring daily bread earners emerged a Himalayan challenge in the backdrop of numbers and limited resources of government, inadequacy of PDS, arranging tests for the virus and medical equipments that largely depended on imports. However, GI has been widely accepted as an effective tool to buy time and restrict the unabated spread of the viruses till herd immunity develops and/or the scientists come out with vaccine and adequate medicines to fight the disease [4].

India, the second largest populous country, known in the world for its inadequate healthcare infrastructure indicated by 0.7 hospital beds, 0.6 doctors, per 1000 people, resorted to social distancing measures to combat COVID-19 by slamming stringent lockdown and strict quarantine measures in the entire country at an early stage, in addition to wide social awareness initiatives for hand washing with soap and/or to sterilize with alcohol based sterilizers [5]. These measures have widely been appreciated by international organizations and nations, and the globe is closely watching the fight, GI being the major weapon of the country [6]. Thus, GI can effectively emerge instrumental in developing herd immunity which has also been used for the eradication of many diseases as it provides the basis for vaccines and their applications. [4]. GI may also be noticed to be influenced by the experiences of the other countries. Thus, a little delay in the outbreak of the disease has helped preparedness of the concerned countries, minimizing combat efforts. Considering the veracity and complexity across the nations, it is difficult to measure GI, more so, as any index of measuring these parameters is expected to suffer from subjectivity due to lack of information and proper bench marking on social distancing and lock down. On the contrary, people at large, especially the elderly ones, more susceptible to the disease, relied closely on GI not finding silver lining of discovery of medicine and/or vaccine to fight COVID-19 in near future. Notably, in the case with SARS, vaccines were never used as its spread stopped without the need to vaccinate people [4].

In fine, while the virologists, biologists, protein and related scientists of the globe are tormenting to come out with medicine, vaccine and nature of the virus, GI has emerged as an effective and efficient instrument to buy time. In the process of GI, much talked about herd immunity has also grown strength to strength helping countries to restore normalcy, relaxing it in a phased manner, keeping in view adequate forecasting of the end day of the pandemic [10]. Thus, the issue of GI has hovered around finding a happy blending of measures for restricting spread of COVID-19 and ensuring no death out of starvation in difficult economic situation. This study has dealt with GI to discuss its efficacy for combating COVID-19 and such pandemic; the globe might face on and often in this era of globalization of viruses as well.

2. DATA AND SAMPLE COUNTRIES

The study has sourced all related data for 13 countries, constituting 76% of victim and 83% of toll of COVID-19 in the globe, from the website https://www.worldometers.info/coronavirus/ [7]. The countries include USA and Canada from North America Continent (NAC), six countries namely, Spain, Italy, France, UK, Germany and Russia of Europe (EC), two Latin American countries (LAC) i.e., Brazil and Peru and three countries from Asia (AC), Turkey, Iran and India. The related data is gathered for the period from 26 February, 2020 to 24 May, 2020. Rest of the countries and territories of the globe numbering 200 and constituting about 23% of the COVID-19 victims are kept way from the study for the sake of brevity and adequacy of the sample. The distribution of COVID-19 victims across sample countries of continents is shown in Graph – 1. We have not considered any country from the continents of Africa and Oceania. The data on population density, median age, share of urban population are from https://www.worldometers.info.



Graph 1 : Share of Continent-wise Victims

Table – 1: Sample Countries – A Brief Account

Particulars	First Day	As on 24-05-2020			World Share (%)		As on 24-05-2020		Study	Density	U Pop.	Med	CADG (Ratio)	
Country	Date	Victim (V)	Toll (D)	D/V (%)	Victim	Death	Tests (T)	G=T/V	Days	No/Km^2	(%)	Age	Victim	Death
USA	08-03-2020	1686436	99300	5.89	30.69	28.66	14749756	8.75	78	36	83	38	4.58	5.04
CANADA	16-03-2020	84699	6424	7.58	1.54	1.85	1459288	17.23	70	4	81	41	1.74	3.12
NAC	*07-03-2020*	*1771135*	*105724*	*5.97*	*32.23*	*30.52*	*16209044*	*9.15*	*79*	*20*	*83*	*39*	*4.88*	*5.47*
SPAIN	07-03-2020	282852	28752	10.17	5.15	8.30	3556567	12.57	79	94	80	45	2.90	4.61
ITALY	26-02-2020	229858	32785	14.26	4.18	9.46	3447012	15.00	89	206	69	47	3.53	5.89
FRANCE	05-03-2020	182584	28367	15.54	3.32	8.19	1384633	7.58	81	119	82	42	2.84	6.15
UK	11-03-2020	259559	36793	14.18	4.72	10.62	3458905	13.33	75	281	83	40	2.68	4.81
GERMANY	05-03-2020	180382	8371	4.64	3.28	2.42	3595059	19.93	81	240	76	46	2.62	5.36
RUSSIA	24-03-2020	344481	3541	1.03	6.27	1.02	8685305	25.21	62	9	74	40	2.04	3.01
EC	*26-02-2020*	*1479716*	*138609*	*9.37*	*26.93*	*40.01*	*24127481*	*16.31*	*89*	*34*	*75*	*43*	*5.88*	*8.43*
BRAZIL	18-03-2020	363681	22716	6.25	6.62	6.56	735224	2.02	68	25	88	33	2.38	4.01
PERU	25-03-2020	119959	3456	2.88	2.18	1.00	820967	6.84	61	26	79	31	1.52	1.70
LAC	*17-03-2020*	*483640*	*26172*	*5.41*	*8.80*	*7.55*	*1556191*	*3.22*	*69*	*32*	*83*	*31*	*2.72*	*5.84*
TURKEY	19-03-2020	156827	4340	2.77	2.85	1.25	1832262	11.68	67	110	76	32	2.05	2.61
IRAN	29-02-2020	135701	7417	5.47	2.47	2.14	800519	5.90	86	52	76	32	2.60	2.37
INDIA	23-03-2020	138536	4024	2.90	2.52	1.16	2943421	21.25	63	464	35	28	1.64	1.82
ASIA	*29-02-2020*	*431064*	*15781*	*3.66*	*7.85*	*4.56*	*5576202*	*12.94*	*86*	*150*	*51*	*32*	*3.72*	*3.02*
SAMPLE	***25-02-2020***	***4165555***	***286286***	***6.87***	***75.81***	***82.64***	***47468918***	***11.40***	***90***				***8.06***	***8.74***
GLOBE		**5494455**	**346434**	**6.31**						**52**	**56**			

Note: Figures in italics indicate sum of countries of the respective continents.

CDGR – Compounded Daily Growth Rate from first day till 24-05-2020.

Table – 1 has depicted basic information on victim, toll and it's share in victim, country-wise share of victim and toll in the globe, number of days considered till 24-05-2020 and compounded daily growth rate of victim and toll. Day's count i.e. First Day is the day of the respective country's COVID-19 victim figure reaching close to 500 marks. Furthermore, Table - 1 has also included parameters across countries and continents namely, the ratio of test to victim (**T/V**), population **density** (Number per square KM.), percentage of urban population (**U Pop**), median age of population (**Med**), collected from https://www.worldometers.info/coronavirus/. Data points numbered 960, considering all 13 countries.

3. METHODOLOGY

Although COVID-19 has spread across the world, the first day varies country to country, requiring comparability of data for the sake of understanding the expansion-path properly. We have considered the first day as the number of victims of a country reach closest to 500 marks. To elaborate, irrespective of date, first day in all countries are bench-marked as nearly 500 COVID-19 victims. The period of the study, however, ends on 24 May, 2020. It has of course far reaching connotation as lag in time privilege countries with experiences of early birds. The First Day column of Table – 1 provides the date registering 500 COVID-19 victims by the respective country.

Any research on the subject is constrained by scanty knowledge and information about the disease albeit the scientists of the globe are putting hard efforts to unveil the misty of COVID-19. In order to understand the rapid spread of the disease, we have taken cue of some country specific parameters e.g. government intervention, population density, share of urban population, median age of population and country itself for its all imbedded characteristics. In view of difficulty and influence of subjectivity, instead of standardization and bench-marking government actions, we have considered the ratio of COVID-19 test to victim (T/V in Table – 1) as proxy variable to GI which varies significantly across the countries. The ratio reflects explicitly on the government's will and action on the pandemic.

3.1 *THE MODEL*

The model has estimated the victim of the disease ($\mathbf{V_t}$), considering independent variables, time ($\mathbf{t}$), GI ($\mathbf{G_j}$), nation/continent ($\mathbf{C_j}$), median age of the country/continent ($\mathbf{M_j}$)population density ($\mathbf{D_j}$) and the share (%) of urban population ($\mathbf{U_j}$). Considering a continuous exponential growth function the equation can be presented as under;

$$\mathbf{V_{tj} = a\, e^{(\beta 1\, t + \beta 2\, Gj + \beta 3\, Cj + \beta 4\, Mj + \beta 5\, Dj + \beta 6\, Uj)}} \qquad (1) \qquad \mathbf{a \neq 0.}$$

Where, **a** is the intercept of the equation and β_i are coefficients of the parameters, and j represents the country/continent, (j = 1, 2…...13, for countries, and j = 1, 2 ……4 for continents)

We have pooled daily data of victims for 13 countries in the time horizon of first day (registering the closest to 500 victims) to 24 March, 2020 for analysis of sample countries as a whole. Similarly, for four continents, the aggregate values of the concerned countries got pooled for analysis. Moreover, for each continent the daily victim data is pooled for analysis. Thus, the study considered pooled data in the said time horizon for six groups of countries/continents, namely, all 13 sample countries, four continents as whole, and four individual continents. In order to smoothen serial autocorrelation of the observations, the study resorted to the technique of Auto Regressive Integrated Moving Average, ARIMA (p,q,r) for adequacy of data of the respective countries [8] [9]. The ARIMA (p,q,r) models for each of 13 countries and four continents namely, NAC (comprising aggregation of USA and Peru of North America), EC (sum of Spain, Italy, France, UK, Germany and Russia of Europe), LAC (comprising Brazil and Peru of Latin America) and Asia (aggregation of Iraq, Iran and India) are appended in Table - 2.

Table - 2 : ARIMA (p, q, r) Models, Parameters & Statistics

Nation	Parameter	Estimate	Stnd. Error	t	DW TEST	RMSE	RUNS	RUNM	AUTO	MEAN	VAR
USA					1.86	3186.16	OK	*	***	OK	*
(Days 78)					**MODEL ARIMA (0,2,0)**						
CANADA	AR(1)	-0.58	0.12	-4.89	2.00	255.49	OK	OK	OK	OK	OK
(DAYS 70)	AR(2)	-0.30	0.12	-2.55	**MODEL ARIMA (2,2,0)**						
SPAIN					2.05	1085.02	OK	OK	**	OK	OK
(DAYS 79)	MA(1)	0.33	0.11	3.10	**MODEL ARIMA (0,2,1)**						
ITALY					2.01	503.90	OK	OK	***	OK	*
(DAYS 89)					**MODEL ARIMA (0,2,0)**						
FRANCE (DAYS 81)	AR(1)	0.98	0.02	40.89	1.93	1990.98	OK	**	OK	OK	***
	MA(1)	0.94	0.11	8.26	**MODEL ARIMA (1,2,2)**						
	MA(2)	-0.25	0.11	-2.24							
UK					1.90	926.21	OK	*	OK	OK	OK
(DAYS 75)	MA(1)	0.50	0.10	4.84	MODEL ARIMA (0,2,1)						
GERMANY					1.99	763.06	OK	OK	***	OK	***
(DAYS 81)					**MODEL ARIMA (0,2,0)**						
RUSSIA					2.24	643.59	OK	OK	OK	OK	OK
(DAYS 62)					**MODEL ARIMA (0,2,0)**						
BRAZIL (DAYS 68)	AR(1)	1.06	0.00	390.13	1.97	1692.70	OK	OK	OK	OK	***
	MA(1)	-0.41	0.12	-3.26	**MODEL ARIMA (1,0,2)**						
	MA(2)	-0.29	0.13	-2.24							
PERU	AR(1)	1.03	0.01	106.21	2.01	741.18	OK	OK	OK	OK	***
(DAYS 61)	MA(1)	0.82	0.09	9.57	**MODEL ARIMA (1,1,1)**						
TURKEY	AR(1)	2.01	0.03	70.63	1.92	414.55	OK	OK	OK	*	OK
(DAYS 67)	AR(2)	-1.01	0.03	-34.69	**MODEL ARIMA (0,2,0)**						
IRAN					2.36	249.53	OK	OK	OK	OK	OK
(DAYS 86)					**MODEL ARIMA (0,2,0)**						
INDIA	AR(1)	1.05	0.00	251.58	2.08	364.80	OK	OK	OK	OK	**
(DAYS 63)	MA(1)	0.78	0.07	10.42	**MODEL ARIMA (1,1,1)**						
NAC (DAYS 79)	AR(1)	1.26	0.04	28.90	2.19	2794.31	OK	OK	*	*	OK
	AR(2)	-0.97	0.04	-22.26							
	MA(1)	1.33	0.08	17.03	**MODEL ARIMA (2,2,2)**						
	MA(2)	-0.89	0.09	-10.36							
EC	MA(1)	0.32	0.10	3.09	1.96	3158.95	OK	OK	***	*	*
(DAYS 89)					**MODEL ARIMA (0,2,0)**						
LAC (DAYS 69)	AR(1)	1.05	0.00	210.62	1.93	1999.87	OK	OK	**	OK	***
	MA(1)	0.52	0.11	4.59							
	MA(2)	0.36	0.11	3.35	**MODEL ARIMA (1,1,2)**						
ASIA	AR(1)	0.69	0.10	6.61	2.01	558.30	OK	OK	OK	OK	*
(DAYS 86)	AR(2)	0.33	0.11	3.15	**MODEL ARIMA (2,1,0)**						
Note :	OK - p >= 0.05		* - 0.01 < p <= 0.05,		** - 0.001 < p <= 0.01			*** - p <= 0.001			
	models significant at 95% confidence interval										
Key:	RMSE = Root Mean Squared Error;		RUNS = Test for excessive runs up and down								
RUNM = Test for excessive runs above and below median; AUTO = Ljung-Box test for excessive autocorrelation											
MEAN = Test for difference in mean 1st half to 2nd half ; VAR = Test for difference in variance 1st half to 2nd half											

The models are found to be significant at 95% confidence interval. Before conducting regression analysis for COVID-19 victims on the explanatory variables as mentioned above, multicllinearity test is ensured by using Variance Inflation Factor (VIF) technique. Finally, multivariate regression technique is applied to estimate the parameters of GI and others, to enumerate the implication of government action in combating the menace of COVID-19. Last but not least, the study has also resorted to comparability analysis on the parameter of GI (

β_2) in order to look into whether it varies significantly across the continents as pool of countries, under the hypothesis;

$H_0 : \beta_{2i} = \beta_{2j}$

$H1 : \beta_{2i} \neq \beta_{2j}$ for $i \neq j$, and i, j = 1….4,

The major findings are discussed in the following section.

4. RESULTS AND ANALYSIS

The historical data pooled for 13 countries for the period of First Day (the date of registering nearly 500 COVID cases) to 25 May, 2020 made free of auto-correlation applying ARIMA (p,q,r) and tested for multicollinearity with the technique of VIF. The ARIMA (p,q,r) results are detailed in appended Table – 2.

Table – 2 depicts ARIMA (p,q, r) models, parameters and estimates across countries and continents. Table – 2 has also included the results of five tests run on the residuals to determine whether each model is adequate for the data. The figures in parentheses with the countries/continents represent number of days of study. The models and statistics of estimates are found to be significant at 95% confidence interval. The Durbin-Watson statistics, provided in Table – 2, signifies absence of serial auto-correlation. Majority of the five tests run being 'OK', the data is considered to be adequate for further study. Thus, ARIMA (p,q,r) model has facilitated us with forecast data free from auto correlation which is used for regression subsequently. The ARIMA (p,q,r) smoothen observations are pooled as elaborated in the model section. The set of independent variables namely, time (**t**), GI ($\mathbf{G}_j$), nation/continent ($\mathbf{C}_j$), median age of the country/continent ($\mathbf{M}_j$)population density ($\mathbf{D}_j$) and the share (%) of urban population ($\mathbf{U}_j$), considered for regression, are susceptible to multicollinearity, prompting us to construct VIF for six pool groups, presented in Table – 3.

Table – 3: Variance Inflation Factor (VIF)

Parameters	t (DAYS)	G_J (GI)	C_J (COUNT.)	M_J (MED. AGE)	D_J (DENSITY)	U_J (UR. POP. %)
COUNTRIES' POOL	1.03	2.43	2.75	3.77	2.59	4.33
CONTINENTS' POOL	1.02	2.38	6.84	7.78	X	X
NAC POOL	1.00	1.00	X	X	X	X
EUROPE POOL	1.03	4.50	4.35	3.21	1.39	2.98
LAC POOL	1.00	1.00	X	X	X	X
ASIA POOL	1.06	1.63	1.54	X	X	X

Table – 3 depicts that VIF for GI are found to be free of multicollinearity across data pool of 13 countries, 4 continents as aggregation and all the four continents as pool of its countries (NAC pool of USA and Canada; Europe pool of Spain, Italy, France, UK, Germany and Russia; LAC pool of Brazil and Peru; and Asia pool of Iraq, Iran and India). The VIF being more than 10 or inadequate are marked with cross (X) in the respective cells of Table - 3. It may be observed all the six explanatory variables for countries pool and for EC (European countries pool data) found to be free from multicollinearity problem. In the above backdrop, regression analysis is conducted on the natural logarithmic value of victims to estimate the exponential function of COVID-19 spread.

4.1 *REGRESSION: ALL COUNTRIES*

The result of regression with pooled data on COVID-19 cases for all the 13 countries on all the six explanatory variables is presented in Table – 4. All the six parameters and importantly GI found to be statistically significant at 95% confidence interval. The association of median age with spread of COVID-19 is found to be negative, contrary to the general notion that the elderly people are more susceptible to the disease. An investigation with specific data on age-wise distribution of population might help further insight on the issue. Importantly, C_j is also found to be significant and negative, highlighting prominence of country specific issues in spread of the disease. The negative sign of the parameter may be attributed to the fact that we have assigned number to the countries in descending order of number of victims i.e. higher the number of victims, lower the assigned country number. The findings also reaffirm the fact that higher density and larger share of urban population positively associated to spread of COVID-19. Interestingly, GI indicated by the ratio of tests to victims found to be positively associated with the number of cases across the countries as opposed to our expectations that GI would restrict the spread of the disease. This issue has been taken up for detailed discussion in latter part of this deliberation.

Table - 4 : Exponential COVID-19 Spread - All Countries

$$V_t = 2.22 * e^{(0.06\,t + 0.01\,Gj - 0.12\,Cj - 0.04\,Mj + 0.001\,Dj + 0.02\,Uj)}$$

Parameters	Estimate	Stn. Error	T Statistic	
CONSTANT	2.22	0.48	19.03	
t (DAYS)	0.06	0.001	47.02	
G_J (GI)	0.01	0.01	2.06	
C_J (COUNT.)	-0.12	0.01	-9.31	
M_J (MED. AGE)	-0.04	0.01	-3.85	
D_J (DENSITY)	0.001	0.0004	2.07	
U_J (UR. POP. %)	0.02	0.01	3.08	
Analysis of Variance				
Source	Sum of Squares	Df	Mean Square	F-Ratio
Model	2012.96	6	335.49	413.48
Residual	756.22	932	0.81	
Total (Corr.)	2769.18	938		
R-squared	**0.73**			
Adjusted R-squared	**0.73**			
Standard Error of Est.	0.90			
Mean absolute error	0.73			
Signifinant at 95% CI				

4.2 *REGRESSION: ALL CONTINENTS*

Table – 5 exhibits the exponential regression line of all continents with pooled aggregated data on COVID-19 cases of each of the four continents. Although VIF table ensured absence of multicollinearity among four explanatory variables, the regression result showed that the fourth variable median age found to be statistically insignificant. Thus, we considered three parameters namely, Day, GI and Continent which found to be statistically significant at 95% confidence interval in the exponential spread of the disease. In this model also continent specific issues emerged important and negative. The negative association may again be attributed to the fact that continents are assigned number in descending order. Significantly again GI found to be positively related to the exponential spread of the disease, contrary to our expectations.

C_J (COUNT.)	-0.12	0.01	-9.31	
M_J (MED. AGE)	-0.04	0.01	-3.85	
D_J (DENSITY)	0.001	0.00	2.07	
U_J (UR. POP. %)	0.02	0.01	3.08	
Analysis of Variance				F-Ratio
Source	Sum of Squares	Df	Mean Square	548.67
Model	2012.96	6	335.49	413.48
Residual	756.22	932	0.81	
Total (Corr.)	2769.18	938		
R-squared	**0.73**			
Adjusted R-squared	**0.73**			
Standard Error of Est.	0.90			
Mean absolute error	0.73			
Signifinant at 95% CI				

Table - 5 : Exponential COVID-19 Spread - All Continents

$$Vt = 2.28 * e^{(0.07\,t + 0.04\,Gj - 0.59\,Cj)}$$

4.3 *REGRESSION: CONTINENT-WISE*

In this sub-section results of regression of pooled country data of the continents on the explanatory variables are discussed. Keeping VIF at the backdrop, in NC only two variables, Days and GI considered for the regression analysis and rest of the four variables dropped due to the problem of multicollinearity. Table – 6 presents the results of NAC and the association of GI is found to be negative with the spread of the disease, in line with our expectations. Interestingly, the ratio of tests to cases in Canada (17.25) stood much higher than USA (8.75). General information on USA also suggests lack of government initiatives for combating spread of the disease.

Table - 6 : Exponential COVID-19 Spread - NAC

$$Vt = 2.83 * e^{(0.03\,t - 0.62\,Gj)}$$

Parameter	Estimate	Stn. Error	T Statistic	
CONSTANT	2.83	0.74	22.96	
t (DAYS)	0.03	0.01	3.04	
G_J (GI)	-0.62	0.04	-17.24	
Analysis of Variance				
Source	Sum of Squares	Df	Mean Square	F-Ratio
Model	2858.35	2	1429.18	170.08
Residual	1722.63	205	8.40	
Total (Corr.)	4580.98	207		
R-squared	**0.62**			
Adjusted R-squared	**0.62**			
Standard Error of Est.	2.90			
Mean absolute error	2.09			
Signifinant at 95% CI				

In European continent although all six independent variables found free from multicollinearity as indicated by VIF (Table – 3), the regression results show the estimate of share of urban population insignificant, prompting us to drop the variable. The variables, as shown in Table – 7, include Days, GI, Country, Median age and population density. The sign of variable, country, found to be negatively associated for the reason of numbering countries in descending order of COVID-19 victims. In EC, the sign of Mj found to be positive which corroborates the fact that many of the countries of the continent, Italy, Spain, France have larger share of elderly population becoming easy prey to the virus and the disease. Population density in European countries has been found to be positively associated with the spread of the disease. GI indicated by G_j is found to be positively associated to the COVID-19 spread. Many of these European countries remained the early birds in COVID-19 infection and at the early stage before realization of government the virus took drivers' seat. Thus, apparently GI found to be positively associated with COVID-19 growth.

The regression results LAC have been shown in Table – 8. Considering the VIF for figuring out multicollinearity among the explanatory variables presented in Table – 3, two variables namely, Days and GI considered for regression analysis. In line with our expectations, the variable GI is found to be negatively associated with the spread of the COVID-19 disease. The R^2 value for the continent stood high at 0.95. It may be noted that the disease spread in the continent of LAC with a time lag of about two weeks from the European spread. Brazil reached 500 mark of COVID-19 victim on 18 March, 2020, while the other country Peru reached the figure of 500 victims on 25 March, 2020. Thus, the European experience helped GI measures in LAC.

Table - 7 : Exponential COVID-19 Spread - EC

$$y_t = 4.76 * e^{(0.06\,t + 0.07\,Gj - 0.20\,Cj - 0.05\,Mj + 0.002\,Dj)}$$

Parameter	Estimate	Stn. Error	T Statistic	
CONSTANT	4.76	0.93	5.11	
t (DAYS)	0.06	0.002	35.35	
G_J (GI)	0.07	0.01	5.13	
C_J (COUNT.)	-0.20	0.04	-5.15	
M_J (MED. AGE)	0.05	0.01	4.29	
D_J (DENSITY)	0.002	0.001	4.42	
Analysis of Variance				
Source	Sum of Squares	Df	Mean Square	F-Ratio
Model	828.328	4	207.082	322.03
Residual	290.012	451	0.643043	
Total (Corr.)	1118.34	455		
R-squared	**0.74**			
Adjusted R-squared	**0.74**			
Standard Error of Est.	0.80			
Mean absolute error	0.67			
Signifinant at 95% CI				

Albeit the VIF in Table – 3, suggests three variables for regression model in Asia (Table – 9), C_j was dropped its estimates being statistically insignificant. At the backdrop of stringent and early GI in India, the second largest populous country of the globe, with a costly trade-off of livelihood of billions of marginalized people, the association of GI with COVID-19 spread in Asia has remained significantly negative. This justifies the strict GI of India and the international applaud bestowed on her for it.

Table - 8 : Exponential COVID-19 Spread - LAC

$$Vt = 2.00 * e^{(0.09\,t - 0.06\,Gj)}$$

Parameter	Estimate	Stn. Error	T Statistic	
CONSTANT	2.00	0.10	77.74	
t (DAYS)	0.09	0.002	49.24	
G_J (GI)	-0.06	0.01	-4.40	
Analysis of Variance				
Source	Sum of Squares	Df	Mean Square	F-Ratio
Model	365.92	2	182.96	1259.57
Residual	18.16	125	0.15	
Total (Corr.)	384.08	127		
R-squared	**0.95**			
Adjusted R-squared	**0.95**			
Standard Error of Est.	0.38			
Mean absolute error	0.32			
Signifinant at 95% CI				

In fine, GI has been found to be negatively associated with growth of the disease in three continents namely, NAC, LAC and Asia as against positive for All Countries, All Continents and EC. The three independent variables namely, median age, population density and share of urban population without exception have shown positive association with COVID-19 infection growth in line with our expectations. Country/Continent has shown negative association as we have numbered the variable in descending order of cases.

Table - 9 : Exponential COVID-19 Spread - ASIA

$$V_t = 2.18 * e^{(0.05\,t - 0.03\,G_j)}$$

Parameter	Estimate	Stn. Error	T Statistic	
CONSTANT	2.18	0.15	58.03	
t (DAYS)	0.05	0.002	22.26	
G_J GIO)	-0.03	0.01	-3.60	
Analysis of Variance				
Source	Sum of Squares	Df	Mean Square	F-Ratio
Model	310.75	2	155.37	256.59
Residual	114.72	208	0.55	
Total (Corr.)	425.46	210		
R-squared	**0.73**			
Adjusted R-squared	**0.73**			
Standard Error of Est.	0.74			
Mean absolute error	0.57			
Signifinant at 95% CI				

The value of the R^2 remained significant across the models, ranging from 0.62 for NAC to 0.95 for LAC. It may not be out of place to mention that a composite index taking into more such indicator of GI help deriving further robust result. It's also worth mentioning that the correlation coefficient between the Compounded Daily Growth Rate (CDGR) of victim and GI (provided in Table – 1) works out to be – 0.24.

4.4 *COMPARABILITY ANALYSIS OF GI*

The technique of comparability analysis is used in this study to understand the intensity of GI across the models, under the given set of assumptions. The lower triangle of Table – 10, represents the t statistics for GI for inter-continent comparison. The null hypothesis - H_0 : $\beta_{2i} = \beta_{2j}$, for i≠j, and i, j = 1….4, elaborated in 'The Model' (Section 3.1), is rejected at more than 95% confidence interval. The value of β_2 is the highest at -0.62 for NAC followed by EC at 0.07, while for LAC and Asia it stood at -0.06 and -0.03 respectively. The inter-continent t value indicates that comparability intensity of β_2 is the highest in EC-NAC followed by NAC-Asia, NAC-LAC.

Table - 10 : Inter-continent Value of t

Continents	*NAC*	*EC*	*LAC*	*ASIA*
NAC				
EC	**-16.73**			
LAC	**-13.58**	**9.19**		
ASIA	**-14.31**	**7.07**	**-2.12**	

5. CONCLUSION

The unstoppable ravage of the pandemic, COVID-19, has bewildered the governments of the nations of the globe on intervening the spread of the disease. The trade-off, economic stringency or intervening the forces of virus by slumming lock down remained baffling to the civilization. The situation is more precarious in developing countries as stringent GI measures expose billons of marginalized people of the globe to starvation. At this juncture, a revisit to the GI is of immense importance from the policy point of view. This study has looked into the efficacy of GI in resisting the forces of the disease. The study considers historical data of 13 most affected countries of the globe for the period, first day (defined as reaching 500 COVID-19 victims mark) till 24 May 2020. ARIMA (p,q,r) is followed for removing serial correlation of the time series data. Smoothen data across countries is pooled to from groups, All Countries, All Continents, NAC, EC, LAC and Asia on the basis of location of the countries. Aggregated data of concerned countries is used in the analysis of All Continents group. In addition to GI (the proxy variable defined as the ratio of COVID-19 test to victims), five other variables namely, day, nations, median age, population density and share of urban population are taken into account to formulate the exponential growth model of COVID-19 disease. Multicollinearity among the explanatory variables is checked with the technique of Variance Inflation Factor (VIF). The regression analysis reveals that GI is negatively associated with the spread of COVID-19 in NAC, LAC and Asia out of the six groups explained above. Comparability analysis of the coefficient depicts inter-continent intensity of GI, indicated by t value. The study finds GI effective in NAC, LAC and Asia, conducive for buying time for herd immunity growing strength to strength and scientists getting time in coming out with vaccine and/or medicine for the disease. The countries like India having inadequate healthcare infrastructure and the second largest population of the world have fall back heavily on stringent GI to buy time and restrict the skewed exponential COVID-19 growth path. The comparability analysis also suggests importance of GI, especially when there is no silver lining of vaccine or medicine to arrest growth of the pandemic in near future. The study brings forth the suggestion of a happy blending of measures, caring the marginalized for their livelihood by selective loosening of the GI and making it stringent at vulnerable pockets to restrict the spread of COVID-19.

6. DECLARATIONS

6.1 ACKNOWLEDGEMENTS

The author takes this opportunity to express deep sense of respect & regards to Prof. Arabinda Bhattacharyya, (Calcutta University) for all academic inputs in this study.
(Statistical exercises - STATGRAPHICS 18 and Microsoft Excel)

6.2 FUNDING

The author received no specific funding for this work.

6.3 COMPETING INTERESTS:

The author declares that no competing interests exist.

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