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The Socio-Economic Determinants Of Covid 19 Transmission

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THE SOCIO-ECONOMIC DETERMINANTS OF COVID19 TRANSMISSION

Abstract

Our study examines the mediating role of key socio-economic factors in the spread of COVID-19 pandemic from a global perspective to explain the asymmetry in the distribution of the burdens and responses across countries. We use Covid-19 global data to estimate an 'analysis of covariance model' to study the correlations between temperature, income, and size of the country, and if planned economies have managed the crises better. We find that spread of virus transmission has a positive correlation with a country's income and an inverse relationship with temperature, and population (size). The performance of high-income countries on the parameter total tests as a ratio of total cases' is inadequate. In contrast, the performance of low-income countries on the parameter total recovered as a ratio of total cases' is weak.

Keywords: COVID*19*, transmission, temperature, income, population

1 introduction

The coronavirus COVID-19 pandemic continues its relentless spread around the world. The virus has affected almost every country in the world. As on 08 May, the total cases and deaths from the pandemic are more than 38,56,000 and 267,000, respectively. However, most reports suggest that the official figures may be significantly underestimating the actual numbers.

The impact has primarily been on two dimensions. First, the swelling afflictions, a direct result of the rapid spread of the virus. The exponential growth in the cases has overwhelmed the health systems of all countries. The second, is the unprecedented scale of the looming economic-impact from the lockdown and other mitigation responses the pandemic. The deep demand shock is expected to herald a particularly severe global depression in the ensuing months.

The spread and the impact of the pandemic have not been uniform; there is significant asymmetry in the distribution of the burdens and responses across countries. There is wide variation in respect of the total cases, including total cases per million related to the afflictions, deaths, tests and recovered cases. To illustrate, we compare the USA and India. The USA is about three times bigger than India; however, India has four times more population. Further, an average American is about 18 times more prosperous as compared to an average Indian. Yet, India has just 4 per cent of the total cases and 2.3 per cent of the comparable figures in the USA. India's death-per-million at 'one' is significantly lower than the global average of 52.8. India's relatively light exposure to Covid-19 is a puzzle.

What explains this asymmetry across countries.? A particularly stringent and early lockdown, intensive testing and tracking of cases, a responsive public health interventions, are some theories put forth to explain the lower incidence in some countries. However, while all the above have a significant role in slowing the spread of the virus, they alone do not adequately explain the wide variations across countries.

The relative success of the nations with lower incidence and deaths are widely attributed to geography and demographics. It is conjectured that the virus has a lower lifespan in hot temperatures. The tropical climates foment disease, particularly malaria. The first line of explanations centres around the use of domestic hydroxychloroquine use to combat malaria and the universal BCG vaccination against tuberculosis, which appears to have provided a level of immunity against the virus.

The second line of explanations centres around India's favourable demographics. India has a relatively young population, with more than 50 per cent below the age of 25 years and more than 65 per cent below the age of 35 years. Others question, whether Indian's endemically are at some level immune to Covid19?

The data also suggests that higher-income countries are more vulnerable to the virus. Further, large nations with respect to populations have also recorded lower incidence of the pandemic, suggesting effectiveness and scale economies in the operation of health systems. Other explanations suggest that developing countries are at an early stage of the pandemic, and question validity of the data with respect to reporting and testing of cases.

COVID-19 represents a global public health emergency, and its economic consequences could surpass the global financial crises of 2008–09 (Loayza and Pennings, 2020). Policy makers are grappling with the competing objectives of the effectiveness and socioeconomic consequences of the containment and mitigation policies. The economic costs of the lockdown and other interventions control the spread of the virus and save lives are increasingly severe.

Almost all countries have intervened intrusively, albeit, at different times, employing a wide array of policy instruments at their disposal to control the pandemic. The countries which acted early, appear to have done well in controlling the pandemic. The early lockdown in India delayed the epidemic peaking by at least three months, which assisted the general population in making lifestyle changes, and the government to build surge capacity in the public health systems.

The exponential growth in pandemic has overwhelmed the public health systems of all major countries. Many countries have invoked war provisions to tackle the rapidly evolving crisis. Current reports worldwide indicate a flattening of the curve across most countries purportedly driven by improvements in the level of testing and recoveries, however, India, Brazil, Russia are prominent exceptions.

This study is of interest to all given the unprecedented scale and global nature of the Covid19 pandemic and its devastating impact on the global economy. In this study, we empirically examine the impact of temperature, population, and income to explain the asymmetry in the spread and severity of the Covid19 pandemic.

The paper is structured as follows. In section 2, we review the literature on the socio-economic determinants of Covid19 transmission. In Section 3, we discuss the data and descriptive statistics of key variables. In section 4 we present the results, and finally, in section 5 we conclude

2 literature review

Seasonal variations affect the intensity of infectious diseases (Sajadi et al., 2020). Temperature is considered an important variable affecting the transmission of COVID-19 virus. Most studies suggests a positive correlation with temperature (Bannister-Tyrrell et al., 2020; Oliveiros et al., 2020; Notari and Torrieri, 2020). On the other hand, some studies like Yao et al. (2020), hold that there is lack of any association between transmission of COVID-19 and temperature.

International travel restrictions helped slow the virus spread across the world (Chinazzi et al., 2020). Social distancing, isolation, and hygiene, rather than long-distance travel restrictions have played the largest part in controlling the virus spread (Kraemer et al., 2020). Rocklöv and Sjödin (2020) argue that high population densities catalyze the spread of COVID-19. To avoid close proximity, Kim et al. (2020) argue for delaying the opening schools. However, Murgante et al. (2020), find that denser and bigger regional capital cities are not affected any more than their less dense neighbouring provinces.

Walker et al. (2020) dwells on differences in demography, social structure and availability of health care systems and quality combine which can potentially influence the impact of measures that can help reduce the spread of the virus. Krieger, Chen, and Waterman (2020) argue that there is excess mortality in men as compared to women in the COVID-19 pandemic. The cardiovascular mortality is higher in African Americans with COVID-19, and more so in African American communities in large cities (McGonagle et al., 2020). The surge in excess death rates was higher in jurisdictions with higher poverty, higher household crowding, higher percentage of populations of color, and higher radicalised economic segregation (Chen et al., 2020).

The human and economic costs are likely to be larger for developing countries, which generally have lower health care capacity, larger informal sectors, shallower financial markets, less fiscal space, and poorer governance (Loayza and Pennings, 2020). The challenges low and middle income countries face up to COVID-19 where comorbidities abound with diverse quality in healthcare systems are studied in (Shuchman, 2020).

Wilder-Smith, Chiew, and Lee (2020) argue that traditional public health measures would be effective in reducing peak incidence and global deaths. Laster Pirtle (2020) argue that government interventions should address social inequality to achieve health equity across pandemics as the poor appear to be more vulnerable. The failure to extend protection to vulnerable sections of the society increases the risk of the virus spread with severe health and economic consequences for all (Devakumar et al., 2020). San Juan (2020) argue for a socialist perspective in policy responses to the pandemic, including nationalization of private hospitals for a more affective to better equip the state to deal with evolving and future pandemic.

3 data and descriptive analysis

3.1 Response Variables

The total number of cases, deaths, tests, recovered and active cases and also calculated per million are popular measures to assess the spread, severity and effectiveness of the policy intervention to combat the Covid-19 virus.

We collate the above statistics on the COVID-19 pandemic from online[1] resources. We consider the following response variables.

- Total cases (tc)
- Total deaths (td)
- Total tests (tt)
- Total recovered (tr)
- Active cases (ac)
- Total cases per million (tc1m)
- Total deaths per million (td1m)
- Total tests per million (tt1m)
- Total recovered per million (tr1m)
- Active cases per million (ac1m)

- Calculated Ratios
  - Total deaths as % of active cases (tdac)
  - Total tests as % of active cases (ttac)
  - Total recovered as % of total tests (trtt)
  - Total death per million as % of total cases per million (td1mtc1m)
  - Total tests per million as % of total cases per million (tt1mtc1m)
  - Total recovered per million as % of total cases per million (tr1mtc1m)
  - Active cases per million as % of total cases per million (ac1mtc1m)
  - Total death per million as % of active cases per million (td1mac1m)

We consider the following explanatory variables.

[1] https://www.worldometers.info/coronavirus/countries

- Total Population (size)
- GDP per Capita (income)
- Temperature[2] of Capital city (temp)
- Planned/Market Economies (plan)

3.2 Explanatory Variables

We categorize countries on the basis of temperature (temp) in Celsius, GDP per capita (income) in USD and Population (size) in Million in Table 1

Table 1 Categorisation of Countries

	Temp	Income	Size
1	<18˚C Cold	$3000 Low	<4.3M Small
2	18-25 ˚C Moderate	$3000-15000 Middle	4.3-18.7M Medium
3	>25˚C Hot	> $15000 High	>18.7M Large

The data on temperature is of the country's capital city. However, one temperature may not be representative for a large country, and therefore a significant limitation.

The communist economies have centralized planning, and the market economies are the most decentralized. We hypothesize that the planned economies are better positioned to manage the Covid19 crises. The data on communist influence is a proxy for planning in the economy, as countries like India have a history of planning.

We categorised all countries into three categories on the basis of planning (Dawson, 2017). First, countries belonging to the erstwhile Soviet state. Second, other countries with communist influence. Third, all other countries, are considered market economies.

The Soviet Union dissolved into 15 countries in the early 1990s, under turbulent circumstances. The progress of newly independent countries on the path to a market-driven economy has been mixed. Consequently, the analysis of these countries is not expected to be conclusive.

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2 https://www.timeanddate.com/weather/?sort=1low=c

3.3 Descriptive Statistics

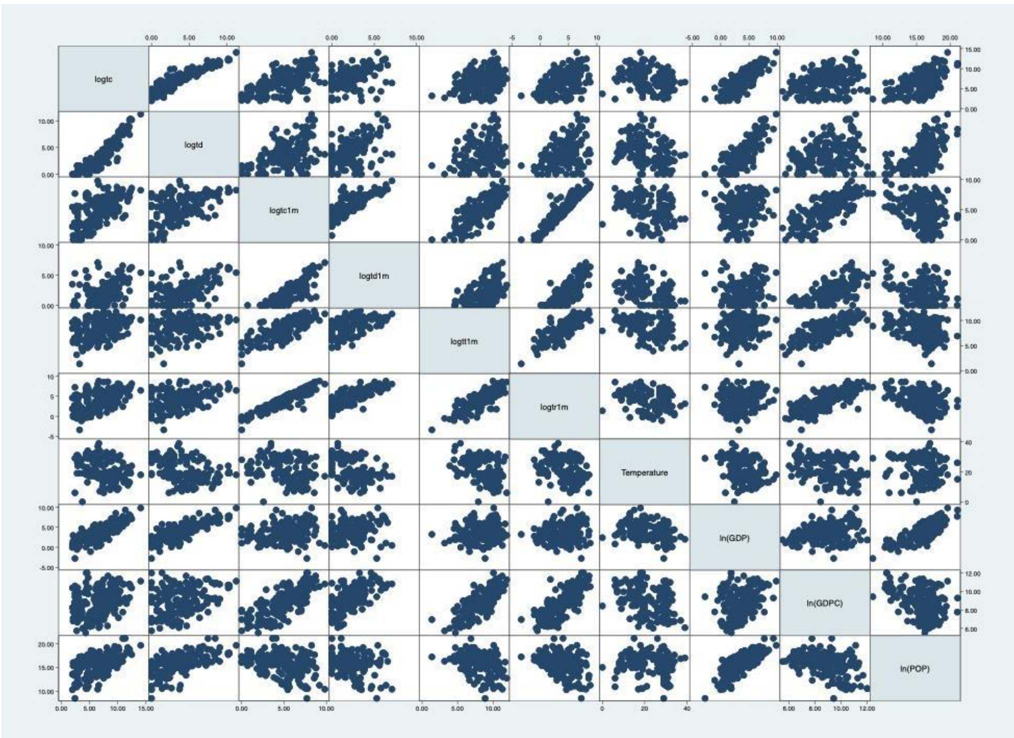
The mean and standard deviations of the various response variables, for the countries categorised by income are presented in Table 2. The average total cases (tc) for low income, middle income and high income countries are 2081, 14666 and 42118 respectively. The positive correlation with income is also identified in respect of total deaths (td), total tests (tt), total recovered (tr) and active cases (ac). The descriptive statistics indicate that the rich countries are more afflicted [3] . This positive correlation is identified in respect of the statistics calculated per million of population.

The total deaths per million as ratio of total cases per million (td1mtc1m), is most adverse for the high income countries. This is counter intuitive, as rich countries are expected to have superior health care systems.

The total tests per million (tt1m) is highest for the rich countries, as expected. However, total tests per million as ratio of total cases per million (tt1mtc1m), in respect of low income countries is the best and the rich countries the worst.

In respect of the total recovered cases per million as ratio of total cases per million (tr1mtc1m) the performance of middle countries is the best. However, middle income countries have performed poorly on the parameter - total deaths as a ratio of active cases (tdac) and total deaths per million as ratio of active cases per million (td1mac1m).

Fig. 1 Correlations with Temperature, Income and Size



[3] https://www.pewresearch.org/fact-tank/2020/04/22/populations-skew-older-in-some-of-the-countries-hit-hard-by-covid-19/

Table 2 Means and SDs of Variables

Variable	Low	Middle	High	Total
tc	2081.60	14666.31	42118.04	20402.73
	7565.48	35168.48	161000.00	99222.54
td	74.17	692.72	3644.21	1627.49
	267.80	1640.78	11600.17	7334.94
tt	79430.91	180000.00	432000.00	251000.00
	223000.00	630000.00	1110000.00	802000.00
tr	622.28	6615.03	13415.31	7160.85
	2180.11	18256.03	38546.28	25680.54
ac	1431.10	7447.94	25722.08	12015.96
	5233.78	22007.25	121000.00	73848.67
tc1m	67.58	414.73	1957.25	851.34
	177.56	551.25	2759.47	1864.54
td1m	1.56	17.39	123.16	52.74
	2.52	31.76	217.58	145.32
tt1m	2019.16	6781.23	31948.55	15249.32
	3834.86	8148.19	28777.65	22838.73
tr1m	25.56	166.79	915.56	387.55
	101.08	260.35	1365.19	913.17
ac1m	42.10	232.75	954.66	428.14
	111.35	362.51	1912.19	1220.30
td1mtc1m	3.97	3.87	5.14	4.38
	7.63	3.00	4.79	5.35
tt1mtc1m	13153.52	6769.83	3937.56	7304.75
	26587.08	21605.45	4865.64	19123.18
tr1mtc1m	1.88	3.79	3.22	3.09
	2.52	5.97	4.46	4.75
ac1mtc1m	57.45	50.36	41.64	49.52
	26.51	26.44	28.30	27.77
tdac	13.13	48.79	19.01	26.83
	22.54	225.87	24.50	129.51
ttac	49780.26	68265.37	20811.71	45302.23
	127000.00	366603.00	37901.16	230000.00

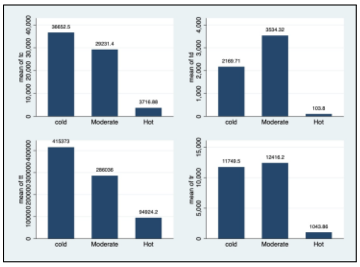


Fig. 2 Temp

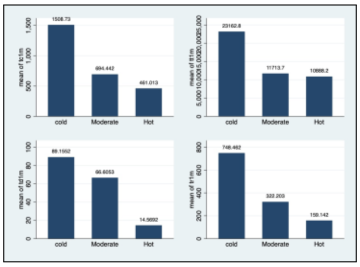


Fig. 3 Temp 1m

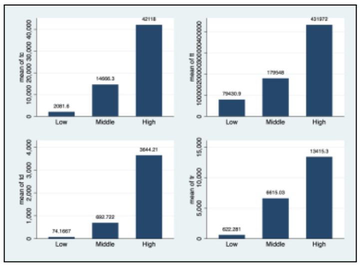


Fig. 4 Income

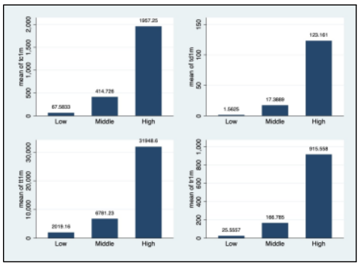


Fig. 5 Income 1m

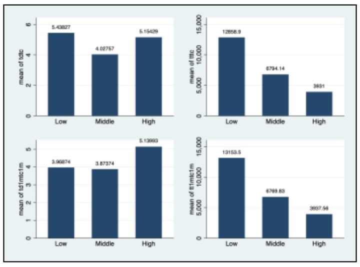


Fig. 6 Income (% of Tc)

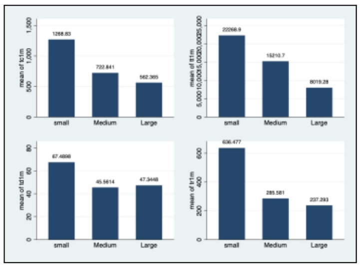


Fig. 7 Size 1m

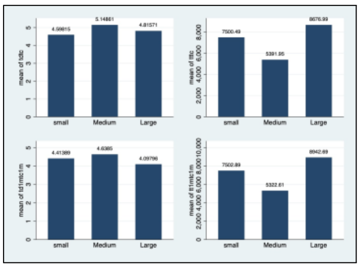


Fig. 8 Size (% of Tc)

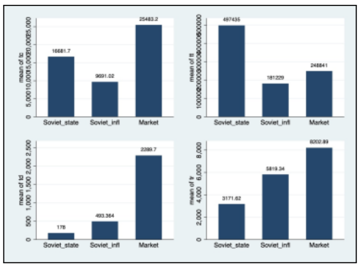


Fig. 9 Economy

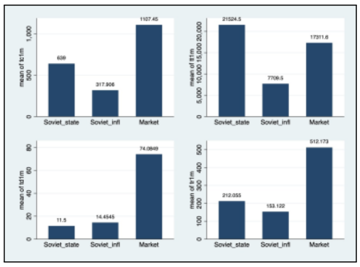


Fig. 10 Economy 1m

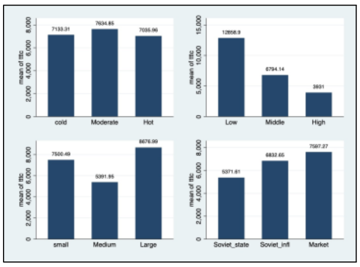


Fig. 11 tttcx

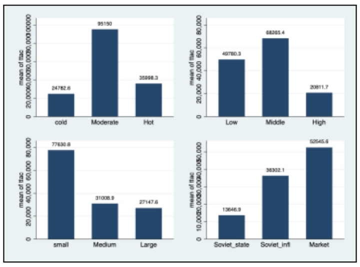


Fig. 12 ttacx

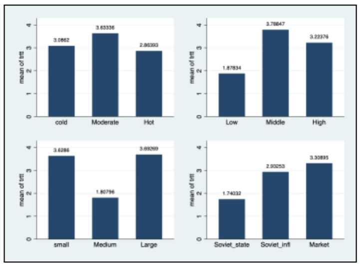


Fig. 13 trttx

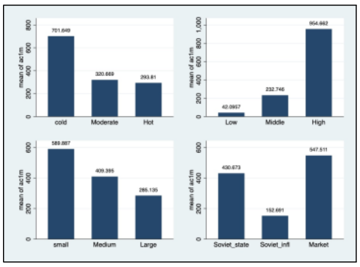


Fig. 14 ac1mx

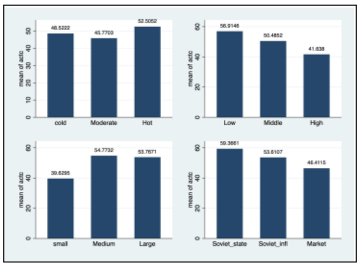


Fig. 15 actcx

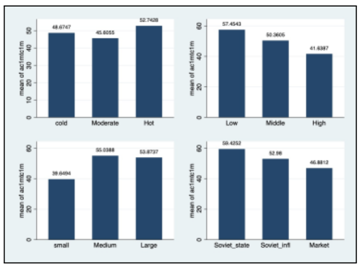


Fig. 16 ac1m.tc1mx

In Figure 1, we examine relationship among key variables of interest. The following relationships can be identified from the matrix scatter plot .

- Temperature has an inverse correlation with tc, td, tc1m, td1m,tt1m and tr1m.
- GDP per capita (GDPC). This measure of income has a direct correlation with tc, td, tc1m, td1m, tt1m and tr1m.
- Population (size) has a positive correlation with tc and td, and an inverse relationship with tc1m, td1m, tt1m and tr1m.
- Population (size) has an negative correlation with income, indicating that more populous countries have less income.

The trends identified in the scatter plot are investigated further. Figure 2, and Figure 3, indicate an inverse correlation between temp and tc, tt, and tr. However, td is higher in countries with moderate temperature. The results indicate an inverse correlation of temperature and tc1m, td1m, tr1m and tr1m.

The results indicate a positive correlation of GDP per capita (income), with the key response variables. High-income countries are affected more. Figure 4, and Figure 5, indicate that income has direct correlation with tc, td, tt and tr. Figure 6 indicates that total deaths calculated as a ratio total cases, are similar across countries in all three income groups. The results also suggest that high-income countries test significantly less as compared to low-income countries.

Figure 7, indicates that population (size) has a negative correlation with the spread of the pandemic. The larger countries have lower tc1m, td1m, tt1m, and tr1m. This suggests some kind of scale economies in the public health systems. Figure 8 indicates that the results are similar for statistics calculated as a ratio of total cases (tc).

Figure 9, indicates the impact of openness in the economy on the pandemic. The planned economies have performed better, as they have lower total cases (tc), total deaths (td) and they have tested (tt) more as compared to the market economies. The erstwhile Soviet countries have on average tested (tt) the most. However, total recovered (tr) cases are the least for these countries. The results are similar for the statistics calcuated per million Figure 10. This could suggest inefficiencies in the testing infrastructure of these countries.

Figure 11, indicates how countries have fared on the parameter total tests as a ratio of total cases (tttc). The high income countries have performed poorly on this parameter and have tested the least. The performance of the low income is best on this parameter. A possible explanation is that the rich countries were affected first, and consequently are on a different stage of the pandemic. The scale of afflictions appears to have overwhelmed the public health systems of these countries. The results also indicate that the market economies have performed better than planned economies.

Figure 12, indicates that on the parameter total tests as the ratio of active cases (ttac), the smallest countries performance is the best and the largest the poorest. The results also indicates that high-income countries performance is the poorest on this parameter. The market economies have performed well on this parameter.

In Figure 13, we examine the total recovered as a ratio of total tested (trtt). The higher income countries have done better, and the rich countries also have significantly higher levels of recoveries. The low-income countries scored highest on the parameter (tttc), have performed poorly on the parameter (trtt). This result requires to be investigated further, as it suggests to inefficiencies in the testing infrastructure and administration.

In Figure 14, we examine active cases per million (ac1m). The results are broadly consist with the finding of tc1m. The number of active cases per million is highest in the cold countries and the lowest in hot countries. The average of ac1m is highest in high income groups and least in low income group countries. Similarly, the small countries have higher incidence of the ac1m. The active cases per million are also significantly higher in the market economies, as compared to the planned countries.

In Figure 16, we examine active cases per million as ratio of total cases per million (ac1m.tc1m). The high-income countries and market economies have performed well on this parameter, with least ratings. The hot countries have highest values indicating that their performance is the worst. This result is against earlier findings that temperature has a negative correlation which lends support to the hypothesis that the virus is less potent in hot temperatures. The results indicate that larger countries have not performed well on this parameter.

Figure 15 and Figure 16 indicates the performance on the parameter, active cases as a ratio of total cases (actc) and the statistic calculated per million (ac1m.tc1mx). The smaller countries, high-income countries and market economies have performed well on this parameter, with the least scores. The hot countries have performed the worst on this parameter.

4 results of the empirical analysis

4.1 The Empirical Model

Our discussion in section 3 suggests that the response variables vary across the countries with changes in income, size and temperature. Accordingly, for our analysis we estimate the following analysis of covariance model.

$$\log(Y_i) = \alpha + \beta_1 \mathrm{TEMP} + \beta_2 \mathrm{POP} + \beta_3 \mathrm{INC} + X_i^{0}\delta + \varepsilon \qquad (1)$$

This above specification is similar to standard specifications used in the empirical industrial organization literature to evaluate the impact of policy interventions on performance. We use a Log-linear model in which TEMP, POP, and INC are dummy variables categorising the countries by temperature, population (size) and income as described in Table 2.

TEMP categorizes countries as cold, moderate and hot. POP categorizes countries as small, medium and large countries. INC classifies the countries on the basis of GDP per capita as lower income, middle income, and high income countries. X denotes the vector of control variables and ε denotes the error term with the usual classical properties.

4.2 Regression Results

The regression model is estimated for each response indicator. Table 3 reports the results of the regressions that were estimated by Ordinary Least Squares (OLS) technique.

The coefficient of the dummy variable ’Middle’ income is positive and significant at the 1 percent level in the models - (1) log of total deaths (logtd), (2) total cases per million (logtc1m), (3) total deaths per million (logtd1m), (4) total tests per million (logtt1m). The coefficient is negative and significant at 5 percent level in the model logtttc.

All the models are log-linear. The coefficients have a percentage interpretation in log-linear models. e.g. in the logtc1m model, the coefficient of ’Middle’ is 1.951, indicating that on average ’Middle’ income countries have tc1m 195 percent more than low-income countries.

The results are similar in respect of the dummy variable ‘High’ income countries indicating a higher level of afflictions in high-income countries. In the logtd1m, model, the coefficient of “Hot’ is negative 1.124 and significant at 1 percent level. The results indicate that hot countries have on average, 112 percent less total deaths per million (td1m) than cold countries.

In the log(tttc) model, the coefficient of ‘High’ income is negative 0.526 and significant at 10 percent level. The results indicate that countries in the Middle-income category score on average 52.6 percent less on the parameter - total tests as a ratio of total cases.

In respect of population (size), the coefficient of ‘Medium’ and “Large’ is positive and significant at 1 percent level. The results indicate that larger countries have a significantly higher number of deaths from the Covid-19. The result is to be expected, larger the size, more the number of cases. The results of the regression on logtc1m model is interesting. The coefficient of Medium and Large are negative, but not significant. The results suggest scale-economies in public health systems. In the logtttc regression, the coefficient of Medium, and Large is negative but not significant.

In respect of temperature, the coefficient of ‘Hot’ is negative and significant at the 1 percent level in logtd, logtc1m, logtd1m, and logtt1m. The results are similar for Moderate temperature. The results indicate that temperature has a negative impact on the spread and severity of the Covid-19 virus.

In respect of coefficient 'Market', the coefficient is not significant in any of the models, In the model logtd, the sign of 'Market' is negative. The coefficient is positive in the models logtc1m and logtd1m. The positive sign in td and negative sign of coefficient in td1m could be due to a low density of population. The 'market' dummy also indicates lower tests lower (per million) and lower tests as a ratio of total cases.

5 discussion and conclusions

The results indicate that high-income countries are most afflicted and with more severity. The high-income countries are best equipped to manage this pandemic with relatively lower population densities and superior public health systems. It is, therefore, to be expected that these countries will test more, and consequently have higher recoveries. However, on the parameter ' total tests as a ratio of total cases' the high-income countries have performed the worst, this suggests that they should test significantly more. However, on the parameter ' total recovered as a ratio of total-tested' the high-income countries have performed significantly better than the low-income countries. The low-income countries, performed best on the parameter ' total tests as a ratio of total cases', however, they performed poorly on the parameter ' total recovered as a ratio of total cases'. The results suggests inefficiencies in the administration of the tests, including the testing kits.

Our analysis supports a priori expectations that temperature has a benign effect, that temperature negatively impacts the spread and severity of the virus. The temperature recorded is of the capital city. With substantial variations across geographies, one temperature may not be representative of a vast country and is a limitation of this study. Our analysis of active cases per million as a ratio of total-cases per million does not support our hypothesis that the virus is less potent in hot temperature. The contrary results on other parameters raise the suspicion that hotter countries are in the early stages of the pandemic.

The results indicate that size has a benign effect on the spread and severity of the virus. The large countries have less number of cases and deaths per million. This result is interesting and also counterintuitive. Russia and the USA, are two of the most affected countries by the pandemic. These two countries are also among the largest countries in the world.

The planned economies have a more comprehensive array of policy instruments, organization structure and the experience to facilitate more direct interventions in response to such contingencies at the national level. The 'universal immunization programmes' during the communist regime and in other planned economies could have made these societies more resistant to the Covid-19 virus; however, the results do not provide support to this hypothesis.

Some limitations of the study. The temperature could vary significantly across geographies, and one temperature may not be representative of a vast country. The study does not control for age of the population. Most high-income countries have a significantly higher average age. Further, with and a significantly large proportion of the elderly in these countries, age could be a significant variable explaining the spread and severity.

The trends observed in the large metropolitan cities of India suggest that the density of the population appears to be an essential variable. The extend of public transportation and their usage, including overcrowding in high-density public transportation systems, are also considered important variables affecting the spread and severity of this pandemic.

The ’stage’ of the pandemic in a country is a critical input, and it varies widely across countries. It appears to be mainly contingent on the agility and comprehensiveness of a country’s response to the pandemic and the capacity of its public health systems. Other factors which could affect it are the openness of an economy to trade, FDI and international travel.

Table 3 Effect of Temperature, Income, Size, and Market Economy

	logtd		logtc1m		logtd1m		logtt1m		logtttc	
Middle	1.841***	(0.000)	1.951***	(0.000)	1.047***	(0.002)	1.402***	(0.000)	-0.635**	(0.030)
High	2.712***	(0.000)	3.561***	(0.000)	2.419***	(0.000)	3.110***	(0.000)	-0.526*	(0.091)
Medium	2.290***	(0.000)	-0.022	(0.941)	-0.351	(0.231)	-0.141	(0.571)	-0.078	(0.773)
Large	4.177***	(0.000)	-0.097	(0.744)	-0.104	(0.729)	-0.434*	(0.088)	-0.343	(0.215)
Moderate	-0.988**	(0.011)	-0.888***	(0.006)	-0.200	(0.552)	-0.615**	(0.026)	0.296	(0.321)
Hot	-1.423***	(0.000)	-0.766***	(0.007)	-1.124***	(0.000)	-0.866***	(0.001)	-0.091	(0.733)
Market	-0.044	(0.891)	0.081	(0.750)	0.342	(0.212)	-0.049	(0.830)	-0.111	(0.655)
Constant	0.845*	(0.077)	3.640***	(0.000)	1.365***	(0.001)	7.423***	(0.000)	8.424***	(0.000)
Observations	161		184		142		166		166	
F	30.684		30.467		16.956		31.900		1.055	
r2	0.584		0.548		0.470		0.586		0.045	
ll	-309.481		-331.155		-239.801		-266.675		-280.812	

p-values in parentheses

Corona Virus Statistics: (i) Cases (ii) Deaths (iii) Tests

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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