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The Interaction between Youthfulness and COVID-19 in a Bio-Socio-Economic Context: A Rare Event Analysis

Ibrahima Amadou Diallo*

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Abstract

This paper studies the relationship between Youthfulness and COVID-19 using a wide sample of countries around the world. It utilizes the new Generalized Extreme Value (GEV) estimation technique to analyze the effect of being young on the probability of high COVID-19 modeled as a rare event. The results illustrate that an increase in young people in a country reduces the probability of high COVID-19. The empirical findings also show how numerous other Bio-Socio-Economic variables affect the probability of high COVID-19. The negative impact of Youthfulness on the probability of high COVID-19 is maintained when we control for subsamples of Least Developed Countries (LDCs) and Non-Least Developed Countries, and perform several other robustness checks.

Keywords: COVID-19; CORONAVIRUS; SARS-CoV-2; Youth; Generalized Extreme Value (GEV) Distribution; Infectious Diseases

JEL Classification: A12, I12, I15, I18, I19, O57

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1 Introduction

The COVID-19 pandemic is one of the most disturbing global health crises of the twenty-first century. It has instigated millions of deaths and disturbed the lives and livelihoods of billions of people. As of October 2023, according to the World Health Organization (WHO), there have been 771549718 *confirmed cases* of COVID-19 and 6974473 *deaths* worldwide. The global case fatality rate (CFR) is about 0.9%¹. However, these numbers might not reflect the true extent of the pandemic, because many cases and deaths may go undetected or unreported. Likewise, the Spanish flu was the deadliest pandemic of the twentieth century. It happened between 1918 and 1920, and infected an estimated 500000000 *people*. The death toll is inexact, but it is assessed to be around 33500000. The global CFR was approximately 5.85%. Based on these numbers, we observe that the COVID-19 pandemic has exceeded the Spanish flu in terms of the number of confirmed cases, but not in terms of the number of deaths or the CFR. Nonetheless this comparison should be understood with carefulness, since there are many factors that affect the correctness of the data. It is hard to compare the two pandemics directly as they are infecting dissimilar people in dissimilar times. However, it is worth noting that the COVID-19 outbreak has become the most infectious pandemic in world history, exceeding the 1918-1920 flu pandemic in terms of infections. In simple words, these data make studying the COVID-19 pandemic an important research topic because it can improve our knowledge, health, and resilience in the face of a global challenge and show us the ways to overcome and deal with it. This is what motivated this current research paper.

[Hartl, Walde, and Weber \(2020\)](#) demonstrate that the growth rate of COVID-19 cases in Germany decreased from 26.7% to 13.8% in 7 days after the enactment of lockdowns in the nation. [Ferguson, Laydon, Nedjati Gilani, and Others \(2020\)](#) suggest that a combination of several interventions is essential to have a considerable effect on transmission. The optimal mitigation strategy, which includes case isolations, home quarantining, and social distancing of risky groups, would decrease the number of deaths by half and the demand for beds in intensive care units by two-thirds in the United States and the United Kingdom. [Hsiang, Allen, Annan-Phan, and Others \(2020\)](#) illustrate that social distancing measures avoided around 62 million confirmed cases, corresponding to the avoidance of roughly 530 million total infections in China, South Korea, Italy, Iran, France, and the United States in 7 days.

¹The case fatality rate (CFR) is a measurement of the proportion of confirmed cases that result in death. It is computed as the number of confirmed deaths divided by the number of confirmed cases.

[Gourinchas \(2020\)](#) states that a modern economy is an intricate web of interrelated modules. A collapse in the circular flows and in the supply chains, due to the COVID-19 pandemic, will have cascading impacts. [Carlsson-Szlezak, Reeves, and Swartz \(2020a,b\)](#) identify three main transmission channels of the COVID-19 pandemic. The first channel is the direct impact, which is associated to diminished consumption of goods and services. Extended lengths of the pandemic and the simultaneous social distancing measures might decrease consumer confidence by restraining consumers at home, cautious of discretionary spending, and doubtful about their long-term economic prospects. The second channel is the indirect impact happening through financial market shocks and their impacts on the real economy. Household wealth will probably drop, savings will augment, and consumption spending will decline further. The third channel is made up of supply-side disruptions. As restrictions hinder production activities, they will harmfully affect supply chains, labor demand, and employment, causing prolonged periods of firings and mounting unemployment. [Baldwin \(2020\)](#) highlights the expectation shock by which a “wait-and-see” behavior is espoused by economic agents. He states that this is usual throughout economic situations characterized by uncertainties, as there is less sureness in markets and in entering in economic transactions. Eventually, the magnitude of the shock is characterized by the epidemiological characteristics of the virus, consumer behavior, and firm behavior in the face of adversity and uncertainty, and public policy actions.

Examining the effects of COVID-19 on small firms, [Fairlie \(2020\)](#) discovers that the number of active business owners in the United States of America decreased by 22% between February and April 2020. Female and immigrant-owned businesses were disproportionately impacted. According to a study by [Kahn, Lange, and Wiczer \(2020\)](#), companies in the United States diminished job vacancies significantly from the second week of March 2020, which coincided with a rise in Unemployment Insurance Claims. The decline in job vacancies was uniform across states, industries, and occupations, except for front-line jobs such as nursing. The study discovered no significant differences in labor market decreases across states that experienced the spread of the pandemic or implemented stay-at-home orders sooner than others. [Gupta, Montenovo, Nguyen, and Others \(2020\)](#) find that the employment rate in the United States dropped by approximately 1.7 percentage points for each additional 10 days that a state established a stay-at-home mandate between March 12th and April 12th.

Hermosilla, Ni, Wang, and Zhang (2020) illustrate that COVID-19 has ejected non-COVID-19-associated health care demands in China. A study by Brodeur, Clark, Fleche, and Powdthavee (2021) finds a significant rise in Google searches for “loneliness” and “boredom” throughout the post-lockdown era in nine Western European Countries and the United States. Knittel and Ozaltun (2020) discover a positive association between the portion of elderly population, the prevalence of commuting using public transportation and COVID-19 deaths in the United States of America. The authors also find that there is no evidence of a relationship between the death rate and obesity rates, the number of intensive care unit beds per capita, or poverty rates.

Almond, Du, and Zhang (2020) argue that, as a whole, the general lockdown and the substantial stagnation of economic activities are anticipated to have a positive impact on the environment in China.

Similar to the works cited above, this paper studies the COVID-19 disease. Compared to the previous works, it makes numerous contributions. First, this is the first study to explicitly examine how Youthfulness affects the probability of high COVID-19 in a wide sample of countries around the world. Second, we analyze the COVID-19 illness in a Bio-Socio-Economic context by investigating how numerous other Bio-Socio-Economic variables affect the probability of high COVID-19. Third, although most of the countries in the world are affected by COVID-19, we believe that this impact is not uniform. Thus, some countries are more impacted than others. To highlight this effect, we use a Latent Profile Model to classify the countries in the world into Low COVID-19 and High COVID-19 countries. Fourth, since there is a high asymmetry in the distribution of the Low COVID-19 and the High COVID-19 countries, we use an estimation technique explicitly tailored to handle rare events phenomena, specifically the new Binary Generalized Extreme Value (GEV) estimation method. This classification scheme and this estimation technique have not been used in the previous literature of COVID-19. Our results show that Youthfulness has a negative and statistically significant impact on the probability of High COVID-19. That is, an increase in the Young People in a country reduces the probability of High COVID-19. We also find that an increase in the Older Population in a country augments the probability of High COVID-19. Additionally, our results illustrate how numerous other Bio-Socio-Economic variables affect the probability of high COVID-19. These results remain unchanged when we perform various robustness checks including: control for subsamples of Least Developed Countries (LDCs)

and Non-Least Developed Countries, World Bank Regions, World Bank Income Groups, the use of small samples and the use of different estimations techniques.

The remaining of the paper is organized in the following manner: the first section presents the conceptual framework, the second section exposes the econometric models and estimation methods, the third section exhibits the data, the fourth section displays the results and the last section concludes.

2 Conceptual Framework: The Latent Profile and Random Utility Models

Although most of the countries in the world are affected by COVID-19, we believe that this impact is not uniform. Thus, some countries are more impacted than others. To highlight this effect, we use a Latent Profile Model to endogenously classify the countries in the world into Low COVID-19 and High COVID-19 countries. That is, we use the information given by the data to classify the countries without setting ourselves the threshold. But we let the model and the data to speak and reveal the classes by using the internal information given by the data. The latent profile analysis that we conduct here is a statistical technique that aims to identify the underlying groups or classes of countries based on their COVID-19 Status. We use the number of confirmed cases, deaths, and recovered cases of COVID-19 per 100000 people as the indicators of the COVID-19 status. Since these indicators are continuous, we apply a latent profile model with two classes, and assigns each country to the class that has the highest probability of generating its observed values of the indicators. We then create a binary variable, COVID-19 Status, that indicates whether a country belongs to the Low COVID-19 Class (0) or the High COVID-19 Class (1).

In terms of the random utility model, the latent profile analysis conducted here can be interpreted as follows. Each country has a latent propensity or characteristic of being a High COVID-19 country, which is determined by a combination of the indicators and a random error term. The latent propensity is unobserved, but it can be inferred from the observed values of the indicators. The combination of indicators and random error term is used to estimate the latent propensity of each country to belong to each class, and the class with the highest propensity is assigned to the country. The COVID-19 Status variable is the observed outcome of this assignment process. For example, if a country has a high number of confirmed cases and deaths, and a low number of recovered cases, it will have a high propensity to belong to the class of High COVID-19 countries, and a low propensity to belong to the class of Low COVID-19 countries. The model will assign this country to the High COVID-19 class. Hence, this allows us to classify the countries in our sample as whether they are a Low COVID-19 or a High COVID-19 country.

In our resulting database that we created from this categorization process, we verified that most of the countries classified by the Latent profile model as Low COVID-19 countries are

indeed those categorized by *The news media* as Low COVID-19 countries. Similarly, most of the countries classified by the Latent profile model as High COVID-19 countries are indeed those categorized by *The news media* as High COVID-19 countries. Thus, our Latent profile model does a pretty good job in the classification of the countries.

3 Econometric Models and Estimation Methods

To empirically analyze the effects of Youthfulness on COVID-19, we estimate the following econometric model:

$$\Pr(\text{COVID19Status}_j = 1 \mid \mathbf{x}_j) = F(\alpha + \gamma \text{PopulationAges014}_j + \mathbf{z}_j \boldsymbol{\delta}) \quad (1)$$

Where $\Pr(\cdot)$ denotes *Probability*. $F(\cdot)$ is the Cumulative Distribution Function of the *Generalized Extreme Value (GEV)* probability law to be specified below. \mathbf{x}_j is the vector of all *Explanatory Variables*. COVID19Status_j is the *COVID-19 Status*. This variable is our *Dependent Variable*. As explained in section 2, it is a binary variable indicating whether a country is a Low COVID-19 (**0**) or a High COVID-19 (**1**) country. $\text{PopulationAges014}_j$ is *Population Ages 0-14 over Total Population*. This variable is our measure of *Youthfulness* and it represents our *Variable of Interest*. \mathbf{z}_j is the vector of all *Control Variables*. These *Control Variables* constitute our measurements of the *Bio-Socio-Economic Variables* to be explained thoroughly further below. The *Coefficients of Interest* are α , γ and $\boldsymbol{\delta}$. The subscript j specifies the countries.

In our two databases that we use in this study, we inspected the variable *COVID-19 Status* to have a detailed view on its structure. We saw that the variable *COVID-19 Status* takes on two unique values, **0** and **1**. The value **0** denotes **Low COVID-19**, and **1** denotes **High COVID-19**. We observed that there are **124 Zeros** and **56 Ones** in the first dataset. We noticed that there are **138 Zeros** and **49 Ones** in the second dataset. Hence, there are far more **Zeros** than **Ones** in both datasets. Thus, there is an asymmetry in the distribution of **Zeros** and **Ones** in both databases. The number of **Ones** is rare relative to the number of **Zeros**. Consequently, these two particular datasets appropriately lend themselves to be modeled by the **Binary Generalized Extreme Value (GEV) Estimation Technique** because: first, the dependent variable is binary, and second, one of the outcomes is rare relative to the other. These are the reasons why we use the **Binary Generalized**

Extreme Value (GEV) Estimation Method in this work to estimate equation (1) because it allows to model the probability of events that are more extreme than any formerly noticed. That is, it is utilized to estimate the risk of extreme rare events in the context of binary variables. Also said differently, the **Binary Generalized Extreme Value (GEV) Regression Technique** estimates a model for a binary dependent variable, typically with one of the outcomes rare, or extremely rare, relative to the other. Please, see Diallo (2021) for how to implement this estimation method in the **Software Stata**². The theory behind the **Binary Generalized Extreme Value (GEV) Estimation Method** can be found in Calabrese and Osmetti (2013) and Wang and Dey (2010).

Now, we explain, in more details, the **Binary Generalized Extreme Value (GEV) Estimation Method**. In general terms, the estimated econometric model can be written as:

$$\Pr(y_j = 1 \mid x_j) = F(x_j\beta) \quad (2)$$

Where:

- $\Pr(\cdot)$ denotes *Probability*.
- y_j is the dependent variable. It is a Binary variable. That is, it can have only two possible outcomes. This means that it is a (1/0) or (Yes/No) outcome. Typically, one of these two outcomes is rare, or is extremely rare, relative to the other.
- x_j indicates the vector of independent variables.
- $F(\cdot)$ is the Cumulative Distribution Function of the Generalized Extreme Value (GEV) probability law.
- The vector of parameters β is typically estimated by Maximum Likelihood.
- j indicates the j th observation.

The Cumulative Distribution Function of the Generalized Extreme Value (GEV) probability law, $F(\cdot)$, has the following formula:

$$F(x_j\beta) = \exp \left\{ - \left([1 + \xi(x_j\beta)]_+ \right)^{-\frac{1}{\xi}} \right\} \quad (3)$$

With:

²For the interested reader, I introduce a new Stata User-Written command named “**probgenextval**” that Performs Estimations of Binary Generalized Extreme Value (GEV) Models. The command is downloadable at: <https://ideas.repec.org/c/boc/bocode/s459020.html>. Please, see this website for more details.

- $[1 + \xi(x_j\beta)]_+ = \text{Max}(0, 1 + \xi(x_j\beta))$
- ξ is the shape parameter. It can be any Real Number.

The log-likelihood function for the Generalized Extreme Value (GEV) model is:

$$\ln(L) = \sum_{j \in S} w_j \ln \{F(x_j\beta)\} + \sum_{j \notin S} w_j \ln \{1 - F(x_j\beta)\} \quad (4)$$

Where:

- S is the set of all observations j such that $y_j = 1$.
- $F(x_j\beta)$ is the Cumulative Distribution Function of the Generalized Extreme Value (GEV) probability law defined above.
- w_j denotes the optional weights.
- $\ln(L)$ is maximized as described in the `[R] Maximize` routine in **Stata**.

The command **probgnextval**, that implements this estimation technique in **Stata**, supports the Huber/White/sandwich estimator of the variance and its clustered version using **vce(robust)** and **vce(cluster clustvar)**, respectively. The command can also calculate the equation-level scores. The command **probgnextval** also supports estimation with survey data.

4 Data and Variables

As we thoroughly explained in sections 2 and 3, our *Dependent Variable* is *The COVID-19 Status*. Please, see these sections for more details on how this variable is calculated and what it is. Our *Variable of Interest* is *Population Ages 0-14 over Total Population*. This is our measurement of *Youthfulness*. It is calculated as *The Population between the Ages 0 to 14* divided by *The Total Population*. Our *Control Variables* are: Democratic Accountability, the Human Capital Index, Real Consumption over Real GDP, Gross Capital Formation over GDP, the Logarithm of GDP per Capita, Trade over GDP, Population Ages 65 Above over Total Population, the Logarithm of International Tourism Number of Arrivals, the Domestic Credit to Private Sector over GDP and the Logarithm of Life Expectancy at Birth Total Years. Our *Variable of Interest* and our *Control Variables* are part of what we call in this paper the *Bio-Socio-Economic Variables*. Now, let us explain what a *Bio-Socio-Economic Variable* means. A *Bio-Socio-Economic Variable*, first, relates to

biological living individuals, like: *Population Ages 0-14*, *Population Ages 15-64* and *Population Ages 65 Above*. Second, it is a *Social Variable* because these individuals live in a society and are part of a community where they interact with other persons. Third, it is an *Economic Variable* because these individuals engage in various economic activities and produce numerous economic outcomes, like: *Gross Capital Formation*, *GDP per Capita*, *Trade*, . . . , which affect the *Economy*. Here, the *Bio-Socio-Economic Nature* of these variables must be stressed because we are studying a disease which affects the lives, the behavior of people, the society and the wellbeing of individuals which all have an impact on the *Economy*. Hence, resulting in a complex interaction among these entities.

We suspect a potential endogeneity problem between our *Variable of Interest*, the *Control Variables* and the *The COVID-19 Status* because of the complex interaction that exists between the *Bio-Socio-Economic Variables* and *The COVID-19 Status*. To circumvent this potential endogeneity problem, we lag all our *Independent Variables* by at least one period compared to the *Dependent Variable*, in order to be on the safe side. Thus, in our first dataset that we use for the main results in the paper, the *The COVID-19 Status* is measured on the averages over the period 2020-2022. The *Independent Variables* are measured on the averages over the period 2017-2019. For the second database that we utilize in one of our robustness analysis, *The COVID-19 Status* is measured for the year 2020, while the *Independent Variables* are measured for the years 2018 or 2019 according to their availability. Hence, the *Variable of Interest* and the *Control Variables* are predetermined compared to the *Dependent Variable*. Consequently, there is no endogeneity issues in our estimated models using both datasets. We decided to proceed as such, because there does not exist, to this date, a *Binary Generalized Extreme Value (GEV) Estimator* that allows to explicitly take into account an endogeneity problem that might exist between the *Regressors* and the *Dependent Variable*.

As explained previously, we employ two samples in our estimations: the first one is used in our main regressions results and the second one is utilized in our robustness analysis. The two samples of study are cross-sectional data that contain 180 developed and developing countries, and 187 developed and developing countries in the world respectively. The choice of the samples is based on the availability of data and the choice of the variables of the study. The data on which *The COVID-19 Status* variable is calculated come from the **Stata Package** of Diallo (2023)³. This **Stata Package** is based on the works of Guidotti and Ardia (2020); Guidotti (2022). Please see also

³For the interested reader, I introduce a new Stata User-Written command named “`xtstfatchcovid19`” that downloads COVID-19 datasets from the COVID-19 Data Hub. The command is downloadable at: <https://ideas.repec.org/c/boc/bocode/s459212.html>. Please, see this website for more details.

the **COVID-19 Data Hub** web page for further information⁴. The data on the *Regressors* come from the World Bank (World Development Indicators, WDI, 2021 and 2023), the International Country Risk Guide (ICRG, 2019 and 2022) and the Penn World Tables (PWT, 10.0 and 10.01).

5 Econometric Results

In this part, we will present the main estimation results and the robustness analysis.

5.1 Main Estimation Results

Table 1 gives the Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status using the GEV Estimator with our first dataset⁵. All 8 equations, in the table, show that Youthfulness is statistically significant at all conventional levels and have the expected sign. Hence, an increase in Youthfulness reduces the predicted probability of High COVID-19. Since Youthfulness is a predetermined variable, it is possible to say that the negative relationship between Youthfulness and High COVID-19 seems to go from Youthfulness towards High COVID-19 and not the reverse. Our findings illustrate that, the negative effect of Youthfulness on High COVID-19 is robust to the introduction of different control variables. In fact, through the 8 equations we have varied the introduction of the control variables but the coefficient of Youthfulness retains its expected sign and is always statistically significant. The magnitude of the effect of Youthfulness on the predicted probability of High COVID-19 is very large. Referring to regression (5) in Table 1, a rise in Youthfulness by 1 unit decreases the predicted probability of High COVID-19 by 1.832. Said differently, this result indicates that if Youthfulness increases by 1 unit, the predicted probability of High COVID-19 decreases by 183.2 percentage points. Or more precisely, the change in the predicted probability of High COVID-19, for 1 instant change in Youthfulness, decreases by 183.2 percentage points. This is a very big value, suggesting that Youthfulness has a large diminishing impact on the predicted probability of High COVID-19. As we see, the marginal

⁴Browsable at: <https://covid19datahub.io>. Please, see this website for more details on the collection, the source and additional information on the data.

⁵In all the tables of results presented in this study, we use the short names forms of the variables due to space constraints. For a full name description of the variables, please see section 4. Also, in this study, we present only the Marginal Effects Tables, not the original tables of results giving by **Stata**, simply because the GEV Distribution is a nonlinear function as explained in section 3. Thus, the original coefficients are difficult to interpret since this function is highly nonlinear. The original tables of results are available upon request.

effect of Youthfulness on the predicted probability of High COVID-19 is very huge. In fact, larger than the marginal effect of any other variable in this table of results. This suggest that a way of reducing High COVID-19 is to increase Youthfulness in the country because countries that have huge Youthfulness tend to have Low COVID-19. In a *Bio-Socio-Economic Context*, some possible and plausible explanations could be. **Biological Factors:** Young people tend to have stronger immune systems and lower risk of chronic diseases than older people, which may make them more resistant to COVID-19 infection and complications. Also, young people may have less exposure to other coronaviruses that could enhance the severity of COVID-19 through antibody-dependent enhancement. **Socio-Cultural Factors:** Young people may have different social and cultural norms and behaviors than older people, which may affect their susceptibility to COVID-19. For example, young people may be more likely to follow public health measures such as wearing masks, social distancing, and hand hygiene, or they may have less contact with high-risk groups such as the elderly or health care workers. Alternatively, young people may have more access to information and education about COVID-19 prevention and treatment, or they may have more trust in the health authorities and the vaccine development process. **Economic Factors:** Young people may have different economic opportunities and constraints than older people, which may influence their vulnerability to COVID-19. For example, young people may have more flexible and remote work or study options, or they may have less dependence on public transportation or crowded places, which could reduce their exposure to the virus. In Table 1, we observe that the standard errors of the coefficients of Youthfulness are relatively small. This implies that the corresponding confidence intervals, though not reported, are tinier meaning that the coefficients of Youthfulness are estimated with great precision. The number of observations is approximately stable in all 8 equations, hence the phenomenon we are studying covers most of our sample. Many control variables are also statistically significant and have their expected signs. For example, GDP per Capita, Consumption and Human Capital have positive and significant effects, while Financial Development has a negative and significant impact. In a *Bio-Socio-Economic Context*, we could explain these findings on the control variables in the following manner. The positive impact of GDP per Capita could mean that, when Real GDP per Capita augments, work and economic activity become higher. This could in turn augment the contact rate, and through these means, rise the chance of infection when Real GDP per Capita becomes higher. The positive sign of Consumption

does not mean that consuming increases COVID-19. It simply says that the activity of consuming increases the contact rate between the infected and the susceptible populations, and through this, augments the probability of infection transmission. The positive effect of Human Capital simply means that increasing Human capital causes Work to increase, and through this medium, this augments the contact rate, which in turn, rises the chance of infection. The negative sign of Financial Development can be explained as follows. Financial Development can reduce the spread of COVID-19 by enabling better access to healthcare, information, and resources. For example, countries with more developed financial systems may have more efficient and effective health care systems, which can help detect and treat COVID-19 cases earlier and prevent further transmission. Financial development can also facilitate the distribution of medical supplies, vaccines, and other essential goods and services, which can help mitigate the impact of the pandemic. Additionally, financial development can promote digitalization and e-commerce, which can reduce physical contact and exposure to the virus.

Table 2 provides the Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status with Control for Democracy using the GEV Estimator. All 4 equations illustrate that Youthfulness is statistically significant at all conventional levels and have the expected sign. Hence, even after controlling for Democracy, Youthfulness continues to have a negative and significant effect on the predicted probability of High COVID-19. The absolute value of the impact of Youthfulness on the predicted probability of High COVID-19 continues to be very large even after the taking into account the effect of Democracy. Referring to regression (2) in Table 2, an augmentation of Youthfulness by 1 unit, reduces the predicted probability of High COVID-19 by 197.3 percentage points. Or more precisely, the change in the predicted probability of High COVID-19, for 1 instant change in Youthfulness, decreases by 197.3 percentage points. This is a very big value, in fact bigger than the magnitude of any other variable in the table including that of Democracy, suggesting that Youthfulness has a big reducing impact on the predicted probability of High COVID-19. In this table of results, we also investigate if *Institutions*, here *Democracy*, have an impact on the predicted probability of High COVID-19. We observe that, Democracy has a positive and significant effect on the predicted probability of High COVID-19. In a *Bio-Socio-Economic Context*, a first explanation could be that in democracies, governments are less inclined to establish draconian measures of **COVID-19 lockdowns** for fear of retaliations

from the electorate compared to autocratic governments. This could in turn augment the contact rate, and through this medium, rise the chance of infection in democracies. A second explanation could be that, in most democracies, work, economic activity and extra-activities are higher. This could in turn augment the contact rate, and through these means, rise the chance of infection in democracies. We observe that the standard errors of the coefficients of Youthfulness are relatively small. This implies that the corresponding confidence intervals, though not reported, are tinier meaning that the coefficients of Youthfulness are estimated with great precision. The number of observations is stable in all 4 equations, hence the phenomenon we are studying covers most of our sample.

Table 3 exhibits the estimation results of the Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status with Region Interaction using the GEV Estimator. All 2 equations illustrate that Youthfulness is statistically significant at all conventional levels and have the expected sign. Hence, even after interacting Youthfulness and the World Bank Regions, Youthfulness continues to have a negative and significant effect on the predicted probability of High COVID-19. The absolute value of the impact of Youthfulness on the predicted probability of High COVID-19 continues to be very large even after interacting it with the World Bank Regions. Referring to regression (2) in Table 3, an augmentation of Youthfulness by 1 unit, reduces the predicted probability of High COVID-19 by 285.2 percentage points. Or more precisely, the change in the predicted probability of High COVID-19, for 1 instant change in Youthfulness, decreases by 285.2 percentage points. This is a very big value, in fact bigger than the magnitude of any other variable in the table including that of the World Bank Regions, suggesting that Youthfulness has a big reducing impact on the predicted probability of High COVID-19. In this table of results, we also investigate if the World Bank Regions have an impact on the predicted probability of High COVID-19 by interacting Youthfulness and the World Bank Regions. We observe that, even after interacting Youthfulness and the World Bank Regions, some World Bank Regions have a significant effect on the predicted probability of High COVID-19 compared to the base level *East Asia & Pacific*. More precisely, referring to regression (2), we see that, the change in the predicted probability of High COVID-19 when the World Bank Region varies from *East Asia & Pacific* to *Europe & Central Asia* increases by 16.7 percentage points or 0.167, and is significant. The change in the predicted probability of High COVID-19 when the World Bank Region varies from *East Asia & Pacific* to *Latin*

America & Caribbean increases by 22.3 percentage points or 0.223, and is significant. The change in the predicted probability of High COVID-19 when the World Bank Region varies from *East Asia & Pacific* to *North America* increases by 33.3 percentage points or 0.333, and is significant. The change in the predicted probability of High COVID-19 when the World Bank Region varies from *East Asia & Pacific* to *South Asia* decreases by 33.8 percentage points or -0.338, and is significant. The change in the predicted probability of High COVID-19 when the World Bank Region varies from *East Asia & Pacific* to *Sub-Saharan Africa* decreases by 33.8 percentage points or -0.338, and is significant. In other words, in the following World Bank Regions: *Europe & Central Asia*, *Latin America & Caribbean* and *North America*, the predicted probability of High COVID-19 is increasing compared to the base level *East Asia & Pacific*. Whereas in the following World Bank Regions: *South Asia* and *Sub-Saharan Africa*, the predicted probability of High COVID-19 is decreasing compared to the base level *East Asia & Pacific*. In Table 3, we also observe that, Democracy continues to have a positive and significant effect on the predicted probability of High COVID-19.

Table 4 presents the Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status with control for Income Groups using the GEV Estimator. All 2 equations illustrate that Youthfulness is statistically significant at all conventional levels and have the expected sign. Hence, even after controlling for the World Bank Income Groups, Youthfulness continues to have a negative and significant effect on the predicted probability of High COVID-19. The absolute value of the impact of Youthfulness on the predicted probability of High COVID-19 continues to be very large even after controlling for the World Bank Income Groups. Referring to regression (2) in Table 4, an augmentation of Youthfulness by 1 unit, reduces the predicted probability of High COVID-19 by 175 percentage points. Or more precisely, the change in the predicted probability of High COVID-19, for 1 instant change in Youthfulness, decreases by 175 percentage points. This is a very big value, in fact bigger than the magnitude of any other variable in the table including that of the World Bank Income Groups, suggesting that Youthfulness has a big reducing impact on the predicted probability of High COVID-19. In this table of results, we also investigate if the World Bank Income Groups have an impact on the predicted probability of High COVID-19 by controlling for the World Bank Income Groups. We observe that, the World Bank Income Groups have a significant effect on the predicted probability of High COVID-19 compared to the base level *High income*. More precisely, referring to regression (2), we see that, the change in the predicted

probability of High COVID-19 when the World Bank Income Group varies from *High income* to *Low income* decreases by 45.7 percentage points or -0.457, and is significant. The change in the predicted probability of High COVID-19 when the World Bank Income Group varies from *High income* to *Lower middle income* decreases by 45.7 percentage points or -0.457, and is significant. The change in the predicted probability of High COVID-19 when the World Bank Income Group varies from *High income* to *Upper middle income* decreases by 20.6 percentage points or -0.206, and is significant. In other words, in the following World Bank Income Groups: *Low income*, *Lower middle income* and *Upper middle income*, the predicted probability of High COVID-19 is decreasing compared to the base level *High income*. In Table 4, we also observe that, Democracy continues to have a positive and significant effect on the predicted probability of High COVID-19.

Table 5 exposes the Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status with the Development Level Interaction using the GEV Estimator. The results in Table 5, illustrate that the effect of Youthfulness after taking into account its interaction with the Developed Country dummy variable is negative and statistically significant at all conventional levels. This demonstrates that Youthfulness continues to have a negative and significant effect on the predicted probability of High COVID-19 even after taking into account its interaction with the Developed Country dummy variable. Table 5 also shows that the impact of the Developed Country dummy variable after taking into account its interaction with the Youthfulness variable is positive and statistically significant at all conventional levels. This result illustrates that being a Developed Country, increases the predicted probability of High COVID-19. Referring to equation (2) in Table 5, being a *High income* country augments the predicted probability of High COVID-19 by 33.9 percentage points compared to the base level *Not High income*. This result suggest that *High income* countries have a very high probability of High COVID-19 compared to the *Not High income* countries. Going in the same direction, we plot in Figure 1, the Conditional Marginal Effects of the Developed Country dummy variable taking into account its interaction with Youthfulness, and the values of all the other control variables taken at their means. We use equation (2) in Table 5 for this. In Figure 1, the x-axis represents Youthfulness and y-axis is the predicted probability of High COVID-19. We see that for very low and very high values of Youthfulness, being a Developed Country has no effect on the predicted probability of High COVID-19. But for values of Youthfulness approximately between 0.18 and 0.30⁶, being a Developed Country augments

⁶That is, when Youthfulness is approximately between 18% and 30% of Total Population.

the predicted probability of High COVID-19. We also observe that the impact of the Developed Country dummy variable on the predicted probability of High COVID-19 varies with the values of Youthfulness nonlinearly. When Youthfulness goes approximately from 0.18 to 0.26⁷, the impact of Developed Country dummy variable on the predicted probability of High COVID-19 approximately varies from 30 percentage points to 70 percentage points compared to the base level. And, when Youthfulness goes approximately from 0.26 to 0.30⁸, the impact of Developed Country dummy variable on the predicted probability of High COVID-19 approximately varies from 70 percentage points to 51 percentage points compared to the base level. The results from Figure 1 corroborate those we found in Table 5. That is, *High income* countries have a very high probability of High COVID-19 compared to the base level *Not High income*. In a **Bio-Socio-Economic Context**, we could explain this finding in the following manner. When Income becomes higher, Real GDP per Capita augments, hence, work, economic activity and extra-activities become higher. These could in turn augment the contact rate, and through these means, rise the chance of infection when Real GDP per Capita and Income become higher. Another explanation could be that in *High income* countries, the proportion of young people in the population is small due to the reduction of fertility because of the high level of development in these countries. So, these countries might be in the interval of Youthfulness where the level of development is conducive to COVID-19 infections, due to, for instance, to higher Contact-Enhancing-Economic-Activities. We are aware of the fact that Table 4 and Table 5 might convey the same information by slightly overlapping into each other. But, it is important to underline that the 2 Tables are somewhat different: in Table 4 we just control for the Income Groups, while in Table 5, we take the interaction with the Development Level. Also, since this is the first study on the relationship between Youthfulness and COVID-19, we wanted to be as exhaustive as possible by doing a thorough study with the aim of leaving no stone unturned.

Table 6 gives the Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status with Control for the Least Developed Countries (LDCs) using the GEV Estimator. Figure 2 presents the Conditional Marginal Effects for the Control of Being a Least Developed Country (LDCs). The results in Table 6, illustrate that the effect of Youthfulness after controlling for the Least Developed Countries (LDCs) is negative and statistically significant at all conventional

⁷That is, when Youthfulness goes approximately from 18% to 26% of Total Population.

⁸That is, when Youthfulness goes approximately from 26% to 30% of Total Population.

levels. This demonstrates that Youthfulness continues to have a negative and significant effect on the predicted probability of High COVID-19 even after controlling for the Least Developed Countries (LDCs). Table 6 also shows that the impact of the Least Developed Countries (LDCs) dummy variable is negative and statistically significant at all conventional levels. This result illustrates that being a Least Developed Country, decreases the predicted probability of High COVID-19. Referring to equation (2) in Table 6, being an *LDCs* country diminishes the predicted probability of High COVID-19 by 12.3 percentage points compared to the base level *Not LDCs*. This result suggest that *LDCs* countries have a very low probability of High COVID-19 compared to the *Not LDCs* countries. Going in the same direction, we plot in Figure 2, the Conditional Marginal Effects for the Control of Being a Least Developed Country (LDCs). We use equation (1) in Table 6 for this. In Figure 2, the x-axis represents Youthfulness and y-axis is the predicted probability of High COVID-19. We see that for values of Youthfulness approximately between 0.13 and 0.28⁹, being a Least Developed Country diminishes the predicted probability of High COVID-19 by approximately from 60 percentage points to 10 percentage points compared to the base level. But for values of Youthfulness above 0.28¹⁰, being a Least Developed Country has no effect on the predicted probability of High COVID-19. The results from Figure 2 corroborate those we found in Table 6. That is, *LDCs* countries have a very low probability of High COVID-19 compared to the base level *Not LDCs*.

Table 7 provides the Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status with Control for the Elderly using the GEV Estimator. All 4 equations, in the table, show that Youthfulness is statistically significant at all conventional levels and have the expected sign even after controlling for the Elderly. Hence, an increase in Youthfulness reduces the predicted probability of High COVID-19 even after controlling for the Elderly. Our findings illustrate that, the negative effect of Youthfulness on High COVID-19 is robust to the introduction of the Elderly control variable. The results in Table 7 also demonstrate that the Elderly has a positive and statistically significant impact on the predicted probability of High COVID-19. This means that an increase in the Elderly in a country augments the predicted probability of High COVID-19. The magnitude of the effect of the Elderly on the predicted probability of High COVID-19 is very large. Referring to regression (4) in Table 7, we see that if the Elderly increases by 1 unit, the

⁹That is, when Youthfulness is approximately between 13% and 28% of Total Population.

¹⁰That is, when Youthfulness is above 28% of Total Population.

predicted probability of High COVID-19 increases by 247.1 percentage points. Or more precisely, the change in the predicted probability of High COVID-19, for 1 instant change in the Elderly, increases by 247.1 percentage points. This is a very big value, suggesting that the Elderly has a large augmenting impact on the predicted probability of High COVID-19. As we see, the marginal effect of the Elderly on the predicted probability of High COVID-19 is very huge. In fact, larger than the marginal effect of any other variable in this table of results. This suggest that countries that have huge Elderly tend to have High COVID-19. In a *Bio-Socio-Economic Context*, some possible and plausible explanations could be. **Biological Factors:** The Elderly are more vulnerable to COVID-19 because they have weaker immune systems, higher rates of chronic diseases, and lower lung capacity than younger people. These factors make them more likely to develop severe symptoms and complications from the infection, such as pneumonia, respiratory failure, organ damage, and death. **Socio-Cultural Factors:** The Elderly may face more social and cultural barriers to prevent and cope with COVID-19, such as lack of access to information, health services, and social support. They may also have more difficulty following public health measures, such as physical distancing, wearing masks, and avoiding crowded places, due to mobility issues, cognitive impairments, or cultural norms. Moreover, they may experience more social isolation, loneliness, and mental stress during the pandemic, which can affect their physical and mental well-being. **Economic Factors:** The Elderly may bear more economic costs and risks from COVID-19, such as loss of income, savings, and assets, increased health expenditures, and reduced access to social protection and welfare programs. They may also face more discrimination and stigma in the labor market, health care system, and society, due to their age and health status. Furthermore, they may have less capacity and opportunity to recover from the economic shocks and disruptions caused by the pandemic.

5.2 Robustness Analysis

Table 8 gives the Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status using the Complementary Log-Log Estimator with our first dataset. All 8 equations, in the table, show that Youthfulness is statistically significant at all conventional levels and have the expected sign. Hence, an increase in Youthfulness reduces the predicted probability of High COVID-19. Since Youthfulness is a predetermined variable, it is possible to say that the negative relation-

ship between Youthfulness and High COVID-19 seems to go from Youthfulness towards High COVID-19 and not the reverse. Our findings illustrate that, the negative effect of Youthfulness on High COVID-19 is robust to the introduction of different control variables. In fact, through the 8 equations we have varied the introduction of the control variables but the coefficient of Youthfulness retains its expected sign and is always statistically significant. The magnitude of the effect of Youthfulness on the predicted probability of High COVID-19 is very large. Referring to regression (4) in Table 8, a rise in Youthfulness by 1 unit decreases the predicted probability of High COVID-19 by 2.726. Said differently, this result indicates that if Youthfulness increases by 1 unit, the predicted probability of High COVID-19 decreases by 272.6 percentage points. Or more precisely, the change in the predicted probability of High COVID-19, for 1 instant change in Youthfulness, decreases by 272.6 percentage points. This is a very big value, suggesting that Youthfulness has a large diminishing impact on the predicted probability of High COVID-19. As we see, the marginal effect of Youthfulness on the predicted probability of High COVID-19 is very huge. In fact, larger than the marginal effect of any other variable in this table of results. This suggest that a way of reducing High COVID-19 is to increase Youthfulness in the country because countries that have huge Youthfulness tend to have Low COVID-19. The results found in this Table corroborate those found in all the previous Tables, in subsection 5.1. Hence, even after using a different estimation method, here the Complementary Log-Log Estimator, the results found in the previous Tables using the GEV Estimator are maintained and confirmed. That is, an increase in Youthfulness reduces the predicted probability of High COVID-19. Consequently, our main results are robust to the use of different estimation methods. It is important to inform the reader that the GEV Estimator is more general than the Complementary Log-Log Estimator because its underlying Probability Law nest that of the Complementary Log-Log Probability Law. Please, see Diallo (2021) for further details on this matter. This is one of the reasons why we use the GEV Estimator instead of the Complementary Log-Log Estimator in our main estimation results because it is more general. In a *Bio-Socio-Economic Context*, the results found in this Table concerning Youthfulness, Table 8, can be interpreted in the same way as we interpreted those we found in Table 1. In Table 8, we observe that the standard errors of the coefficients of Youthfulness are relatively small. This implies that the corresponding confidence intervals, though not reported, are tinier meaning that the coefficients of Youthfulness are estimated with great precision. The

number of observations is reasonable in all 8 equations, hence the phenomenon we are studying covers most of our sample. Many control variables are also statistically significant and have their expected signs. For example, Democracy and GDP per Capita, have positive and significant effects. In a *Bio-Socio-Economic Context*, we can interpret the results found here on the control variables, in the same way as we interpreted those we found in Tables 1 and 2.

Table 9 presents the Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status using the GEV Estimator with the Second Dataset. All 8 equations, in the table, show that Youthfulness is statistically significant at all conventional levels and have the expected sign even after using a different database. Hence, an increase in Youthfulness reduces the predicted probability of High COVID-19. Since Youthfulness is a predetermined variable, it is possible to say that the negative relationship between Youthfulness and High COVID-19 seems to go from Youthfulness towards High COVID-19 and not the reverse. Our findings illustrate that, the negative effect of Youthfulness on High COVID-19 is robust to the introduction of different control variables. In fact, through the 8 equations we have varied the introduction of the control variables but the coefficient of Youthfulness retains its expected sign and is always statistically significant even after using a different dataset. The magnitude of the effect of Youthfulness on the predicted probability of High COVID-19 is very large. Referring to regression (7) in Table 9, a rise in Youthfulness by 1 unit decreases the predicted probability of High COVID-19 by 2.448. Said differently, this result indicates that if Youthfulness increases by 1 unit, the predicted probability of High COVID-19 decreases by 244.8 percentage points. Or more precisely, the change in the predicted probability of High COVID-19, for 1 instant change in Youthfulness, decreases by 244.8 percentage points. This is a very big value, suggesting that Youthfulness has a large diminishing impact on the predicted probability of High COVID-19. As we see, the marginal effect of Youthfulness on the predicted probability of High COVID-19 is very huge. In fact, larger than the marginal effect of any other variable in this table of results. This suggest that a way of reducing High COVID-19 is to increase Youthfulness in the country because countries that have huge Youthfulness tend to have Low COVID-19. The results found in this Table corroborate those found in all the previous Tables. Hence, even after using a different dataset, here the second database, the results found in the previous Tables using the first dataset are maintained and confirmed. That is, an increase in Youthfulness reduces the predicted probability of High

COVID-19. Consequently, our main results are robust to the use of a different dataset¹¹. In a *Bio-Socio-Economic Context*, the results found in this Table concerning Youthfulness, Table 9, can be interpreted in the same way as we interpreted those we found in previous Tables. In Table 9, we observe that the standard errors of the coefficients of Youthfulness are relatively small. This implies that the corresponding confidence intervals, though not reported, are tinier meaning that the coefficients of Youthfulness are estimated with great precision. The number of observations is reasonable in all 8 equations, hence the phenomenon we are studying covers most of our sample. Many control variables are also statistically significant and have their expected signs. For instance, Democracy, Human Capital, Investment and Consumption, have positive and significant effects. In a *Bio-Socio-Economic Context*, we can interpret the results found here on the control variables, in the same way as we interpreted those we found in previous Tables. For the Investment variable, which is significant only in this Table, its interpretation in a *Bio-Socio-Economic Context*, is the same as we explained previously. Meaning that, increasing the activity of investing augment the contact rate, and through this medium, rise the chance of infection.

We finish this section by examining if there exists a quadratic effect for the variable Youthfulness. Hence, in Figure 3, we plot the Average Marginal Effects for the Existence of a Quadratic Effect for the Variable Youthfulness with the Second Dataset. From this graphic, we observe that the Average marginal effects of Youthfulness on the predicted probability of High COVID-19 are negative and statistically significant for Youthfulness ranging from 0.13 to 0.31¹². But for Youthfulness ranging from 0.34 to 0.46¹³, the Average marginal effects of Youthfulness are not different from 0.

¹¹For more details on these databases, please see section 4 where they are described.

¹²That is, when Youthfulness is approximately between 13% and 31% of Total Population.

¹³That is, when Youthfulness is approximately between 34% and 46% of Total Population.

6 Conclusion

This paper examines the relationship between Youthfulness and COVID-19 in a *Bio-Socio-Economic Context*. Using the Binary Generalized Extreme Value (GEV) Estimation Technique, we find that an increase in Youthfulness reduces the predicted probability of High COVID-19. We discover that if Youthfulness increases by 1 unit, the predicted probability of High COVID-19 decreases by 183.2 percentage points. Since Youthfulness is a predetermined variable, it is possible to say that the negative relationship between Youthfulness and High COVID-19 seems to go from Youthfulness towards High COVID-19 and not the reverse. The robustness checks illustrate that the negative impact of Youthfulness on High COVID-19 is stable to the use of subsamples of Least Developed Countries (LDCs) and Non Least Developed Countries (NLDCs), World Bank Regions, World Bank Income Groups, the use of small samples and the use of different estimations techniques.

Though the results found were informative, some extensions could be made. If there was a Binary Generalized Extreme Value (GEV) Estimator that allows to explicitly take into account an endogeneity problem that might exist between the Regressors and the Dependent Variable, we could use it to illuminate further our understandings. These avenues of research are left for our future studies.

From economic policy perspectives, the results illustrate that Youthfulness might be a good endowment for a country, because our findings suggest that a way of reducing High COVID-19 is to increase Youthfulness in the country since countries that have huge Youthfulness tend to have Low COVID-19.

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Table 1: Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status using the GEV Estimator

| Dependent Variable: COVID-19 Status | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|-------------------------------------|-----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|-----------------------|
| Youthfulness | -1.597*** (0.351) | -1.307*** (0.357) | -1.770*** (0.369) | -0.988*** (0.377) | -1.832*** (0.405) | -1.660*** (0.412) | -1.817*** (0.440) | -1.130** (0.573) |
| GDP per Capita | 0.0950*** (0.0331) | 0.0985** (0.0476) | | 0.134*** (0.0414) | | | 0.0823** (0.0398) | 0.110*** (0.0384) |
| Financial Development | -0.0740 (0.0747) | | -0.0622 (0.0681) | | -0.0701 (0.0691) | -0.0719 (0.0792) | -0.145** (0.0595) | -0.120*** (0.0321) |
| Consumption | | 0.162 (0.251) | | 0.378** (0.193) | | -0.207 (0.187) | | |
| Human Capital | | | 0.162*** (0.0625) | | 0.169*** (0.0631) | 0.171** (0.0671) | | 0.0722 (0.122) |
| Openness | | | | 0.0474 (0.0376) | -0.00468 (0.0419) | | | |
| Investment | | | | | | | -0.191 (0.348) | 0.113 (0.236) |
| Life Expectancy | | | | | | | 0.695 (0.829) | |
| Observations | 162 | 178 | 135 | 166 | 131 | 135 | 152 | 131 |

Standard errors in parentheses
 *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 2: Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status with Control for Democracy using the GEV Estimator

| Dependent Variable: COVID-19 Status | | | | |
|-------------------------------------|-----------------------|-----------------------|-----------------------|----------------------|
| Regressors | (1) | (2) | (3) | (4) |
| Youthfulness | -1.542*** (0.486) | -1.973*** (0.396) | -1.542*** (0.487) | -1.561*** (0.479) |
| Democracy | 0.0742*** (0.0168) | 0.0820*** (0.0178) | 0.0742*** (0.0168) | 0.0764** (0.0311) |
| Life Expectancy | 0.778 (0.536) | | 0.780 (0.543) | |
| Consumption | | -0.103 (0.195) | 0.000955 (0.193) | -0.140 (0.254) |
| Human Capital | | | | 0.0686 (0.0779) |
| Observations | 134 | 134 | 134 | 126 |

Standard errors in parentheses
 *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 3: Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status with Region Interaction using the GEV Estimator

| Dependent Variable: COVID-19 Status | | |
|-------------------------------------|----------------------|-----------------------|
| Regressors | (1) | (2) |
| Youthfulness | -2.564*** (0.519) | -2.852*** (0.763) |
| Europe & Central Asia | 0.167** (0.0842) | 0.00934 (0.0929) |
| Latin America & Caribbean | 0.223** (0.0935) | 0.140 (0.114) |
| Middle East & North Africa | -0.0950 (0.106) | -0.167 (0.118) |
| North America | 0.530 (0.367) | 0.333*** (0.107) |
| South Asia | 0.177 (0.160) | -0.338*** (0.0866) |
| Sub-Saharan Africa | 0.00136 (0.354) | -0.338*** (0.0866) |
| Investment | | 0.623 (0.401) |
| Tourism | -0.0149 (0.0176) | -0.0127 (0.0184) |
| Democracy | | 0.0525*** (0.0188) |
| Openness | 0.0321 (0.0441) | |
| Observations | 155 | 120 |

Standard errors in parentheses
 *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 4: Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status with control for Income Groups using the GEV Estimator

| Dependent Variable: COVID-19 Status | | |
|-------------------------------------|-----------------------|-----------------------|
| Regressors | (1) | (2) |
| Youthfulness | -1.047** (0.408) | -1.750*** (0.543) |
| Low income | -0.428*** (0.0944) | -0.457*** (0.0654) |
| Lower middle income | -0.428*** (0.0898) | -0.457*** (0.0654) |
| Upper middle income | -0.151 (0.204) | -0.206** (0.0923) |
| Democracy | 0.0622** (0.0275) | |
| Tourism | | 0.00276 (0.0276) |
| Observations | 133 | 167 |

Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 5: Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status with the Development Level Interaction using the GEV Estimator

| Dependent Variable: COVID-19 Status | | |
|-------------------------------------|---------------------|----------------------|
| Regressors | (1) | (2) |
| Youthfulness | -1.651** (0.641) | -1.810*** (0.636) |
| High income | 0.301* (0.178) | 0.339* (0.202) |
| Tourism | 0.00764 (0.0169) | 0.0174 (0.0180) |
| Financial Development | | -0.101 (0.0630) |
| Observations | 168 | 152 |

Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Figure 1: Conditional Marginal Effects of the Interaction of Being a Developed Country with Youthfulness

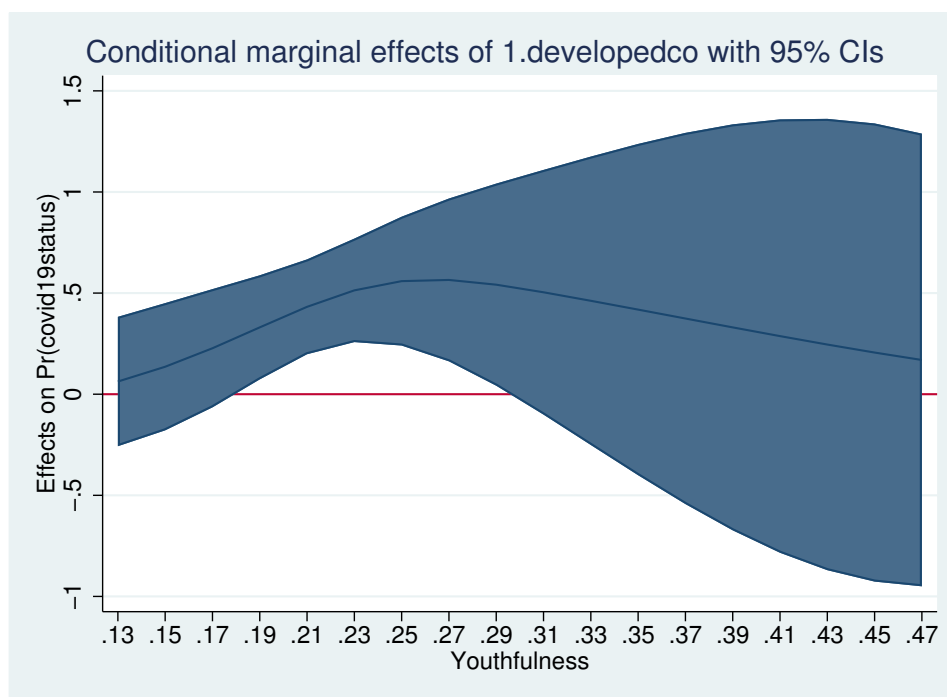


Table 6: Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status with Control for the Least Developed Countries (LDCs) using the GEV Estimator

| Dependent Variable: COVID-19 Status | | | | |
|-------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Regressors | (1) | (2) | (3) | (4) |
| Youthfulness | -1.759*** (0.474) | -1.625*** (0.474) | -1.565*** (0.492) | -1.619*** (0.538) |
| LDCs | -0.120*** (0.0313) | -0.123*** (0.0316) | -0.119*** (0.0307) | -0.120*** (0.0338) |
| Tourism | -0.00877 (0.0239) | | -0.0136 (0.0187) | |
| Investment | | 0.231 (0.260) | | 0.219 (0.352) |
| Consumption | | | -0.114 (0.186) | 0.0944 (0.242) |
| Human Capital | | | | 0.0228 (0.0763) |
| Observations | 112 | 109 | 112 | 92 |

Standard errors in parentheses
 *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Figure 2: Conditional Marginal Effects for the Control of Being a Least Developed Country (LDCs)

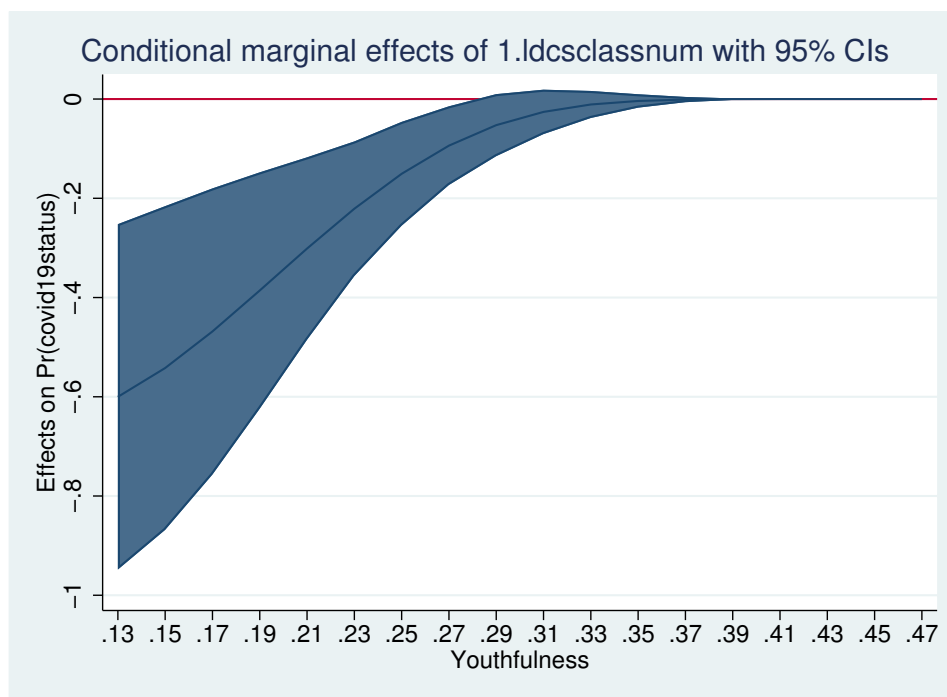


Table 7: Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status with Control for the Elderly using the GEV Estimator

| Dependent Variable: COVID-19 Status | | | | |
|-------------------------------------|----------------------|---------------------|---------------------|---------------------|
| Regressors | (1) | (2) | (3) | (4) |
| Youthfulness | -1.374*** (0.460) | -0.998* (0.517) | -1.151** (0.559) | -0.865* (0.506) |
| Elderly | 2.111*** (0.585) | 2.270*** (0.579) | 1.512** (0.722) | 2.471*** (0.514) |
| Tourism | -0.00343 (0.0157) | | | |
| Consumption | | -0.187 (0.140) | | |
| Human Capital | | | 0.0575 (0.0579) | |
| Openness | | | | 0.00148 (0.0396) |
| Financial Development | | | | -0.0597 (0.0599) |
| Observations | 168 | 180 | 144 | 152 |

Standard errors in parentheses
 *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 8: Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status using the Complementary Log-Log Estimator

| Dependent Variable: COVID-19 Status | | | | | | | | |
|-------------------------------------|-----------------------|----------------------|----------------------|----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Regressors | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Youthfulness | -1.899*** (0.634) | -2.174*** (0.432) | -2.684*** (0.554) | -2.726*** (0.704) | -1.792*** (0.582) | -1.774*** (0.550) | -1.371** (0.687) | -1.750*** (0.579) |
| Life Expectancy | 0.526 (0.630) | | | | 0.768 (0.751) | | 0.975 (0.767) | -0.375 (0.759) |
| Democracy | 0.0863*** (0.0235) | 0.103*** (0.0271) | | | 0.0949*** (0.0264) | 0.0781*** (0.0255) | 0.0976*** (0.0256) | 0.0850*** (0.0231) |
| Financial Development | | -0.0236 (0.0681) | -0.123 (0.0817) | | -0.0664 (0.0877) | | -0.104 (0.0805) | -0.110 (0.0883) |
| GDP per Capita | | | 0.0774** (0.0378) | 0.0630* (0.0353) | | 0.0494 (0.0337) | | 0.0905* (0.0483) |
| Tourism | | | | | | | 0.0372 (0.0239) | |
| Investment | | | | | | -0.278 (0.599) | | |
| Observations | 134 | 125 | 162 | 166 | 125 | 126 | 118 | 125 |

Standard errors in parentheses
 *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 9: Average Marginal Effects of the Impact of Youthfulness on the COVID-19 Status using the GEV Estimator with the Second Dataset

| Dependent Variable: COVID-19 Status | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|-------------------------------------|--|---------------------|---------------------|----------------------|---------------------|-----------------------|-----------------------|----------------------|---------------------|
| Regressors | | | | | | | | | |
| Youthfulness | | -1.874** (0.743) | -1.873** (0.795) | -1.901*** (0.700) | -1.798** (0.855) | -1.248*** (0.403) | -2.038*** (0.440) | -2.448*** (0.821) | -1.873** (0.808) |
| Tourism | | 0.0148 (0.0296) | | | | | | | 0.00238 (0.0244) |
| Democracy | | 0.0460* (0.0273) | 0.0461* (0.0264) | | 0.0548* (0.0311) | 0.0714*** (0.0167) | 0.0732*** (0.0200) | | |
| GDP per Capita | | | 0.00714 (0.0406) | | | | | 0.0668 (0.0552) | |
| Human Capital | | | | 0.158* (0.0908) | | | | | 0.187* (0.110) |
| Openness | | | | -0.104 (0.0949) | | | | | -0.0980 (0.107) |
| Financial Development | | | | | -0.0725 (0.147) | -0.0106 (0.0679) | | | |
| Life Expectancy | | | | | 0.457 (1.081) | | | | |
| Investment | | | | | | 0.824** (0.346) | 1.006** (0.506) | 0.393 (0.516) | |
| Consumption | | | | | | | 0.426 (0.270) | 0.598** (0.285) | |
| Observations | | 113 | 131 | 127 | 110 | 99 | 115 | 142 | 107 |

Standard errors in parentheses
 *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Figure 3: Average Marginal Effects for the Existence of a Quadratic Effect for the Variable Youthfulness with the Second Dataset

