Covid – 19 Endogenous Policy Response: Evidence from Affected Countries

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List of Acronyms

CGE	Computable General Equilibrium
DSGE	Dynamic Stochastic General Equilibrium
GDP	Gross Domestic Product
FDI	Foreign Direct Investments
HANK	Heterogeneous Agent New Keynesian Model
HCI	Health Containment Index
ILO	International Labour Organization
IMF	International Monetary Fund
JHU CSSE	John Hopkins University Center for Systems Science and Engineering
LSI	Lockdown Stringency Index
OECD	Organization for Economic Co – Operation and Development
OxGCRT	Oxford Covid – 19 Government Response Tracker
RANK	Representative Agent New Keynesian Model
SIR	Susceptible – Infected - Recovered
WHO	World Health Organization

As always to my parents, to whom I owe everything.

Abstract

The Covid – 19 pandemic triggered severely different policies response across countries and waved the discrepancy in the exposure that each country has in respect to the health crisis. This work offers a first quantitative framework for further investigations on how and whether the mitigation policy mix deployed by the different authorities reflects structural differences in the socio – economic background of developing countries. Starting from an extended version of the SIR theoretical model, I formulate a dynamic optimization problem for the governments to control the spread of the coronavirus. The quantitative analysis identifies the features that outline both the progression of the disease as well as the (disease) mitigation response commitment of each country. Whilst the differences in the intensity of the Covid – 19 policy response is only partially driven from differences in the gradient of the transmission rate, I find that the socio – economic characteristics of each country have a deeper influence on the government's response commitment. Once national authorities and international institutions are able to "endogenize" the pandemic dynamics in their recursive policy planning, the trade – off between health benefits and economic costs will be lower and the agents' cooperation higher (in adherence with the deployed mitigation regime).

Keywords

Covid – 19, Pandemic, Policy Response, Lockdown, Recession.

Chapter 1
Introduction

The Covid – 19 pandemic outbreak has put the ability of Micro and Macro aggregates[1] to react to such shock to a hard test. The literature which has been published and on which different subjects in the economics field are currently working on touches pivotal points in the formal – technical analysis of the Covid – 19 issue. Far from reaching a deep and thorough understanding of the dynamics underlying the novel coronavirus, economic authorities and policymakers have to face a new challenge for which no reliable protocols and benchmarks have been formulated. Since its outbreak in late 2019, indeed, Covid – 19 encompassed a broad range of transmission and fatality rates across different countries and, most importantly, across different areas within the same country. In line with what Belot et al. (2020: 2) said, policy plans and predictions, in first instance, hinged on very limited information which redirects the progression of the pandemic differently accordingly to the (un)biasedness of these. At the moment, a cross-countries analysis of the available high frequency (Covid – 19) data over the last few months will lead us to controversial interpretation. Whilst many countries, especially in the Euro zone and Middle East (the first struck area after china), are facing a second wave of the pandemic or never managed to limit a first wave of transmission (Latin America), others have recovered from the disease peak with progressive ease of the lockdown measures and a restart of all the economic and social activities.

In light of this, it might be wise to take a step backwards and focus on the aspects and policy responses which have led countries to heterogeneous performance in the Covid – 19 crisis. Over the past several months, the CEPR (Centre of Economic Policy Research) has discussed themes which vary from an optimal configuration of containment and lockdown policies to the role that international cooperation might have on the pick - up of the economic activity. If the optimal configuration in terms of response to the Covid – 19 crisis proves to work, it is rightful to think that the pandemic might be controlled below given emergency limits and therefore also Covid – 19 cases and Covid – 19 deaths might be limited. Why then there is no evidence of convergence in infectious rates across countries? To answer

[1] Examples can be the economic agents, goods and financial markets, national and international institutions, etcetera.

this question, it might be helpful to read what the FMO, the Dutch entrepreneurial development bank, said:

> "*most of the key developing countries keep showing increasing cases of COVID-19 indicating that lockdowns are not sustainable, or measures do not have the desired effect […] This might indicate a rising discrepancy between developed and developing markets as regards their ability to contain the pandemic […] One may speculate that most developing countries and their inhabitants simply lack the "luxury" to have an effective lockdown, as it disrupts local economies and prevents poor individuals to earn their daily income […] This is of concern, as it suggests that there is no obvious way to stem the virus in many developing countries until a vaccine has been found and applied."* (FMO, 2020).

In this case, the main difference, which has been highlighted, was between developed and developing countries. However, it can be possible to adapt such concept to a broader picture, as it happens for the differences that each country reports in the number of Covid – 19 of cases and/or deaths, also the level of lockdown policies tends to diverge among countries. In other words, there is enough evidence to show how the Covid – 19 progressions and response is not driven by exogenous parameters common to all the countries but is the result of an endogenous exposure to the disease and of an endogenous capacity to cope with the health crisis and the following aftermath.

The aim of this work is to empirically analyse whether, how and to what extent the Covid – 19 policy responses deployed by different (developing) countries are driven by parameters endogenous to the demographic, social and economic context. To the best of my knowledge, this represents the first attempt to econometrically test the correlation between previous existing levels of lockdown or fiscal stimulus and independent variables as a proxy of the economic background which may affect both the mitigation response and the virus spread itself.

To provide these crucial, I follow the newly emerging literature on the economic aspects of the pandemic, and I combine a standard general equilibrium model with a variant of the SIR, Susceptible – Infected - Recovered model (Kermack and McKendrick 1927). Starting from the theoretical framework of representative economic agents, as in Arellano et al. (2020), I build a benchmark in which the agents' can freely allocate they time endowment between consumption (leisure time) and labour. In addition to this, firms hire labour based on the available technology, and the government has a fiscal capacity which depends on a given budget constrain. I include the epidemiological dynamics using the SIR variant in which the economic decisions of the agents trigger a higher or lower rate of transmission of the virus (e. g. Eichenbaum et al. 2020; Chang and Velasco 2020; Alvarez et al. 2020). Once I capture the evolution of the pandemic due to economic interaction, I will formulate a dynamic problem of optimal control of the pandemic for a given representative government and study different policy scenarios according to the different objective functions and variables specified in it.

Instead of calibrating the resulting model, as I already mentioned, I will run an econometric model to confirm or disprove the assumptions of the theoretical framework. I first test the impact on various types of policies, such as lockdown and health containment, of the reported number of Covid – 19 cases and Covid – 19 deaths in addition to several covariates which match the endogenous differences of the countries upon investigation. Later, I will test the impact of a new set of variables on the fiscal spending deployed by the countries to test the trade-off condition between health benefits and economic costs arising from the pandemic and the consequent general shutdown. In this case, I validate the model's fit on different endogenous socio-economic main features as trade openness and indebtedness. Jointly, these findings offer new evidence to assess health and economic outcomes during Covid – 19 time together with new considerations on the optimal level of containment measures. Overall, indeed, I find that more exposed countries tend to score a higher level of lockdown stringency. However, there is limited proof evidence to verify whether higher levels of lockdown involve higher effectiveness in the containment of the virus. The results, moreover, prove how governments and different policy authorities may benefit from international cooperation in terms of macro interventions aimed to stabilise the (health and economic) losses of the pandemic. The latter is consistent with the hint of a conference call that I had earlier this year with professor Van Staveren in which we did highlight the pivotal importance that international interventions of debt relief for developing countries fostering debt bonds purchases[2].

The rest of the work is structured as follows. Section 1.1 provides a brief overlook of the related literature regarding the Covid – 19 economics debate. Section 2 is dedicated to the contextualization of the issue to give a background for the meaning of the paper; I will show some descriptive statistics on how countries differ for demographic characteristics and socio-economic parameters and introduce the concept of Covid – 19 multipliers. In section 3 and 4, I will alternatively present the model and discuss the first order of conditions which will guide the following analysis. Section 5 exposes the methodology I used with a particular focus on the identification strategy. Besides, it presents and explains the data that support

[2] Can be accessed through the following link: https://issuu.com/devissues/docs/01519_devissues_spring_2020_v3

the research. Section 6 is dedicated to the analysis and discussion of the empirical results. Finally, conclusions will follow.

1.1 Related Literature

The Covid – 19 literature in the past months has focused on several aspects of the pandemic progression with particular attention to epidemiological and socio-economic outcomes. This work relates to the novel and fast-growing literature on the macroeconomic analysis of the Covid – 19 crisis. Furthermore, the paper contributes to the literature which focuses on health and economic trade-offs in the developing world, starting from a theoretical model of (dynamic) general equilibrium. Eichenbaum et al. (2020), modify the DSGE benchmark to include epidemiological dynamics into the classic Neo – Keynesian synthesis. They found how the progression of the pandemic is strictly related to consumption and labour decisions of the representative agents and show the negative externalities which may arise from higher levels of productivity and labour allocation. Similarly, Alvarez et al. (2020) develop a macro – epidemiological system in which they show how the intensity and duration of the optimal lockdown policy depend on the gradient of the fatality rate of the virus and the value of a statistical life. Glover et al. (2020), have focused on the distributional effects of the Covid – 19 pandemic lockdowns. Building on the Eichenbaum et al. (2020) results of smaller economic aftermath in case of (behavioural) adjusted decision of the agents in terms of consumption and working preferences in the belonging sector, they show the interaction between (health) mitigation plans and (wealth) redistribution effects across the different segments of the population[3]. On the same matter, Faria – Castro (2020) calibrates a non – linear DSGE model to analyse the different outcomes of fiscal policies in the US; he finds significant evidence to support how unconditional transfers and liquidity assistance may guarantee, respectively, income and employment stabilisation for the hardest hit from the Covid – 19 emergencies. Moser and Yard (2020), emphasise the role that each government has in supporting more optimistic expectations of the population. Credible announcements from policymakers can improve the efficiency of lockdown programmes and close the gap between health benefits and economic costs. This represents one of the first attempts to investigate how the pandemic first and the related policy responses afterwards might differ in precarious contexts, such as developing countries. Alon et al. (2020) focus on the main

[3] In this research, different groups of the population are assumed to be more or less exposed to the Covid – 19 pandemic due to age – specific factors and wealth distributional effects across generations.

differences (age structure, health care capacity, socio-economic context, etcetera) between developed and developing countries and prove how untargeted (conventional) lockdown measures are less effective in threshold economies with less saved livelihoods against a drop in GDP. Almas et al. (2020) calibrate the Eichenbaum et al. (2020) macro – epidemiological model to study lockdowns effects in Uganda. Arellano et al. (2020) on one side stress out the role that high debt levels together with default risk have on developing countries' ability to cope with the Covid – 19 pandemic. Finally, Bonadio et al. (2020) study the same outcome but in terms of trade openness and global supply chains. The purpose of this work is then to give a contribution in evaluating the several policy responses and policy outcomes in developing countries due to differences in the socio – economic characteristics.

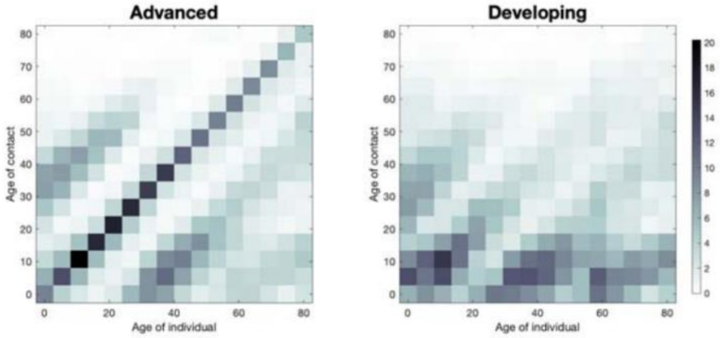
Chapter 2
Background Overview

Despite being timely, the Covid – 19 research has already highlighted the heterogeneous impact that the pandemic has across different countries and the heterogeneous response that each country has deployed to overcome such impact. The remainder of the paper will suggest an analytical approach to investigate such differences in the countries' exposure and management of the Covid – 19 crisis. For now, I will show preliminary evidence that confirms the endogenous nature of the pandemic's progression and control.

2.1 Demographic Multipliers

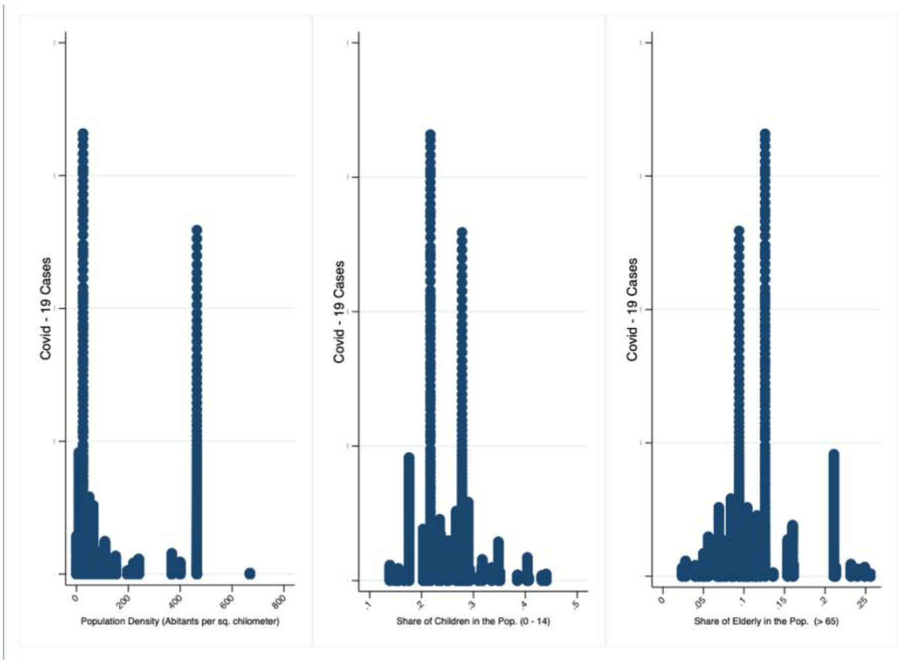
Up to this point, it is clear that the spread of the disease is mainly driven by physical contacts that might take place in several different locations as working facilities or household dwellings. Countries with a higher density of population; therefore, will resent from a higher rate of transmission of the virus. To be affected will also be the physical distancing capacity that each country might benefit from. Graph 1 compares the frequency and intensity at which human interactions occur between developed and developing countries. In line with Alon et al. (2020), I notice how developing countries tend to experience, on average, more frequent physical contacts that might directly increase the rate of transmission of the virus.

Moreover, it is possible to notice how in developing countries, different age groups across the population tend to interact with each other if compared to advanced economies where physical contacts are mainly "age-specific". This represents an additional channel through which endogenous characteristics of a given country, such as demographic factors, work as a multiplier in shaping the pandemic curve. In fact, intergenerational encounters put into contact segments of the population which have a different resistances and immune responses to the disease. It is well known, indeed, how children and elderly people are most affected once they have contracted the virus. In this regard, graph 2 shows how the limits in the physical distancing capacity due to for instance, as I said, to a higher population density and a more prevalent share of those at risk across the population are correlated to the number of new Covid – 19 cases.



Graph 1. Intergenerational Contact Matrices for Developed and Developing Countries in the Household

Source: Alon et al. (2020)

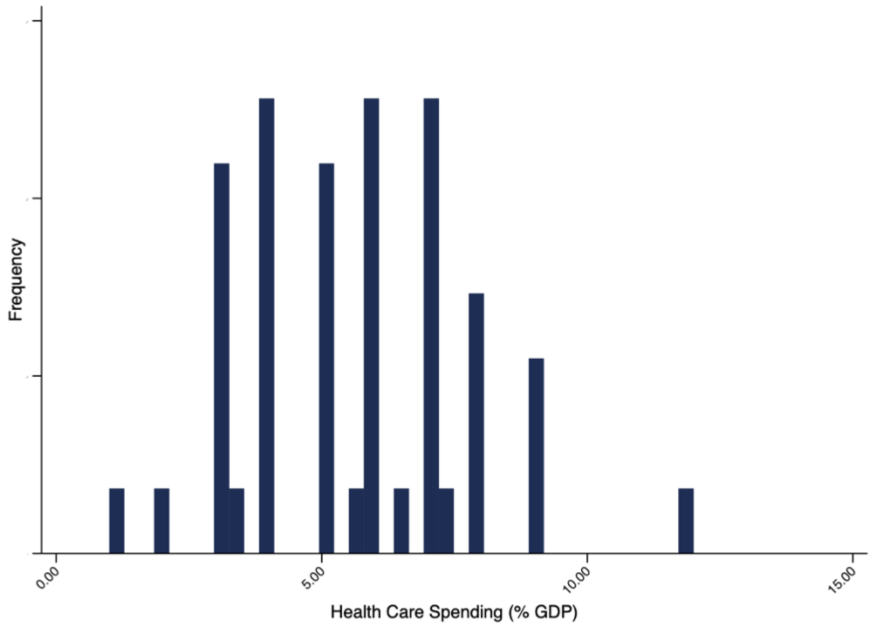


Graph 2. Scatter (distributional) matrix for the number of Covid – 19 Cases to demographic characteristics of the country

Source: Own Preparation.

2.2 Health Sector Structure

Another possible factor that may increase the vulnerability of the countries to the Covid – 19 pandemic shown by the health care sector investments over the last years and its related products. The immediate effect of higher public or private investments in the health care system increases the resilience of the sector to cope with the spread of the virus thanks to a larger number of intensive care units. Graph 3 illustrates the frequency of health care spending (over the last three years) as per cent of the GDP from 20 different developing countries. Although the health expenditure accounts, on average, for almost 5% of the national GDP, many developing countries have shown a negative relation with hospital capacity and health outcomes in terms of staff preparedness and quality of the service. Prin and Wunsch (2012) have highlighted the main differences across different countries with a spotlight on the number and effectiveness of intensive care units as a proxy of nature and well - being of the health care system. As will be empirically evident also in the results section, against highest public health expenditures, the number and quality of the health services remain insufficient in many developing countries.

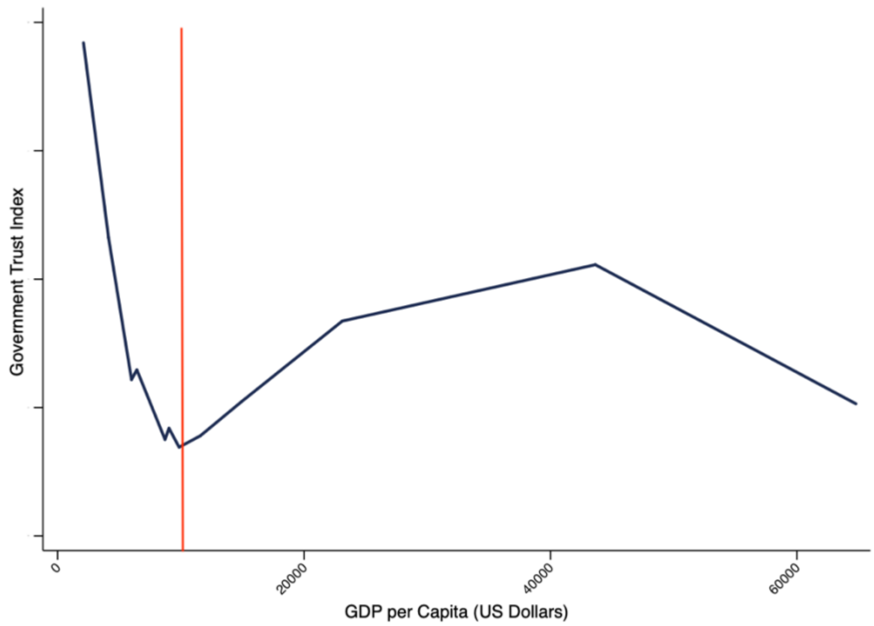


Graph 3. Public Health Care spending frequency over the GDP per capita

Source: Own Preparation.

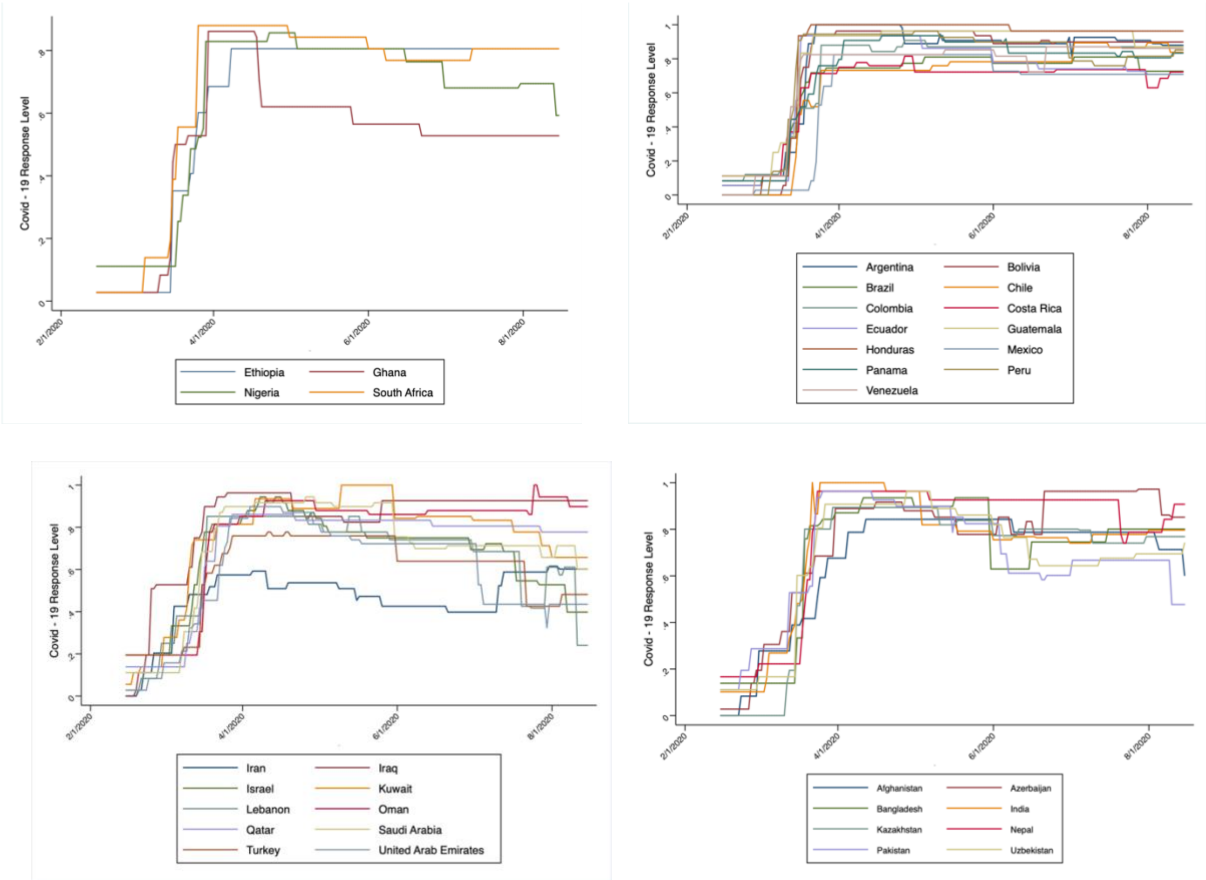
2.3 Pandemic Response Bias

To avoid the collapse of the vulnerable medical system, the epidemiological response to contain the spread of the virus has to rely on behavioural adjustments of the population. Indeed, a public adherence to correct and proactive behaviours will help policymakers to contain the health emergency and limit extra interventions which might affect the already precarious health – economic condition. It is clear, therefore how the perceived trust and truthfulness of the government announcements will redirect in one direction or the other the self–behaviour of the different agents across the population. Graph 4 plots the relation between the government trust index of the population and the GDP per capita. The government trust weights on a scale from 0 to 1 the prosocial behaviour of the population and the perceived government and institutions satisfaction. The plot region shows how the trust that the agents place in the national and local authorities increases in the level of welfare. Poorer countries will resent from this lack of confidence and presumably be more affected by the Covid – 19 shock. An immediate consequence of these cross-countries differences is in the set of policies which have to be implemented. I can highlight such differences looking at how the Covid – 19 policy response differs across countries and how it tends to align for similar contexts. Graph 5 shows the trend of mitigation responses of the different governments grouped by region. It is safe to assume that countries within the same region tend to have similar characteristics, and therefore a similar policy pattern over time. Hence, I have a homogeneous evolution of the mitigation policies over time due, among the other, also to similar levels of trust and satisfaction in the local and national institutions.



Graph 4. Government satisfaction index as an even function of the GDP per capita. Red lower bound represents the minimum observation for the amount of GDP in the sample of reference

Source: Own Preparation.



Graph 5. Time trend of the average between the Lockdown stringency index and the Health Containment index plotted by region. Respectively: 1) Sub – Sharan Africa; 2) Latin America; 3) Middle East; 4) Central – Southern Asia

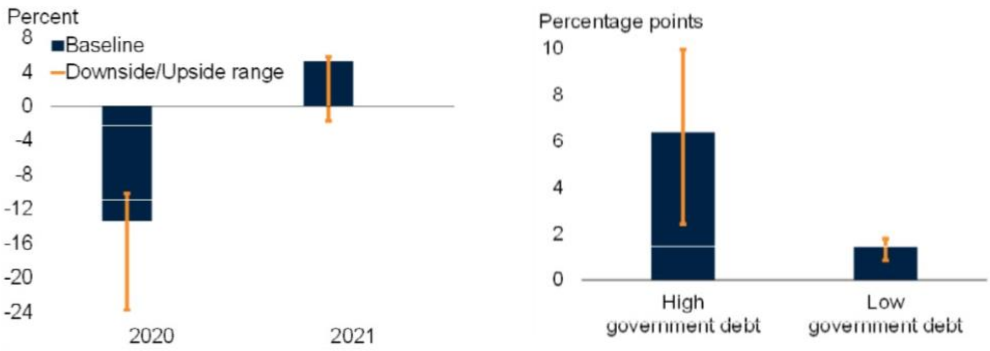
Source: Own Preparation.

2.4 Markets Downturn

The dependence of developing countries on global value chains and their high reliance on debt denominated in foreign currencies are vulnerable to disruptions in production abroad and to fluctuations in the exchange rate. The initial shutdown of the economic activity in China in late 2019 and the consequent stoppage of every transaction in the rest of the world has led to shortages of intermediate and final inputs for many developing economies in Latin America and in the Sub – Sharan African region. Due to the Covid – 19 economic shutdown, countries which were heavily integrated to global supply chains have been forced to re - shore production processes for essential inputs and goods which were otherwise traded. Depending on how the international trade downturn exacerbates the GDP contraction, countries tend to impose more or less severe lockdown policies.

In addition to this, the stoppage of international transactions has also led to financial stress for countries and institutions heavily dependent on foreign borrowing and, therefore, to exchange rate fluctuations. Such debt service has to be financed through (un)conventional fiscal and monetary instruments will affect the sustainability of the debt/GDP ratio and most importantly crowd out investments from other public expenditures such as public health care.

In this regard, graph 6 box plots the downturn in international trade for 2020 in developing countries and the expected pickup for 2021. It also shows how the spread on developing countries' debt. I find proof of the theoretical framework above expressed with developing countries deeply affected from the economic shutdown and with an unsustainable long – term debt service for high indebted developing countries.



Graph 6. Box Plot of Trade Downturn and Debt Spread Spike

Source: World Bank Group (2020)

Chapter 3
Model

My analysis starts with a technical formulation that links the, discussed above, descriptive evidence of the countries' exposure to the pandemic, with the empirical analysis of such endogenous dynamics. I consider an economy model whose openness to the international markets and trade, as in Arellano et al. (2020), is limited to the use of foreign debt (with default option on it)[4]. The economy is outlined to be populated by a continuum of representative agents (RANK[5]) which maximize an objective function in terms of consumption and working hours, subject to a budget constraint.

For the sake of simplicity, I will not differentiate between fiscal, credit or health authorities ascribing the latter functions to a single representative government. In the empirical section, I will relax this assumption. The government's problem is to minimize a loss in the welfare function, as a result of health and recession costs due to the Covid – 19 pandemic, arbitrarily imposing either lockdown measures and using elements of fiscal and/or monetary policy. The pandemic dynamics follow a macroeconomic epidemiological SIR, Susceptible – Infected – Recovered, model (Eichenbaum et al. 2020) in which the economy endogenously describes the transitions between the different states of the disease. In the following section, I will first present the household and government main features. I will then describe in detail the evolution of the pandemic according to the macro - SIR extended model and finally formulate the dynamic problem which will offer the lay ground for this research.

In line with Alvarez et al. (2020: 4), the most critical limitations I find in the model regarding the lack of heterogeneity in the preferences and, in turn, in the transmission and mortality rate across the economic agents. Needless to say, the lockdown policies cannot be targeted to particular agents' type. As it will be clear later on the drop in the economic activity may be driven by 1) the containment measures, deployed by the policy authorities of reference, which will shut down the economy; and by 2) the consumers and workers expectations and behavioural adjustments. Indeed, people who are afraid and more exposed to the virus will voluntarily decide to consume and work less to prevent social meetings.

[4] Later on, however, I will discuss the results of a given openness to international trade also.

[5] Representative Agent New Keynesian Model. As opposed to HANK (Heterogeneous Agent New Keynesian Model), see work by Kaplan et al. (2020).

Although the model considers such an aggregate drop in economic activity, the single effect of these two channels is not quantified. Following up, "*the model ignores any economic consequence of temporary lockdowns*" (Alvarez et al. 2020: 4). In addition to this, I would say that my rearrangement also ignores any health consequence of a temporary lockdown such as the risk of a second wave of Covid – 19.

3.1 Households

As I previously said, the economy is populated by a mass of identical representative agents whose preferences are framed by the following utility function:

$$\sum_{t=0}^{\infty} \beta^t [(u(c_t, n_t)], \tag{1}$$

where $\beta \in (0,1)$ is a discount factor and c_t, n_t are respectively consumption and hours worked. The utility function can be written as:

$$u(c_t, n_t) = lnc_t - \frac{\theta}{2} n_t^2, \tag{2}$$

subject to the following budget constraint $c_t = wn_t + \Gamma_t$, where w is the real wage rate and Γ is any transfer from the government to the household.

3.2 Firms

The total output is produced using labour, provided by the households, and a linear technology. The representative firm produces:

$$Y_t = A_t N_t \quad , \tag{3}$$

where $\alpha \in (0,1)$, A is the labour productivity. In equilibrium the total labour supply equals the mass of agents, i.e. $n_t = N_t$

3.3 Government

Following Faria – Castro (2020), I assume that the government has outflows related to non - service consumption and (foreign) debt repayments while its inflows are represented by taxes and debt issuances. In this regard, the government budget constraint is:

$$\mathrm{G_t} + B_{t-1}^{g} + \aleph_t = T_t + B_t^{g}, \tag{4}$$

where $\aleph_\mathrm{t}$ is a set of one – time fiscal and/or credit instruments that the government has access to.

3.4 Pandemic

In 1927 Kermack and McKendrick proposed an epidemiological model which described the evolution and dynamics over time of a given population exposed to a given epidemic. Building on the SIR model[6] (Kermack and McKendrick 1927) the representative population of this economy is described as follows:

$$S_t + I_t + R_t = N_t = 1 \tag{5}$$

with S_t people susceptible to the virus, I_t people who are already infected and R_t people who have recovered or died from the virus. At the beginning of the pandemic $I_0, S_0 > 0$. In the standard SIR model, the evolution of the pandemic over time, in terms of new infections, is described by the map of interactions $\Gamma_1 = \Omega_1(S_t, I_t)$ between susceptible and infected people. Although such interactions may provide an unbiased and reliable picture of how the pandemic may exogenously evolve, it is useful for this research to include endogenous parameters which may drive the trend of the pandemic over time in the economy. In fact, according to the behaviour and actions of the representative agents, the rate of infection of the virus might speed up or slow down. Besides the map $\Gamma_1 = \Omega_1(S_t, I_t)$ it seems to be useful to introduce a second set of interactions between susceptible and infected people which this time are driven by the single decisions of the household. The agents of the economy, indeed, may decide to consume and/or work and this will put them in contact with other agents

[6] See McAdams (2021).

increasing the number of social interactions within the population and, according to Γ_1, the progress of the pandemic as a function of the number of new infected. Therefore, the second map of interactions is equal to $\Gamma_2 = \Omega_2(S_t, C_t)(I_t, C_t)(S_t, N_t)(I_t. N_t)$. The total number of new cases in the economy will be equal to:

$$\mu_t^I = \Gamma_1 + \Gamma_2 = \Omega_1(S_t, I_t) + \Omega_2(S_t, C_t)(I_t, C_t) + \Omega_3(S_t, N_t)(I_t N_t) \tag{6}$$

It can be noticed that I have slightly rearranged the notation of the aforementioned equality in order to separate the interaction between the different agents with respect to consumption and hours worked respectively. This simplification lightens the notation and leaves unchanged the results. The equation (6) represents an unbiased benchmark to understand the transition between the different subgroups (Susceptible – Infected – Recovered) of the population. At this point, it is possible to track an evolution over time also of the trend within the same category to have a complete picture of how the pandemic moves along the curve of time. In fact, the number of susceptible people (net of new cases) in a period $t + 1$ will be equal to:

$$S_{t+1} = S_t - \mu_t^I \tag{7}$$

In the same way, as in Arellano et al. (2020) and Alvarez et al. (2020) I define the total number of infected, recovered as it follows:

$$I_{t+1} = \pi\mu_t^I + \mu_t^I \tag{8}$$

$$R_{t+1} = (1 - \pi)\mu_t^I \tag{9}$$

The term $\pi \in (0,1)$ is the probability of non – recovery for an infected agent, hence $1 - \pi$ is the probability according to which each infected agent either recoveries or dies. This probability π, I assume is a function of the same endogenous characteristics of the economy Ω pointed out in (6), i.e. $\pi = \phi(\Omega)$. It is useful to think about Ω as a vector which describes the health system well - being, health system capacity, demographic variables (population density, hygienic conditions), international supply chains, etcetera of the economy. By definition, these may slow down or boost either the meetings and the recoveries of the population and, therefore, slow down or boost the spread of the virus as number of new cases.

3.4.1 Pandemic Control

In the SIR baseline discussed in the previous section, the function Ω is the main factor that determines the dynamics of the pandemic and its consequences in terms of cost of lives, i.e. new cases[7]. What I have not said yet is that the government has an indirect influence on this set of parameters. Presenting this model, among the conventional and unconventional instruments of fiscal and monetary policies of the government, I mentioned discretional lockdown thanks to which the planner has the opportunity to limit the economic activity of the given economy to burden the spread of the virus. It is clear how, according to (6), economic activity and spread of the pandemic are positively correlated. Hence, I introduce the role of lockdown in the pandemic and model on how the evolution of the disease is affected by it. I assume that the government decides on a sufficient high degree of economic lockdown $L(t) \in (0,1)$, where $L(t) = 1$ is the maximum value of that the lockdown L can assume (suitable with a total blackout of the economic activity). In line with Alvarez et al. (2020), it seems appropriate to set a $\max L(t) = \bar{L} < 1$ to guarantee a continuum of given economic activities necessary to the agents' subsistence. The targeted economic and untargeted social lockdown L has $\theta \in (0,1)$ effectiveness, therefore the number of interactions across the population are decreased by the factor $L(t)\theta$. Substituting $1 - L(t)\theta$, as the number of still ongoing interactions which can transmit the virus, in to (6) we obtain the following:

$$\mu_t^I = (1 - L\theta)[\Omega_1(S_t, I_t) + \Omega_2(S_t, C_t)(I_t, C_t) + \Omega_3(S_t, N_t)(I_t N_t)] \qquad (6')$$

The empirical evidence of the past months of the pandemic has shown how the lockdown measures across countries have an effectiveness $\theta < 1$; as in the case of Ω of the previous section, it goes without saying how the level of effectiveness θ is dependent on an additional

[7] So far, I have not distinguished among recovered and dead, hence the number of total losses will be a fraction of the number of cases. Later on, I will relax this assumption.

set of parameters and characteristics of the government's authorities and (again) of the economy itself. This new term is of pivotal importance in what will follow later on in this paper because it represents a second new endogenous parameter according to which the pandemic moves over time across a given population and state of the events. As we may note, this leaves us with a trade-off condition in which the costs of the pandemic in term of decreasing consumption and labour productivity clash with the loss of lives in the population.

3.5 Dynamic Problem

Once the Covid – 19 pandemic formulation has introduced in our model, it is possible to reformulate the consumers, firms and governments problems introducing the trade-offs arising from a disease which proved to be dependent from the aggregate decisions and interactions within the economy. In this sense (1) and (3) can be reformulated to include a health component (Guerrieri et al. 2020) in the following way:

$$\sum_{t=0}^{\infty} \beta^t [(u(c_t, n_t) + h_t], \tag{1'}$$

where $h_t = H(c_t, n_t, Y_t)$ is the health component which is dependent on the consumption and the labour that each agent is free to implement in the economy and the total output of the whole system. On the other hand, the economic output given by (2) can be written as:

$$Y_t = A_t N_t (1 - \theta L_t), \tag{2'}$$

Due to the lockdown measures implemented to contain the spread of the pandemic, the amount of labour that the firms are able to hire is limited. Therefore, in equilibrium $c_t = A_t L_t$. Now that all the elements are specified, it is possible to finally integrate the pandemic dynamics in the objective function of the government and write the stages of the recursive problem of welfare maximization. The following problem will rely on the theoretical framework of Moser and Yard (2020). The timeline of the events will be as follows:

1. In $t = 0$ while the government learns about the stage and rate of spread of the disease, the economic agents formulate their expectations (deciding on consumption

and worked hours) on the basis of lockdown measures and financial/monetary interventions.

2. In $t = 1$ the government chooses on L_t and $\aleph_t$.
3. In $t = 2$ the pandemic spreads according to the map $\Gamma_t = \Omega(S_t, I_t, c_{t=0}, n_{t=0})$.

As said by Gourinchas earlier this year "*flattening the infection curve inevitably steepens the macroeconomic recession curve*" (Gourinchas, 2020). Thus, the objective function of the government will be parametrized according to two sets of state variables, economic costs and health benefits. The government solves the following maximization problem:

$$1 \; {}_{L_t \in (0,1), \aleph_t} \max \{u(c_t, n_t) - \chi\} + V_t[\Gamma_t(\Omega_t(L_t, \theta)], \qquad (10)$$

subject to the government budget constraint (4). The term χ is a fixed cost which depends on the duration, severity and other uncontrolled variables of the pandemic. In this functional form, I do not include a medical preparedness element considering that the only adequate response to the virus is represented by a vaccine which I assume will be developed and functional far in time. The objective function (10) as it can be noticed is increasing in the value of consumption and labour productivity and in the effectiveness of the lockdown measure. The fiscal and monetary instruments by definition can expand the consumption and, due to the positive relation between consumption and social interactions, the effective amount of new cases and infections. However, in this case, I assume that expansionary movements will not affect c_t and n_t period – by – period. Thus, I will focus my attention on the impact that fiscal and credit instruments might have on consumption smoothing. In an optimal equilibrium, in fact, I might expect that fiscal transfers and/or lower interest rates will: 1) lower the cost opportunity of not working and, consequently, the number of meetings amongst the population; and 2) enhance the credibility of the government's announces.

From now on, equation (10) will be pivotal in the research. All the variables that enter the objective function (10), in fact, differ across countries and reflects the socio – economic context of reference. The health benefits as well as the economic costs, due to the Covid – 19 pandemic, will have a different incidence on (10) according to (among the others) the endogenous characteristics that I have discussed in section 2. With the aim of testing how the policy response differs across countries, the econometric model that I will present later on has some predictive power on each of the variables that affect the value of (10[8]).

[8] I take for granted that the reader has noticed that the different variables may have a direct or indirect impact on (10). For example, Γ_t depends on the lockdown policy implemented L_t. At the same time, c_t and n_t depend on L_t. Moreover, it is immediate to notice how χ might depend from endogenous characteristics of the countries and, most importantly, how this might affect the objective function and in turn the response policies to deploy.

Chapter 4
Analysis Set Up

Instead of deepening the analytical resolution of the recursive welfare maximization problem, I will present only present the first order of condition to (10) and discuss the economic main takes that lie underneath the relation between marginal costs and marginal benefits. The following first order of condition relies on the work of Moser and Yard (2020). Substituting $c_t = A_t L_t$ and $n_t = N_t = 1$ in (10) and solving for the level of lockdown and fiscal and/or credit policies, the optimal condition of the problem can be written as follows:

$$-V_{L,\aleph}[\Gamma_t(\Omega_t(L_t, \theta)] = A \tag{11}$$

The right – hand side of (11) depicts the "*future health benefits in terms of reduced mortality from inhibiting the disease spread, as captured by the marginal change in the continuation value* $-V_{L,\aleph}[\Gamma_t(\Omega_t(L_t, \theta)]$" (Moser and Yard 2020: 9). The left – hand side, considers the marginal cost of the labour productivity which is affected by 1) the upper bound limit to the labour supply due to the lockdown measures; 2) a sub–optimal level of investments due to the lower return on capital.

4.1 Credibility and Time - Inconsistency

The optimum condition (11) opens a path to a wide range of consideration in terms of policies regime. There is a huge related literature to the issue of government flexibility against government commitment in the subject of fiscal and monetary policies, highlighting the time inconsistencies that might arise over time. With time inconsistency of fiscal and monetary policies the common knowledge defines a situation in which, at time $t = 0$ policy authorities might ponder upon a given set of decision to implement in $t = 1$. However, once $t = 1$ is reached the same range of decisions does not look efficient anymore and leave the players of this simple game with a dilemma on what action to undertake. The model of time inconsistency was presented by Barro and Gordon (1983) with respect to the problem of inflation targeting and stabilization bias of the central bank in the US. However, this framework might be as helpful for dynamic analysis of optimal response to the Covid – 19 emergencies. According to the formulation of the game I have represented in section 2.5 the policy authorities benefits of the so-called *first mover advantage*, i.e. the government can see what the economic agent will do in $t = 0$ and, given these decisions, subsequently decide for the best response in $t = 1$.

4.1.1 The Role of Commitment

Let's assume that the government in $t = 0$ announces that, in $t = 1$, it will pursue a containment policy characterized by a high level of L_1. The agents will formulate their expectations accordingly. In this case

$$-V_{L,\aleph}[\Gamma_{\mathrm{t}}(\Omega_t(L_t,\theta)] > A$$

does not represent an optimal solution because the agents will never trust such announcement. In fact, the benefit from a smaller loss in livelihoods will be greater than the costs of an economic recession and the government will choose on a milder containment policy rather than boost the economy recovery (by definition more expensive). The agents, therefore, will continue in their social activity, and the disease will spread causing health and economic losses and forcing the government to start the containment late. On the contrary, with a lockdown announcement of $L_1 \to 0$

$$-V_{L,\aleph}[\Gamma_{\mathrm{t}}(\Omega_t(L_t,\theta)] < A$$

where the health costs are unsustainable, and the productivity has to necessarily decrease to restore the equilibrium. From what has been seen, the credibility that the agents restore in the announcements of the government is pivotal for maximum welfare and a long–run equilibrium. In particular, it is essential that governments with low credibility or that have always had a denial point of view with respect to the pandemic and to the economic consequences that may arise from it, commit themselves to future levels of lockdown or fiscal/credit aids to instil trust in consumers, workers and investors. Once the authorities have committed themselves to time consistent solutions, they will limit decline in the values of the welfare function and drive the beliefs of the agent towards more responsible behaviours. Moreover, it is interesting to investigate how containment measures and fiscal/monetary interventions intertwine in a regime of flexibility or commitment of policymakers. In light of the role of expectations I have described above, the economic intuition behind this twist should be immediate. Indeed, following Chang and Velasco (2020), the expectation of high monetary reward and good health in the future for will lead people to follow the containment guidelines staying at home and closing the gap between lockdown and economic recovery phase. In turn, this will positively affect the government budget constraint and the possibility of undertaking expansionary policies.

Chapter 5
Quantitative Analysis

The paper aims to empirically test how and whether the policy authorities' commitment to specific mitigation policies in the context of the Covid – 19 pandemic depends on the socio – economic structure of the countries and therefore differs across them. In a given country, the linkage between policy mix commitment, health outcomes and agents' response prove to be correlated with endogenous characteristics of the underlying economy. I will study how these variables intertwine in the context of the Covid – 19 pandemics assessing in which way national authorities take as endogenous socio–economic parameters in the decision process of the set of policies to implement to control the spread of the virus. By doing so, I tend to believe that it will be possible to test the correlation between mitigation policies and economic background numerically[9]. The responsiveness of the governments' decisions to each one of these factors will be the lay ground of my research. I will focus my attention on countries that are more affected from the virus due to country-specific characteristics and time-invariant constraints as demographic factors, high level of indebtedness, poor health systems, etcetera. The interplay among these variables has an impact either on (6') and on (10). For instance, health care systems and their capacity will directly affect both L and θ, respectively level of lockdown and effectiveness of it. In turn, the present value of the health benefits arising from a given lockdown announcement might change and, therefore, the objective function of the representative government will take into account such discrepancies in the health preparedness. Same is the underlying intuition behind demographic factors as stated in section 2; higher population densities, for example, affect the frequencies of physical contacts and in turn the transmission rate of the virus expressed by the map $\Gamma(\cdot)$. Once evaluated the role that endogenous variables have on the level and composition of Covid – 19 mitigation policies, I will move on to the second stage of my analysis. So far, referring to mitigation policies, I have not distinguished between mere health containment plans and plans which seek to alleviate the economic recession driven by the stop of the economic activity. Therefore, the goal now will be to study the relation

[9] The focus of this paper therefore will be on the second stage of the dynamic game presented in section 3.5 and deepened in section 4. I will take as given the agent's expectations and assess the policy response to these.

between containment measures and (un)conventional interventions to pick up economic activity and assess their interaction.

5.1 Empirical Methodology

First, I will present a structural specification that might help me to test the dynamics presented by (6'). What the related literature has done so far it has been to calibrate the dynamic problem presented above with a DSGE (Dynamic Stochastic General Equilibrium) model substituting each variable with numeric values. These parameters are taken from international health and economic institutions which have defined, among the others, rate of spread of the virus, rate of mortality and so forth. The DSGE algorithm will give then back the parameters of interest. My approach will be different. I will draw on a set of explanatory variables to test the linear relation between anti Covid – 19 policies and different socio-economic context. In order to do so, I will run the following baseline regression[10]:

$$y_{i,tw} = \alpha + \delta covid_{it} + \beta\xi + \eta_{im} + \varepsilon_{i,tw} \tag{12}$$

where $y_{i,tw}$ is alternatively the lockdown stringency index and the health containment index[11] of a country i in day t of week w, $covid$ is the log number of Covid – 19 cases or Covid – 19 deaths reported in a country in the last 7 days or in the last 10 days, ξ is a vector of the characteristics of the country, η_{im} is, in line with El Faoyoumi and Hengge (2020: 10), a country x month fixed effect "*which controls for slow moving domestic factors*". It is legitimate to think about these slow-moving variables, other than in terms of testing capacity and unobserved variation in containment policies, also in terms of different endogenous responses of the population as the development of a general herd immunity. I present results using different clustering methods as there is within correlation of errors within countries due to the pandemic nature of the model. Standard errors are two-way clustered at the country and country x week level. The country level clustering takes into account per error correlation within the country. The country x week level clustering, instead, will allow me to

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[10] Although my approach is not formally elegant, it allows me to derive some first results on the policy configuration expressed by (11).

[11] As I am going to explain later such indexes measure on a scale from 0 to 1 the entity of the Covid - 19 response deployed by a country.

take into account for error correlation within each week per unit in the country group. The underlying idea behind this strategy is that within each cluster I assume a similar experienced pressure on the health care system and the policy makers, due to the progression of the virus (i.e. number of active cases)[12]. The lockdown stringency index and the health containment index are both two indicators whose value ranges from 0 to 1 according to respectively the degree of severity of the lockdown and the health response for each country upon discussion. As it is immediate to notice the information given by the dependent variable will be different according to which index it is included in the specification. The number of new Covid – 19 cases and new Covid – 19 deaths are taken into account at two different frequencies to absorb any possible difference in the reaction time of policies authorities. The intuition behind these two different lag periods, precisely a 7 days lag period and a 10 days lag period, is that policy makers might need time to collect information on pandemic related events and agree on a new policy containment mix to deploy. I will return to this point later on.

The main difference between a standard SIR standard model and a macro extended SIR model, as I already said, is that the spread of the described disease is not exogenous anymore but driven from parameters endogenous to the country and population. It is safe to assume that the number of the infections will be significantly correlated to my ξ vector. I assumed that in $t = 0$ each country learns about the stage and progress of the pandemic according to the available technology. This technology can be expressed as a function of the testing capacity, data sharing within and between countries, and reporting. Such differences are controlled in our fixed effects model. Besides, any progress in the testing or reporting technology, that I assume to be linear over time, is also controlled by η_{it} fixed effects. However, it would be a mistake to give to the fixed effects the same interpretation both in the case of lockdown stringency and health containment index. Consistent with the way these two indexes are built, not only the results of the model will be different but also the fixed effects analysis will be. I will spend some time on this in the following section.

The weakness of this model is that takes into account only the positive aspects of lockdown policies as the number of saved livelihoods; however, the economic costs of

[12] The limit of the country x week clustering is that I do not assume any error correlation from one week to another. Alternatively, it might have been possible to cluster standard errors contemporarily on the country and week level. In this case, besides error correlation within country, I assume error correlation across countries for the same week. Countries, in fact, might implement given containment policies in light of what others foreign governments will do in the same time.

reduced output and labour productivity are not considered. I can justify this limit affirming that in the short–run (as the period I am considering in this research) the economic costs are smaller compared to the health benefits of a given lockdown programme. While this is valid in the short term, the economic growth concern can arise once the period of study stretched. In addition to this, it can be said that economic consequences dealt with once the spread of the virus is controlled or stand below given country endogenous limits that will avoid the collapse of the health system. I will rely the second stage of my research on this last consideration. I will indeed assume that the sample of countries of interests is ready to pick up the economic activity and assess the opportunity cost of an economic stimulus. To boost the economy recovery, the policymakers have conventional and unconventional fiscal and monetary instruments to use. Although the empirical evidence has debated on the optimal level of lockdown and testing policies, not much has been said on the optimal combination between health containment and economic recovery measures. The following model will evaluate the impact that the countries' socio – economic structure has on their commitment towards not only mitigation policies but also on economic measures to pick up the economic activity and equal marginal health benefits and marginal economic costs. The baseline regression is expressed as follows:

$$z_{i,tw} = \alpha + \phi mitigation_{i,tw} + \delta covid_{it} + \beta\xi + \eta_{im} + \varepsilon_{i,tw} \quad (13)$$

where $z_{i,tw}$ is an index which weights the fiscal stimulus as percent of the country's GDP and the economic support granted with unconventional fiscal tools; the variable $mitigation$ is in turn the lockdown stringency index and health containment index; as in the model expressed by (12), $covid$ stands alternatively for the log number of new Covid – 19 cases and Covid – 19 deaths reported in the last 7 days and in the last 10 days; the rest of the model follows what said previously in this section with control vector, country and time fixed effects. The fiscal stimulus variable included in the above specification captures the discretionary fiscal spending that each country has issued during the pandemic. This merges different policies as wage subsidies, investments or tax deferment, under one indicator. According to the government budget constraint, both lockdown and fiscal packages financed through tax revenues and debt issuances. To accommodate a higher economic fiscal stimulus, I might expect countries to carve out reliable fiscal space to face new challenges. Whilst I will assume tax revenues and debt issuances to be constant over time, I will play with the other government's budget constraint component, the debt repayment. The empirical evidence furnished by the anti Covid – 19 IMF policy tracker has shown how several central banks and monetary authorities, along the pandemic curve, have substantially decreased the policy interests' rates which now for a lot of countries are close to zero or even below the zero – lower bound. With the same level of debt issued but lower interest rates a given country may benefit from a decrease in the debt service side and larger windows for fiscal interventions. Also, in this case, I will further explain the specification mechanism behind this intuition in the following section. For now, the main take I would like to keep is that countries have additional fiscal flexibility granted from central banks and international institutions.

5.1.1 Identification Strategy

The identification process hinges on the main element of coupling data available at a high frequency and at a low frequency and adjusting the observations for robustness purposes. The first two outcomes on which I focus my attention are the variation in the scores for respectively the lockdown stringency index and the health containment index. These policy response indexes are collected by the Oxford university Covid - 19 Government Response Tracker (OxGCRT) which collects and systematically evaluates the cross - national measures against the health crisis. The lockdown stringency index weights the social distancing measures that each country has committed towards, due to a closure of public spaces, public offices and to a general shutdown of the socio – economic activity. On the other hand, the health containment index adds on this social distancing and non – pharmaceutical benchmark. Thus, the health containment index depicts also health interventions as changes in contact tracing, testing policies or info campaigns and offers a more comprehensive outcome[13]. The OxGCRT collects data from almost 190 countries at a daily frequency.

For my dependent variables I draw on the national daily reports for Covid – 19 cases and Covid – 19 deaths that each country administers to the World Health Organization. The available data on the number of reported cases and deaths is, reached this point of the

[13] Precisely:

- LSI $= \frac{1}{k}\sum_{i=1}^{k} C_i$, with i different containment measures, such as: social distancing policies, restriction to gatherings, cancellation of public events, school and work place closing, etcetera.
- HCI = LSI $+ \frac{1}{k}\sum_{1=j}^{k} H_j$, with j different health measures, such as: contact tracing, testing policies, investments in vaccines. (OxGCRT, 2020)

research, clearly dependent on endogenous economic and epidemiological factors. However, to include these variables and compute their effects on the dependent variable is not straightforward. The covariates for each country, as again demographic characteristics, health care spending, informal sector, etcetera, in fact, are mostly available at a yearly frequency. To match the two different time dimensions, it is necessary to build a set of interaction variables which can absorb the filtered effect that the control variables have on the number of Covid – 19 cases or Covid – 19 deaths and, in turn, on the variation of policy measure. With this goal in mind I take the number of Covid – 19 cases and Covid – 19[14], hence I log transform the obtained value[15].

At this point the log value of the total number of Covid – 19 cases and Covid – 19 deaths are interacted with the covariates of interest. Every interaction has some predictive power on how the economic constants affect the mitigation policy mix for each country. The log Covid – 19 cases and Covid – 19 deaths controls for the spread of the virus and for the cumulative amount of total cases or deaths. Although, the lockdown stringency index and the health containment index are available at a daily frequency it would be inaccurate to assume a one – to – one correlation with the number of active cases or reported deaths. To avoid endogeneity issues, it is safe to take the first difference in the log value of Covid – 19 cases and Covid – 19 deaths. As afore mentioned, the log number of Covid – 19 cases and Covid – 19 deaths already give us information on how the policy makers react to the magnitude of active infections. Moreover, the first difference in the cumulative value, absorbs any possible endogenous variation in the policy response. This approach is consistent with the hypothesis of exogeneity of the instruments.

While it is quite mechanical and immediate to correct the specification for reverse causality concerns between the independent variable and the different explanatory variables, the model upon discussion leaves me with measurement biases I cannot control for. In fact, the different interactions that are included in the econometric model strictly depend on the unbiasedness of the Covid – 19 cases observations. I might expect errors in the reported

[14] My initial strategy was to scale the number of Covid – 19 cases and Covid – 19 deaths by the total population of the country and then divide by its standard deviation. By doing so, I would have had the have the number of Covid – 19 cases and Covid – 19 deaths per capita. Nevertheless, I tend to believe that the simple log transformation is more appropriate.

[15] Precisely, the log transformation is of the type log + 1 in order to deal with Covid – 19 cases and Covid – 19 deaths equal to zero and avoid missing values.

value of Covid – 19 cases and Covid – 19 deaths due to unobserved characteristics across countries as malfunctions in the Covid – 19 reporting system. An exogenous measurement error in this variable, might overestimate or underestimate the predictive power of the interaction and lead to distort estimates[16].

In addition to this, I control for the number of new Covid – 19 cases and new Covid – 19 deaths reported in the country alternatively in the last 7 days and in the last 10 days. The reason behind testing for two different frequencies the responsiveness of the policy authorities to changes and shocks in the amount of new contagions is to gather some information on how governments adjust their decisions to new available information, as differences in the rate of transmission of the virus and consequently in the agents' epidemiological behaviour. The two lag periods might provide results on the policy commitment given the available amount information; nevertheless, these open to new endogeneity concerns. In fact, it may be plausible to assume that governments and policy authorities recur also to epidemiological predictions to decide on the optimal level of containment to deploy. Interpreting the results of the model, it is necessary to keep in mind the intrinsic level of endogeneity of the model.

Finally, following El Fayoumi and Hengge (2020: 11), the fixed effects specification "*capture shocks to aggregate economic and market conditions that enter the objective function of the government*". Therefore, country x month fixed effects allow me to control for baseline differences across countries and for slow moving fluctuations in the outcome under investigation.

The same approach can be used for the parallel analysis depicted by (13). The identification strategy in this case follows the same logic with (12). The log number of Covid – 19 cases and Covid – 19 deaths are also in this case interacted with a set of control variables to test the endogenous response of the government to deal with the negative economic consequences of the pandemic. This time the lockdown stringency index and the health containment index are specified on the right – hand side of the equation to evaluate the impact and existing relation between health gains and economic costs of implemented mitigation policies. In order to have a comprehensive indicator of the economic stimulus that countries have deployed along the pandemic curve I have built an index which combines

[16] There is evidence to support the hypothesis of under reporting errors in the number of Covid – 19 cases across (developing) countries. See Lachmann et al. (2020). This, in particular, will lead to underestimated results.

the fiscal spending issued by the government as percent of the country GDP and the private economic support index provided by OxGCRT. The latter evaluates on the usual 0 to 1 scale the sum of the economic transfers to private households that the country has deployed during the pandemic. These transfers take into account only income support under the shape of cash payments and freeze loan repayments for people who have lost their job or whose salary is below arbitrary levels imposed by the economic department of each country. On the other hand, the expansionary fiscal policy might be intended as a new liquidity injection to the public sector and the share of population not targeted by the income support measures.

By interacting these two variables I tend to believe I have a reliable picture of the economic pickup activity of the studied countries. To facilitate the interpretation, I have standardized the income support indexes and only then interact it with the fiscal stimulus variable. Moreover, this allows me to consider the effect of the fiscal policy only for the period in which this has been effectively deployed. In fact, while the fiscal spending data is available at the year level, the economic support index is available at the high frequency daily level. If the value of the latter is zero it is presumable that, up to that date, the policy authorities have not decided on any economic support measures.

5.2 Data

Table 1 offers a summary of all the dependent, independent and control variables used in my analysis with the description of how they have been generated. Building my dataset, I took into account observations on Covid – 19 cases and Covid – 19 deaths from the second and third trimester of 2020 from the World Health Organization Covid – 19 tracker (WHO, 2020). Precisely, I collected observations for the period 15.02.2020 – 15.08.2020. Countries which have reported, during the previous month of the epidemic, a total amount of cases greater than 45000 units[17] were part of my initial sample.

From this raw group, I have dropped all the countries in which the spread of the virus was due to a located cluster transmission. This allows me to avoid the construction of several concentration indexes and consider only countries which have experienced a "smooth" and homogeneous spread of the virus over the national territory. If I would have not done so, the already strong hypothesis of representative agents would have been unfeasible. In fact, countries which have experienced a clusters transmission of the virus over the national territory are more likely to deploy and commit to different mitigation policies according to

[17] This choice is purely arbitrary but asymptotically consistent with the results of Alvarez et al. (2020)

where the clusters are effectively located. Moreover, economic agents from different locations will benefit from different level of lockdown and shape their differences accordingly. Hence, rather than one representative objective function of the government I might have more according to the rate of transmission of the virus that each region\province experience.

I have also dropped countries for which data on lockdown and health measures are not available or significantly fragmented. Finally, high-income countries labelled as advanced economies by the IMF have been dropped from my sample in order to assess the governments' response to the Covid – 19 pandemics in low–middle income threshold contexts. Such exclusions will allow me to pursue the research focusing on developing countries.

The dataset includes 47 countries grouped into six geographic regions. The dataset is slightly different for what concerns the second stage of my research. In this case, the observations on the Covid – 19 cases and Covid – 19 deaths are collected only for countries which, in the 15.02.2020 – 15.08.2020 period, have scored at least one variation in the economic stimulus index. Such need is driven from the research purpose of investigating the interplay of already existing health and economic policies in developing economies. Therefore, the dataset includes 5 307 observations from 29 out of the initial 47 countries. Table 2 reports all the countries included in the research.

Variable	Source
Outcome	
Fiscal Stimulus Index	Own Preparation
Health Containment Index	OxGCRT (2020)
Lockdown Stringency Index	OxGCRT (2020)
Independent	
Covid - 19 Cases	JHU CSSE (John Hopkins University, 2020)
Covid - 19 Deaths	JHU CSSE (John Hopkins University, 2020)
Covariates	
Broadband Coverage (% population)[18]	OECD/World Bank (2020)
Public Health Care Spending (% GDP)[19]	International Labour Organization (ILO, 2020)
Exchange Rate Stabilization	International Monetary Fund (IMF, 2020)
Informal Employment (Non – Service Sector)[20]	International Labour Organization (ILO, 2020)
Policy Rate	International Monetary Fund (IMF, 2020)
Population density (Number of habitants x sq. km)	UN Population Division (2020)
Public Debt level (% GDP)[21]	OECD/World Bank (2020)
Share of Children in the Population (0 – 14)	UN Population Division (2020)
Share of Elderly in the Population (>65)	UN Population Division (2020)
Trade Openness Index (% GDP)[22]	OECD/World Bank (2020)
Unemployment Rate (% labour force)	International Labour Organization (ILO)
Interactions	
Covid - 19 Cases x Health Care Spending	Own Preparation
Covid - 19 Cases x Informal Employment	Own Preparation
Covid - 19 Cases x Internet Access	Own Preparation
Covid 19 Cases x Share of Children	Own Preparation
Covid - 19 Cases x Share of Elderly	Own Preparation
Covid - 19 Cases x Trade Openness	Own Preparation
Covid - 19 Cases x Policy Rate	Own Preparation
Covid - 19 Cases x Exchange Rate Stabilization	Own Preparation
Parameters of Interest	
Hospital Bed Capacity: 0.00011 per capita	Glover et al. (2020)
Tax Collection Cost: 2.22 per tax unit	Dzansi et al. (2018)
Fatality Rate: 0.01 x Infected Recoveries Rate	Alvarez et al. (2020)

Table 1. Data Summary

[18] Total population with access to internet over the period 2017 – 2019.

[19] Weighted average over the period 2017 – 2019.

[20] Share of the total labour force employed in the informal sector to the latest available data.

[21] Weighted average over the period 2017 – 2019.

[22] Share of GDP of traded semi – finished products over the period 2017 – 2019.

Country	Region
Afghanistan	Central - Southern Asia
Azerbaijan	Central - Southern Asia
Bangladesh	Central - Southern Asia
India	Central - Southern Asia
Kazakhstan	Central - Southern Asia
Nepal	Central - Southern Asia
Pakistan	Central - Southern Asia
Uzbekistan	Central - Southern Asia
Belarus	Eastern Europe
Czech Republic	Eastern Europe
Poland	Eastern Europe
Romania	Eastern Europe
Russia	Eastern Europe
Ukraine	Eastern Europe
Argentina	Latin America
Bolivia	Latin America
Brazil	Latin America
Chile	Latin America
Colombia	Latin America
Costa Rica	Latin America
Dominican Republic	Latin America
Ecuador	Latin America
Guatemala	Latin America
Honduras	Latin America
Mexico	Latin America
Panama	Latin America
Peru	Latin America
Venezuela	Latin America
Iran	Middle East
Iraq	Middle East
Israel	Middle East
Kuwait	Middle East
Lebanon	Middle East
Oman	Middle East
Qatar	Middle East
Saudi Arabia	Middle East
Turkey	Middle East
United Arab Emirates	Middle East
Algeria	Northern Africa
Egypt	Northern Africa
Morocco	Northern Africa
Indonesia	South - Eastern Asia
Philippines	South - Eastern Asia
Ethiopia	Sub - Saharan Africa
Ghana	Sub - Saharan Africa
Nigeria	Sub - Saharan Africa
South Africa	Sub - Saharan Africa

Table 2. Country Summary

Chapter 6
Results

In this section I present the empirical results of my analysis. I will first show the results from the regression model specified in (12) and explore how the endogenous exposure to the Covid – 19 pandemic for the studied sample might have determined different policies response. Later, I will report the results of the discretionary fiscal policies implemented by the countries and evaluate the trade – offs between health and economic outcomes.

6.1 Lockdown Policy Commitment

Table 4 reports the first estimates of the effect of the Covid – 19 interaction variables and the log number of new Covid – 19 cases and Covid – 19 deaths on the level of lockdown stringency. In each column, all the coefficients of the log values prove to be significant at 1% level. It is immediate to notice how the log number of new Covid – 19 cases and new Covid – 19 deaths per capita are positively correlated with the lockdown stringency index. Looking at the response of the policy authorities in column (1) and (1'), the lockdown stringency increase ranges on average between 0.24 and 0.25 % points due to a 1% increase in the new reported number of Covid – 19 cases over the past 7 days. In column (1) and (1') I also report that the lockdown stringency index increase by 0.187 and 0.2 points in response to a one standard deviation unit increase in the new number of reported infections over the past 7 days. The magnitude of the stringency increment suggests that policy authorities are reactive to every variation in the number of infections and prefer to control the spread of the virus by imposing more stringent measures. However, the effect of a 1% increase in the number of cases over 7 days has only a limited incidence in determine the degree of lockdown stringency deployed by a country. In fact, I notice how the average of the lockdown index within the sample is equal to 0.66 points with a 25th percentile equal to 0.52 points.[23] In particular, interpreting the coefficients in column (2) and (2'), it is possible to notice how the

[23] Please notice, however, that the within average of the increment of new Covid – 19 cases and new Covid – 19 deaths over a 7 days period is equal to 11.3% and 10.3% respectively. Over a 10 days period, instead, the average is respectively equal to 18% and 16%. Therefore, in response to a 11.3% increment in the number of new cases the lockdown index increases by 2.7% points. It should be easy to compute the real effect from now on following the same rules. Table 3 offers some descriptive evidence to further interpret the results.

countries' response, on average, tends to be more severe once the lag period is extended. In fact, an additional 1% in the number of Covid – 19 cases over the last 10 days, leads to an increase of the lockdown stringency index of 0.3% - 0.32% points. I will discuss the importance of this result in the following section. For now, I can confirm that policy makers appear to be sensitive and cautious in response to each unit surge in the number of Covid – 19 cases. The commitment to given lockdown scores is remarkable and shows the sensitivity of such containment policies to higher transmission rates. Columns from (3) to (4') report the estimates for the log number of Covid – 19 deaths per capita. In this case the responsiveness of the lockdown stringency occurs to be higher. I illustrate how the lockdown stringency score increases by, on average, 0.68% points and 0.62% points in response to a 1% raise in the log number of Covid – 19 deaths in the last 7 and 10 days respectively. Here, the governments seem to be more responsive once the lag period is smaller. This can be because of the urgency and importance that policy makers give to human losses.

Next to this, the estimates for the Covid – 19 cases x health care spending variable show how countries that spend more in healthcare tend to score more on the lockdown stringency scale. Indeed, in column (1'), (2) and (2') I point out that a one percent increase in the public health care spending as share of the national GDP, opens to lockdown stringency scores which are higher by 0.34 to 0.44 points[24], on average. This result partially clashes with what I stated before in section 2. In fact, I might expect less stringent lockdowns for countries with more developed and pandemic – prepared health care systems as proxy of the medical preparedness to face a health crisis[25]. However, against a higher investments flow towards the health care system, the hospital capacity remains insufficient for most of the developing countries with a bed per capita ratio equal to 0.00011 (Glover et al., 2020). Graph 7 shows an interesting and helpful visualization of the non – linear interaction between the Covid – 19 cases and the public health care spending. For a given number of Covid – 19 cases, countries with a higher public health care spending over the period 2017 – 2019 tend to have a higher chance to implement strict lockdown policies in response. Although the variation in terms of probability of lockdown is negligible, it shows that such countries may place greater importance on health issues and decide to spread the extent of lockdown and commit to spread of the virus containment faster.

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[24] Please remember that the lockdown stringency index ranges from 0 to 1 and therefore is perfectly equivalent to refer to variations either in terms of percentage points or in terms of points variation.

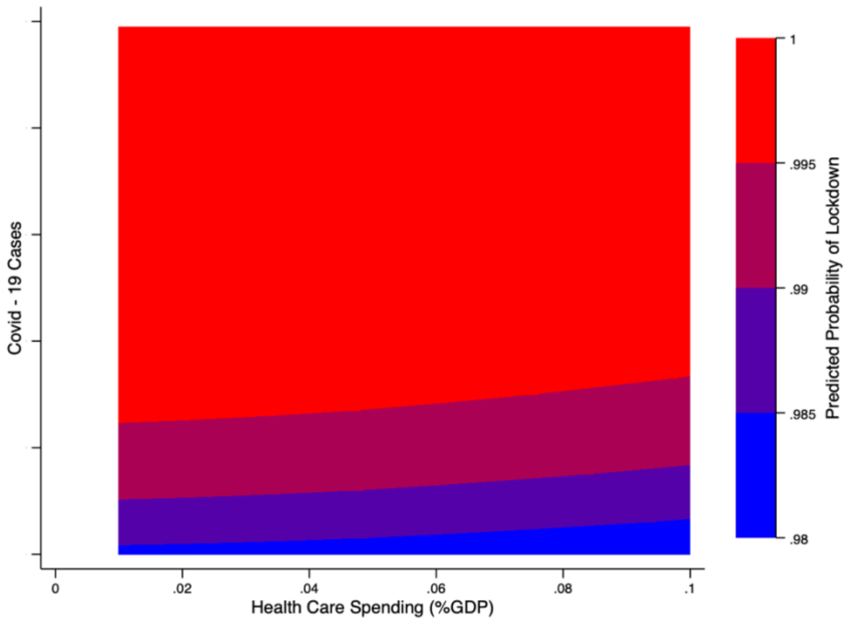
[25] See section 2.

I also note a significant discrepancy in the coefficients related to the share of children and the share of elderly in the population. I decided to run the regression separately for the two variables to avoid any issue due to multicollinearity. I might expect a positive correlation between a higher presence of children and elderly people in the population and the lockdown stringency due to the vulnerability that these two categories have shown during the past months of the pandemic. Please note that the vulnerability I am referring to is different for the two categories. Obviously, elderly people tend to be more exposed to infective disease because of weaker immune systems. Children instead benefit from a virus which does not affect and erode their immune defence. Nevertheless, children are more affected because of the impossibility to frequent schools, gather with friends and play outside[26]. Whilst I found that a higher prevalence of children in the country leads to a higher level of lockdown, the sign for the impact of elderly appears to be negative. In particular, I notice that a one percent point increment in the share of children between 0 and 14 years of age is correlated with a lockdown stringency that is 0.2 points higher. On the other hand, the coefficient of the share of elderly (above 65 years of age) is negative but perfectly equivalent in the magnitude. It is possible to notice this in column (1') and (2'). In light of this aspect, it may be possible to breakdown the overall effect. On one side, in fact, older countries should lockdown earlier and more as happened eastern Europe countries (from the sample) such as Poland and Ukraine. However, on the other hand, I might interpret a higher presence of elderly people as a proxy of the robustness of the institutions in general and again of the health care and social security sector. In this case, accordingly to the theoretical framework, policy authorities benefit from lower lockdown costs and a higher health (and wealth) of the population. Furthermore, this result proves to be consistent in light of the negligible share of people older than 65 encountered in developing countries. The marginal effect that a percentage increase of this group might have on policy decisions is smaller. On the other hand, in response to dramatically younger populations, policy makers are forced to implement stringent measures to prevent physical contacts. School closing policies and interventions against public movements or social gatherings will have a greater influence on the lockdown stringency score.

[26] Such vulnerability reflects also a more challenging management of the pandemic. Indeed, more resources have to be deployed for home schools' programs, limit to gatherings and to deal with the parents' concerns (especially for infants).

Variable	Obs.	Mean	St. Dev.	Median (25th Pctl)
Covid - 19 Cases	8.601	71464.03	2333605.8	9684
Covid - 19 Deaths	8.601	2245.14	8.212.654	180
Lockdown Stringency Index	8.601	0.6628	0.287	0.7731 (0.527)
Health Containment Index	8.601	0.6484	0.257	0.7424 (0.537)
Transmission Rate (7 Days)	6.698	0.1173	0.2919	0.377
Transmission Rate (10 Days)	6.510	0.1782	0.4169	0.06
Fatality Rate (7 Days)	6.698	0.1032	0.2472	0.0322
Fatality Rate (10 Days)	6.510	0.1604	0.3516	0.052

Table 3. Descriptive Statistics of Variable of Interest



Graph 7. Probability of Lockdown over Number of Covid-19 Cases and Public Health Care Spending

Source: Own Preparation.

6.1.1 Stringency Effectiveness

Before moving on, I would like to discuss some important consideration deriving from the above presented results. Presenting the lockdown stringency index, I said how this ranges from 0 to 1 according to variation on the non – pharmaceutical and social distancing interventions that each country has decided to deploy over the pandemic curve. Needless to say, that countries which have agreed on broadly targeted and strict mitigation policies will be characterized by a higher stringency level. However, this stringency index is not giving us any reliable information on the effectiveness of a particular level of stringency rather than another. In other words, this score is not telling us anything on θ in $L(t)\theta$[27], with θ level of technology of the lockdown instrument. Going back to the results, given the higher response of policy makers (in terms of stringency scores) to an increase in the number of new cases over the 10 days lag period, I might assume that the tracking and reporting technology of new Covid – 19 cases is less efficient in the countries under investigation. Hence, policy authorities opt in favour of a higher lockdown level. Moreover, if I assume that the lockdown technology effectiveness and the Covid – 19 cases reporting technology effectiveness are positively correlated, the results in table 4 prove to be even more significant. Thus, countries under investigation need to deploy higher degrees of lockdown to compensate the lack of technology. The result of a higher level of lockdown finds support also from the study of Fetzer et al. (2020) on the reactions of the population to the Covid – 19 pandemic outbreak. The empirical evidence suggests indeed that in low – middle income countries there is a widespread lack in the compliance with the behavioural messages and anti – Covid guidelines issued by the national and international health institutions to prevent the transmission of the virus. Policy authorities find themselves forced to commit to a higher level of lockdown. Again, if I assume that the lockdown effectiveness and the population compliance to behaviours aimed at preventing the Covid – 19 spread, countries have to commit to more severe lockdown policies. At this point investments in health care sector have a negligible effect and the results in table 4 can confirm it.

[27] See section 3.4.1

VARIABLES	(1) Lockdown Stringency Index	(1') Lockdown Stringency Index	(2) Lockdown Stringency Index	(2') Lockdown Stringency Index	(3) Lockdown Stringency Index	(3') Lockdown Stringency Index	(4) Lockdown Stringency Index	(4') Lockdown Stringency Index
(Log) New Covid - 19 Cases (t - 7)	0.0238***	0.0252***						
	(0.00761)	(0.00758)						
	(0.0117)	(0.0117)						
(Log) New Covid - 19 Cases (t - 10)			0.0305***	0.0317***				
			(0.00679)	(0.00668)				
			(0.0108)	(0.0107)				
(Log) New Covid - 19 Deaths (t - 7)					0.0683***	0.0687***		
					(0.00721)	(0.00720)		
					(0.0115)	(0.0118)		
(Log) New Covid - 19 Deaths (t - 10)							0.0616***	0.0619***
							(0.00619)	(0.00622)
							(0.0107)	(0.0109)
(Log) Covid - 19 Cases (t - 1)	0.0186	0.0909***	0.00994	0.0842***	-0.00547	0.0930***	-0.00748	0.0925***
	(0.0394)	(0.0164)	(0.0392)	(0.0161)	(0.0376)	(0.0165)	(0.0372)	(0.0167)
	(0.0390)	(0.0182)	(0.0394)	(0.0182)	(0.0427)	(0.0228)	(0.0427)	(0.0231)
Covid - 19 Cases x Health Care Spending	0.292	0.390*	0.340*	0.448**	0.170	0.288	0.195	0.317
	(0.196)	(0.203)	(0.197)	(0.204)	(0.198)	(0.206)	(0.200)	(0.209)
	(0.290)	(0.309)	(0.292)	(0.312)	(0.328)	(0.351)	(0.332)	(0.356)
Covid - 19 Cases x Informal Employment	-0.189**	-0.187**	-0.204**	-0.203**	-0.125*	-0.118*	-0.128*	-0.121*
	(0.0797)	(0.0780)	(0.0823)	(0.0805)	(0.0713)	(0.0673)	(0.0734)	(0.0692)
	(0.102)	(0.0991)	(0.106)	(0.103)	(0.102)	(0.0948)	(0.106)	(0.0981)
Covid - 19 Cases x Public Debt (% GDP)	0.0387**	0.0351**	0.0399**	0.0360**	0.0275*	0.0224	0.0244	0.0193
	(0.0160)	(0.0161)	(0.0162)	(0.0162)	(0.0154)	(0.0155)	(0.0155)	(0.0156)
	(0.0188)	(0.0191)	(0.0190)	(0.0193)	(0.0219)	(0.0224)	(0.0218)	(0.0224)
Covid - 19 Cases x Internet Access	0.0353	0.0144	0.0371	0.0165	0.0488**	0.0192	0.0506**	0.0207
	(0.0263)	(0.0189)	(0.0261)	(0.0188)	(0.0247)	(0.0170)	(0.0244)	(0.0167)
	(0.0250)	(0.0183)	(0.0251)	(0.0184)	(0.0281)	(0.0194)	(0.0281)	(0.0192)
Covid - 19 Cases x Share of Children	0.172**		0.176**		0.233***		0.236***	
	(0.0808)		(0.0804)		(0.0799)		(0.0791)	
	(0.0878)		(0.0896)		(0.0986)		(0.0955)	
Covid - 19 Cases x Share of Elderly		-0.162**		-0.175**		-0.209***		-0.214***
		(0.0697)		(0.0701)		(0.0673)		(0.0672)
		(0.0827)		(0.0856)		(0.0866)		(0.0860)
Constant	-0.237***	-0.242***	-0.215***	-0.221***	-0.188***	-0.197***	-0.196***	-0.205***
	(0.0336)	(0.0339)	(0.0350)	(0.0353)	(0.0313)	(0.0316)	(0.0318)	(0.0320)
	(0.0420)	(0.0409)	(0.0439)	(0.0424)	(0.0466)	(0.0475)	(0.0473)	(0.0480)
Observations	8 084	8 084	7 943	7 943	8 084	8 084	7 943	7 943
R-squared	0.898	0.898	0.889	0.889	0.907	0.907	0.898	0.898
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses are clustered at country x week and country groups.

*** p<0.01, ** p<0.05, * p<0.1

Table 4. Fixed Effect regression of the lockdown stringency index on endogenous parameters set

6.2 Health Mitigation Regime

Table 5 reports the results for the health containment index. Here the coefficients for the log number of new Covid – 19 cases and new Covid – 19 deaths prove to be significant at the 1% level. In column (1) and (1') I show that a 1% increase in the number of new reported Covid – 19 cases guides to higher containment scores by 0.2% points and 0.21% points respectively. As happened in table 4, once the lag period is stretched from 7 to 10 days the coefficients tend to increase. Indeed, in column (2) and (2') I signal a positive +0.25% points and +0.26% points. Following up, the magnitude of the effect of one more reported death in the total number of new Covid – 19 losses is greater if I look at the estimates of column form (3) to (4'). The effect in this case is double and equal to an increase of 0.5% points in response to a unit variation in the number of deaths[28]. To this end, the health containment index seems to be less responsive than the lockdown stringency index.

As in previous model, I find a much slighter effect of the number of new Covid – 19 cases on the containment index compared to the number of Covid – 19 deaths. Also, in this case, there is evidence to support that countries which spend more in health care show on average a higher level of containment. Precisely, the public health care spending variable level of significance wavers between 1% and 5% level as I can see from column (1) to (2'). The coefficient instead suggests that countries which spend 1% more in their health systems tend to score between 0.28 and 0.4 points more on the containment index scale. It has to be noticed that in this model I am not referring only on the extent of lockdown stringency that each country has compelled towards, but I am controlling also for changes in the Covid – 19 mitigation health measures. Thus, the overall effect of the Covid x health spending interaction embeds two different effects: 1) the variation in social distancing and non – pharmaceutical interventions; and 2) the variation in the medical response. This proves how countries which have spent more in the health care sector over the last three years (2017 – 2019) are more likely to be pharmaceutically prepared against the Covid – 19 pandemic thanks to better testing and contact tracing policies or, in some cases, thanks to investments in vaccines research and development. Next to this and in line with the prior results, I note how a greater internet coverage across the national territory is positively correlated with the health containment score. A greater share of the population who can access online resource, leads to containment index which are 0.4 points higher on average. The coefficients of

[28] Although I am talking about causality please keep in mind that the various models control instead for correlation.

interest in this case prove several levels of significance[29]. The adoption of online resources against the Covid – 19 pandemic, has been highlighted by the previous literature with focus on the adoption of technology to improve pandemics performances in the context of health care units and SME's[30]. Alongside a broader internet coverage, a country might benefit from lower costs in human contacts tracking and Covid – 19 cases reporting. Besides, I would say that a country might benefit of "positive – behaviour economies of scale" which will arise thanks to increased online catchment areas.

6.2.1 Second Best Solution

Using a CGE calibrated model, Glover et al. (2020) have discussed the distributional effects of the Covid – 19 pandemic on the different segments of the population, showing how workers active in the shuttered sectors are mostly affected by the containment policies. The general shutdown of the economic activity, as stated by Furceri et al. (2020) "*has affected the prospects of job market opportunities, driving more activity in the precarious work*". In light of this, it is interesting to discuss the impact that the share of informal employment has on both the stringency index and the containment index. Both table 4 and 5 illustrate how countries which experience a higher incidence of the informal sector on the labour force tend to score, on average, between 0.12 points and 0.20 points less on the (0 – 1) index scale. The intuition behind the negative sign of the estimate is not immediate. I might have expected a higher level of lockdown given the impossibility to control all the "hidden" transactions and economic activities. In fact, (6') illustrates how the total amount of Covid – 19 cases and, in turn, Covid – 19 deaths are positively dependent from the total consumption and worked hours in the economy. Please remind that I assume that consumption and hours worked set up social interactions between individuals. Informal activity, given the impossibility of control, in this sense favours the transmission of the virus through consumption of informal products and social interaction on the informal workplace. Therefore, policy authorities might be forced to implement strict shutdown measures to prevent this unrestrained economic and social activity. Let's think now about informal employment in terms of (low skilled) unemployed labour forced which, given the lack of job opportunities due to the (lock-)shutdown of regular activities, now decides to enter the informal sector. In this case, the informal employment represents the negative outcome of a too stringent lockdown policy.

[29] It is enough to see the standard errors differ across the columns.3

[30] See Kumar, Syed, Pandey (2020).

The policy authorities now, incorporating this market distortion and the expectations of the agents, might ponder upon a less stringent level of containment in order to mitigate the negative distributional effects on income[31]. The informal employment coefficients in table 4 and 5 prove such hypothesis.

[31] Partially confirming this result, Glover et al. (2020) discuss how welfare gains and losses might depend from different lockdown levels.

VARIABLES	(1) Health Containment Index	(1') Health Containment Index	(2) Health Containment Index	(2') Health Containment Index	(3) Health Containment Index	(3') Health Containment Index	(4) Health Containment Index	(4') Health Containment Index
(Log) New Covid - 19 Cases (t - 7)	0.0201***	0.0214***						
	(0.00653)	(0.00647)						
	(0.0104)	(0.0103)						
(Log) New Covid - 19 Cases (t - 10)			0.0255***	0.0266***				
			(0.00580)	(0.00567)				
			(0.00954)	(0.00942)				
(Log) New Covid - 19 Deaths (t - 7)					0.0575***	0.0579***		
					(0.00596)	(0.00602)		
					(0.00960)	(0.00991)		
(Log) New Covid - 19 Deaths (t - 10)							0.0520***	0.0523***
							(0.00517)	(0.00524)
							(0.00895)	(0.00920)
(Log) Covid - 19 Cases (t - 1)	0.00925	0.0798***	0.00208	0.0741***	-0.0110	0.0816***	-0.0127	0.0810***
	(0.0327)	(0.0136)	(0.0324)	(0.0134)	(0.0311)	(0.0139)	(0.0308)	(0.0140)
	(0.0318)	(0.0151)	(0.0322)	(0.0151)	(0.0357)	(0.0192)	(0.0356)	(0.0196)
Covid - 19 Cases x Health Care Spending	0.274*	0.368**	0.313*	0.415**	0.171	0.281	0.192	0.306*
	(0.166)	(0.173)	(0.167)	(0.173)	(0.168)	(0.176)	(0.170)	(0.178)
	(0.252)	(0.270)	(0.253)	(0.271)	(0.283)	(0.305)	(0.287)	(0.310)
Covid - 19 Cases x Informal Employment (Non - Service Sector)	-0.182**	-0.180**	-0.195**	-0.193***	-0.129*	-0.122*	-0.131*	-0.124*
	(0.0761)	(0.0731)	(0.0780)	(0.0749)	(0.0701)	(0.0649)	(0.0720)	(0.0667)
	(0.107)	(0.101)	(0.110)	(0.103)	(0.108)	(0.0978)	(0.112)	(0.101)
Covid - 19 Cases x Public Debt (% GDP)	0.0299**	0.0264*	0.0309**	0.0272**	0.0205	0.0157	0.0179	0.0131
	(0.0133)	(0.0135)	(0.0134)	(0.0135)	(0.0130)	(0.0132)	(0.0132)	(0.0133)
	(0.0163)	(0.0168)	(0.0163)	(0.0168)	(0.0192)	(0.0199)	(0.0193)	(0.0199)
Covid - 19 Cases x Internet Access	0.0406*	0.0200	0.0421*	0.0218	0.0520**	0.0240*	0.0535***	0.0254*
	(0.0219)	(0.0157)	(0.0217)	(0.0156)	(0.0207)	(0.0143)	(0.0204)	(0.0141)
	(0.0213)	(0.0157)	(0.0215)	(0.0158)	(0.0243)	(0.0169)	(0.0242)	(0.0168)
Covid - 19 Cases x Share of Children	0.168**		0.171**		0.219***		0.222***	
	(0.0682)		(0.0675)		(0.0668)		(0.0662)	
	(0.0697)		(0.0709)		(0.0809)		(0.0787)	
Covid - 19 Cases x Share of Elderly		-0.156***		-0.166***		-0.196***		-0.199***
		(0.0588)		(0.0592)		(0.0574)		(0.0572)
		(0.0702)		(0.0726)		(0.0770)		(0.0761)
Constant	-0.150***	-0.156***	-0.132***	-0.138***	-0.110***	-0.118***	-0.116***	-0.124***
	(0.0284)	(0.0288)	(0.0296)	(0.0299)	(0.0263)	(0.0267)	(0.0268)	(0.0270)
	(0.0354)	(0.0350)	(0.0373)	(0.0365)	(0.0387)	(0.0399)	(0.0394)	(0.0405)
Observations	8 084	8 084	7 943	7 943	8 084	8 084	7 943	7 943
R-squared	0.906	0.906	0.896	0.897	0.915	0.914	0.905	0.905
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses are clustered at country x week and country groups
*** p<0.01, ** p<0.05, * p<0.1

Table 5. Fixed Effect regression of the health containment index on endogenous parameters set

6.3 Discretionary Fiscal Policy

So far, I have discussed how differences in the exposure to the Covid – 19 pandemic might lead to different health mitigation policies. In addition to containment instruments to cope with the health negative consequences of the Covid – 19 emergency, policy authorities from different countries can decide to address the wealth and economic outcomes of the health crisis. I already said, in fact, that social distancing and lockdown measures deployed by the different countries have drastically, of necessity, repress the economy. Likewise, in section 3 I have introduced the concepts of first order of condition with emphasis on the economic marginal costs and the health marginal benefits linked to the pandemic. Hence, in this section I will address the trade - off between health and wealth outcomes which arise once the governments decide on a fiscal package to restore the economic activity. Table 6 and 7 report the empirical results for the fiscal stimulus index scores. I notice that countries which register higher scores in the lockdown stringency index and the health containment index, tend to record higher scores in the fiscal stimulus indicator too. In both cases, the estimates of the two variables prove to be significative at 1% level. In table 6, Countries who score a 1% point higher lockdown stringency index, tend to report in column from (1) to (2') a fiscal stimulus index between 4.8% points and 5% points greater. In column from (3) to (4') the coefficient remains positive and 1% level significant but ranges between +3.6% points and +3.76% points. In table 7, I find same results for the health containment index but in this case the effect of higher containment measures on the fiscal stimulus deployed by the country is larger (from a minimum value of +4.4% points in column (3) to a maximum value of +6.1% points in column (2')). It is interesting to dwell on the magnitude of such coefficients. In fact, in the countries under investigation, a 1% point increase in the level of lockdown can actually lead to a 6% points in the fiscal stimulus index. Obviously, such magnitude depends on the unbiasedness of the fiscal index that I built but it still offers me important results. In fact, there is evidence to support a positive relation between health and economic measures. Countries which presumably have control of the spread of the virus thanks to higher levels of lockdown, can pick up the economic activity more than others.

Following up, in both tables in column (1) and (1'), the increase by one percent of new reported Covid – 19 cases decreases the fiscal stimulus score by 0.08% points, on average. In column (2) and (2'), when the lag period is equal to 10 days, a percent increase in log number of new Covid – 19 infections leads to 0.06% points decrease. All the presented coefficients prove to be significant at 1% level.

The opposite sign of the coefficients for the share of children and the share of elderly people in the population is recurrent. The presence of children negatively affects the fiscal stimulus. For a one percent increase in the share of the (0 – 14 years old) children on the population I report, on average, a decrease between 2.8% and 3.4 % points in the fiscal room capacity of the country. On the contrary, the public expenditure benefits from older generations. Here, not only the sign of coefficient is positive but, in both tables (6 and 7), the size of it is greater. Countries which have a 1% point greater share of (older than 65 years of age) elderly over the population tend to score +0.07 points more on the fiscal index. In accordance with the previous sections, children represent the trickiest category to deal with in the health crisis and the fiscal capacity of the country might be affected by this. Additional school closing interventions, limit to public events, public info campaigns etcetera might be necessary at the expenses of fiscal ones. Older populations, instead, vouch for stronger wealth systems. Thus, the budget constraints of the local and national institutions are relaxed, and the fiscal capacity positively affected.

6.3.1 Pro-Fiscal Interventions

In addition to fiscal spending policies issued by the different governments, central banks and international credit institutions have deployed several interventions to stabilize the economy. The IMF Covid – 19 policy tracker takes record of such interventions. During the past months of the pandemic, several central banks have decided to decrease the interest (policy) rates in place of an expansionary monetary policy in favour of the economy. Due to this policies and lower interest rates, countries and investors may benefit from an increased monetary basis. Moreover, central bank in agreement with credit institutions and countries governments themselves, have decided on structural interventions to stabilize any fluctuation in the currency exchange rate in order to limit heavy depreciations of weak national currencies due to stop of international trade. Therefore, a priori, it is legitimate to think that such open market interventions interact and have an impact on the fiscal capacity of the national governments. Countries open to the international trade and heavily affected by a lockdown which stops every transaction on the international market, might benefit from policies which stabilize the exchange rate within a safe corridor. The impact of these macroeconomic interventions is captured by the Covid – 19 cases x policy rate interaction variable and the exchange rate variable. In particular, the exchange rate variable is a dummy indicator which assumes value of 1 if the country adopted macro – financial stability plans and 0 in the contrary. In both tables (6 and 7), there is broad evidence of a positive relation between the public debt level of the country and the fiscal stimulus index score. The Covid – 19 cases x public debt level shows how countries that are 1% point more indebted tend to have a fiscal stimulus score higher by 0.8% points in column (2') by 1% points higher in column from (3) to (4'). The budget constrain expressed by (4) in section 3, confirms how the public expenditure increases in the amount of debt issued with equal tax revenues and debt service payments. Indeed, it is possible to think about the latter variable (given the way I built it) as a proxy of new amounts debt issued by the country during the pandemic. Up to this point, however, there is no evidence to support any relationship between the policy rate movements and the fiscal spending index. Coefficients prove to be not significant in both the cluster groups (country x week group and country group). Besides, I would like to stress that new issued debt deteriorates the deficit of the country and opens to a debate on the sustainability of heavy debt levels in the long – term. I do not take into account such aspects in this research. Whilst I do not find any proof of a correlation between the trade openness of the country and his expansionary policy, for the exchange rate the results found are heterogeneous. The heavy reliance of a countries on international trade, indeed, has led to reconsider global supply chains and reshape the balance of payments in view of a sound debt management. If only slightly, the exchange rate stabilization dummy variable has positive sign and proves to be significant at 1% level as it is possible to notice in both tables[32]. Hence, countries might benefit from limited currency fluctuations, but the magnitude of the dummy variable does not suggest me any significant difference between the two groups with a coefficient of +0.05% points in the best scenario. Countries with active programs of financial macro stabilization tend to have a fiscal spending which is on average only 0.05% points higher than countries that have not implemented such prudential measures.

[32] It is interesting to notice that I witness a level of significance only when the fixed effect model incorporates the share of children variable instead of the share of elderly one.

VARIABLES	(1) Fiscal Stimulus Index	(1') Fiscal Stimulus Index	(2) Fiscal Stimulus Index	(2') Fiscal Stimulus Index	(3) Fiscal Stimulus Index	(3') Fiscal Stimulus Index	(4) Fiscal Stimulus Index	(4') Fiscal Stimulus Index
Lockdown Stringency Index	0.0477***	0.0481***	0.0501***	0.0503***	0.0357***	0.0373***	0.0360***	0.0376***
	(0.00930)	(0.00887)	(0.00930)	(0.00877)	(0.00984)	(0.00938)	(0.0101)	(0.00960)
	(0.0159)	(0.0158)	(0.0155)	(0.0153)	(0.0157)	(0.0152)	(0.0156)	
(Log) New Covid - 19 Cases (t - 7)	-0.00848***	-0.00843***						
	(0.00213)	(0.00205)						
	(0.00217)	(0.00210)						
(Log) New Covid - 19 Cases (t - 10)			-0.00644***	-0.00627***				
			(0.00196)	(0.00188)				
			(0.00221)	(0.00217)				
(Log) New Covid - 19 Deaths (t - 7)					0.00383	0.00286		
					(0.00262)	(0.00251)		
					(0.00384)	(0.00373)		
(Log) New Covid - 19 Deaths (t - 10)							0.00299	0.00221
							(0.00216)	(0.00204)
							(0.00321)	(0.00311)
(Log) Covid - 19 Cases (t - 1)	0.00425	-0.00540	0.00511	-0.00550	0.00451	-0.00689	0.00446	-0.00692
	(0.00684)	(0.00484)	(0.00680)	(0.00480)	(0.00692)	(0.00498)	(0.00691)	(0.00499)
	(0.0123)	(0.00812)	(0.0124)	(0.00805)	(0.0118)	(0.00771)	(0.0118)	(0.00774)
Covid - 19 Cases x Unemployment	-0.0142	-0.0188	-0.0154	-0.0201	-0.0230	-0.0280*	-0.0234	-0.0283*
	(0.0165)	(0.0146)	(0.0159)	(0.0141)	(0.0166)	(0.0146)	(0.0167)	(0.0147)
	(0.0218)	(0.0163)	(0.0217)	(0.0164)	(0.0260)	(0.0209)	(0.0262)	(0.0210)
Covid - 19 Cases x Trade Openness (Semi Finished Products)	0.00796	0.000822	0.00782	0.000995	0.00733	0.000746	0.00751	0.000827
	(0.00498)	(0.00567)	(0.00499)	(0.00565)	(0.00505)	(0.00576)	(0.00509)	(0.00579)
	(0.00841)	(0.0103)	(0.00849)	(0.0103)	(0.00839)	(0.0101)	(0.00846)	(0.0101)
Covid - 19 Cases x Public Debt Level (% GDP)	0.00803	0.00832	0.00836	0.00883*	0.0106*	0.0113**	0.0107*	0.0114**
	(0.00542)	(0.00515)	(0.00533)	(0.00508)	(0.00576)	(0.00541)	(0.00577)	(0.00542)
	(0.00876)	(0.00831)	(0.00863)	(0.00818)	(0.00942)	(0.00869)	(0.00944)	(0.00871)
Covid - 19 Cases x Policy Rate	0.00561	0.00150	0.00479	0.000174	0.000708	-0.00458	0.000440	-0.00481
	(0.0228)	(0.0210)	(0.0228)	(0.0211)	(0.0239)	(0.0221)	(0.0240)	(0.0221)
	(0.0221)	(0.0198)	(0.0222)	(0.0200)	(0.0236)	(0.0208)	(0.0236)	(0.0208)
Covid - 19 Cases x Exchange Rate Stabilization	0.00590**	0.00372	0.00575**	0.00363	0.00557**	0.00355	0.00558**	0.00355
	(0.00278)	(0.00291)	(0.00278)	(0.00291)	(0.00282)	(0.00298)	(0.00283)	(0.00299)
	(0.00460)	(0.00510)	(0.00461)	(0.00510)	(0.00454)	(0.00499)	(0.00456)	(0.00501)
Covid - 19 Cases x Share of Children	-0.0289*		-0.0316**		-0.0337**		-0.0337**	
	(0.0158)		(0.0156)		(0.0165)		(0.0165)	
	(0.0251)		(0.0252)		(0.0249)		(0.0250)	
Covid - 19 Cases x Share of Elderly		0.0721***		0.0722***		0.0727***		0.0730***
		(0.0189)		(0.0189)		(0.0193)		(0.0193)
		(0.0336)		(0.0334)		(0.0330)		(0.0330)
Constant	-0.275**	-0.488***	-0.275**	-0.477***	-0.241**	-0.433***	-0.257**	-0.445***
	(0.117)	(0.156)	(0.116)	(0.153)	(0.114)	(0.150)	(0.119)	(0.153)
	(0.167)	(0.248)	(0.165)	(0.245)	(0.152)	(0.225)	(0.157)	(0.225)
Observations	4 986	4 986	4 899	4 899	4 986	4 986	4 899	4 899
R-squared	0.944	0.945	0.941	0.943	0.942	0.943	0.939	0.941
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses are clustered at country x week and country groups.

*** p<0.01, ** p<0.05, * p<0.1

Table 6. Fixed Effect regression of the fiscal stimulus index on endogenous parameters set

VARIABLES	(1) Fiscal Stimulus Index	(1') Fiscal Stimulus Index	(2) Fiscal Stimulus Index	(2') Fiscal Stimulus Index	(3) Fiscal Stimulus Index	(3') Fiscal Stimulus Index	(4) Fiscal Stimulus Index	(4') Fiscal Stimulus Index
Health Containment Index	0.0586***	0.0591***	0.0616***	0.0616***	0.0441***	0.0460***	0.0445***	0.0463***
	(0.0111)	(0.0106)	(0.0111)	(0.0105)	(0.0118)	(0.0112)	(0.0193)	(0.0187)
	(0.0188)	(0.0186)	(0.0183)	(0.0180)	(0.0188)	(0.0182)		
(Log) New Covid - 19 Cases (t - 7)	-0.00857***	-0.00852***						
	(0.00213)	(0.00205)						
	(0.00216)	(0.00210)						
(Log) New Covid - 19 Cases (t - 10)			-0.00652***	-0.00636***				
			(0.00196)	(0.00188)				
			(0.00219)	(0.00216)				
(Log) New Covid - 19 Deaths (t - 7)					0.00375	0.00279		
					(0.00262)	(0.00250)		
					(0.00388)	(0.00374)		
(Log) New Covid - 19 Deaths (t - 10)							0.00293	0.00215
							(0.00216)	(0.00204)
							(0.00324)	(0.00312)
(Log) Covid - 19 Cases (t - 1)	0.00391	-0.00608	0.00475	-0.00620	0.00426	-0.00744	0.00419	-0.00748
	(0.00684)	(0.00487)	(0.00680)	(0.00483)	(0.00693)	(0.00501)	(0.00692)	(0.00502)
	(0.0123)	(0.00820)	(0.0124)	(0.00813)	(0.0118)	(0.00778)	(0.0119)	(0.00781)
Covid - 19 Cases x Unemployment	-0.0134	-0.0180	-0.0145	-0.0193	-0.0225	-0.0275*	-0.0229	-0.0278*
	(0.0165)	(0.0146)	(0.0160)	(0.0141)	(0.0166)	(0.0146)	(0.0167)	(0.0146)
	(0.0216)	(0.0160)	(0.0216)	(0.0160)	(0.0257)	(0.0204)	(0.0259)	(0.0205)
Covid - 19 Cases x Trade Openness (Semi Finished Products)	0.00792	0.000838	0.00779	0.00102	0.00729	0.000744	0.00747	0.000827
	(0.00498)	(0.00565)	(0.00498)	(0.00564)	(0.00505)	(0.00574)	(0.00509)	(0.00577)
	(0.00845)	(0.0103)	(0.00852)	(0.0103)	(0.00843)	(0.0101)	(0.00850)	(0.0101)
Covid - 19 Cases x Public Debt Level	0.00769	0.00802	0.00800	0.00851*	0.0104*	0.0111**	0.0105*	0.0112**
	(0.00541)	(0.00515)	(0.00532)	(0.00508)	(0.00574)	(0.00540)	(0.00575)	(0.00541)
	(0.00874)	(0.00832)	(0.00862)	(0.00820)	(0.00937)	(0.00866)	(0.00939)	(0.00868)
Covid - 19 Cases x Policy Rate	0.00520	0.000966	0.00438	-0.000363	0.000305	-0.00511	0.000305	-0.00533
	(0.0229)	(0.0211)	(0.0229)	(0.0212)	(0.0240)	(0.0222)	(0.0241)	(0.0222)
	(0.0219)	(0.0197)	(0.0220)	(0.0199)	(0.0235)	(0.0207)	(0.0235)	(0.0207)
Covid - 19 Cases x Exchange Rate Stabilization	0.00633**	0.00416	0.00621**	0.00409	0.00591**	0.00390	0.00592**	0.00390
	(0.00278)	(0.00292)	(0.00278)	(0.00292)	(0.00283)	(0.00299)	(0.00284)	(0.00300)
	(0.00462)	(0.00513)	(0.00463)	(0.00513)	(0.00456)	(0.00501)	(0.00458)	(0.00503)
Covid - 19 Cases x Share of Children	-0.0299*		-0.0325**		-0.0345**		-0.0345**	
	(0.0159)		(0.0158)		(0.0167)		(0.0167)	
	(0.0252)		(0.0253)		(0.0251)		(0.0251)	
Covid - 19 Cases x Share of Elderly		0.0725***		0.0726***		0.0732***		0.0735***
		(0.0189)		(0.0188)		(0.0192)		(0.0192)
		(0.0336)		(0.0334)		(0.0331)		(0.0330)
Constant	-0.268**	-0.480***	-0.268**	-0.468***	-0.235**	-0.426***	-0.251**	-0.438***
	(0.115)	(0.154)	(0.115)	(0.151)	(0.113)	(0.149)	(0.118)	(0.152)
	(0.168)	(0.248)	(0.165)	(0.245)	(0.152)	(0.225)	(0.158)	(0.225)
Observations	4 986	4 986	4 899	4 899	4 986	4 986	4 899	4 899
R-squared	0.944	0.946	0.941	0.943	0.942	0.943	0.940	0.941
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses are clustered at country x week and country groups.

*** p<0.01, ** p<0.05, * p<0.1

Table 7. Fixed Effect regression of the fiscal stimulus index on endogenous parameters set

Chapter 7
Conclusion

Since its outbreak in late 2019, the Covid – 19 pandemics has taken a clear and pivotal priority in the several countries agenda. On par with shocks and broad issues as the technological progress or climate change, the spread of coronavirus has forced policymakers and economic authorities to incorporate epidemiological features in the long – term planning. The consequent health and economic crisis arising from the Covid – 19 surges have been widespread and threatened countries and institutions with a trade-off between the two counter elements above.

In this paper, I studied how the policy response differ across developing countries once the Covid – 19 pandemic is endogenized in the decision process of the several policymakers. More accurately, I studied how and whether the governments' commitment to different Covid – 19 mitigation responses depends and reflects the countries socio-economic context. I developed a theoretical framework which could formally present and illustrate how Covid – 19 and mitigation policies take part in the dynamics of a representative economy and shape the objective function of economic agents as well as governments. Starting from the formulation of the governments' objective function, I then build up an econometric model that tested individually the impact that each different endogenous parameter of the country (such as demographic characteristics, health care capacity, well - being indicators, fiscal constraints etcetera) had on the spread of the virus and on the policy response deployed.

My quantitative results prove that policymakers are responsive to each variation in the number of Covid – 19 cases and Covid – 19 deaths reported within the country. I show a common tendency to a progressive lockdown with a stringency index that in many countries reached the maximum value in correspondence of the peak months of the pandemic. Although the presence of outliers, I confirm the positive relation between lockdown stringency and exposure of the population to the pandemic due to age-specific, urban and demographic characteristics. Moreover, the well - being of the economy and the medical preparedness of the country have a relevant influence on the positive behavioural adjustments deployed by the agents and on the importance posed by the country on the population general health.

Overall, I find evidence of a positive effect on the economic pickup of stabilization interventions aimed at relaxing the lockdown constraints and encourage an economic stimulus. It is interesting to highlight how countries with a higher level of containment indexes are the one in which I found higher fiscal stimulus scores. This might prove a raw timeline of the events, with countries that first deal with the health crisis and once they have control over it (as shown by higher containment scores) decide to cope with the economic aftermath.

From these findings, I can assume that the governments' commitment towards given containment policies reflects the endogenous baseline differences across countries. I would like to conclude this paper emphasizing the idea on which it was based and the perspectives it opens. In fact, more than with respect to present results, I see this research as a raw but solid quantitative basis on which build future works. Relaxing strong assumptions together with a rigorous formalism, I might deepen such analysis for further goals.

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