Corona Virus and Economic Growth*

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***Abstract*— this article examines how the world economy is affected by the corona virus pandemic. Using an overlapping generation model where numerical experiments are conducted, it is highlighted the fact that, both individuals and countries' inequalities remain the same in contrast however, intensive capital and the economic growth are highly affected. Since, the first go back to the Solow (1956) finding i.e poor countries grow faster than richer countries and the second shows sudden boost of the least advanced economies, the pandemic makes emerging countries catch-up the industrialized countries faster and similarly, developing countries converge and also catch-up emerging countries faster. Indeed, this article provides, sudden shocks foundations in multi-countries exchange context.**

Keywords—corona virus, convergence, catching-up, market-based economy, multi-country's economic growth

I. INTRODUCTION

This article is a contribution to *the corona virus* debate (see table1 and figure1 for presentation). It precisely focuses on the corona virus impact on the economy through income, capital and growth. Using an overlapping generation model, we find that, negative shocks on multi-countries' connection make growth decrease but inequalities remain the same. Moreover, growth decrease, faster convergence and catching-up, making Solow [1] finding i.e poor countries grow faster than rich countries, back in the economic literature. Therefore, there are looser and winners of the current international context. Moreover, our study is inspired of several works which are, *first,* Robert Lucas [2] where human capital initiated by Becker [3] and Shultz [4] in microeconomics study is introduced in growth theory in order to explain what causes the existing heterogeneities in levels and rate of growth among countries, explaining the observed facts to be the resulting effect of the incentives to invest in human capital.

Table1: brief presentation of the corona virus shock effect and transmission risk

Corona virus in 2020	INFECTED	DEATHS	RECOVERED
FRANCE	170.752	30.004	
BRAZIL	1,604.585	64.900	9,787.615
INDIA	698.233	19.703	424.928
RUSSIA	681.251	10.261	450.750
USA	2,982.928	132.569	1,289.564

Source: SARS-COV2, Corona Virus

Second, Lucas [5] and [6] investigate initial divergence and subsequent convergence of income across countries in a multi-country version of a simple economic growth model. *Third,* Linder and Strulik [7] is a multi-countries' growth model, where connected countries exchange knowledge, addressing five new facts: increasing flow of ideas through globalization, accelerating growth rates, across-country variations of growth rates that increases with distance from the technology frontier, large income and TFP differences across countries, per-capita human capital increase throughout the world. Therefore, the economic integration and subsequent growth is endogenously explained and understood by the increasing diffusion of knowledge through the world. On the basis of the quoted works, our work investigates convergence and catching-up of income across countries in a multi-country version of the economic growth model where, integrated economies operate through a globalized market, making, knowledge spillovers emerge, thus boost the economies toward more advanced countries. However, the previous articles don't take account of a sudden negative shock while countries are operating, thus what happens? i.e what about transmission risks to other countries partners, specifically disease? However, the aim of international trade, is increasing returns and long-run growth ([8]) which in the economic globalization context, yield *convergence* and *catching-up.* Therefore, the corona virus pandemic, transmits almost everywhere in the whole world beginning in China (see figure1), yields mutations like inequalities stability and growth decrease, thus creates evictions in the main goal followed by the least advanced economies actually i.e the transition toward market-based economy thus, must be submitted to reflections on how to maintain that goal and get good results on its functioning change. Indeed, the research question addressed by this article is, the pandemic impact on the economic growth summarized by: income in levels and growth rates, capital and the economic growth rate. The following figure1 show-off the corona virus evolution from January to July, as the first part of the inverted U-shape curve, meaning that, a pic exists, where the curve will begin to decrease, thus makes growth sustainable.

The article presentation is done like follow, section II presents the theory, section III provides numerical experiments, section IV provides a conclusion.

II. THE THEORY

A Knowledge externalities in the closed economy

In the overlapping generation model, the world is composed of N countries indexed by i, where in each of them, the agents live for two periods of time, works in the first period and dies at the end of the second period. The utility function of the agents of country $i\epsilon N$ at time, t, is expressed such that equation, (1) i.e

$$u_{i,t}=ln(c_{i,t})+\beta ln(d_{i,t+1})+\mu ln(e_{i,t}) \quad (1)$$

Where, $\beta>0$ is the elasticity of the second period consumption, $c_{i,t}$ and $d_{i,t+1}$ are the respective per-capita consumption, of the first and the second period of the agents. Since, the first period per-capita income, $y_{i,t}$ is spent on consumption, working taxes for future resting income levy by public system θ, savings, s_{it} and education for children e_{it}, the first period budget constraint of the agent, can be written such that,

$$(1-\theta)y_{i,t}=c_{i,t}+e_{i,t}+s_{it}$$

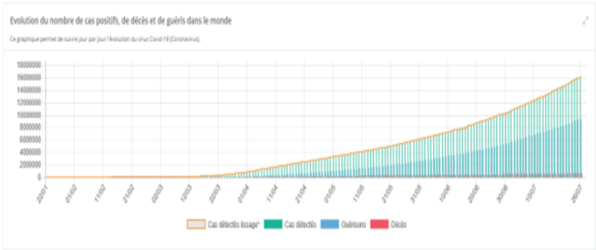
Since the second period income comes from the resting income, $R_{i,t+1}$ plus saving income, $(1+r_{i,t})s_{it}$ spent on health state, $m_{i,t+1}$ and the second period consumption, then, the second period budget constraint of the agent can be written, such that, $R_{i,t+1}+(1+r_{i,t})s_{it}=d_{i,t+1}+m_{i,t+1}$. Eliminating, s_{it} from the first constraint, yields, the intertemporal budget constraint, expressed such that, $(1\theta)y_{i,t}+R_{i,t+1}/(1+r_{i,t})$
$=(c_{i,t}+e_{i,t})+(d_{it+1}+m_{i,t+1})/(1+r_{i,t})$

Indeed, utility optimization yields, the equilibrium of the first and the second period consumption as well as, the education effort i.e

$$c_{i,t}=\xi W_{i,t+1} \quad (2)$$

$$d_{i,t+1}/1+r_{it}=\beta\xi W_{i,t+1} \quad (3)$$

Figure1: corona virus evolution in the world



Captions of figure1: *yellow line*: regression of the detected cases, ***green box***: detected cases record, ***blue box***: healed cases record, ***red box***: deaths number record

$$e_{i,t}=\mu\xi W_{i,t+1} \quad (4)$$

Where the intertemporal wealth of the agent is, $W_{i,t+1}=(1-\theta)y_{i,t}+(R_{i,t+1}-m_{i,t+1})/1+r_{i,t}$ associated with the parameter, $\xi=(1/1+\beta+\mu)>0$

The representative firm uses knowledge freely accessible, $A_{i,t}$ and the respective stocks of human capital, $h_{i,t}$ and physical capital, $K_{i,t}$ in order to produce an homogenous consumption good through the Cobb-Douglas production function, $Y_{i,t}$ i.e

$$Y_{i,t}=A_{i,t}(h_{i,t})^{\alpha}(K_{i,t})^{1-\alpha} \quad (5)$$

Where the parameter, $\alpha\epsilon[0,1]$ is the elasticity of human capital.

Firm optimization yields the equilibrium equations in per-capita income or the wage rate income, $y_{i,t}$ and in the interest rate, $r_{i,t}$ respectively expressed by equations (6) and (7) i.e

$$y_{i,t}=\alpha A_{i,t}(k_{i,t})^{1-\alpha} \quad (6)$$

$$1+r_{i,t}=(1-\alpha)A_{i,t}(k_{i,t})^{\alpha} \quad (7)$$

Where, $k_{i,t}=h_{i,t}/K_{i,t}$

Human capital, accumulates over time[1], such that, equation (8), i.e

$$h_{i,t+1}=B(c_{i,t})^{1-\eta}(e_{i,t})^{\eta} \quad (8)$$

Where, $B>0$ is a parameter

The economic growth rate defined by, $g=h_{i,t+1}/h_{i,t}$ where the equilibrium expression of human capital accumulation, according to utility optimization, is

$$h_{i,t+1}=B((1/1+\beta+\mu)W_{i,t+1})^{1-\eta}((\mu(1+\beta+\mu)W_{i,t+1})^{\eta}$$
$$=B(W_{i,t+1})^{1-\eta}(\mu W_{i,t+1})^{\eta}$$

Since the intertemporal wealth is expressed by, $W_{i,t+1}=(1-\theta)y_{i,t}+(R_{i,t+1}-m_{i,t+1})/(1+r_{i,t})$, introducing equations (5) and (6) inside the previous equation expression, yields the intertemporal wealth final expression given by, $W_{i,t+1}=(1-\theta)\alpha A_{i,t}(k_{i,t})^{1-\alpha}$ $+(R_{i,t+1}-m_{i,t+1})((1-\alpha)A_{i,t}(k_{i,t})^{\alpha})^{-1}$ then, the growth rate expression is,

$$g=W_{i,t+1}/W_{i,t}=(k_{i,t-1}/k_{i,t})^{\alpha}(A_{i,t-1}/A_{i,t})\vartheta$$

Where, $\vartheta=(\Delta_t k_{i,t}+\Gamma_{t+1})/(\Delta_{t-1}k_{i,t-1}+\Gamma_t)$

[1] See Loubaki (2016), The Theory of Investment in Schooling

$\Delta_t=\alpha(1-\alpha)(1-\theta)\,)(A_{i,t})^2$ and
$\Gamma_{t+1}=(R_{i,t+1}-m_{i,t+1})/A_{i,t}$

Proposition1: *the long-run growth of country i at time t is expressed by equation (9) i.e,*

$g=(\Delta_t k^*+\Gamma_{t+1})/(\Delta_{t-1}k^*+\Gamma_t)$ (9)

Proof: applying the growth rate definition, $g=W_{i,t+1}/W_{i,t}$ yields, $g=(k_{i,t-1}/k_{i,t})^{\alpha}(A_{i,t-1}/A_{i,t})\vartheta$

Therefore since in the long-run, $k_{it}=k_{it-1}=k^*$, $A_{it}=A_{it-1}=A^*$, then, the growth rate expression, is finally given by, $g=(\Delta_t k^*+\Gamma_{t+1})/(\Delta_{t-1}k^*+\Gamma_t)$

B. Knowledge externalities in multi-countries' economies

Assumption1: the connected countries *i* and *j* in E for knowledge exchange purpose, i.e technology, yields to the existence of a scalar, $\lambda>0$ such that, $\lambda i+(1-\lambda)j \in E$ then, the exchange space, *E* is a convex set (see figure2)

Lemma1: *let a set $E\subset R$ be the set of N countries $\{C_1, C_2, \ldots, C_N\}$ indexed by i, then, according to assumption1, there exist, a sequences, $\{\lambda_i\}_{i\in N}$ such that, $\Sigma_{i=1}^{N}\lambda_i i \in E$, and $\Sigma_{i=1}^{N}\lambda_i=1$ i.e E is a convex set of N countries (see figure3)*

Proof: generalizing the connections of a single country *i* to *N-1* connections i.e to *(N-1)* partners, then, it yields to the existence of a sequences $(\lambda_k)_{k\in I}>0$, such that, $\Sigma_{k=1}^{N}\lambda_k k \in E$ and according to the set, *E* its whole exchanges are reduced to 1, then the whole partners yield, $\Sigma_{k=1}^{N}\lambda_k=1$. Therefore, the whole countries' sequences, is a union of the convex sets, $U\{C_i\}_{i\in N}\subset U\{E_i\}_{1\leq i\leq N}\subset E$ where, each, E_i is a convex set.

C. Corona virus transmission risks

Lemma2: *let a country, $C_i \subset E$, be a convex set endowed of inhabitants satisfying the corona virus positive tests, then, there exists an application, q such that, $q(vc_{i,t})=vc_{j,t} \in C_j$*

Proof: when *i* and *j* countries are connected, then, $i,j\in E_i\cap E_j$, is a convex set, therefore, negative externalities are also exchanged among the both countries i.e, there exists $\lambda>0$ such that, $\lambda i+(1-\lambda)j$ belong to $E_i\cap E_j$, yields $[i,j]\in j\in E_i\cap E_j$

Figure2: a convex set

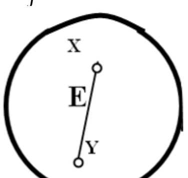
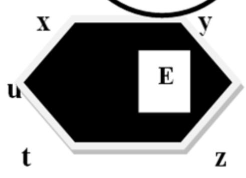


Figure3 : convex set generalization



Then, the relationships between those 2 countries is expressed by, $q(vc_{i,t})=vc_{j,t}$ i.e risk transmission makes the country *j* also gets the pandemic transmits by *i*. Generalizing the process yields to the existence of the parameters, $(\lambda_k)_{1\leq k\leq N}$ such that, $\Sigma_{1\leq k\leq N}\,(\lambda_k)k\subset E$ and $\Sigma_{1\leq k\leq N}\lambda_k=1$ then, two opposite forces are in play, knowledge externalities generates spillovers that increase the economic growth, whereas, disease generates negative externalities that affect the economic growth. Then if the both curves are moving in the monotonic ways, they meet somewhere one the space-time, that locus is the equilibrium, signaling the economic stabilization.

D. The World Economic Environment

The corona virus shock in the *i* country's consumer utility function at time *t* enters such that, it appears in the both ages i.e when young and when older according to the data observations, thus expressed by equation, (10) such that,

$u_{i,t}=ln(c_{i,t})+\beta ln(d_{i,t+1})$
$+\mu ln(e_{i,t})-\gamma_0 ln(vc_{i,t})-\gamma_1 ln(vc_{i,t+1})$ (10)

However, human capital stock accumulates such that, equation (11) i.e

$h_{i,t+1}=B(e_{i,t})^{\eta}(vc_{i,t})^{1-\eta}$ (11)

Where, β, μ, η are parameters, inside [0,1]

Proposition2: *the respective per-capita income, the education effort and the corona virus deaths equilibrium are expressed by equations, (12)-(16) i.e,*

$c_{i,t}^*=\Lambda W_{i,t}$ (12)
$d_{i,t+1}^*/1+r_{it}=\theta\beta\Lambda W_{i,t}$ (13)
$e_{i,t}^*=\mu\Lambda W_{i,t}$ (14)
$vc_{i,t}^*=-\gamma_0\Lambda W_{i,t}$ (15)
$vc_{i,t+1}^*/1+r_{it}=-\theta\gamma_1\Lambda W_{i,t}$ (16)

Where,
$\Lambda=1/(1-\gamma_0+\mu+\theta(\beta-\gamma_1))$
$W_{i,t}=R_{it+1}/(1+r_{ti})+(1-\theta)y_{i,t}$

Proof: Since the first period income is spent on the first period consumption and health state in the concern of corona virus, savings and education for children, the budget constraint is, $(1-\theta)y_{i,t}=c_{i,t}+vc_{i,t}+s_{it}+e_{i,t}$ in the first period and the second period, income is spent on the second period consumption and health state i.e, $R_{i,t+1}+(1+r_{ti})s_{ti}=d_{i,t+1}+vc_{i,t+1}$ is the second period budget constraint. Therefore, the intertemporal budget constraint is $R_{it+1}/(1+r_{ti})+(1-\theta)y_{i,t}$
$=(c_{i,t}+vc_{i,t}+e_{i,t})+(d_{i,t+1}+vc_{i,t+1})/(1+r_{ti})$

Utility optimization yields, $c_{i,t}^*=\Lambda W_{i,t}$ where, $\Lambda=1/(1+\mu+\beta-(\gamma_0+\gamma_1))$

Indeed, the consumer other equilibrium equations are: $vc_{i,t}*=-\gamma_0\Lambda W_{i,t+1}$, $e_{i,t}*=\mu\Lambda W_{i,t+1}$, $vc_{i,t+1}*/1+r_{it} =-\gamma_1\Lambda W_{i,t+1}$, $d_{i,t+1}*/1+r_{it}=\beta\Lambda W_{i,t+1}$

Per-capita income and physical capital dynamics are given by equations, (17) and (18) i.e

$$y_{i,t+1}=A_{i,t}(y_{i,t})^{\sigma}(vc_{i,t})^{1-\sigma} \quad (17)$$

$$k_{i,t+1}=A_{i,t}(k_{i,t})^{\tau}(vc_{i,t})^{1-\tau} \quad (18)$$

Where, σ and τ are parameters inside [0,1]

Proposition2: *in the country indexed by i, the respective growth rate, virus growth rate and per-capita income growth rate, (g^i, g_{vc}^i, g_y^y) are given by equations, (19)-(21) i.e*

$$g^i=[\zeta(A_{it})/\zeta(A_{it-1})(A_{i,t})^2](k_{i,t}/vc_{i,t})^{2(1-\tau)} \quad (19)$$

$$g_{vc}^i=\theta(1-\alpha)(\gamma_1/\gamma_0)A_{i,t}(k_{i,t}) \quad (20)$$

$$g_y^i=A_{i,t}[vc_{i,t}/y_{i,t}]^{1-\sigma} \quad (21)$$

Proof: the country *i* growth rate in income definition is given by, $g^i=W_{i,t+1}/W_{i,t}$ $=(R_{it+1}/(1+r_{ti})+(1-\theta)y_{i,t})/(R_{it+1}/1+r_{ti}+(1-\theta)y_{i,t})$.

According to the firm's optimization behavior, the respective economic growth rate of country *i*, g^i and the virus evolution rate of the same country, g_{vc}^i are respectively expressed such that,

$g^i=[(R_{it+1}/(1-\alpha)A_{i,t}(k_{i,t})^{\alpha})$ $+(1-\theta)y_{i,t})]/[(1-\alpha)A_{i,t}(k_{i,t})^{\alpha}+(1-\theta)y_{i,t}]$
$=[R_{it+1}/(1-\alpha)A_{i,t}(k_{i,t})^{\alpha}$
$+(1-\theta)\alpha A_{i,t}(k_{i,t})^{1-\alpha}]/[(R_{it}/(1-\alpha)A_{i,t-1}(k_{i,t-1})^{\alpha}$
$+(1-\theta)\alpha A_{i,t-1}(k_{i,t-1})^{1-\alpha}]$
$=(k_{i,t-1}/k_{i,t})^{\alpha}[(\delta_t+\alpha(1-\alpha)(1-\theta)(A_{it})^{(1+\alpha)})/(\delta_{t-1}$
$+\alpha(1-\alpha)(1-\theta)(A_{it-1})^{(1+\alpha)})]=\zeta(A_{it})/\zeta(A_{it-1})(g_k)^{-(1+\alpha)}$

Where

$g_k=k_{i,t}/k_{i,t-1}$

$\zeta(A_{it})=\delta_t+\alpha(1-\alpha)(1-\theta)(A_{it})^{(1+\alpha)}$

Then, $g^i=\zeta(A_{it})/\zeta(A_{it-1})(g_k)^{-(1+\alpha)}$
$=[\zeta(A_{it})/\zeta(A_{it-1})](g_k)^{-(1+\alpha)}$

Since, $g_k=A_{i,t}(vc_{i,t}/k_{i,t})^{1-\tau}$, then, the economic growth sequences under corona virus can be written, such that, equation (20), like a decreasing function of the virus,

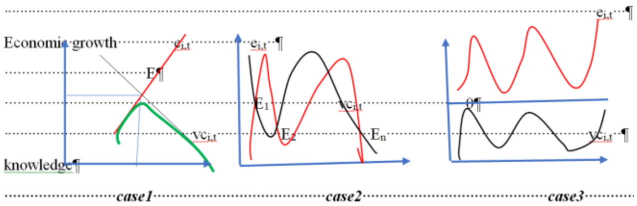
$g^i=[\zeta(A_{it})/\zeta(A_{it-1})(A_{i,t})^{(1+\alpha)}](k_{i,t}/vc_{i,t})^{(1+\alpha)(1-\tau)}$

In parallel, the corona virus evolution rate, $g_{vci}=vc_{it+1}/vc_{it}=(1+r_{it})(\theta\gamma_1\Lambda W_{i,t})/(\gamma_0\Lambda W_{i,t})$ according to utility optimization, yields,

$g_{vci}=((1-\alpha)A_{i,t}(k_{i,t})^{\alpha})(\theta\gamma_1\Lambda W_{i,t})/(\gamma_0\Lambda W_{i,t})$
$=(1-\alpha)\theta(\gamma_1/\gamma_0)A_{i,t}(k_{i,t})^{\alpha}$ indeed,
$g_{vci}=\theta(1-\alpha)(\gamma_1/\gamma_0)A_{i,t}(k_{i,t})^{\alpha}$

Therefore, per-capita income growth rate, $g_y^i=y_{i,t+1}/y_{i,t}=A_{i,t}[vc_{i,t}/y_{i,t}]^{1-\sigma}$ is the product of knowledge and the impact of the virus on per-capita income of the current time is a positive function of the virus such that, $g_y^i=A_{i,t}[vc_{i,t}/y_{i,t}]^{1-\sigma}$ an increasing function of the virus and a decreasing function of per-capita income

Figure4: Multiple cases equilibria



Proposition3*: three cases are highlighted by a given affected country: the economy is in equilibrium (case1) i.e, located on the locus on the space where the virus and the education effort curves meet since they move in the opposite direction, the economy oscillates (case2), when the virus and the education effort curves meet several times, the equilibrium doesn't exist (case3) i.e when, the virus and the education effort curves no meet on the space.*

Proof: see the figure4 and equations (19)-(21)) where, **case1** is the unique equilibrium i.e *E* exists, since the curves of e_{it} and vc_{it} are respectively monotonic increasing and decreasing, thus, meet on the space at *E*. Then, yields an inverted U-shape curve (drawn in green), thus the balanced growth path converges to its sustainable growth path equilibrium. **Case2** is the oscillatory dynamics with cycles, thus composed of multiple equilibria, $(E_l)_{1\leq l\leq n}$ where the balanced growth path converges to a poverty trap equilibrium, E_n where $E_n<E_l$ for all $l\epsilon\{12...N\}$. **Case3**: describes a separation between the virus action and knowledge externalities such that, the virus as no impact on the economy, able to hold after a successful international economic policy based on, "confinement sanitary policy" conducted in most countries affected by the corona virus in 2020 when growth sustainability began to oscillate because of economic activities slow couples to both deaths and the associated illness

Lemma3*: let the whole multi countries be connected on the space, E, then, E is a compact, convex set of multiple countries, $(C_i)_{i\epsilon I}$, therefore, $(C_i)_{i\epsilon I}$ converge to its steady state equilibrium, C* for all $i\epsilon\{1,2,...,N\}$*

Proof: since the network *E* is a union of compact, convex set as viewed in A1 and lemma1, then, *E* is closed and bounded i.e each country admits a sequences, $(x_i)_{i\epsilon I}$ such that, $(x_i)_{i\epsilon I}\rightarrow x*$ where $x*$ is the economic transition threshold level.

Lemma4: *the remedy to fight corona virus is an inverted U-shape curve, thus render growth and development sustainable respectively in* *developed, emerging and developing countries inside the space, E* (see figure5 bellow and the following observations for proof)

III. NUMERICAL EXPERIMENTS

In order to establish the fundamental variables relationship with the virus, the previous equations are submit to numerical experiment.

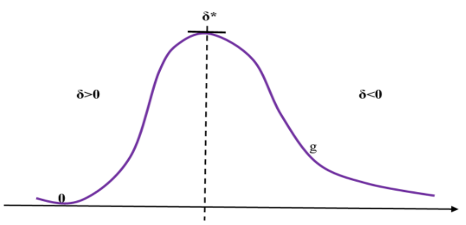
Equation, (19) i.e $g^i=[(\zeta(A_{it})/\zeta(A_{it-1}))(A_{i,t})^{(1+\alpha)}](k_{i,t}/vc_{i,t})^{(1+\alpha)(1-\tau)}$ depends both on the virus and on intensive capital, then fixing intensive capital to 1, yields, the relationship between the virus and the growth rate, such that, $g^i=\Theta^i(vc_{it}))^{(1+\alpha)(1-\tau)}$ i.e the corona virus impact on the economic growth rate, where $\Theta^i=[\zeta(A_{it})/\zeta(A_{it-1})(A_{i,t})^{(1+\alpha)}]$, thus can be submitted to numerical experiment.

Equation, (20) i.e $g_{vc}{}^i=\theta(1-\alpha)(\gamma_1/\gamma_0)A_{i,t}(k_{i,t})^{\alpha}$ yields, $k_{i,t}=(\theta(1-\alpha)(\gamma_1/\gamma_0)A_{i,t})^{1/\alpha}(g_{vc}{}^i)^{1/\alpha}$ allowing the study of the impact of the virus evolution rate on intensive capital. Since equation (21) i.e $g_y{}^i=A_{i,t}[vc_{i,t}/y_{i,t}]^{1-\sigma}$ is composed of 2 variables, then, fixing $y_{i,t}$ such that it equals to1, yields, $g_y{}^i=(vc_{i,t})^{1-\sigma}A_{i,t}$ i.e the impact of the virus on per-capita income evolution can numerically be studied, and fixing now $g_y{}^i=1$, yields, $y_{it}=(A_{i,t})^{1/1-\sigma}(vc_{it})$ i.e the impact of the virus on per-capita income level study.

Indeed, numerical experiment consists on the study of the impact of the corona virus on the economic growth rate, $g^i=\Theta^i(vc_{it}))^{(1+\alpha)(1-\tau)}$, the impact of the corona virus on intensive capital, $k_{i,t}=(\theta(1-\alpha)(\gamma_1/\gamma_0)A_{i,t})^{1/\alpha}(vc_{it})^{1/\alpha}$, the impact of the corona virus on per-capita income growth rate, $g_y{}^i=(vc_{i,t})^{1-\sigma}A_{i,t}$, the impact of the corona virus on per-capita income level, $y_{i,t}=(A_{i,t})^{1/1-\sigma}(vc_{it})$

Setting *r=developing countries (D), emerging countries (E) and industrialized countries, (H)* yield calibration (I) and simulation (II) after that are fixed according to data observations, where *r* is composed of several countries such that, the whole equals, *N*

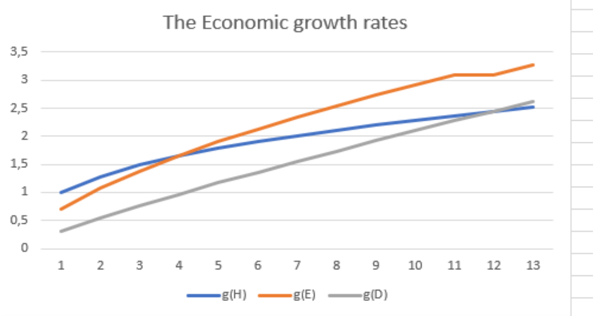
Figure5: the inverted U-shape curve



A. Calibration

Cr	α	τ	γ_0	γ_1	$A_{i,t}$	σ	Θ^i
D	0.30	0.45	0.1	0.3	0.45	0.05	0.3
E	0.55	0.6	0.45	0.75	0.7	0.1	0.7
H	0.8	0.8	0.25	0.65	0.8	0.2	1

Figure6: the economic growth rates of the developing, the emerging and the industrialized countries



B. Simulations

Simulations yields, the following equations:

The respective economic growth rates of the industrialized countries, $g^H=(vc_{i,t})^{0.36}$ of the emerging countries $g^E=0.7(vc_{i,t})^{0.62}$ of the developing countries, $g^D=0.3(vc_{i,t})^{0.845}$ all display by figure6 then, the pandemic causes multiple equilibria i.e *first*, it pushes emerging countries, catch-up the industrialized countries faster and, *second*, developing countries converge toward emerging countries growth path and finally catch them later-on

B.2 The respective intensive capital of the industrialized countries, $k_{H,t}=0.44(vc_{Ht})^{1.25}$ of the emerging countries, $k_{E,t}=0.162(vc_{Et})^{1.82}$ of the developing countries, $k_{D,t}=0.01(vc_{Dt})^{3.33}$ are displayed in figure7 where, the intensive capital of the developing, the emerging and the industrialized countries and, it can be seen that, the pandemic yields, Solow (1956) finding i.e poor countries grow faster than richer countries since, it becomes the first followed by emerging countries whereas, the industrialized countries become the last. In the both following cases i.e income in levels and rates of growth, inequalities don't stop despite of the growth and capital mutations due to the pandemic. Now, the curves testify that, around the world, countries are not same because of inequalities that can be seen in the concern of the economic agents too.

B.3 The respective per-capita income levels of the industrialized countries, $y_{H,t}=(0.816)vc_{Ht}$ of the emerging countries, $y_{E,t}=(0.675)vc_{Et})$ of the developing counties, $y_{D,t}=(0.431)vc_{Dt}$ are display in figure8

B.4 The respective per-capita income growth rate of the industrialized countries, $g^H{}_y=0.85(vc_{Ht})^{0.8}$ of the emerging countries, $g^E{}_y=0.7(vc_{Et})^{0.9}$ of the developing countries, $g^D{}_y=0.45(vc_{Ht})^{0.95}$ are display in figure9

V. Conclusion

Above, the model as shown the virus negative effects on intensive capital as well as on the economic growth rate, since they obey to the old findings without empirical support, whereas inequalities behave the same both inside an isolated country and outside i.e among the other countries partners, thus, join the literature. Therefore, since technology i.e goods, knowledge, schooling or human capital accumulation in general, is highly affected by the disease it yields to the advanced countries regression in contrast to the least advanced countries specifically because they are less affected by the virus. Thus, grow more and converge faster to the advanced economies. The question now is: why do increasing returns mechanisms provided by the literature, don't play like before? Is it necessary to look for new mechanisms causing the economic growth? This article doesn't provide answers to those questions.

Figure7: intensive capital per-region

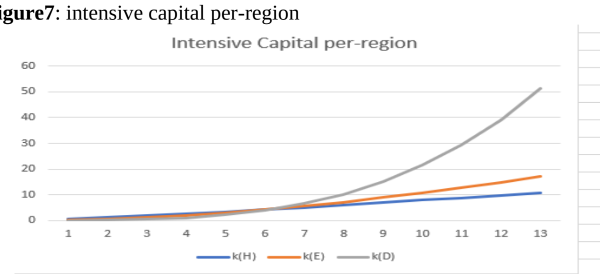
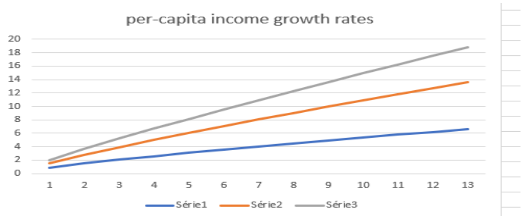


Figure8: income levels of the developing, the emerging and the industrialized countries

Figure9: income growth of the developing, the emerging and the industrialized countries



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