Global Risks and the Theory of Economic Growth

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Abstract: Although global risks may be sorted into different categories – economic, environmental, geopolitical, societal, and technological – they are strongly intertwined and they tend to reinforce one another, easily transforming a localized problem into a perfect storm capable of deeply affecting all economic sectors and all aspects of people’s lives. This short essay undertakes a systematic and integrated discussion of global risks in the context of economic growth theory. A standard endogenous growth (SEG) model is adapted and reconfigured into a global risk endogenous growth (GREG) model.

1. INTRODUCTION

Contemporaneous economic growth models, devised over the last couple of decades, follow in the steps of the ground-breaking contributions of the twentieth century, namely those by Solow (1956), Romer (1986), Lucas (1988), and Aghion and Howitt (1992), among others. To the original contributions, recent research has appended new insights, mostly about innovation and the creation of knowledge. Innovation is approached through the lens of creative destruction processes that firms undertake to enhance productivity (Acemoglu et al., 2018, 2022; Aghion et al., 2016; Akcigit et al., 2016, 2021; Akcigit and Kerr, 2018; Grossman & Helpman, 2018); creation of knowledge is interpreted as a process of propagation of ideas that requires social interaction (Lucas, 2009; Lucas & Moll, 2014; Perla & Tonetti, 2014).

The above-cited literature, paradigmatic of the current state of growth theory, implicitly adopts an optimistic view of growth. Under this perspective, sustained growth is the inevitable outcome of the ability of people to organize themselves into groups (firms and institutions) that share a common goal (increased material wealth and well-being) and that will work together to attain such a goal. A mix of market competition and efficient bureaucracies make the path to prosperity the only conceivable outcome of most of the growth paradigms offered by research in economics. Notwithstanding, reality tends to contradict such an optimistic view, a view that overlooks the many potential dangers, obstacles, conflicts, and challenges, that economies face, namely when taking into consideration the global panorama they integrate, in which they participate, and in which they contribute.

In this short essay, growth is looked upon from the perspective of global risks. Global risks are a series of exogenous forces that may condition the decisions of economic agents and that, ultimately, are prone to hamper economic growth in a more or less significant way. Global risks will
be attached to an endogenous growth model, in order to discuss how the lack of care in dealing with global common goods may lead to significant disruptions in the ability of individual countries in securing growth rates compatible with their effort in organizing production and creating the right environment to increase the quality of their inputs.

To assess global risks, this study relies on the global risks reports, published every year by the World Economic Forum (2006-2022). This publication undertakes a thorough and insightful evaluation and discussion about the main risks faced by the world economy and how these risks can be counteracted by the action of those notoriously recognized as being the decision-makers (governments, institutions, firms, and individuals) with the greatest power and influence in the world.

The mentioned reports separate global risks into five categories, namely economic, environmental, geopolitical, societal, and technological risks. Although they have distinctive features, in most cases the risks in the five categories are intertwined, and they cannot be fully perceived and understood unless one takes an integrated view of them. A global crisis may likely erupt from a single event (some seed of dystopia); however, there is a strong chance that this event suddenly spreads over other areas of the economy and society, leading to a perfect storm that will deeply and pervasively affect all sectors of economic activity and all aspects of people’s lives.

The analysis and discussion of global risks are not completely absent from growth theory. In the past, several studies have approached the influence of risks about some of the above-highlighted categories over the ability of economies to increase living standards [see, e.g., the work of William Nordhaus on environmental risks (Nordhaus, 2015, 2019), and the work of Daron Acemoglu and his co-authors on geopolitical and technological risks (Acemoglu, 2005; Acemoglu & Robinson, 2008; Acemoglu & Yared, 2010; Acemoglu et al., 2012, 2017, 2019). However, an integrated view of global risks and growth theory is still missing in the literature. This paper points in this direction, by associating the various classes of risks to a single endogenous growth model.

The remainder of the manuscript is organized as follows. Section 2 introduces global risks, by briefly surveying the contents of the global risks reports. Section 3 recovers the standard endogenous growth model, which is transformed, in Section 4, into a global risks endogenous growth model by appending each of the five categories of risks to the planning problem of the representative agent of the national economy. Section 5 concludes.

2. THE GLOBAL RISKS REPORT: AN OVERVIEW

The World Economic Forum, an independent international organization that congregates political, business, and other leaders to reflect upon the state of the world, publishes every year, since 2006, the Global Risks Report. This publication identifies, discusses, and proposes solutions to mitigate the most relevant and pressing risks faced by humankind. The report defines global risk as “the possibility of the occurrence of an event or condition that, if it occurs, could cause a significant negative impact for several countries or industries (...) over the next 10 years.” (World Economic Forum, 2022 Report, page 93). The identified risks are classified as belonging to one of five categories: economic, environmental, geopolitical, societal, and technological.

On the economic front, the latest issues of the report highlight the following risks: asset bubbles, the collapse of important industries, debt crises in large economies, inability to control inflation, the proliferation of illicit activity (organized crime, illicit trade, tax evasion), economic stagnation
and recessions, and commodity shocks. Regarding the environment, the concern resides essentially in the incapacity to control and revert climate change and other possible environmental setbacks, such as biodiversity loss, extreme weather events, human-made environmental damages, geophysical disasters, and overexploitation and mismanagement of critical natural resources.

The geopolitical risks include interstate conflicts, the collapse of nation-states, terrorism, the threat posed by weapons of mass destruction, the collapse of multilateral institutions, and geo-economic and geopolitical confrontations. On the societal category, a vast array of risks can be listed, which include the erosion of social cohesion, the hypothetical failure of public institutions and social security systems, the deterioration of working conditions and job opportunities, large-scale involuntary migrations, youth disillusionment, and health-related risks including the spread of infectious diseases (epidemics and pandemics). Finally, from the technology perspective, fundamental risks are associated with digital inequality and digital power concentration, failures in regulating and governing technology, adverse outcomes of technological advances, breakdown of critical information infrastructures, and cybercrime.

The items enumerated in the two previous paragraphs constitute a comprehensive list of the risks that pose the most significant danger for economies and societies today and in the near future. The perception of these risks has evolved, as documented in the reports. While the first editions of the Report concentrated attention on some of the topics of primary concern at the time, such as terrorist attacks, oil price spikes, and the global financial crisis, other topics gradually or suddenly emerged at the top of the agenda of the global worries. Over the last decade, climate change, increasing income and wealth inequality, signs of retrenchment from globalization, and cybersecurity concerns, progressively came into the spotlight. Other risks became, as well, as the result of particular events, the center of attention, namely the worldwide spread of infectious diseases and the disruption of the existing geopolitical world order.

A fundamental point to make about global risks is the recognition that they are strongly interconnected, not only within the mentioned categories but in many ways also across categories. For example, a geopolitical world conflict necessarily implies a disruption of business supply chains and, therefore, exacerbates a series of interconnected economic risks; evidently, such a conflict is also detrimental to the societal dimension, because resources that could be allocated to improve life in society are diverted to the war effort. Conflict and destruction are also necessarily harmful to the environment. From a technological perspective, one should remark that modern warfare is also a cyber war, which can be extremely damaging for the digital systems on which contemporaneous societies rely upon.

In the above paragraph, the seed of dystopia (a term often used in the reports), was attributed to geopolitical conflict. However, it can also be placed elsewhere with pretty much the same outcome. Take, for instance, the Covid pandemic. Initially a societal issue, its implications rapidly spread to the economy (with an increased risk of inequality and poverty) and to technology (with the fast growth of digital dependency). The social unrest emerging from the containment measures also had strong political implications. Another potential seed of a catastrophic chain of events may come from climate change. The economic, political, and societal implications of higher environmental risk are obvious, and they are already being felt in every economy.

Although in many respects the world has shown resilience in avoiding and fighting existential threats (as in the case of the Covid pandemic), there is always the danger of a perfect storm, i.e.,
of a series of unfortunate events coming together to trigger a catastrophic and highly destructive outcome, that eventually culminates in a civilizational regress. In the last few centuries, humanity has witnessed a systematic and ever-increasing improvement in living standards and quality of life. In statistical terms, this is easily confirmed, by looking at the GDP growth series. However, despite the wonders of technology that are available today and that are the fruit of many years of sustained growth, there are no guarantees that we will continue on the path of prosperity. Some of the mentioned risks are human-made, while others are, at least partially, outside the direct control of human action. Anyway, the possibility of a dark combination of some of them is today more probable than ever (because the underlying realities are also increasingly complex) and cannot be ignored (or avoided).

Besides enumerating risks, the Global Risks Report also offers in-depth discussions on the possible paths to mitigate them and to create mechanisms, at the global and national levels, to cope with large-scale threats. One should acknowledge that global risks are associated with what economists designate as public goods, i.e., common resources that are available to everyone and that require collective regulation and management. This is the case for many of the items mentioned above, from the environment to international security and digital networks.

3. THE NO-RISK SCENARIO (SEG MODEL)

In this section, a standard endogenous growth (SEG) model is presented. The framework constitutes the basis upon which the impact of global risks will be addressed afterward.

Assume a representative agent, who solves a typical optimal control problem, which consists of the maximization of intertemporal utility, defined as

$$ U(0) = \int_0^{+\infty} e^{-(\rho-n)t} u[c(t)]dt $$

In expression (1), $c(t) \geq 0$ represents per capita consumption, and parameters $\rho \geq 0$ and $n \geq 0$ define, respectively, the rate of time preference and the population growth rate. The instantaneous utility function, $u(\cdot)$, obeys trivial properties of continuity, differentiability, and concavity; in particular, a constant intertemporal elasticity of substitution (CIES) utility function is assumed, with the elasticity of intertemporal substitution of consumption equal to $1/\theta$, $\theta > 0$.

The maximization of (1) is subject to a series of constraints that characterize the accumulation of factors of production. For the sake of the current analysis, three constraints are assumed, which characterize the dynamics of physical capital, human capital, and technology. Start by considering the following differential equation, representative of the process of physical capital accumulation,

$$ \dot{k}(t) = f[a(t)k(t), h(t)u(t)] - c(t) - (n + \delta)k(t), \quad k(0) = k_0 \text{ given} $$

In equation (2), $k(t) \geq 0$ represents the per capita stock of physical capital. The other variables are a technology index, $a(t) \geq 0$, a measure of the efficiency of labor (i.e., a human capital variable), $h(t) \geq 0$, and the share of labor allocated to the production of physical goods, $u(t) \in (0,1)$. Parameter $\delta \in (0,1)$ defines the rate of depreciation of capital. Observe that the technology variable $a(t)$ is directly associated with the productivity of capital and, therefore, it can be interpreted as a synthesis of the outcome of radical and incremental innovations that eventually take
place under a process of creative destruction. In the particular case of the proposed model, this variable is attached to a catching-up process relative to the world's technology frontier.

The production function in equation (2) is a typical neoclassical production function that exhibits constant returns to scale and diminishing marginal returns for each input. The tractability of the model requires taking a specific functional form; the most common functional form is a Cobb-Douglas production function with \( \alpha \in (0,1) \) defining the output-capital elasticity.

The equation of motion for the labor efficiency variable is expressed as follows,

\[
\dot{h}(t) = g[1 - u(t)]h(t) - \delta_h h(t), \quad h(0) = h_0 \text{ given}
\]  

(3)

The production function of human capital is subject to constant marginal returns, with the productivity of the education sector \( g > 0 \). The term \( 1 - u(t) \) corresponds to the share of human capital allocated to the generation of additional human capital, and \( \delta_h \in (0,1) \) is the rate of obsolescence of this capital input.

Regarding technology, a simple mechanism of convergence to the world technology frontier is adopted. Let \( A(t) \) represent the world technology frontier and let this grow at a constant rate \( \gamma \),

\[
\dot{A}(t) = \gamma A(t), \quad A(0) = A_0 \text{ given}
\]  

(4)

The dynamics of the national technology variable is given by the differential equation

\[
\dot{a}(t) = \dot{\tilde{a}} \left[ 1 - \frac{a(t)}{A(t)} \right] a(t), \quad a(0) = a_0 \text{ given}
\]  

(5)

Equation (5) characterizes the process of convergence in the direction of \( A(t) \); the further away \( a(t) \) is from the world frontier, the faster will be the convergence.

The SEG model is defined as the maximization of (1) subject to (2), (3), and (5), given the exogenous growth rate of the world’s technology frontier, (4). The control variables of this planning problem are \( c(t) \) and \( u(t) \), and the state variables are the remaining three endogenous variables, namely \( k(t) \), \( h(t) \), and \( a(t) \). The dynamic model can be solved by resorting to standard optimal control techniques. The outcome is a balanced growth path (BGP) in which variables \( c(t) \), \( k(t) \), \( h(t) \), and \( a(t) \), all grow at constant rates. Income, \( y(t) = f(\cdot) \), will also grow at a constant rate which is, given the specification of the model,

\[
\frac{\dot{y}}{y} = \frac{1}{\theta} \left[ g - \delta_h - (\rho - n) + \frac{\alpha}{1 - \alpha} \gamma \right]
\]  

(6)

Expression (6) highlights the role of the productivity of the human capital sector \( g \) and of the rate of innovation at a global level \( \gamma \) as the main drivers of growth in this simple model of economic growth.

4. **RISK PERVERSIVENESS (GREG MODEL)**

As characterized, the SEG model considers no global risk endangering the nation’s ability to absorb technology, accumulate knowledge, and grow. In this section, five global risks are attached to the SEG model, each one of them associated with one of the five risk categories highlighted
in the World Economic Forum reports. The SEG model is, under this perspective, transformed into a global risks endogenous growth (GREG) model.

The first set of risks to consider is those of an economic nature. In the context of the proposed setting, economic risks are illustrated through their potential impact on the aptitude of the world’s economy to continue to innovate at a given risk-free pace. The prospect of economic imbalances (e.g., extreme income inequality, high unemployment, financial instability, illicit trade) constitutes a threat to the innovation capabilities of the world economy and, therefore, simply and straightforwardly, economic risks are circumscribed to the international dimension and attached, in the GREG model, to a potentially lower global innovation rate than the one considered in equation (4). Analytically, equation (4) is adapted to become

\[ \dot{A}(t) = \left[ y - \frac{\dot{x}(t)}{x(t)} \right] A(t) \]  

In expression (7), variable \( x(t) \geq 0 \) synthesizes the economic threats over the expansion of the world’s technology frontier. As modelled, the higher the rate at which economic risks increase, the lower will be the growth rate of the technology frontier, relative to the benchmark case. If economic risks are lowered, this has a positive impact on the growth of the technology frontier.\(^2\)

The second group of risks, environmental risks, will enter the GREG model through the negative impact that environmental degradation has on the production of final goods. Climate change, pollution, the loss of biodiversity, and environmental disasters compromise the capacity of the economy to generate wealth, and, therefore, environmental risks are translated, in the model, in a change in the shape of the aggregate production function (as in Brock & Taylor, 2010; and Acemoglu et al., 2016). The new production function is expressed under the form,

\[ y(t) = \left[ \frac{z(t)}{\bar{z}} \right]^{-\xi} f[a(t)k(t), h(t)u(t)], \quad \xi \geq 0 \]  

In equation (8), \( z(t) \) is a measure of environmental degradation (e.g., the concentration of carbon in the atmosphere); \( \bar{z} \leq z(t) \) is a minimal level of pollution below which production is not compromised. Variable \( z(t) \) is an exogenous variable in the model, under the interpretation that the environment is a global public good; the individual economy has no control over the value or the evolution of \( z(t) \).

The third set of risks to consider are those under the geopolitical sphere. Geopolitical tensions are concretized, in the GREG model, in barriers to the adoption of global technologies (as in Stokey, 2015). This essentially expresses the retrenchment from globalization concern, i.e., the idea that international conflict makes countries close borders, reducing access to foreign knowledge. Let \( b(t) \geq 0 \) be the variable representing barriers to adoption; the higher the value of \( b(t) \), the stronger are the barriers. This variable will enter the technology adoption equation of motion, modifying it to be:

\[ \dot{a}(t) = \dot{\hat{a}} \left[ 1 - \frac{a(t)}{A(t)} b(t)^\beta \right] a(t), \quad \beta \geq 0 \]  

Notice that the interpretation adopted under the GREG model is that a risk does not need to materialize to have a factual nefarious impact on growth. The threat itself makes agents change behavior and adopt cautious actions that, in themselves, may slowdown growth. This logic is extensible to all other classes of risks beyond economic risks.
In equation (9), stronger barriers to adoption will make it harder for \( a(t) \) to approach \( A(t) \). Parameter \( \beta \) translates the elasticity of adoption to barriers. As in the case of previous risks, the assumed variable is exogenous to the economy: international tensions and conflict will determine the evolution over time of variable \( b(t) \).

The fourth set of risks are those of a societal nature. Societal risks will, in general, lead to a loss of social interaction (as the result of public health issues or a breakdown of social cohesion). An increase in societal risks will translate, in the GREG model, into a faster obsolescence of human capital. Let \( \omega(t) \geq 0 \) is a measure of social interaction loss or societal risk, with higher values of the variable meaning lower levels of interaction. Relative to the SEG model, the new rate of obsolescence of human capital will be: \( \delta_h + \frac{\dot{\omega}(t)}{\omega(t)} \). The human capital accumulation equation is changed to contemplate this new effect:

\[
\dot{h}(t) = g[1 - u(t)]h(t) - \left[ \delta_h + \frac{\dot{\omega}(t)}{\omega(t)} \right] h(t)
\]

Finally, to represent technological risks, consider the use of digital data as an input in the production of ideas, and the associated risks to the security of data, i.e., cybersecurity risks. Represent digital data by variable \( d(t) \); \( d(t) \) in a non-rival global good that the national economy can access to generate new ideas and knowledge. Assuming this new variable, the technology adoption process is enhanced by the use of data, leading to the replacement of equation (5) by:

\[
\dot{a}(t) = \dot{a} \left[ 1 - \frac{a(t)}{A(t)} d(t)^{-\eta} \right] a(t), \quad \eta \in (0,1)
\]

In equation (11), the use of data to improve the state of the economy’s technology will allow \( a \) to grow at a faster rate than \( A \) in the BGP. In the specified circumstances,

\[
\frac{\dot{a}}{a} = \gamma + \eta \frac{\dot{d}}{d}
\]

The growth of the country’s technological state will be faster than the growth of the world’s technology frontier if the use of digital data as an input grows positively over time. However, data can have a disruptive effect in the presence of cybercrime, in the sense that cybercrime is likely to destroy data. Let \( \delta_d(t) \geq 0 \) be the variable representing cybercrime. If \( \delta_d(t) = 0 \), then data will have the positive effect of enhancing technology as described above. As \( \delta_d(t) \) emerges and eventually becomes very large, the growth rate of technology approaches zero. This effect is modelled by replacing \( d(t) \) in (11) by expression \( d(t)\delta_d(t)^{-\varepsilon}, \varepsilon \in (0,1) \). In this case, the BGP growth rate of variable \( a(t) \) becomes:

\[
\frac{\dot{a}}{a} = \gamma + \eta \left( \frac{\dot{d}}{d} - \varepsilon \frac{\delta_d}{\delta_d(t)} \right)
\]

While under (12), in the absence of cybercrime, the use of digital data to improve the state of technology would always increase the growth rate of \( a \) above the benchmark (no data) growth rate \( \gamma \); with cybercrime this outcome is attenuated, and can even be reversed if the change in cybercrime is faster than the growth rate of the use of digital data.

In fact, if \( \frac{\dot{d}}{d} < \varepsilon \frac{\delta_d}{\delta_d(t)} \) then \( \frac{\dot{a}}{a} < \gamma \).

The important corollary is that the use of data may make the economy worse off if cybercrime increases at a faster rate than \( d(t) \).
Taking together the set of systematized risks, one may, as in the SEG model, compute the growth rate of income in the BGP. The income growth rate of the GREG model is:

\[
\frac{\dot{y}}{y} = \frac{1}{\theta} \left\{ g - \left( \delta_h + \frac{\dot{\omega}}{\omega} \right) - (\rho - n) + \frac{\alpha}{1 - \alpha} \left\{ \frac{\dot{x}}{x} - \beta \frac{\dot{b}}{b} + \eta \left( \frac{\dot{d}}{d} - \varepsilon \frac{\dot{\delta_d}}{\delta_d} \right) \right\} \right\} - \frac{\xi}{1 - \alpha} \frac{\dot{z}}{z} \tag{14}
\]

To maintain the integrity of the BGP, i.e., for the growth rate in equation (14) to be constant, all the risks must grow at constant rates. The higher the value of any of these rates, the lower will be the growth rate of the economy.

5. CONCLUSION

Economic growth theory has been designed to explain how the optimal behavior of agents and the efficient use of resources eventually conduct sustained growth over time. However, economic growth faces many obstacles, including a series of global risks that pervasively affect the economy and that are, to a large extent, exogenous to the economy’s decision-makers. This essay has discussed how such global risks might affect income growth, by embedding them in a standard endogenous growth model and by analyzing the corresponding BGP, subject to risk perturbations.

The discussion relied upon the classification set forth by the World Economic Forum in its reports about global risks, which allocate such risks to five categories: economic, environmental, geopolitical, societal, and technological. The risks tend to stimulate one another and, therefore, the analysis of the impact of global risks over national growth should, first and foremost, explain how some initial shock (i.e., a rise in the probability of a risk to occur) may eventually spread to other risk areas, leading to a strong fall in the growth rates of technology adoption, human capital accumulation, consumption and income. This has been approached in the context of a standard growth model, which was reconfigured into a GREG model.

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