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Neo-sustainable Growth Theory: Study of Extended HO Model to Productive Factors' Virtual Movements

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Author's contribution

The sole author designed, analysed, inteprted and prepared the manuscript.

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ABSTRACT

This paper aims to fill the critical gap in the existing literature, which often treats trade and sustainability as separate fields. By combining these two dimensions, it would open avenues for new policy recommendations and strategies for promoting sustainable development in an increasingly interconnected global -economy. In terms of theoretical foundations, I link economics, technology and environmental sciences, to enrich the academic discourse and provide a comprehensive framework for future studies. This provides a unique perspective between economic growth and volatility through the lens of intergenerational and international productive factors' virtual movements. By extending the Heckscher-Ohlin theory to incorporate virtual trade and intergenerational dynamics, the findings offer a fresh theoretical framework and empirical evidence that enrich our understanding of globalization's mechanisms. The study's findings on the Production Possibilities Frontier (PPF) and its implications for achieving general equilibrium contribute to ongoing debates about sustainable development and economic interdependencies. The article's innovative approach and its comprehensive analysis offer a unique foundation to addressing real-world economic challenges. More specifically, using panel data to test the positive and negative relationships between growth

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and volatility and the impact of productive factors' virtual movements, I find, the Heckscher-Ohlin theory extended to the virtual movements of factors between countries and between generations is not only empirically verified but constitutes the real foundation of sustainability. Thus, a systematic practicing of the whole set of the extended Heckscher-Ohlin theory's full set of hypotheses as a nation's social laws and policies or strategies, is necessarily leading to sustainable development locally and globally.

Keywords: Productive factors' virtual movement; multidimensional trade; ho model; sustainable development; education for sustainable development.

1. INTRODUCTION

This article is a critique of the theory of multidimensional trade (2x2x2x4), (Edgeweblime, 2019) that states: "Factors of production that exist in abundance in one generation and are not intensively used to produce goods and services in that generation are exported to other generations in exchange for scarce factors of production intensively used to produce goods and services that should be scarce in the generation under consideration. Low-consumption goods and services are indirectly exported from one generation to the next, while high-consumption goods and services are indirectly imported from other generations. In this way, positive externalities (non-natural resources) are exchanged for negative externalities (over-consumption of natural resources). Clearly, this exchange of externalities is the fundamental mechanism that generates links between growth and volatility", is the main basis of this paper. But, in the original Heckscher Ohlin model (2x2x2), the two most important hypotheses, goods and countries 'unequal intensity or endowments in productive factors, are crucial for transferring local behaviour, Neoclassical principles or social laws' effects to other countries in a relevant and ineluctable Globalization. Goods are produced with different proportions of productive factors in countries having an unequal abundance in labour and in capital, which are available in fixed quantities, used optimally in full employment and being immobile internationally. If these hypotheses were not realised, the approach would not be said "factors proportion model and Heckscher and Ohlin's main finding "countries export products which intensively use the productive factors that they have in abundance and import products which use intensively the productive factors that at home are scarce", could not arise in their mind since their first question was "what are the explanatory factors for the price differences between countries even before trade opens". Furthermore, Heckscher and Ohlin have translated their finding saying "Thus, indirectly, it is factors with abundant supply that are exported, while factors with limited supply are imported". It's therefore crucial, if you want to test this model, to investigate if the abundant productive factor is really indirectly exported and the scarce factor indirectly imported, i.e through goods exchange only. But, can we, after the trade is opened, measure the decreasing of the supply of abundant productive factor and the increasing of the quantity of the scarce one in each country? Since these productive factors are indirectly exchanged (incorporated in traded goods), the measure will be difficult in the context of representative agent. I think, we've two ways to overcome this great problem:

1) If these productive factors' prices are equalised in the countries through goods' trade, we're justified to assume that their offers are also; but sometime other economic and none economic factors contribute to price determination. However, in HO's world these latter effects can be neglected. 2) A qualitative evaluation of the decreasing of abundant factor's supply and the increasing of the scarce one, is to measure the movements of the Production Possibilities.

Frontier (PPF)'s effects on aggregate production, assuming an absolute PPF's fixity or null growth volatility in autarky or in steady state level. It's shown, growth volatility in the cross-county and cross-generation's evidence, is due to PPF disturbance. For example, in Aghion, (1998a, b), productivity change is assumed to be the result of purposeful (internal) learning through deliberate actions which substitute for production activities. Under such circumstances, the productive factors allocated to productivity improving activities are a convex function of the state of the economy and hence the average productivity increases as volatility increases. On the other hand, the models that follow Arrow, (1962), where the mechanism of technological change takes the form "learning by-doing" show that the relationship between growth and volatility tends often (but not always) to be negative. For example, in Martin and Rogers (1997, 2000), productivity change takes place through serendipitous (external) learning through

non-deliberate actions which are complements to production activity. In this case, the factor through which expertise, knowledge and skills are acquired and disseminated is a concave function of the shocks, so that increased volatility decreases growth. By incorporating the above two conflicting mechanisms for endogenous technological change, Blackburn and Galindev (2003) shows that "the any shocks can have a permanent effect on output if it changes the amount on which productivity improvements depend". For Aghion and Howith, (1998), Dinopoulos and Thompson (1998), Jones, (1995), Kortum, (1997), Peretto, (1998), Segerstrom, (1998) and Young, (1998) "there exists a positive linkage between productivity growth rate and the share of R&D in GDP. It's therefore clear that the steady state or sustainable development or the fixity of productive factors' supply in each country is the lack of growth volatility".

"My understanding of sustainable growth stems from the Brundland Report definition, which states that sustainable development means meeting the needs of each generation without compromising the ability of future generations to meet their needs. Thus, all the models of development with the unique exception of Neoclassical model fail to guarantee that each generation will have an equal share of available natural productive factors. It's generally accepted that the Neoclassical model is the best model of productive factors allocation but difficult to implement: the Neoclassical founding principles of productive factors ' optimal allocation, full productive factors employment, pure and perfect competition, the best available technology, the remuneration to marginal productivity of each productive factor, cost minimization under production constraints, production maximization under cost constraints, the equality of marginal cost of a product and its price, the international levelling out of goods and productive prices seem to be the best material in economics to avoid waste and can be considered as model of sustainability. This means, the other models like monopoly, oligopoly, monopolistic competition should be viewed as generating waste and fluctuations" (Kcodgoh L. Edgeweblime et al., 2019). Thus, the research question is: Does a systematic practicing of the whole set of the Neoclassical principles as a nation's ultimate social laws and policies, generate sustainable development locally and globally? My aim in this paper is to test the two most important hypotheses of the HO model' s corollary, ""Thus, indirectly, it is factors with abundant supply that are exported, while factors with limited supply are imported", and its crucial capacity to transferring local behaviour, Neoclassical principles or social laws' effects to other countries in a relevant and ineluctable Globalization theoretically, and their implementation in order to ensure in each process of production sustainability and cleanliness. At this end, I'm founded to follow the second way since the first one needs great measurement's means that do not exist nowadays; also, productive factors' prices equalization shall be tested. Assuming that there is no volatility in the sustainable or optimal growth, I will, first, present the background of the theory; then deal with Neoclassical Trade Model as local behaviour or practice that produces multidimensional effects on other countries and generations. In section 3, I will deal with the importance of factor proportions of Heckscher -Ohlin theory as sustainability processes. Finally, I will present an evidence on Multidimensional Trade optimality and the Sign of the Link between Growth and Volatility.

2. BACKGROUND ON THE PRODUCTIVE FACTORS VIRTUAL INTERNATIONAL MOVEMENTS IN HOS MODEL

The factor proportions model and its extensions into neo-factorial approach and model with specific factors are very important to show how goods trade is a substitution to productive factors exchange between countries. Breaking down the labor factor, from the different skill levels into distinct sub-categories making these ones more or less substitutable with each other depending on the nature of the goods to be manufactured has had crucial results theoretically and in testing HO model. Another way to test HO model has been to considers that skilled labor is the result of the combination of capital and unskilled labor. Vanek ,(1968) and Keesing, (1965, 1966, 1968, 1971). The differences in factor abundances and international trade in skilled labor is considered to be the result, the output, of the combination of two primary factors: capital and unskilled labor. The empirical difficulty will lie in the measurement of human capital, that is to say in the evaluation of the quantity of capital incorporated in each unit of skilled labor. In general, the level of qualification is considered to be entirely due to the amount of capital invested in education by an individual. Empirically, the rate of return on capital invested in training will be estimated from the wage differences between unskilled and skilled labor.

3. MATERIALS AND METHODS

In HO model, it's said, "Thus, indirectly, it is factors with abundant supply that are exported, while

factors with limited supply are imported. In other words, "countries export products which intensively use the factors of production which they have in abundance and import products which use intensively the factors of production which at home are scarce." Let see what happens when we consider the multidimensional level.

3.1 Multidimensional Trade with Productive Factors International Virtual Movements

1. Neoclassical growth model
2. Behavior of households and firms
3. Hypothesis

Each country (generation) has different initial endowments composed of natural and unnatural resources. Natural resources (the physical environment) and unnatural resources (other resources) are the productive factors in the economy.

A_1- The available produced goods in fixed quantities in each generation are used in full consumption during the time of each generation and optimally;

A_2 - At the opening of trade, natural resources and unnatural resources are immobile (mobile) between countries (generations) but mobile (immobile) through generations (counties); the goods produced are mobile (immobile) between countries (generations) but immobile (mobile) between generations (countries).

A_3- The market is characterized by perfect competition; natural resources input can be used interchangeably in all productions; there is full employment in both countries and both generations;

A_4- The production function is the same in both countries and both generations for good; production functions are homogeneous of degree 1, with constant returns to scale and decreasing marginal productivities; but the technique to produce goods is different;

A_5- The marginal utility of each good is always decreasing.

A_6- Transportation costs and other barriers to trade are zero.

A_7- The two countries only exchange the goods they produce; these assets are perfectly mobile internationally; the two generations only exchange natural resources against unnatural resources, these resources are perfectly mobile inter-generationally;

A_8- Each good is produced with relative natural resource intensity or distinct unnatural resource: DVD production is unnatural resource intensive and the wheat is natural resource intensive.

Our hypothesis contradicts the neoclassical international trade model. We propose that only the productive factors are tradable, while final goods cannot be stored. To illustrate our intergenerational exchange model, we consider the Edgeworth box. The beginning allocation is u, with the final allocation being noted at point X. At point X, a perfect equilibrium of production and consumption for the two generations is realized. Each generation improves its utility when passing from a lower to a higher indifference curve. At that point, the quantities of goods produced and consumed by all the generations (in pairs of two), are determined. Through these conditions, we can establish the following analysis based on common neoclassical literature. The neoclassical HO model (1933) states that, “countries export goods that require in their production the intensive use of productive factors found in abundance locally and goods where production demands the inverse proportions of the same factors are imported.” The free trade production level is W. Consumption and world equilibrium are noted at X. At point X, a general equilibrium of production and consumption for the two countries is reached. Each country improves its utility when passing from a lower indifference curve to an upper one. That is the level of utility of each country in autarky is lower than its level when the international trade becomes possible. At this point, the quantities of goods produced and consumed for both countries are determined.

Intergenerational Trade Model with productive factors’ virtual movements: Each generation in a country is a seat of sinusoidal movement (intergenerational movement effects). These movements can vary through different countries. For simplicity we assume, in this instance, that moments are the same, therefore cosine $(2\pi W_{ijt})e^{-t/\tau}$ is their most appropriate estimate. World income distribution is supposed to be homogenous. W_{ij} is the period of time when the initial transaction impacts on countries revenue, during a group of processes. W_{ijt} represents the

exchange for each group of processes. W_{ijt} is defined in equation 7.

$P_i(t) = \sum$, x_i is the share of merchandise i within the value of total exports during the base year and pi is the current merchandise ratio price during the base year.

$P_j(t) = \sum$, m_i is the share of merchandise i within the value of total imports during the base year and pi is the current merchandise ratio price during the base year. W'ij is the number of times the initial movement impacts on generations during a group of processes. W'_{ijt} represents the exchange of value for each group of processes. W'ijt is defined in equation 6.

$P'_i(t) = \sum$ ″, x'_i is the share of merchandise i within the value of total exports for the base generation and p'i is the current merchandise ratio price for the base generation.

$P'_j(t) = \sum$ ″, m'_i is the share of merchandise i within the value of total imports for the base generation and p'i is the current merchandise ratio price for the base generation.

The production function is

$$Y=AE^{\alpha}N^{ß}X^{*} \quad (1)$$

Y_r is increasing, concave, continuously differentiable and homogenous of degree one.

Producers minimize their costs, taking given prices and earn no profit.

Consumers in each country and generation maximize their utility, as stated above.

I now consider τ as the time period of an intra-industrial transaction (W_{ij}). This transaction (W_{ij}) generates a sinusoidal impact on world current income. W'_{ij} is an intergenerational movement and τ' is its time period. This transaction (W_{ij}) generates a sinusoidal impact on intergenerational incomes (the sum of all generations' incomes).

The resulting technological frontier and net imports: The unique technological frontier: Caselli and Coleman (2000) define the country's technology as a combination of the efficiency of skilled labor, unskilled labor and capital. They find a negative correlation between the efficiency of unskilled labor and the efficiency of skilled labor and capital and interpret this relationship as evidence of the existence of a global technological frontier in which an increase in labor efficiency unskilled can only be obtained at the cost of a decrease in the efficiency of skilled labor and capital. The global technological frontier will be affected by variations in the supply of factors of production in the world as well as the intergenerational distribution of this supply.

Totally Neutral Growth: Suppose that the supply of all factors of production increases at the same rate in all countries. It is obvious that such factor growth will have no effect on the tastes of economic agents as long as per capita incomes do not change. The geometry of the figures of the exchanges would remain unchanged. Only differences in factor growth rates would affect international trade and therefore economic growth. Thus, if the choices of all economic agents in all countries of the world and in all generations were fully compensated so that the world technological frontier and the intergenerational technological frontier merge perfectly, neither international trade nor trad intergenerational growth would affect economic growth, which would evolve at a constant rate.

3.2 Misalignment of Global and Intergenerational Technological Frontiers

The resulting technological frontier unfavorable to the living generation and destruction of trade- As the analysis of international trade and intergenerational trade has clearly established, there is a single global technological frontier and a single intergenerational technological frontier. These boundaries may or may not coincide. Under the hypothesis of a misalignment of the new global and intergenerational technological frontiers with the result unfavorable to the silent generation (the resulting technological frontier virtual shifts to the right for the living generation and to the left for the silent generation, i.e. say higher values of the explanatory variables Levin and Renelt for the living generation), economic fluctuations are negatively correlated with growth, if this misalignment is destructive of trade.

Suppose further that this shift to the right of the resulting technological frontier corresponds to a more than proportional increase in non-natural resources. This growth in non-natural resources will lower its price and encourage companies to produce more DVDs. Thus the current production of DVD will experience a stronger expansion than

that of wheat. The increase in DVD production will cause a decrease in imports of non-natural resources by the living generation.) The systematic tendency of the growth of non-natural resources to encourage current DVD production reduces imports of non-natural resources by the living generation. At the given intergenerational price, the living generation has reduced its dependence on the silent generation on non-natural resources. This type of growth in factors of production reduces intergenerational and international trade and negatively affects growth.

The fluctuations & growth relationship is negative in this case (see Tables 4a-4d).

Countries lose more than they gain in comparative advantages. The sign is positive otherwise. Thus the elasticity of international or intergenerational trade after a movement of the frontier of production possibilities (ei) determines the sign of the relationship fluctuations & Growth.

If ei -1 <0, the sign is negative and positive if ei -1> 0.

The factorial endowments difference between two generations/countries creates pressure difference (TRADE pressure) across a separating semi permeable border. Solvent (Populations) immigration takes place from the lower endowed generation/country to that of higher wealth, until equilibrium is reached. The equilibrium economy (steady state or sustainable development) has the same concentration of wealth both inside and outside the borders. In economics, this state is achieved when international and intergenerational leveling out of all prices is realized avoiding any growth volatility.

The technological frontier favorable to the living generation and growth of trade: Suppose further that this shift to the right of the resulting technological frontier corresponds to a more than proportional increase in natural resources. This growth in natural resources will lower its price and encourage firms to produce more wheat. Thus the current production of wheat will experience a stronger expansion than that of DVD. The increased production of wheat will cause an increase in the exports of natural resources by the living generation. The systematic tendency of the growth of natural resources to encourage the present production of wheat increases the exports of natural resources of the living generation. At the given world price, the living generation has increased its dependence on the silent generation for natural resources. This type of growth in factors of production creates intergenerational and international trade and positively affects growth. The fluctuations & growth relationship is positive in this case (see Tables 4a-4d).

Countries gain more than they lose comparative advantages. The sign is negative otherwise. Thus the elasticity of international or intergenerational trade after a movement of the frontier of production possibilities (ei) determines the sign of the relationship fluctuations & Growth.

If ei -1 <0, the sign is negative and positive if ei -1> 0.

Equilibrium: The behavior of competitive households and firms in a generation interacting with households and firms of another generation has been completely described. The resulting equilibrium is multidimensional. This equilibrium is obtained through the international and intergenerational levelling out of goods and factors' prices.

International Trade and Volatility Model: International levelling out of goods and factors' prices

Um_{DVD}/ represents the « DVD » price while $Um_{»\ WHEAT\ »}$/ represents the price of « WHEAT ».

The « DVD » price is shown as p_g and « WHEAT » prices are indicated by p_l.

Marginal utility is described by U_m.

The international equilibrium price is 2g/l (for example, two units of « DVD » to one « WHEAT »). This result indicates « DVD » prices have risen in North compared to the autarky, which was 3g/l (three units of « DVD » for one unit of « WHEAT »).

The same international trade price indicates « WHEAT » prices fell in North. A symmetric adjustment will take place in the SOUTH where p_g decreases and p_l augments. In North, « DVD» production augments and « Wheat » production decreases. « Capital » demand will increase causing price rises. Proportionally, the « capital » in « DVD » production will decrease while the proportion of « unnatural resources» in « DVD » production will increase. In NORTH, the changing factor prices will modify production techniques. The techniques will be « unnatural resources» intensive. In the SOUTH the reverse will be the case; techniques will be intensive in « Capital » with prices decreasing.

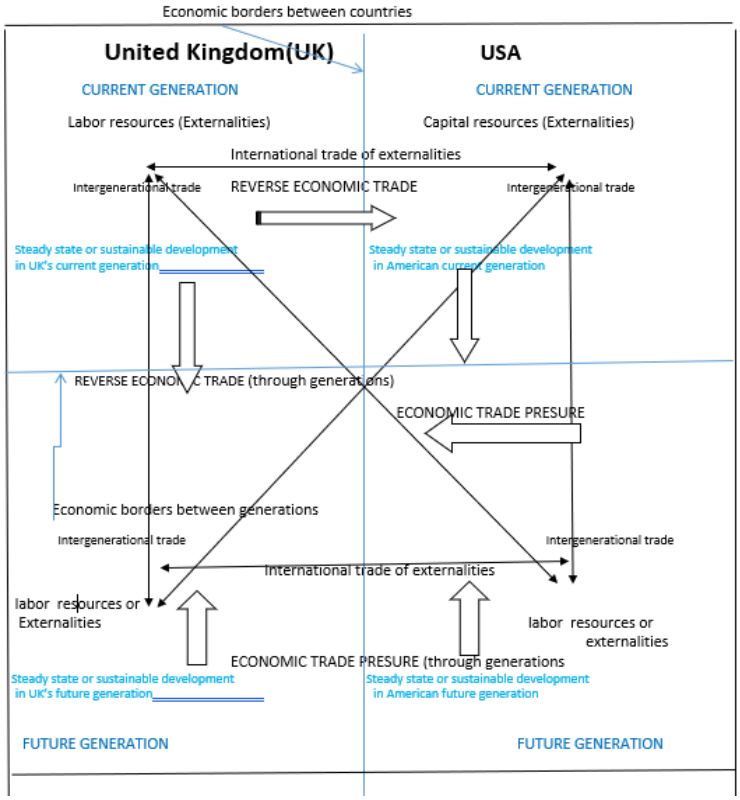

Fig. 1. Impacts on productive factors of worlds and intergenerational PPF' s movements

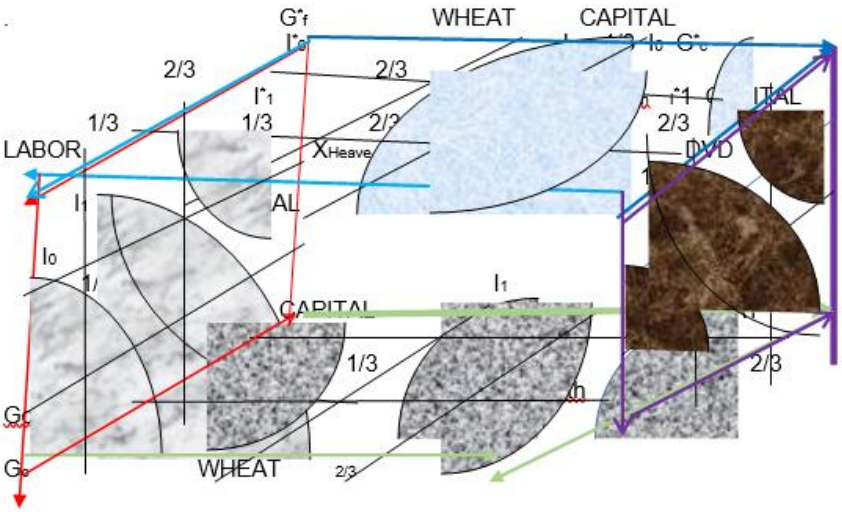

Fig. 2. Multidimensional trade box: initial and final endowments and multidimensional trade equilibrium determination

I_i :Indifference curves. The first component of the box (the base of the cube) describes trade between G_c and G_f. W_{South}(2/3LABOR, 1/3CAPITAL) is the initial endowment of South current generation.
On each face of the cube I describe trade between two generations of the same country (intergenerational trade) or between one generation of one country and the current generation of another country (international trade): The base of the cube (the base the green box) describes trade between G_c and G_f. W_{South}(2/3LABOR, 1/3CAPITAL) is the initial endowment of South's current generation. Its final endowment is X_{Earth}(1/3LABOR,2/3UR). The equilibrium between G_c and G_f is determined

Therefore, in North, wage rates augment while in the South wage rates decrease. The general international equilibrium will have all prices levelling out because changes are the symmetrical reverse from one country to another.

The first order conditions for profit maximization are:

$P_b \geq (w+r)f_b(q_b, q_d)$, if $q_b>0$ (2)

$P_d \geq (w+r)f_d(q_b, q_d)$, if $q_d> 0$. (3)

For the production functions with constant output, the minimum cost is a linear function of π, $o\phi$ $\varphi_{\tau\phi,}$ π depends on w et r.

Then,

$C_{usd}(w, r, Q_{usd}) = \pi. Q_{usd}$ and $\pi = \pi f(w, r)$r) (4)

$P_{usd} = \frac{\partial C_{at}}{\partial Q_{usd}} = \pi_t(w, r)$ for the «WHEAT» and (5)

$P_{usb} = \pi_{us}(w, r)$ for the « DVD »,

$r = r(P_{usd}, P_{usb})$ b and $w = w(P_{usd}, P_{usb})$

where $\frac{w}{r} = h\left(\frac{P_{usb}}{P_{usd}}\right)$. (6)

The relationship within the two countries is identical. The price of goods and services is levelling out as are the factor prices in all countries. We conclude there is a convergence towards a constant rate of equilibrium growth, where the stocks of « Capital » and» unnatural resources» are superior to their equilibrium level.

Intergenerational Trade and Volatility Model: Intergenerational levelling out of goods and factors' prices: At the intergenerational equilibrium the following relations are identified:

Um_{DVD}/» DVD » price = $Um_{»\ WHEAT\ »}$ / « WHEAT » price.

The intergenerational trade equilibrium can also be represented through a system of isoproduct curves for each good as a dual program.

For example, the current French generation is well endowed in « unnatural resources» while the following generations are well endowed in capital. At the beginning of intergenerational trade, 'current French' will export « unnatural resources» (indirectly the « WHEAT », a product» unnatural resources» intensive) and will import capital (indirectly the « DVD », a product « Capital » intensive) from the 'future French' with an intergenerational equilibrium price of 3r/w (or 3a/p). This result indicates the price for « unnatural resources» has been augmented compared with the autarkic price, which was 2r/w (2a/p).

The same intergenerational trade shows the price for « Capital » has reduced for the 'current French'. A symmetrical adjustment will take place with the 'future French', when pp decreases and Pa augments. For the 'current French', the proportion of « Capital or unnatural resources » in « DVD » production will increase while the proportion of « unnatural resources» decreases. For the 'current French', the change in the factor prices will modify production techniques. Techniques will use more « Capital » and less « unnatural resources». For the 'future French', the reverse applies; techniques will be intensive in « unnatural resources» as their prices will fall. The substitution of « Capital » for « unnatural resources» in « DVD » production causes « DVD » prices to fall for the 'current French'. A symmetric analysis indicates « WHEAT » prices will decrease and « DVD » prices will rise for the 'future French'. Therefore, for the 'current French', decreases and for the 'future French', — increases. At the general intergenerational equilibrium, all prices will level out because their changes are the symmetrical reverse from one period to another. Intergenerational trade productive factors reduce the prices of rare factors in each period and enable the production of goods and services consumed in a particular period. The lower prices of goods and services in a particular period cause intergenerational trade earnings for consumers and producers of the given period. For the production functions with constant outputs, the minimum cost is a linear function of π, $o\phi$ $\varphi_{\tau\phi,}\pi$ depending on w and r.

$$MinC_r = wE_r + rN_r \quad (7)$$

subject to

$Y_r = AE^{\alpha}N^{ß}\ X^*_i(t)\ \exp(\varepsilon i, t)$.

For example, iso-product unit curves and iso-cost curves can be established. This program's solution enables us to determine the optimal production corresponding to the minimum cost.

This equilibrium is obtained at the tangency point of the iso-product unit curve and the lowest possible iso-cost curve. This point gives the leveling out of the intergenerational terms of trade and the equivalency of the values of the goods and the factors exchanged

Then,

$C_{usd}(w,r,Q_{usd}) = \pi.Q_{usd}$ and $\pi = \pi f(w,r)$r) (8)

$P_{usd} = \frac{\partial C_{at}}{\partial Q_{usd}} = \pi_t(w,r)$ for the DVDs and (9)

$P_{usb} = \pi_{us}(w,r)$ for the wheat,

$r = r(P_{usd}, P_{usb})$b and $w = w(P_{usd}, P_{usb})$

where $\frac{w}{r} = h\left(\frac{P_{usb}}{P_{usd}}\right)$. (10)

The relationship within the two countries is identical. The price of goods and services is leveling out as are the factor prices in all countries. We conclude there is a convergence towards a constant rate of equilibrium growth, where the stocks of unnatural and natural resources are superior to their equilibrium level.

3.3 Methodology and Data

Methodology: My objective is to study the sign of the relationship between average growth in GDP per capita and fluctuations in that growth. I consider this relationship as the result of disturbances of the frontier of world production possibilities (FPP), disturbances attributable to the productive factors' international virtual movements. In order to achieve this objective, I will present and test a new model of intergenerational exchange using a sample of 108 developing countries and a sample of 25 OECD countries on panel data.

First, it will show how virtual shifts in intergenerational and international balances influence the frontiers of generation and country production possibilities to determine the quantities produced, consumed and prices in each country and / or generation. These virtual shifts in the world technological frontier determine the new configuration of intergenerational trade and international trade as well as the mechanism of the relationship between fluctuations and growth. I'll consider two samples of countries: The first sample contains 25 OECD countries observed from 1980 to 2010. With the second sample, I study the same relationship with 108 developing countries over the same period (1980-2010). The number of observations in the first sample is 588 and 3240 for the second. The reason for this choice is that each group of countries is characterized by similar production technologies. All data is taken from the World Development Indicators.

Secondly and for this component of the model (how changes in the supply of factors of production affect exchanges between generations), I'll first consider France through ten generations of 25 years with 10 control generations; In the third case, I mix France of ten generations with the rest of the 124 countries, each country being considered as a generation. The study of France of ten generations with the rest of the 124 countries or generations, highlights the intergenerational relations while the introduction of other countries makes it possible to take into account the international aspect of this relation (relation between growth and growth fluctuations) using well-chosen explanatory variables. Movements in the FPP are taken into account through changes in the Levin and Renelt variables considered here as measures of the supply of productive factors. The nature (positive or negative) relationships between the standard deviation of growth or volatility of growth (Vol) and the Levin Renelt variables are of key interest in the tests: In Aghion (1998a, b), productivity change is assumed to be the result of purposeful (internal) learning through deliberate actions which substitute for production activities. Under such circumstances, the productive factors allocated to productivity improving activities are a convex function of the state of the economy and hence the average productivity increases as volatility increases (positive relationships between growth and volatility). On the other hand, the models that follow Arrow (1962), where the mechanism of technological change takes the form "learning by-doing" show that the relationship between growth and volatility tends often (but not always) to be negative. For example, in Martin and Rogers (1997, 2000), productivity change takes place through serendipitous (external) learning through non-deliberate actions which are complements to production activity. In this case, the factor through which expertise, knowledge and skills are acquired and disseminated is a concave function of the shocks, so that increased volatility decreases growth (negative relationship between growth and volatility). Here Log of GNP/Initial Head is considered as the growth. Levine and Renelt variables are the measures of productive factors (labor or capital in Heckscher

Ohlin model. These are: the Share of average investment in GNP, Average initial capital, average annual population growth rate, my own representation is natural resources and unnatural resources more aligned with neo-sustainability theory.

The models of intergenerational free trade, international free trade and the. multidimensional trade (free trade interaction between generations and countries) - are built on the basis of Samuelson's two-period, two-agent (young and old) model of an economy but in terms of the allocation of macro-dynamic resources. This model, with particular emphasis on the theoretical and know-how aspects and the introduction of new types of economic agents (generations) and the sector international and intergenerational interdependencies, reinforce the importance of political choices in the programs of development and highlight the relationship between growth and economic fluctuations.

Cross-country and cross-generation volatility evidence: For the second component (how changes in production factors supply affect intergenerational trade), I will first consider France through five generations of 50 years with 10 witness generations. In the second case, I mix France five generations with the remaining of 124 countries considered as current generations. For the results, see Table 1 and Table 2. The relationship between growth and volatility, under overlapping generations hypothesis, is positive, confirming Mirman conclusion "if there is a precautionary motive for saving, then higher volatility should lead to a higher saving rate, and hence a higher investment rate which is positively linked to growth". But, in this case, generation PPF movements' trend is indeterminate, because two control variables are positively linked to growth rate and two other control variables are negatively linked to the growth rate (Table 3). It is possible that the relationship between growth and cross-generation volatility would be positive if I consider control variables with their weight (t-stat). In that case, we should expect to meet very often over-optimal growth than suboptimal growth because the first generations tend to mortgage the capacities of future generations (absence of intergenerational levelling out of prices of goods and factors).

1st step

- Table 1 mean growth and growth volatility with a sample of France's 16 generations (1800-2000) with Levin-Renelt control variables.
- Table 2 test of Mean growth and growth volatility with a sample of 108 countries and its generations (multidimensional trade)
- Table 3 test of Mean growth and growth volatility with a sample of 8 generations of France trading with all the generations of the 2 samples

A- Intergenerational optimality and general equilibrium are the necessary and sufficient conditions for multidimensional growth 1) Intergenerational interdependencies follow a trajectory of limited optimality. To operationalize the theory of multidimensional growth, consider two generations of time in a given country: the current generation (A) and the future generation (F). Even in a single country, distinct nations or generations can live (the current generation would be a country distinct from the country represented by the future generation. Therefore, the analysis can be done from the Neoclassical Education model (2x2x2) and my theory on intergenerational Educations would be stated: generations import from other generations productive factors intensively used in the production of goods and services highly consumed in the current generations and export productive factors intensively used in the production of goods and services weakly consumed in the same generations. Indirectly, generations import goods and services that use a high proportion of technically scarce productive factors and a low proportion of technically abundant productive factors and export goods and services that use the reverse proportions of the same productive factors. Thus, positive externalities (power in priesthood) are Traded against negative externalities (overconsumption of capital). A productive factor is technically scarce in a generation if the part of this productive factor imparted to this generation is insufficient to produce as much of these goods and services that it wishes to consume. A productive factor is technically abundant if its proportion existing in this generation is superior to its production needs.

Current generations would have an abundance of goods and services that make intensive use of « Capital » if in their time they could have as much « Capital » as past generations because of the abundance of the bequeathed "Labor factor. Likewise, past generations would have an abundance of goods and services that make intensive use of the "Labor factor if they could

have as much "Labor as current generations in addition to the past abundance of capital.

But unlike the Neoclassical Education model, I assume that only the factors of production are Education, final consumer goods being immobile from one generation to the next.

I deduce that it is the intergenerational movements of productive factors (Education) that changes the values of factors that would be scarce in each generation and allow the production of goods that are particularly consumed during these periods or generations. It follows that each generation realizes equitable gains from intergenerational Education.

In Edgeweblime (2019) it's said that, as in the Neoclassical Education model, the intergenerational equalization of the values of goods and factors and the resulting general macrodynamic equilibrium depend on the choice of the optimum production combination. Consequently, when a generation chooses a combination of initial production different from the optimal combination W (disturbance in the function of intergenerational production possibilities), it is no longer possible for this generation and the others to reach equilibrium X in the Temporal Edgeworth Box.

Data and computation: The models tested are of the form:

$$grgdpit = \lambda voli + \theta Xit + \varepsilon it \quad (1a)$$

$$\varepsilon it\ N\ (0, \sigma 2i) \quad (1b)$$

i = 1, ..., I t = 1, ..., T grgdpi average annual growth in GDP / Head for country i and for year t (obtained in taking the logarithm differences).

σi: is the standard deviation of the residuals, εit; εit is the standard deviation of the growth obtained from the predicted values based on the Xit variables. Xit variables differing from country to country, From one year to another. Xit: is the vector of control variables Θ: is the vector of coefficients common to the countries in the sample; λ denotes the relationship between growth and «growth volatility represents the most important parameter in this specification. The vector of control variables, X proposed by R. Levine and R. Renelt (1992) are the most important variables for the analysis of the growth of countries. These variables are defined as follows: 1) ≪ inv ≫ Share of average investment in GDP; 2) (gdppccp): the logarithm of the initial GNP / head (at the start of the period); 3) hc or hcresidus when hc is purged of the difference between observed values and predicted values obtained using a partial regression of hc on other control variables; aapgr: average rate of population growth. In the sample of 108 countries, human « Capital » is the average number of years of schooling of individuals in the population aged 25 and over. But in OECD countries, human « Capital » is the secondary school enrolment rate as a percentage of the relevant age group. For the regressions, we will use the maximum likelihood method on panel data. The number of observations for the 108country sample is 3240 and 630 for the second sample which becomes a 21country sample in this new specification. The results of the regressions are presented in the Tables.

4. RESULTS AND DISCUSSION

4.1 Evidence on the Effects of the Neoclassical Trade Model on the Multidimensional Exchange of Human Capital

Table 1. Mean growth and growth volatility with a sample of France's 16 generations (1800-2000)

Variable	Definition	Coefficient	T-Stats	Std. Dev.	[95%Conf.Interval] min	[95% Conf.Interval]max
Vol	Std Dev. Of growth. (volatility)	0.0125969	0.98	0.01290 9	-0.012	0.0378
Intercept	Intercept	0.0159509	2.81	0.0056704	0.0048	0.02706
Log likelihood =531.59 Prob>chi2= 0,000						

2nd step

- introduction of Levin and Renelt control variables

Table 2. Mean growth and growth volatility with a sample of France's 16 generations (1800-2000) with Levin-Renelt control variables

Variable	Definition	Coefficient	T-Stats	Std. Dev.	[95%Conf. Interval] min	[95%Conf. Interval]m ax
Vol	Std Dev Of Growth (volatilit y)	0.02892	1.2 5	0.02312	-0.0164	0.07424
Gdppccp	Initial log GDP per capita	-0.0040	0.51	0.0078	-0.0193	0.01134
Inv	Average investment fractio of GDP	0.00128	2.2 7	0.00056	0.00017	0.00238
hc	Initial human capita	0.00652	1.6 3	0.00401	-0.0143	0.00133
aapgr	Average growth of the population	-0.0132	0.9 8	-00679	-0.0265	0.00008
Intercept	Intercept	0.0678	2.8 1	0.0433	-0.0172	0.1528
Log likelihood=543,46						

Table 3. Test of Mean growth and growth volatility with a sample of 108 countries and its 16 generations (multidimensional trade)

Variable Variable	Definition	Coefficient	T Stats	Std. Dev.	[95%Conf.Int erval] min	[95%Conf.Interv al]max
Vol	Std Dev. Of growth(volatility)	0.0125969	0.9 8	0.012909	-0.012	0.0378
Intercept	Intercept	0.0159509	2.8 1	0.0056704	0.0048	0.02706
F(1.127)=0.01 R-squared :0. 0001 Adj Rsquared= -0.0078						

Table 4a. Test of Mean growth and growth volatility with a sample of 16 generations of France trading with all the generations of the 2 samples

Variable	Definition	Coefficient	T-Stats	Std. Dev.	[95%Conf. Interval] min	[95%Conf. Interval]m ax
Vol	Std Dev. of growth(volatility)	-0.3836	186.22	0.00206	-0.3876	-0.379
Gdppccp	Initial log GDP per capita	-0.0027	-8.84	0.0003	-0.0033	-0.0021
Inv	Average investment fraction of GDP	0.0009	27.06	0.00003	0.00084	0.00097
hc	initial human capita	-0.002121	-15.92	0.00013	-0.00238	-0.0018
aapgr	Average growth of the population	-0.0015	-6.45	0.00023	-0.00199	-0.0010
Intercept	Intercept	0.03519	-17.02	0.0020	0.0311	0.0392
Log likelihood=543,46						

Table 4b. Regression of the rate of governmental expensive (govexp) on the trend of resources (control variable contributing to WTF) and on the dummy variables and on 4 time trend variables and the LOG of GDP of 2 periods lag

Variable	Definition	Coefficient	T-Stats	Std. Dev.	[95%Conf.Interval] min	[95%Conf.Interval]max
Volgov	-Croissance des dépensesgouvernementales	6.484	348.09	0.018	6.44	6.52
Gdppccp	-Fluctuations dues aux dépensesgouvernementales -Log -PNB/tête initial	-48.53	-8.0	6.05	-60.42	-36.64
Inv	-part des investissementsdans le PNB	-0.261	-10.62	0.024	-0.31	-0.21
h-c	-Capital humain initial	-0.057	-22.17	0.0025	-0.062	-0.052
aapgr	-Taux de croissanceannuelmoyen de la population	-5.554	-22.13	0.25	-6.045	-5.06
loggdplag2	-log du PNB/tête initial retardé de 2 périodes -Variables factices saisonnières -Constante	48.125	7.97	6.041	36.284	59.96
trend		-0.1422	-2.24	0.063	-0.266	-0.0177
t-square		0.0047	2.70	0.0017	0.0013	0.0082
_Cons		37.75	39.29	0.961	35.87	39.64
Log likelihood=-1824,3						
Prob>chi2= 0,000						

Table 4c. Regression of the rate of per capita growth on the trend of resources (control variable contributing to WTF) and on the dummy variables and on the fixed effects of countries

Variable	Definition	Coefficient	T-Stats	Std. Dev.	[95%Conf.Interval] min	[95%Conf.Interval]max
grgdp	-Taux de croissance du PNB/tête	-0.4706	-94.26	0.0049	-0.48	-0.460
Vol1	- Ecart-type du taux de croissance	-2.4613	-14.27	0.1724	-2.79	-2.123
	--PNB/tête initial					
Gdppccp	-part des investissementsdans le PNB	0.0234	26.64	0.00088	0.0217	0.025
Inv	-Capital humain initial					
	-Taux de croissanceannuelmoyen de la	-0.00227	-21.44	0.000106	-0.0024	-0.002
h-c	population					
	-Variables factices saisonnières	0.0305	4.69	0.0065	0.0177	0.043
aapgr		-0.2364	-6.9	0.0342	-0.3035	-0.169
	‘’					
	‘’					
q1t		-0.1853	-5.42	0.03418	-0.2523	-0.118
q2t	- log du PNB/tête initial retardé de 2	0.04517	2.61	0.0173	0.1119	0.079
q3t	périodes	-0.3703	-1.42	0.02602	-0.088	0.013
dot	Constante	2.4219	14.18	0.1707	2.087	2.756
loggdplag2						
		-0 .2399	-5.58	0.0429	-0.3241	-0.155
Intercept						
Log likelihood=-739,27						
Prob>chi2= 0,000						

Table 4d. Regression of the rate of governmental expensive (govexp) on the trend of resources (control variable contributing to WTF) and on the dummy variables with countries fixed effects

Variable	Definition	Coefficient	T-Stats	Std. Dev.	[95%Conf.Interval] min	[95%Conf.Interval] max
govexp	-Croissance des dépensesgouvernementales	1.43	26.95	0.0532	1.329	1.5381
Volgov	-Fluctuations dues aux dépensesgouvernementales	0.8312	96.22	0.00863	0.814	0.8482
Govexplag2	-Log des dépensesgouvernementales/tête retardé de 2 périodes	-106.20	-22.64	4.69	-115.40	-97.01
Gdppccp	-PNB/tête initial -part des investissementsdans le PNB	0.01598	0.63	0.0253	-0.0336	0.0656
Inv	-Capital humain initial	-0.010	-5.39	0.00189	-0.0139	-0.0064
h-c	-Taux de croissanceannuelmoyen de la population	-0.528	-4.32	0.116	-0.7572	-0.2988
aapgr	-Variables factices saisonnières					
	‘’	-0.3201	-0.52	0.6147	-1.5251	0.8848
q1t	‘’ ‘	-0.0554	-0.10	0.568	-1.169	1.0584
q2t	- log du PNB/tête initial retardé	-0.0076	-0.03	0.2931	-0.5822	0.567
q3t	de 2 périodes	-0.888	-4.29	0.2071	-1.2949	-0.4827
dot	Constante	106.5	22.76	4.6788	97.33	115.67
loggdplag2						
_Cons		3.50	3.41	1.028	1.4928	5.524
Log likelihood=-1465.637						
Prob>chi2= 0,000						

5. CONCLUSION

This paper has investigated the crucial efficiency of globalization's fundamental mechanisms through the question, Does a systematic practicing of the whole set of the Neoclassical principles as a nation's ultimate social laws and policies, generate sustainable development locally and globally? I find, theoretically and empirically, there is no growth volatility at steady state level. PPF's permanent movements and its corollary, growth volatility are the result of this productive factors' virtual trade. So, growth volatility's sign is the qualitative evaluation of the productive factors' virtual movements between countries and generations, ceteris paribus. Indirect scarce productive factors' import may generate positive link between growth and volatility and vice versa. In a world characterized by strong and sensitive economic interdependencies, instability becomes permanent if each disequilibrium in a country or in a generation is easily transmitted to other economies or generations. It becomes now more and more clear that all the choices in the world are inter-generationally and internationally interdependent and their impact on economic volatility is evident. This is to say productive factors' movements through goods' exchange is real and tend more towards steady state in OECD countries than others. International and intergenerational trade and productive factors' virtual movements are the globalization's fundamental mechanisms. Through these mechanisms, bad or good practices are transferred from a country or a generation to another.

This confirms, in part, the finding of Caselli and Coleman's (2000) that, the negative cross-country correlation between efficiency of unskilled labor and efficiencies of skilled labor and capital is the proof of the existence of a World Technology Frontier in which increases in the efficiency of unskilled labor are obtained at the cost of declines in the efficiency of skilled labor and capital.; thus, Neoclassical hypotheses ' systematic practicing as common international program is the Education for the whole world sustainable development.

In terms of theoretical foundations, I link economics, technology and environmental sciences, to enriches the academic discourse and provides a comprehensive framework for future studies. This provides a unique perspective between economic growth and volatility through the lens of intergenerational and international productive factor movements. By extending the Heckscher-Ohlin theory to incorporate virtual trade and intergenerational dynamics, the findings offer a fresh theoretical framework and empirical evidence that enrich understanding of globalization's mechanisms. In theory, the study's findings on the Production Possibilities Frontier (PPF) and its implications for achieving general equilibrium contribute to ongoing debates about sustainable development and economic interdependencies. The article's innovative approach and its comprehensive analysis offer a unique foundation to addressing real-world economic challenges. Using panel data to test the positive and negative relationships between growth and volatility and the impact of productive factors' virtual movements, I find, the Heckscher-Ohlin theory extended to the virtual movements of factors between countries and between generations is not only empirically verified but constitutes the real foundation of sustainability. By combining these two dimensions, it would open avenues for new policy recommendations and strategies for promoting sustainable development in an increasingly interconnected global economy. Thus, a systematic practicing of the whole set of the extended Heckscher-Ohlin theory's full set of hypotheses as a nation's social laws and policies, is necessarily leading to sustainable development locally and globally.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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