Cross-generation and cross-country evidence on productive factors' virtual movements

Abstract

A qualitative evaluation of the decreasing of abundant factor and the increasing of scarce one in HO model is to consider the movements' effects of the Production Possibilities Frontier (PPF). Using Agent-based Modelling (ABM), I find growth volatility in the cross-country and cross-generation's evidence is due to PPF disturbance. This disturbance shall depend on the assumption that economic agents in a given nation or generation can commit more or less serious miss-choices, which they can then repent of. But these miss-choices affect production and consumption more or less considerably, in terms of purchasing or production rights. However, the great global community's tendency to return to right choices, ensures a serendipitous equilibrium in a context of overlapping generations and nations. There is an auto-errors correction between old and young (living and dead generations and between old and young countries) ensuring a permanent equilibrium in the economy, so that the continuous movements of the PPF are not perceptible.(nominal growth volatility). Therefore, the sustainable growth generated by this continuum of opposing shock-vectors of equal intensity, i.e. an exchange of positive externalities for negative externalities between generations and countries, is the normal state of any economy. Because, shocks on PPF have two origins: external(from other generations or nations) and internal (current generation or the same country), the integration of the two conflicting mechanisms for endogenous technological change, eliminates growth volatility. This result confirms at a high level, the Hecksher-Ohlin-Edgeweblime hypothesis that scarce factors are indirectly imported (increasing) and abundant factors exported (decreasing) through the exchange of final goods, and that, the scarce final good in a generation is indirectly imported (increasing) and the abundant final good in a given generation is indirectly exported(decreasing) through the exchange of factors between generations of a given country.

Keywords: Nominal growth volatility, sustainable growth, temporal PPF disturbance, national PPF disturbance, auto-errors correction

Motivation

Can we after the trade is opened, measure the decreasing of abundant productive factor and the increasing of the scarce one in involved countries? 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 equalized in the countries through goods' trade, we're justified to assume that their supplies are also equalized. If we consider that, sometime other economic and none economic factors contribute to price determination, prices equalization is nowhere relevant. These kind of processes in HO's world cannot be observed and therefore must be neglected. 2) A qualitative evaluation of the decreasing of abundant factor and the increasing of scarce factor is to consider the movements' effects of the Production Possibilities Frontier (PPF). It's shown, growth volatility in the cross-country 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 resources 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. At this step, I'm founded to follow the second way as the first one needs great measurement's means that do not exist nowadays. It's clear that there is no volatility in the sustainable or optimal growth. At this end, I will first present the background of the theory; then deal with Neoclassical Trade Model as local behaviour or practice that produce 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. This is particularly the case with the work of Kravis (1956), who demonstrated that the American workforce obtained higher wages than those of other countries and of Leontief (1954, 1956) who, noting a high intensity in work in American exports deduced that an American worker was worth three times a foreign worker. These elements, associated with advances in the economic theory of human capital, have made it possible to identify the concept of skilled and unskilled labor. 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 consider that skilled labor is the result of the combination of capital and unskilled labor. Integration of qualification in the form of different categories of work Already formulated by Ohlin (1933), the analysis of qualification in terms of different categories of work has been carried out in particular by Vanek (1968) and Keesing (1965, 1966, 1968, 1971). The author starts from the principle that the different categories of work are so many factors of production and that the availability of skilled labor becomes a determinant of the Wheat statistics of trade. Countries with a large supply of labor with a high level of technical qualification are able to produce many manufactured goods cheaper than other countries. A plentiful supply of well-educated individuals receiving wages no higher than those of unskilled workers - while in other countries they receive two or three times as much - provides superiority in high demand industries of educated workers. In short, if differences in wages among groups of workers persist in a country for a sufficiently long period of time, these groups must be regarded as separate factors of production just like different qualities of land. In most cases a rough division between only three factors is sufficient: 1) unskilled labor, 2) skilled labor, 3) technical labor. The second group includes mechanics, foremen, office workers etc. and the third group comprises the technical and administrative heads necessary for the production ... Interregional and International Trade, 1933, revised. Then more recently Manning (1982) or Findlay and Kierzkowski (1983) have attempted to model this alternative approach to skilled labor. The modeling of skilled labor and human capital Kenen (1965), inspired by work on the links between education, job qualification and growth, takes up the idea according to which investments made in the education system transform unskilled work in skilled labor and thus adds additional value to labor service flows. 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. Findlay and Kierzkowski take this approach and integrate it into a model which remains close to the basic Heckscher-Ohlin model. Over the past fifteen years international trade theory has gradually developed and adopted what can be considered a third basic model: the specific factor model that Samuelson (1971) still calls the Ricardo-Viner model because it generalizes the notion of diminishing returns from agriculture to all sectors. Developed by Samuelson (1971) and Jones (1971), this model takes up ideas already expressed by Cairnes (1874), Bastable (1903) Haberler (1936) Viner (1937) and Harrod (1957,1958). It is situated at Extensions of the Proportions of Factors. More recently, a second source of gains from trade has emerged from the research of Melitz (2003) and Bernard, Eaton, Jensen, and Kortum (2003). This is the firm-level "reallocation" effect that arises when there is firm heterogeneity. By firm heterogeneity they mean that even within narrowly defined industries some firms are much larger and more profitable than others because, for example, they are much more productive. Globalization generates both winners and losers among fi rms within an industry and these effects are magnified by heterogeneity. Better-performing firms thrive and expand into foreign markets, while worse performing firms contract and even shut down in the face of foreign competition. This generates a new source of gains from trade: as production is concentrated towards better-performing firms, the overall efficiency of the industry improves. In this way, globalization raises average efficiency *within an industry*. Why is it that only the better-performing fi rms grow? Globalization expands markets but also increases competition in those markets. This competition effect dominates for the worse-performing firms while the increased market access dominates for the better performing firms.

The third source of gains from trade comes from the positive impacts of larger markets on *innovation*. New productivity-enhancing products and processes require up-front development costs. Theories of innovation-based gains from trade with homogeneous firms were developed by Grossman and Helpman (1991) and are supported by *Marc J. Melitz and Daniel Trefler* Country-level evidence (Helpman 2004, chap. 5.6). At the firm level, there is a strong relationship between exporting and innovation.

3- The model

3.1- Heckscher -Ohlin theory: the role of factor proportions

3.1.1 -A model of a two-factor economy

1-. Model assumptions

The factor proportions approach is based on the following assumptions:

- Everything happens in a market of pure and perfect competition;

- The economy is made up of two countries North and South, which wish to participate in Neoclassical Trade. Each of them produces and consumes two categories of homogeneous goods, «DVD » and « Wheat » . These goods are produced from two homogeneous factors (Labor L and « Capital » "k");

-Each good is produced with a distinct relative « Capital » or «Labor intensity: The production of « DVD » is Capital intensive and that of the wheat is labor intensive;

- The factors of production available in fixed quantities are used in full employment in production and in an optimal manner. It is assumed that each country produces both goods (partial international specialization).

- The production function is the same in both countries for a good; the production functions are homogeneous of degree 1, at constant return to scale and with decreasing marginal productivities;

- The factors of production are immobile internationally;
- The marginal utility of each good is always decreasing.

From there, we can define the following expressions:

CA_g: units of « Capital » needed per «DVD » ,
CP_g: units of Labor required per «DVD » ,
CA_l: units of « Capital » (hour / machine) needed for Wheat ,
CP_l: units of Labor necessary per Wheat unit,
A: total supply of « Capital » in the economy (general autorities' services)
P: total Labor supply in the economy (local authorities' services).
Wheat production is A intensive, $CA_g / CP_g > CA_l / CP_l$

or $CA_g / CA_l > CP_g / CP_l$.

2- Expression of the frontier of production possibilities

If the economy produces Wheat and «DVD » , it will have used $cl_l.Q_l' + cl_g.Q_g$ 'Labor hours and $ck_l Q_l'' + ck_g Q_g''$units of capital . This total time of «Labor and « Capital » necessary for the production of the two goods cannot exceed the total supply L of «Labor and the total stock of « Capital » available.

$\rightarrow cl_l.Q_l' + cl_g.Q_g' \leq L$ and $ck_l Q_l'' + ck_g Q_g'' \leq K$ (1)

From this it is possible to determine the maximum amount of Wheat or «DVD » that the economy can produce by sacrificing either totally or partially one or the other of the two goods.

$Q_l \leq L/cl_l + K/ck_l) - (cl_l/cl_l + ck_g/ck_l)Q_g$ (2)
or $Q_g \leq L/cl_g + K/ck_g) - (cl_l/cl_g + ck_l/ck_g) Q_l$

If $Q_g = 0 \rightarrow Q_l \leq (L/cl_l + K/ck_l)$ or if $Q_l = 0$

$Q_g \leq (L / cl_g + K/ck_g)$

The shape of the red curve (Figure 1 in Appendix) indicates that the type of determining constraint depends on the combination of goods that the economy produces: at point 1, it is the constraint of K that limits production; at 2, it's work. Also, Wheat s in the resources of an economy will have uneven effects on its capacity to produce different goods. An increase in the supply of K in the economy, for example, will increase the possibilities of producing Wheat more than the «DVD » . The reverse is true if it is the supply of L which increases. Wheat s in the supply of resources in an economy therefore lead to a biased expansion of production possibilities. This difference in the resources of economies is at the origin of Neoclassical Trade Model. More generally, any economy will tend to be relatively efficient in producing goods that are intensive in the factors with which the country is relatively well endowed. This is the basis of HO theory. HO's theory of Multidimensional Trade Model patterns states: "goods whose production requires the use of a high proportion of factors of production which exist in abundance and a low proportion of rare factors are exported against goods the production of which requires opposite proportions of the same factors ", Heckscher-Ohlin, (1939).

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."

« Labor is abundant in a country if the ratio of «Labor to other factors is higher than in the rest of the world. A product is very «Labor-intensive if the Labor costs are a greater share of its value than they represent in the value of other products.

At the start of their H-O study, the question arises: what are the explanatory factors for the price differences between countries even before trade opens? When we know the demand and supply curves, we can highlight production, consumption and the price effects generated by Neoclassical Trade Model.

The merger of the two groups will affect the international price which will be fixed at an intermediate level.

3.2.- Multidimensional trade with productive factors international virtual movements

3.2.1- Behavior of households and firms

3.2.1-. 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

intergenerationally;

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.

3.2.1- The multidimensional trade

3.2.1.1- description

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 47.*

$P_i(t) = \sum$ *,* 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

$$= AE^{\alpha}N^{\beta}X^{*}(). (,) . \qquad (3)$$

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).

All previous equilibrium lead to a multidimensional equilibrium(representing all countries and all generations across time). At this level, there is an international and intergenerational levelling out of goods and factors' prices(see graph 1 in Appendix).

3.2.1.2- The expression of Multidimensional trade

Building upon Grossman and Helpman's (1991b) proposition, $W_{ij}(t)$ is the ratio of country i's total trade (generation i') with country j (generation j'). That is, country i's (generation i') bilateral exports and imports are divided by country i's aggregate output (generation i').

$$Wij = \frac{\frac{Pj(t)}{Pi(t)}\, Li(t)gij(t)+Lj(t)gji(t)}{Li(t)yi(t)} \qquad i \neq j$$

$$W'ij = \frac{\frac{P'j(t)}{P'i(t)}\, L''i(t)g'ij(t)+L''j(t)g'ji(t)}{L'i(t)y'i(t)} \qquad i' \neq j'$$

If these two flows have the same rhythm, but different country (generation) weights, the macro-dynamic equilibrium , or multidimensional trade, represents interference between the international transaction (W_{ij}) and the intergenerational transaction (W'_{ij}). These two situations are described above.

$$\Delta Yt = \Sigma \Delta yit + \Delta yit$$
$$= yi0\cos(Wijt - \varphi_1) + y'i0\cos(W'ijt) - \varphi_2) \qquad (4)$$

If we develop equation (75), we obtain:

$$\Delta Y_O \cos t \cos\varphi + \Delta Y_O \sin Wijt \sin\varphi = y_{i0}\cos Wijt\cos\varphi_1 + y_{i0}\sin Wijt\sin\varphi_1 + y'_{i0}\cos Wijt\cos\varphi_2 + y'_{i0}\sin Wijt\sin\varphi_2$$
. (76)

Solving simultaneously:

$$\Delta Y_O \cos Wijt\cos\varphi = y_{i0}\cos Wijt\cos\varphi_1 + y'_{i0}\cos Wijt\cos\varphi_2 \qquad (5)$$

$$\Delta Y_O \sin Wijt\sin\varphi = y_{i0}\sin Wijt\sin\varphi + y'_{i0}\sin Wijt\sin\varphi_2\varphi_2 \qquad (6)$$

This becomes:

$$\Delta Y_O \cos\varphi = y_{i0}\cos\varphi_1 + y'_{i0}\cos\varphi_2 \qquad (7)$$

$$\Delta Y_O \sin\varphi = y_{i0}\sin\varphi_1 + y'_{i_0}\sin\varphi_2 \qquad . \qquad (8)$$

We then calculate the amplitude of multidimensional trade as:

$$\Delta {Y_O}^2(cos^2\varphi + sin^2\varphi) = {y_i}_o^2(cos^2\varphi_1 + sin^2\varphi_2) + {y'}_{i_o}^2(cos^2\varphi_1 + sin^2\varphi_2) + 2y_{i_o}y'_{i_o}\,(cos\,\varphi_1\,cos\,\varphi_2 + sin\,\varphi_1\,sin\,\varphi_2 \tag{9}$$

$$\Delta {Y_O}^2 = {y_i}_o^2 + {y'}_{i_o}^2 + 2y_{i0_o}y'_{i_o}\ cos(\varphi_1 - \varphi_2) \quad . \tag{9}$$

If multidimensional trade is horizontal ($\varphi_1 = \varphi_2$),

$$\text{we have } \Delta {Y_O}^2 = {y_i}_o^2 + {y'}_{i_o}^2 \ . \tag{10}$$

In this case we have constructive multidimensional trade because the trade increases.

If multidimensional trade is vertical, with different generational weightings ($\varphi_1 = \varphi_2 + \pi$), we obtain $\Delta {Y_O}^2 = {y_i}_o^2 - {y'}_{i_o}^2$. (84)

In this situation multidimensional trade is destructive as it decreases.

Between these two extremes, multidimensional trade varies with the cosine (φ_1- φ_2) or the cosine of different generational weightings.

A generation's weight is calculated by dividing the preceding equations, member by member, as follows

$$Tan\varphi = \frac{y_{i_o}\ sin\,\varphi_1 + y'_{i_o}\ sin\,\varphi_2}{y_{i_o}\ cos\,\varphi_1 + y'_{i_o}\ cos\,\varphi_2} \ . \tag{11}$$

Finally, multidimensional trade is expressed as

$$\boldsymbol{\Delta {Y_O}^2 = {y_i}_o^2 + {y'}_{i_o}^2 + 2y_{i_o}y'_{i_o}\ cos(\varphi_1 - \varphi_2)\ cos\left(Wijt - arctan\varphi \frac{y_{i_o}\ sin\,\varphi_1 + y'_{i_o}\ sin\,\varphi_2}{y_{i_o}\ cos\,\varphi_1 + y'_{i_o}\ cos\,\varphi_2}\right).} \tag{12}$$

With the Fourier transform we obtain spectral frequencies like

$F(Wijt) = \int f(t)\, e2\pi jWtdt = \frac{y_{i_o}}{[2]} \int [e2\pi j(Wij0 + Wij)t + e2\pi j(Wij0 - Wij)t]dt$

$= \frac{y_{i_o}}{[2]} \frac{1}{\left[\frac{1}{\tau} - 2\pi j(wij0+wij)\right]} + \frac{y_{i_o}}{[2]} \frac{1}{\left[\left[\frac{1}{\tau} - 2\pi j(wij0+wij)\right]\right]}$

$[F(wij)]^2 = \frac{1}{\left[\frac{1}{\tau^2} + 4\pi^2 j(Wij0+Wij)^2\right]}$ $\Delta Wij = \frac{1}{[2\pi\tau]}$.

3.2.1.2.1- Derived consumption function

Each generation maximizes its overall utility according to its time of life as given by

U_{gi}=max $\int ß^t u(c\ 1t, c\ 2t) = \int_0^\infty \frac{\Sigma\ \Delta\ y\ i\ t}{[\beta+\delta(1-\beta)]} e^{n\ t} e^{-\rho\ t} dt = \int_0^\infty u(c)\, e^{n\ t}\, dt$

$w\ i\ h u(c) = \frac{\Sigma\ \Delta\ y\ i\ t}{[\beta + \delta(1-\beta)]}$

s.t. pbcid +pdtcidt+wirxit + rit+∂ ≤wit +ritkit+(∂+rit)rit k_{it}*+∂ –(1-δ)*$k_{it} \leq x_{it}$ $c_{ijt} \geq 0$,
$x_{it} \geq 0$, $b_{it} \geq -B$ *ki0≤k-i0, bi0≤0*
: is a generation's rate of time preference

If I pose: y as asset per person; r: interest rate (capital 's value); w is the wage rate (power in priesthood's value) and n is the growth rate of population

these constraints can be resumed as

$\dot{} = (r-n).y + w - c$

With

$$\Delta Y_{0\,t} = \frac{y_{i_0}}{[2]} \frac{1}{\left[\frac{1}{\tau} - 2\pi(jw\,i\;j + \theta\,i)\right]} + \qquad (t).exp(\varepsilon i,t) + AE'^{\alpha'}N'^{\beta'}X'^{*}{}_{i}(t).exp(\varepsilon i',t) + \sqrt{(.)} \qquad (13)$$

$$\frac{y_{i_0}}{[2]} \frac{1}{\left[\left[\frac{1}{\tau} - 2\pi(jw\,i\;j + \theta\,i)\right]\right]} = AE^{\alpha}N^{\beta}X^{*}{}_{I}$$

$$f(.) = \frac{1}{\left[\frac{1}{\tau^2} + 4\pi^2 j(Wi\;(j) + Wi\;)^2\right]}$$

$$P\,j(t) \qquad L\,i \quad and w\,i \neq \frac{\frac{P\,j\,t}{P\,(t)} L\,(t)g\,i(j) + L\,(t)g\,j(t)}{L\,(t)y\,(t)} \qquad i \neq j$$

That is, generation's utility at time 0 is a weighted sum of all contemporaneous consumptions utilities, u(c). We assume that u(c) is increasing in c and convex, u'(c)<0, u''(c) >0. The convexity describes an individual overall satisfaction over time as he tends to the end of his life. At the end of a generation's life, all non- durable goods are consumed and the durable power in priesthood- include the level of technology- survive as a payment of its overconsumption of capital .

The individual utility u(c) has been multiplied by the generation size, L = showing the adding up of utils for all generation inhabitants alive at time t. - with)exhibits time preference rate, describing the fact that generation $t_{-1'}$ s preference to consume at time t_{-1} than t and its reimbursement to generation t should include interests.

A point of time utility function is homothetic, strictly increasing, strictly concave, and continuously differentiable.

The first order conditions of the utility function are:

$$\frac{u\,d(c\;i\;,b\;t\;)d\;t\;P\;d\;t}{U\;b((c\;i\;,b\;t\;)b\;t\;P\;b\;t} > \frac{U\;b(c\;i\;b\;t\;)d\;t}{\beta U\;b((c\;i\;b+1,c\;i\;d+1)} > \frac{P\;b\;t}{P\;b+1}(w\;i\;t+1)(1-\partial) + r\;i+t1 \quad if\ q^{i}_{t} > 0 \qquad (14)$$

$$1 + r\;b(t\;i+1) \geq \frac{w\;i(t+1)(1-\partial)+r\;(t+1)}{w\;i\;t}, = if\ q^{i}_{t} > 0 \qquad . \qquad (15)$$

Consumption function in Ramsey model (see Barro and al(2004) is given by

$$C(t) = c(0).\ ^{/\Theta/[\check{r}()\,]} \qquad (16)$$

The substitution of this result for c(t) into the intertemporal budget constraint in equation (88) leads to the consumption function at time 0:

c (0) = μ(0). [a(0) + (0)] (17)

Where μ(0), the propensity to consume of wealth, is determined from

$$[1/\mu(0).] = \int \check{r}(\,)\,\Theta)/\Theta - \Theta$$

3.2.1.2.2- Derived production function

Considering the multidimensional trade expression:

$$, = y_{i_o}^{2} + y'^{2}_{i_o} + \frac{1}{\left[\frac{1}{\tau^2} + 4\pi^2 j(w\,i\;0j + w\,i\,)\right]} \quad (19)$$

And combining equations 74, 12 and 70:

$$Y_{it} = AE^{\alpha}N^{\beta}\,X^{*}{}_{i}(t).\,exp(\varepsilon i,t) \quad \textit{(see equation 3)}$$

$$'= AE'^{\alpha'}N'^{\beta'}\,X'^{*}{}_{i}(t).\,exp(\varepsilon i',t)$$

We obtain:

$$\mathbf{=AE^{\alpha}N^{\beta}X^{*}{}_{i}(t).exp(\varepsilon i,t)+AE'^{\alpha'}N'^{\beta'}X'^{*}{}_{i}(t).exp(\varepsilon i',t)}+\sqrt{(.)} \quad \mathbf{(20)}$$

$$f(.)=\frac{1}{\left[\frac{1}{\tau^2} + 4\pi^2 j(Wi\;0j + Wi\,)\right]}$$

With

$$w\,i \neq \frac{\frac{P\,j(t)}{P\,(t)}\,L\,(t)g\;i(t)) + L\,(t)g\;j(t))}{L\,(t)y\,(t)} \qquad i \neq j$$

The logarithm linear regression of equation 77 in per labor form can be expressed

$$(\frac{Y}{L})i,t = ln(A_i + A'_i) + (\alpha_E + \alpha'_E)ln(\frac{E}{L} + \frac{E\prime}{L\prime}) + (\beta_N + \beta'_N)ln(\frac{N}{L} + \frac{N\prime}{L\prime}) + [(a_{ij}W_{ij}\,(t) + a'_{ij}W'_{ij}\,(t)]\;\;[Xj\,(t) + X'j\,(t)] + \delta''_X\,X'i\,(t)$$

$$+(\alpha E + \beta' N + aijWij + \delta' X)lnN \; + \frac{1}{\left[\frac{1}{\tau} - 2\pi\,\{w\,i\,0) + w\,i\,)\right]} =$$

3.2.1.2- 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.

3.2.1.2.1- International levelling out of goods and factors' prices

Let 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 « power in priesthood » in « DVD » production will increase. In NORTH, the changing factor prices will modify production techniques. The techniques will be « power in priesthood » intensive. In the SOUTH the reverse will be the case; techniques will be intensive in « Capital » with prices decreasing.

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* $q_b>0$ (21)

$P_d \geq (w+r)f_d(q_b, q_d)$, *if* $q_d> 0$. (22)

For the production functions with constant output, the minimum cost is a linear function of □□ of □$_{tf,}$ □ depends on w et r.

Then,

$$C_{usd}(w,r,Q_{usd}) = \pi.Q_{usd} \text{ and } \pi = \pi f(w,r)r) \quad (23)$$

$$P_{usd} = \frac{\partial C_{at}}{\partial Q_{usd}} = \pi_t(w,r) \text{ for the « WHEAT » and} \quad (24)$$

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

$$r = r(P_{usd}, P_{usb})_b \text{ and } w = w(P_{usd}, P_{usb}) \text{ where } \frac{w}{r} = h\left(\frac{P_{usb}}{P_{usd}}\right). \quad (25)$$

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» power in priesthood » are superior to their equilibrium level.

3.2.1.2.2- 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 iso-product curves for each good as a dual program.

For example, the current French generation is well endowed in « power in priesthood » while the following generations are well endowed in capital . At the beginning of intergenerational trade, 'current French' will export « power in priesthood » (indirectly the « WHEAT » , a product» power in priesthood » 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 « power in priesthood » 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 p_p *decreases and* P_a *augments. For the 'current French', the proportion of « Capital » in « DVD » production will increase while the proportion of « power in priesthood » decreases. For the 'current French', the change in the factor prices will modify production techniques. Techniques will use more « Capital » and less « power in priesthood » . For the 'future French', the reverse applies; techniques will be intensive in « power in priesthood » as their prices will fall. The substitution of « Capital » for « power in priesthood » 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 □□ of $□_{tf,}$□ *depending on w and r.*

$$MinC_r = wE_r + rN_r \quad (26)$$

subject to

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

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 levelling out of the intergenerational terms of trade and the equivalency of the values of the goods and the factors exchanged

Then,

(,,)=. *and* = (,)*r)*

$P_{u\ s\ d} = \frac{\partial\ C_{at}}{\partial\ Q_{t\ s\ d}} = \pi_t(w,r)$ *for the « WHEAT » and*

= (,) *for the « DVD » ,*

$$- \quad (—) \quad =(\ ,\ )_b \text{ and } = (\ ,\ ) \text{ where } = h\ . \quad (27)$$

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» power in priesthood » are superior to their equilibrium level.

The multidimensional equilibrium presented in figure 1 can now be parameterized.

4- Evidence on the effects of the Neoclassical trade model on the multidimensional exchange of human capital

4.1- In order to study the equilibrium in the multidimensional trade processes I will test the relationship between growth and volatility in the context of multidimensional trade, I will follow three steps: 1) In the first case, I consider France through five generations of 50 years with 10 witness generations; 2) In the second case I mix France five generations with the remaining of 124 countries; 3) I will mix

France five generations with the remaining of 124 countries and observe the sign of the relationship between growth rate and growth volatility and with control variables (see tables 1a to 2a in appendix).

4.4.1- 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 5a and Table 5b. 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 5a bis). 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

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 «random walking»and 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 hc-residue 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 enrollment 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 108-country sample is 3240 and 630 for the second sample which becomes a 21-country sample in this new specification. The results of the regressions are presented in the Tables below (see tables 2b and 2c in appendix).:

5- Conclusion

Tests have focused on cross-generation and cross-country evidence on the link between growth and volatility. If production possibilities frontier movements' trend is in the left side (lower values of Levine and Renelt control variables) countries with higher standard deviation of growth shall have their growth adversely affected if at the same time they loose their comparative advantages. The sign is positive in other cases. A qualitative evaluation of the decreasing of abundant factor and the increasing of scarce factor is to consider the movements' effects of the Production Possibilities Frontier (PPF). Using Agent-based Modelling (ABM), I find growth volatility in the cross-country and cross-generation's evidence is due to PPF disturbance. This disturbance shall depend on the assumption that economic agents in a given nation or generation can commit more or less serious miss-choices, which they can then repent of. But these miss-choices affect production and consumption more or less considerably, in terms of purchasing or production rights. The great global community's trend to return to right choices ensures a serendipitous equilibrium in a context of overlapping generations and nations. There is an automatic auto-errors correction between old and young (living and dead generations and between old and young countries) ensuring a permanent equilibrium in the economy, so that the permanent movements of the PPF are not perceptible. Thus, this sustainable growth generated by this continuum of opposing shock-vectors of equal intensity, i.e. an exchange of positive externalities for negative externalities between generations and countries, is the normal state of any economy. Because, shocks on PPF have two origins: external(from other generations or nations) and internal (current generation or the same country).the integration of the two conflicting mechanisms for endogenous technological change, eliminates growth volatility. This result confirms at a high level the Hecksher-Ohlin-Edgeweblime hypothesis that scarce factors are indirectly imported and abundant factors exported through the exchange of final goods, and that final goods are indirectly exchanged through the exchange of factors between generations in the same country. Finally, it's clear that 1) these productive factors' prices are not equalised with goods' trade but there is a strong tendency to general prices' convergence in OECD countries. 2) A qualitative evaluation of the decreasing of abundant factor and the increasing of scarce factor considering the effects the movements

of the Production Possibilities Frontier (PPF) is also shown through positive or negative links between growth and volatility in the cross-county and cross-generation's evidence in the zones HO hypotheses are more realised.

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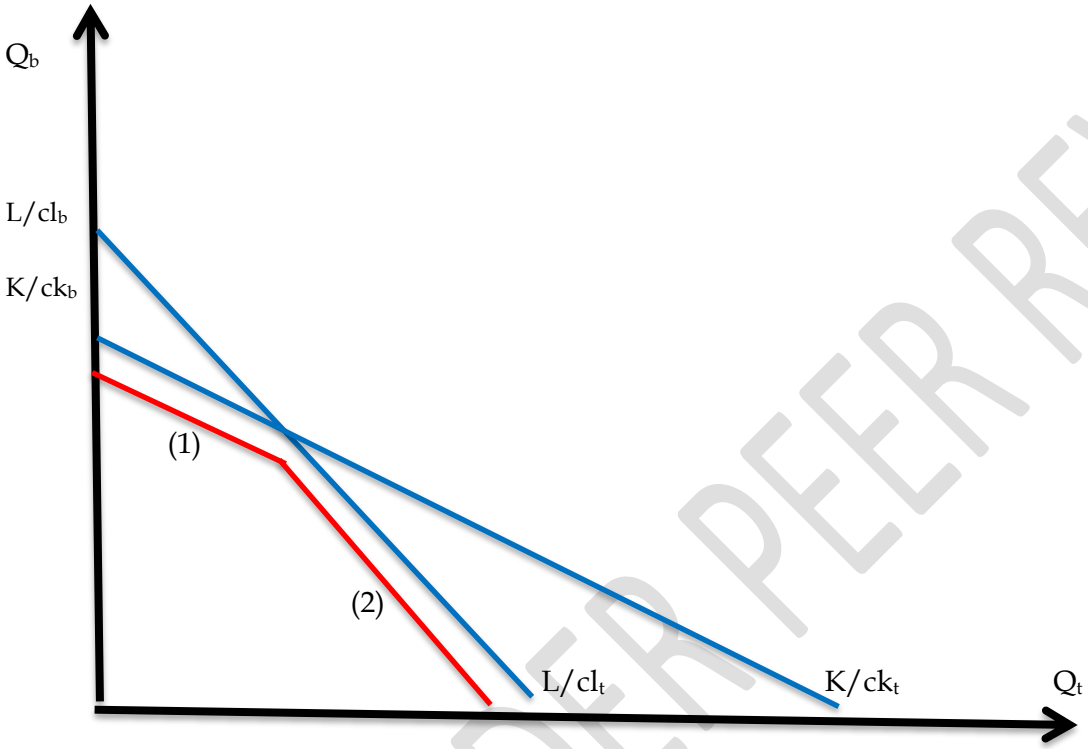
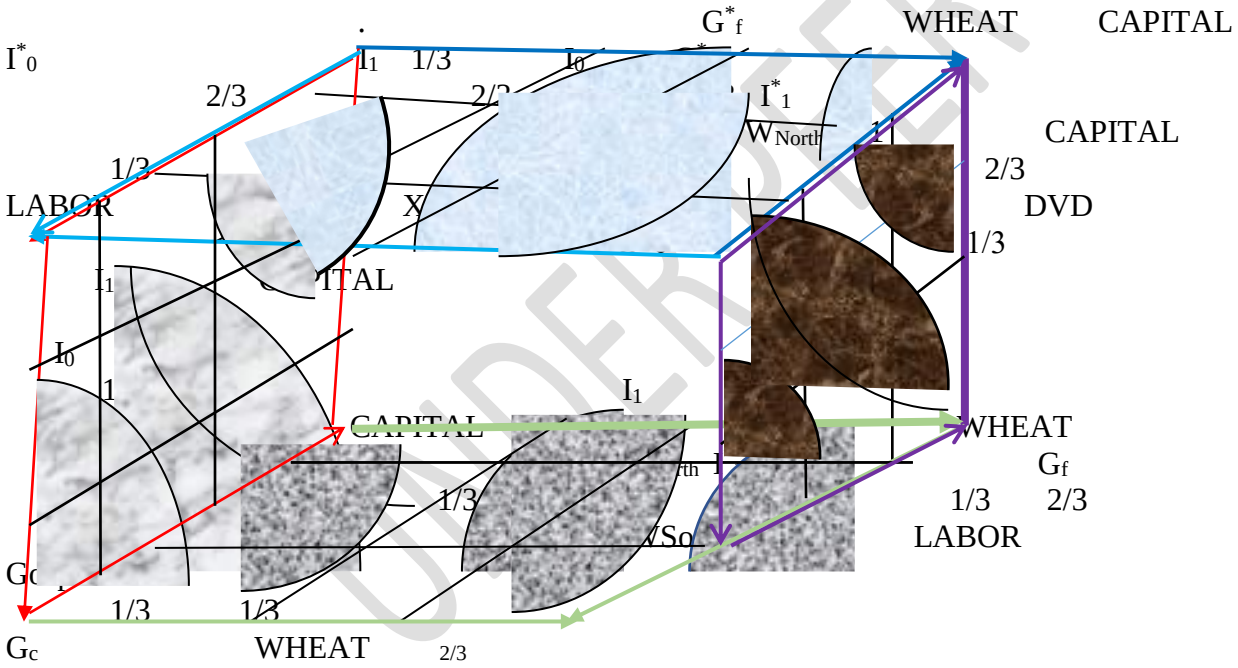
APPENDIX

Fig. 1: Curve of the production possibility frontier in a factor proportions model.



Graph 1: 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.

On the top blue box the same trade happens between G^*_c and G^*_f of North W_{North}(1/3CAPITAL,2/3LABOR) and X_{North}(2/3CAPITAL,1/3LABOR) are respectively G*c initial and final endowment and symmetric values for G^*_f, W_{North} (2/3 CAPITAL,1/3LABOR) and X_{North}(1/3CAPITAL,2/3LABOR).

The red box describes final goods' trade and equilibrium between G_c and G^*_c and purple box describes final goods' trade and equilibrium between G_f and G^*_f.

The multidimensional equilibrium presented in figure 1 can now be parameterized.
In the Walrasian equilibrium we have:

$$\begin{cases} P_d(2/3\text{Wheat} - 1/3\text{Wheat}) + P_g(1/3\text{DVD} - 2/3\text{DVD}) = 0 \text{ Excess demand for North } (G^*_c) \quad (1) \\ P_d(1/3\text{Wheat} - 2/3\text{Wheat}) + P_g(2/3\text{DVD} - 1/3\text{DVD}) = 0 \text{ Excess demand for South } (G_c) \end{cases}$$

$$\begin{cases} P_d(1/3\text{Wheat}) + P_g(-1/3\text{DVD}) = 0 \text{Excess demand for North } (G^*_c) \ (1) \quad P_d(-1/3\text{Wheat}) + P_g(1/3\text{DVD}) = 0 \text{ Excess demand for South } (G_c) \end{cases}$$

$$0 + 0 = 0 \text{ (International equilibrium)}$$

$$\begin{cases} P_d(1/3\text{Wheat} - 2/3\text{Wheat}) + P_g(2/3\text{DVD} - 1/3\text{DVD}) = 0 \text{ Excess demand for North } (G^*_f) \ (2) \quad P_d(2/3\text{Wheat} - 1/3\text{Wheat}) + P_g(1/3\text{DVD} - 2/3\text{DVD}) = 0 \text{ Excess demand for South } (G_f) \end{cases}$$

$$\begin{cases} P_d(-1/3\text{Wheat}) + P_g(1/3\text{DVD}) = 0 \\ (2) \quad P_d(1/3\text{Wheat}) + P_g(-1/3\text{DVD}) = 0 \text{ Excess demand for South } (G_f) \end{cases}$$

$$0 + 0 = 0 \text{ (International equilibrium)}$$

$$\begin{cases} r(1/3\text{LABOR} - 2/3\text{LABOR}) + w(2/3\text{CAPITAL} - 1/3\text{CAPITAL}) = 0 \text{ Excess demand for South } (G_c) \ (3) \\ r(2/3\text{LABOR} - 1/3\text{LABOR}) + w(1/3\text{CAPITAL} - 2/3\text{CAPITAL}) = 0 \text{ Excess demand for South } (G_f) \end{cases}$$

$$\begin{cases} r(-1/3\text{LABOR}) + w(1/3\text{CAPITAL}) = 0 \text{ Excess demand for South } (G_c) \quad (3) \\ r(1/3\text{LABOR}) + w(-1/3\text{CAPITAL}) = 0 \text{ Excess demand for South } (G_f) \end{cases}$$

0 + 0 = 0 (intergenerational equilibrium in South)

$r(1/3\text{LABOR} - 2/3\text{LABOR}) + w(2/3\text{CAPITAL} - 1/3\text{CAPITAL}) = 0$ Excess demand for North ($G^{*}c$) *(4)*

$r(2/3\text{LABOR} - 1/3\text{LABOR}) + w(1/3\text{CAPITAL} - 2/3\text{CAPITAL}) = 0$ Excess demand for North (G^{*}_{f})

$r(-1/3\text{LABOR}) + w(1/3\text{CAPITAL}) = 0$ Excess demand for North ($G^{*}c$) (4)

$r(1/3\text{LABOR}) + w(-1/3\text{CAPITAL}) = 0$ Excess demand for North (G^{*}_{f})

0 + ***0*** = ***0***

Table 1a. Relationship between the mean growth and the volatility with Levin-Renelt control variables

Table 2a.The sample of 108 countries

Variable	**Definition**	**Coefficient**	**T-Stats**	**Std. Dev.**	**[95%Conf.Interval] min**	**[95%Conf.Interval] max**
Vol	Std Dev. Of growth(volatility)	0.6189	-76 ?89	0.0080	-0.6347	-0.6032
Gdppccp	Initial log GDP per capita	-0.003847	-9 .69	0.00039	-0.0046	-0.003068
Inv	Average investment fraction of GDP	0.0012	32.09	0.00038	0.001151	0.0013012
aapgr	Average growth of the population	-0.002511	-9.3	0.00027	0.00304	-0.001982
hc_residu	initial human capita	0.003233	1.85	0.00017	-0.00019	0.00666
Intercept	Intercept	0.0342	15.78	0.0021	0.029	0.03846
Log likelihood=4624,73						
Prob>chi2(5)= 0,000						
Prob>chi2(5)= 0,000						

Table 1b. The sample of 25 countries

Variable	Definition	Coefficient	T-Stats	Std. Dev.	[95%Conf.Interval] min	[95%Conf.Interval] max
Vol	Std Dev. Of growth(volatility)	-0.2956	-23.97	0.01233	-0.3197	-0.2714
Gdppccp	Initial log GDP per capita	-0.03305	-4.77	0.006932	-0.04664	-0.01946
Inv	Average investment fraction of GDP	0.00027	0.64	0.00042	0.0005637	0.0011147
aapgr	Average growth of the population	-0.03507	-18.05	0.00194	0.03887	-0.031264
hc_residu	initial human capita	0.04960	11.20	0.004429	-0.04092	0.05828
Intercept	Intercept	0.1069	3.47	0.03077	0.04658	0.167234
Log likelihood=677,85						
Prob>chi2(5)= 0,000						
Prob>chi2(5)= 0,000						

Growth and growth volatility with a sample of 108 countries and its generations (multidimensional trade)

Table 2a. Test of Mean growth and growth volatility with a sample of 8 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]max
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 2b. Test of Mean growth and growth volatility with a sample of 108 countries and its generations (multidimensional trade)

Variable 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	0.012909	-0.012	0.0378
Intercept					0.0048	0.02706
F(1. 127)=0.01	Intercept	0.0159509	2.81	0.0056704		
R-squared :0. 0001						
Adj R-squared= -0.0078						

Table 2c. Test of Mean growth and growth volatility with a sample of 8 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]max
Vol	Std Dev. Of growth(volatility)	-0.3836	-186.22	0.00206	-0.3876	-0.379
Gdppccp		-0.0027			-0.0033	-0.0021
Inv	Initial log GDP per capita		-8.84	0.00003	0.00084	0.00097
hc	Average investment	0.0009		0.00003		
aapgr	fraction of GDP	-0.002121	27.06		-0.00238	-0.0018
	initial human	-0.0015	-15.92	0.00013	-0.00199	-0.0010
Intercept	capita					
Log likelihood=543,46	Average growth of the population	0.03519	-6.45	0.00023	0.0311	0.0392
			17.02			
	Intercept			0.0020		