ECONOMIC GROWTH AND CYCLES: CROSS-COUNTRY MODELS OF EDUCATION, INDUSTRY AND FERTILITY AND INTERNATIONAL COMPARISONS

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Abstract

We analyse, from a worldwide view, the evolution of real Gross Domestic Product, Population and Gdp per inhabitant and the main differences in the levels of development are explained having into account the results of several cross-country models. The main conclusions highlight the necessity of new international policies for improving the educative level of population in less developed countries.

1.Introduction

The aim of this article is to highlight the importance of education on sustained development, as well the main causes of disequilibria that affect the evolution of supply and demand and that provoque many of the most remarkable declines in the rates of growth of real Gross Domestic Product (Gdp) in less developed countries.

We include some international econometric models that on one hand confirm the great importance education has on development, already commented upon in previous studies by several authors, and that also, offer new perspectives on the main interrelationships that explain the impacts of education on the growth of real Gdp per inhabitant (Gdph or Ph).

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We think that the results of these studies can be of great use in the formulation of well founded economic policy objectives and instruments, addressing the great challenges of diminishing international poverty and improving economic development and social welfare in all the areas of the world, in a more realistic way.

To be efficient in the fight against poverty new international policies require a change of perspective which gives greater emphasis to education and industry, as the main factors of development, rather than to the most common international policies that usually put emphasis on more secondary issues such as inflation or public debt.

Some recommendations for development policies will be made in the conclusions and throughout this article, addressing methods for avoiding recession and stagnation in many areas, like Latin America, Africa and others which, in recent decades, have experienced rates of growth of Gdph less than those expected and desired by their citizens.

In section 2 we present a summary of the evolution of production and population growth in Africa, Asia-Pacific, America, and Europe, based on international statistics and our own estimations for 210 countries. We analyse growth and cycles, having into account that both are clearly related with industrial development and external trade.

In section 3 we present an international cross-country model of inter-sector relations which explains the differences in services development in different countries related with industry and external trade, and which shows that industrial development is generally of primary influence both in economic growth and cycles.

In section 4 we present a cross-country model which shows the positive effect education has on industrial development, and therefore the great importance education has as a main factor of economic growth of real Gross Domestic Product.

In section 5 we analyse the evolution of population, education and fertility, and we present an international cross-country model that shows the great influence that the educative level of population has on the reduction of fertility rate averages, contributing in a powerful way to the improvement of Gdp per inhabitant.

In the same section we also make reference to some of the most interesting studies on the relationship between education, fertility and development, and we emphasise the priority of these issues for improving international policies of cooperation in education and development.

The role of education on development is outstanding not only because education has such an important influence in reducing excessively high fertility rates but also because human capital has shown itself to be very important in improving the development of industry and services, as pointed out in section 4.

Finally in section 6 we make a summary of the main conclusions and recommendations for improving economic policies of international cooperation for world development.

2.- Economic growth and fluctuation in large world areas in the 20th century

Tables 1 and 2 present exponential rates of growth and multiplication factors of real Gdp, Population, and Gdp per inhabitant in the periods 1980-90 and 1990-99, by continent and World, including separate figures, with some distinctions among areas or groups of areas with special features.

Table 1.Rates of   growth of Gdp (Q), Population (Pop) and Production per head (Ph) (exponential rates, per cent yearly growth)

Area	Q80-90	Q90-99	Pop80-90	Pop90-99	Ph80-90	Ph90-99
Africa N + S	3.01	2.52	2.83	1.82	0.18	0.70
Africa W+ E+ C	1.88	1.25	3.09	2.60	-1.21	-1.35
Asia W	1.71	3.79	3.17	2.43	-2.08	1.36
Asia N	6.08	5.69	1.35	1.01	4.73	4.34
Asia S	4.65	5.48	2.09	1.72	2.56	3.76
USA+Canada	2.98	2.66	0.95	1.02	2.03	1.64
Latin America	1.63	3.16	1.91	1.70	-0.28	1.46
Europe W.	2.53	1.68	0.28	0.31	2.25	1.37
Europe C. + East Med.	2.57	2.03	1.18	0.20	1.39	1.83
Russia and ex-Ussr	1.52	-6.28	0.65	0.29	0.87	-6.57
AFRICA	**2.59**	**2.08**	**3.00**	**2.35**	**-0.41**	**-0.27**
ASIA-PACIFIC	4.65	5.44	1.85	1.49	2.80	3.95
AMERICA	2.60	2.80	1.53	1.44	1.07	1.36
EUROPE	2.27	0.23	0.61	0.28	1.66	-0.05
WORLD	3.03	2.82	1.72	1.40	1.31	1.42

Notes: 1.- N=North, S=South, E=East, W=West, C=Central, E. Med= East Mediterranean.   2.-The exponential rate of growth of Ph is the difference between the rates of Q and Pop. 3.- Source: Guisan and Exposito(2001) for Africa and Asia, and Guisan and Aguayo(2001) for America and Europe.

Table 2. Factors of increase of Production (Q), Population (Pop) and
Production per head (Ph) in the periods 1980-90 and 1990-99

Area	Q80-90	Q90-99	Pop80-90	Pop90-99	Ph80-90	Ph90-99
Africa N + S	1.35	1.25	1.33	1.18	1.02	1.06
Africa W+ E+C	1.20	1.12	1.36	1.26	0.88	0.89
Asia W	1.19	1.41	1.37	1.24	0.86	1.13
Asia N	1.84	1.67	1.14	1.10	1.60	1.52
Asia S	1.59	1.64	1.23	1.17	1.29	1.40
USA+Canada	1.35	1.27	1.10	1.10	1.22	1.16
Latin America	1.18	1.33	1.21	1.17	0.97	1.14
Europe W	1.29	1.16	1.03	1.03	1.25	1.13
Europe +E.Med	1.29	1.20	1.13	1.02	1.15	1.18
Russia+ex-Ussr	1.16	0.57	1.07	1.03	1.09	0.55
AFRICA	**1.30**	**1.21**	**1.35**	**1.24**	**0.96**	**0.98**
ASIA-PACIFIC	**1.59**	**1.63**	**1.20**	**1.14**	**1.32**	**1.43**
AMERICA	**1.30**	**1.29**	**1.16**	**1.14**	**1.11**	**1.13**
EUROPE	**1.26**	**1.02**	**1.06**	**1.03**	**1.18**	**1.00**
WORLD	**1.35**	**1.29**	**1.19**	**1.13**	**1.14**	**1.14**

Note: the factor of increase of Ph is the quotient between the factors of Q and Pop.
Source: Guisan and Exposito(2001) for Africa and Asia, and Guisan and
Aguayo(2001) for America and Europe

In the case of Africa, Northern and Southern areas have
performed generally much better than Western, Central and Eastern
Areas, both due to higher rates of growth in real Gdp and to lower
rates of increase in Population. The rate of growth of real Gdp per
inhabitant was very high in Northern and Southern areas of Africa in
the period 1980-90, with an average yearly rate of 3.51%, the second
highest in table 2, but there has been an important drop in this rate in
the period 1990-99 with a low value of only 0.70%.

In Asia, Northern Asia and Southern Asia have performed generally better than Next and Middle East areas, also due to greater increases in real Gdp and to more moderate Population growth. Northern Asia has shown the highest values of rates of growth of real Gdp per inhabitant, both in the period 1980-90 with an average yearly rate of 4.73% and in the period 1990-99 with an average rate of 4.34%.

In America the increases in real Gdp per inhabitant have been higher in the USA and Canada than in the other areas mainly due to more moderate population growth, in spite of lower rates of growth of real Gdp in this area in the period 1990-99 in comparison with the rest of the areas in America and the World. Latin American countries, as a whole, have experienced a lost decade for development in the period 1980-90, with a negative average yearly rate of –0.28% and have performed much better in the period 1990-99 with a positive rate of yearly growth of 1.46% in real Gdp per inhabitant. This positive change was due both to an increase in the rate of growth of real Gdp and to an small reduction in the rate of growth of Population.

In the case of Europe and Central Asia, Western Europe has performed better than other areas while Russia, East Europe and Central Asia have generally experienced important difficulties both at the end of their communist stage and during the period of transition to free market institutions after 1990, although the drop could be quite small in further revisions of statistical figures as mentioned in the Annex.

Western Europe has experienced moderate rates of growth of real Gdp and the increases in real Gdp per inhabitant, which are higher than World averages, have been possible due to the very low rates of Population growth. In Central Europe and East Mediterranean real Gdp per inhabitant was of a rate a little lower than World average in the period 1980-90 and a little higher in 1990-99. The increase in this rate has been mainly due to the significant decline in population growth caused by emigration movements towards Western Europe.

In the following tables we see the rates of increase of real Gdp, Population and Gdp per head, Gdph. Rates have been calculated as first differences of natural logarithms of the variables, which means that we use exponential equations and that the rates of growth represent the percentage of increase on actual values of the variables in year t, not on year t-1 as happens with the usual compound rates.

The exponential rates (Exp rate) have the property that the rate of growth of a ratio between two variables is equal to the difference between the rate of growth of the numerator and the rate of growth of the denominator:

Being C= A/B

Exponential rate (C) = Exponential rate(A) – Exponential Rate (B)

Table 3 shows the exponential rates of growth of real Gdp and in tables 4 and 5 we include the rates of growth of population (Pop) and Gdp per inhabitant (Gdph).

Table 3.
Exponential rates of yearly growth, per cent, 1913-1998: Gdp

Area	1913-50	1950-73	1973-98	1950-98	1913-98
Western Europe	1.18	4.70	2.09	3.34	2.40
USA and w.o.s[1]	2.77	3.95	2.94	3.42	3.14
Japan	2.19	8.88	2.93	5.78	4.22
Asia excl. Japan	0.90	5.05	5.32	5.19	3.32
Latin America	3.37	5.19	2.98	4.04	3.75
Europe E.+ exUssr	1.82	4.73	-0.56	1.97	1.91
Africa	2.65	4.35	2.70	3.49	3.12
World	1.83	4.79	2.97	3.84	2.97

Source: Own calculation from Gdp figures by Maddison(2001).[1] w.o.s means other western offshoots, name used by this author to include also Canada, Australia and New Zealand.

Table 4
Exponential rates of yearly growth, per cent, 1913-1998: Population

Area	1913-50	1950-73	1973-98	1950-98	1913-98
Western Europe	0.42	0.70	0.32	0.50	0.47
USA + w.o.s[1]	1.24	1.54	1.01	1.26	1.25
Japan	1.30	1.14	0.61	0.86	1.05
Asia excl. Japan	0.92	2.17	1.84	2.00	1.53
Latin America	1.95	2.69	1.99	2.33	2.16
Eastern Europe + exUssr	0.34	1.30	0.54	0.90	0.66
Africa	1.64	2.30	2.69	2.50	2.12
World	0.93	1.90	1.65	1.77	1.40

Table 5. Exponential rates of yearly growth, per cent, 1913-1998: Gdph

Area	1913-50	1950-73	1973-98	1950-98	1913-98
Western Europe	0.76	4.00	1.77	2.84	1.93
USA + w.o.s	1.53	2.41	1.93	2.16	1.89
Japan	0.89	7.74	2.32	4.92	3.16
Asia excl. Japan	-0.02	2.88	3.48	3.19	1.79
Latin America	1.42	2.50	0.99	1.71	1.59
Eastern Europe + exUssr	1.48	3.43	-1.10	1.07	1.25
Africa	1.01	2.05	0.01	0.99	1.0
World	0.90	2.89	1.32	2.07	1.56

Note: Gdph=Gdp/Pop, and thus Exp.rate of Gdph= Exp.rate of Gdp-Exp.rate of Pop.

The negative consequences of the lack of agreement in oil markets between consumers, producers and multinational firms of this sector, together with high increases in prices followed by reduction or stagnation of consumption and oscillations in prices, have generally provoked a reduction in the rates of growth of real Gdp, both in the cases of oil-consuming and oil-producing countries.

In table 6 we present together the rates of growth of Gdp, Pop and Gdph for the period 1950-98 in order to see the existing relation between these rates, as the exponential rate of Gdph is the

difference between the exponential rate of growth of Gdp and the exponential rate of growth of Pop.

Table 6. Exponential rates of yearly growth, per centa, of real Gdp, Pop, and Gdph in 1950-98

Area	Rate of Gdp	Rate of Pop	Rate of Gdph
Western Europe	3.34	0.50	2.84
USA + w.o.s	3.42	1.26	2.16
Japan	5.78	0.86	4.92
Asia excl. Japan	5.19	2.00	3.19
Latin America	4.04	2.33	1.71
Eastern Europe + exUssr	1.97	0.90	1.07
Africa	3.49	2.50	0.99
World	3.84	1.77	2.07

From tables 1 to 6 we can observe the following features:

1) In the period 1950-98 the highest values of the rate of Gdp correspond to Japan with 5.78%, Asia excluding Japan with a rate of 5.19%, followed by Latin America with 4.04%, are the areas with a rate of growth higher than the world average of 3.84%. Africa with 3.49, USA and w.o.s. with 3.42%, and Western Europe with 3.34 presented rates of growth close to world average although a little lower, while Eastern Europe and ex-Ussr presented the lowest rates with only 1.97%.

2) In the period 1950-73, before the oil crisis, all the areas had a higher growth than in the second half. The world average of annual rate of growth of real GDP dropped from 4.79% in 1950-73 to 2.97% in 1973-98. In this period Japan occupied first place with an average percentage rate of 8.88, and was followed by Latin America with 5.19 and Asia excluding Japan with 5.05.

3) In the period 1973-98 things changed a lot in almost all areas, the only exceptions being Asia excluding Japan, with little increase in the rate of Gdp, from 5.05 to 5.32, and the group of USA and other western offshoots which only had a moderate diminution. The highest average percentage rates of growth in this period correspond to Asia excluding Japan with 5.32, followed by Latin

America with 2.98, the group formed by USA and other western offshoots with 2.94 and Japan with 2.93.

4) The worst evolution of Gdp in the period 1973-98 corresponds to the area formed by East Europe and ex-Ussr with a negative rate of –0.56. This group performed similar to world average during the periods 1913-50 and 1950-73, but as consequence of the bad results of the period 1973-98 its evolution in the whole of the 20th century was the lowest of all areas, with an average rate of only 1.91 during the period 1913-98.

5) It may be surprising for many people to know that real Gdp of Africa has had percentages of increase superior to Western Europe throughout all the periods except 1950-73, where the effects of recovery from the second world war in Western Europe explain a higher rate. Really, the majority of less developed countries and areas have performed rather well in terms of rates of growth of real Gdp during the 20th century, and they could have had greater rates of Gdph if their rates of growth of population had been more moderate.

6) The rates of growth of population have been very moderate in Europe, with an average yearly value during 1913-98 of only 0.47% in Western Europe and of 0.66% in Eastern Europe and Ex-Ussr. The following had more moderate rates, below the world average of 1.40%: Japan with 1.05%, and USA and western offshoots with 1.25%. The highest rates correspond to Latin America, with 2.16%, Africa with 2.12% and Asia excluding Japan with 1.53%.

7) The highest values of rate of growth of real Gdph corresponds to the period 1950-73 in all areas, except in Asia without Japan, with an average world rate of 2.89%. The highest value corresponds to Japan with 7.74% for this period, followed by Western Europe with 4.0%. In both cases the recovery from the struggles of second world war was important in explaining the difference with respect to the USA. The great boost that China has given its economic growth in the last quarter of the 20th century

explains why Asia, excluding Japan, has had a rate of growth of Gdph in the period 1973-98 which is higher than in the period 1950-73.

8) Latin American countries experienced a rate of growth of Gdph of 1.42% in the first half of the century, higher than world average of 0.90%, but performed worse than world average during the second half, with a rate of 1.71% in the period 1950-98 while world average increased to 2.07%. The impact of the oil crisis and other circumstances lead to an important diminution in the rate, from 1950-73 with a rate of 2.50%, to 1973-98 with only 0.99%.

9) During the second half of the 20th century, with a world average yearly growth rate of nearly 4% (3.84), the rate of growth of Gdph could be nearly 3% if the rate of growth of population was less than 1% instead of 1.77%. With an average rate of 3% world Gdph could have been multiplied by 4.2 in 1950-98 instead of only 2.7 which is the factor corresponding to the period 1950-98. Moderation of excessive rates of growth of population should be an important issue for international policies to fight against poverty and the best way of achieving this goal is to improve education.

10) We can observe that world rate of growth of population reached its highest value in 1950-73, 1.90%, mainly due to the fact of improvement in health conditions, which allowed for more healthy children and reduced rates of infant mortality, but was not accompanied by a general increase in the educative level of population in many areas. When both health and education are improved, the rate of growth of population does not have such high increases because education acts as a moderator of population growth, by reducing the fertility rates of population.

This problem has been of special importance in Latin American countries, as they could have experienced an average yearly rate of 3.18% in Gdph during the period 1950-98, or even more, if the rate of growth of population had been similar to that of Japan at 0.86%. As a consequence Latin American countries would have multiplied their average Gdph by a factor of 4.6 instead of the actual factor of 2.3. This would imply a double value of real Gdp per

inhabitant at the end of the century, and that would have helped them greatly to overcome many economic difficulties.

We see that there is a trend towards moderation of population growth but not at high speed. It would be very advantageous if areas with the highest rates of growth of population, such as Africa and Latin America, lowered their fertility rates. To achieve this end, international cooperation in increasing the educative level of the population is essential. We analyse this important issue in the next section.

The comparison of rates of growth of real Gdp show that the reduction of economic fluctuations does not mean automatically an improvement of economic growth. Usually advanced economies have a trend to be more stable than less developed ones, but the main problem of these last countries is not stability but growth.

After analysing the main features of economic growth and cycles at world level during the 20th century, we present three models which relate education with fertility and industrial development, as well as highlighting the important inter-sector relations existing between industry and services, because the development of these latter relations usually depend on industrial development.

Education is the key variable as it helps less developed countries to be more productive in industry and services, and less reproductive in population growth.

3.- A cross-country model of the relation between Industry and Services

Inter-sector relations, especially between industry and services, are of great importance in explaining both economic growth and cycles, but generally this important aspect of macroeconomics has not received the attention it deserves in the case of less developed countries, LDCs, which have a strong necessity to improve industrial development as we have seen in section 1.

Some important aspects of inter-industry relations were introduced by the research team of Klein many years ago for the case of the USA, based on Input-Output tables, but unfortunately this type of analysis is not very frequent in less developed countries, LDCs.

Graph 1. Inter-sector relation at World level in 1999

PH99SPP vs. PH99AIPP
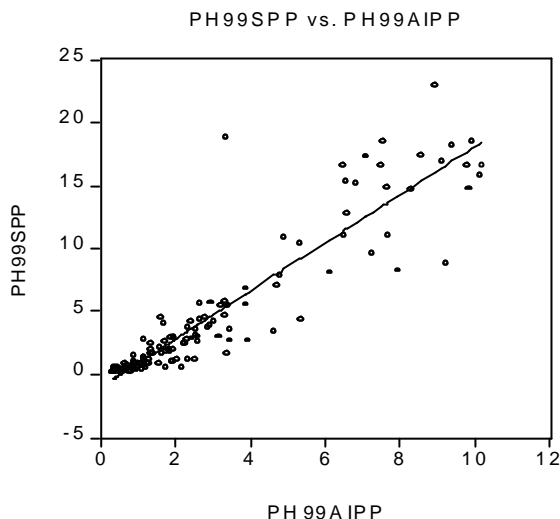
Graph 1 shows the relation in 1999 between real production per inhabitant in agriculture plus industry (phai) and the production per inhabitant in services (phs). Both variables are measured in purchasing power parities in 132 countries with more than one million people, according to data that we have elaborated from World Bank figures and some complementary sources of data.

The only important discrepancy, among 132 countries represented in the graph, with the general regression line, is the case of Hong-Kong where the value of production per head in Services, Phs99, was nearly 20 and very high in relation with the sum of production per head in Agriculture and Industry which was nearly 4.

This discrepancy is due to the significant level of external trade that has allowed a territory like Hong-Kong to develop Services without a great internal development of Industry, buying and selling goods in an international context. These circumstances are rather exceptional and generally speaking we can say that a significant development of Services usually need high levels of industrial development.

The following model shows the importance that the explanatory variables have in the increase of Production in the Services sector. Only countries with high levels of industry and/or external trade of goods or services, usually have high levels of services. Also, agriculture is important but we can see that not one country in the world has a level of production per inhabitant in this sector high enough to guarantee an important development of services.

The explanatory variables included in the cross-country model of Production per head in Services in 1999 (Ph99spp), expressed in PPPs, are: the lagged value of the variable in the year 1990, the increase in the sum of Production per head in Agriculture and Industry during the period 1990-99 (Dphai), and the increase in Exports of Services per head (Dexpsh).

Model 1. Production in Services and inter-sector relations

| Dependent Variable: PH99SPP				
Method: Least Squares				
Sample: 1 132				
Included observations: 132				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
PH90SPP	1.038951	0.018544	56.02532	0.0000
DPHAI	0.818439	0.075997	10.76931	0.0000
DEXPSH	1.739862	0.379749	4.581616	0.0000
R-squared	0.976162	Mean dependent var		4.745967
Adjusted R-squared	0.975793	S.D. dependent var		5.736249
S.E. of regression	0.892488	Akaike info criterion		2.632858
Sum squared resid	102.7530	Schwarz criterion		2.698376
Log likelihood	-170.7686	Durbin-Watson stat		1.770278

The increase of industry seems very easy in countries that have entered the positive circle of sustained growth, and seems almost impossible in countries that have entered the circle of stagnation. Despite these appearances, the change from a circle of stagnation to a positive one is not as difficult as it appears at first sight.

The change is possible if economic policies are addressed correctly to the main factors of production: education and institutions that favour free markets, peace, and industrial development. These measures also positively   influence the self-development of education and institutions, reinforcing the dynamic process of sustained development.

The values of Imports and Exports of goods are generally positively related with Services but these variables are very much related with Industry and their coefficients are not significant in the model because of the complementary relations that they have with industrial production. The goodness of fit is very high and the usual tests of residuals show a good behaviour of the model.

Graph 2 show that generally there is a strong coincidence between the actual observations of Phs99pp and the values of this variable fitted by the model. The order of countries is the alphabetical order of World Bank tables.

Graph 2. Actual and fitted observations of Ph99spp
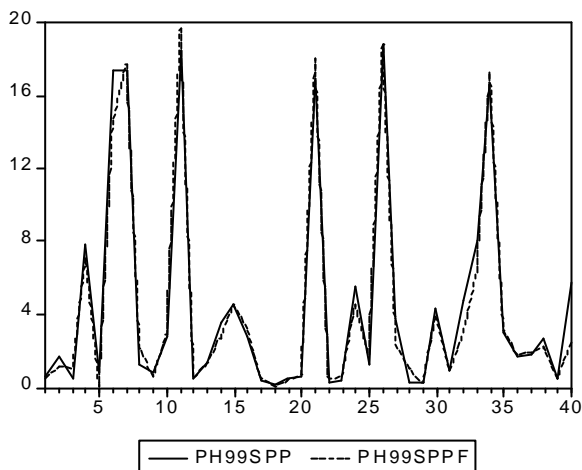
We must insist upon the importance of industrial development in guaranteeing sustained growth in the majority of countries, and the urgency of improving international cooperation to make industrial development in LDCs possible, and at the same time we must insist upon improvement in international cooperation in avoiding great damages to the environment, because it is frequently the case that poorer countries cannot afford the cost of environmental protection to a beneficial degree.

In the following section we present a cross-country model which shows the positive relation which exists between Education and Industry growth.

4.-Cross-country models of education and industrial development

Here we include two versions of the model:

1) Model 2 includes only 88 observations because of unavailable data for all countries. In this model Ph99ipp, the value of real industrial production per inhabitant, in PPPs, is related to two variables of educative level: Expenditure on Public Education per

inhabitant and year (Eduh) and Increase in Total Years of Schooling of adult population in the 9-year period, 1990-99 (Dtyr9). Besides this, the model includes the lagged value of the endogenous variable in 1990, and the increase in Exports of Goods in the period 1990-98.

Model 2. Industrial Production and Education in 88 countries

Dependent Variable: PH99IPP				
Method: Least Squares				
Sample(adjusted): 2 132				
Included observations: 88				
Excluded observations: 43 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DTYR9	0.198247	0.099494	1.992554	0.0496
EDUH	1.461668	0.373564	3.912764	0.0002
PH90IPP	0.788769	0.067147	11.74697	0.0000
DEXPGH	0.152307	0.034122	4.463646	0.0000
R-squared	0.949910	Mean dependent var		2.965379
Adjusted R-squared	0.948122	S.D. dependent var		3.030887
S.E. of regression	0.690340	Akaike info criterion		2.141124
Sum squared resid	40.03183	Schwarz criterion		2.253731
Log likelihood	-90.20947	Durbin-Watson stat		2.638452

2) Model 3 includes the explanatory variable Tyr99f, that is the fitted value of our estimation, for countries without previous data, and the value of the tables of Barro and Lee(1997) in the cases with available data. The model includes the same variables as Model 2, and also an intercept and a dummy variable for lower intercept in countries belonging to Russian Area (DRU)

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Model 3. Industrial production and Education in 132 countries

Dependent Variable: PH99IPP				
Method: Least Squares				
Sample: 1 132				
Included observations: 132				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
TYR99F	0.143899	0.036211	3.973935	0.0001
EDUH	1.314804	0.301780	4.356834	0.0000
PH90IPP	0.648536	0.049526	13.09493	0.0000
EXPG98H	0.067556	0.015283	4.420204	0.0000
C	-0.328836	0.157883	-2.082783	0.0393
DRU	-1.412064	0.199698	-7.070987	0.0000
R-squared	0.944226	Mean dependent var		2.442570
Adjusted R-squared	0.942013	S.D. dependent var		2.711456
S.E. of regression	0.652935	Akaike info criterion		2.029710
Sum squared resid	53.71680	Schwarz criterion		2.160746
Log likelihood	-127.9609	F-statistic		426.6216
Durbin-Watson stat	2.288964	Prob(F-statistic)		0.000000

The special case of countries of Russian Area, including also ex-Ussr countries, may be due to the special circumstances of transition from communism to market rules, but also it may be due to an overestimation of Tyr99f, as data of this variable in these countries are only provisional estimations that we have elaborated because unavailability from international sources.

We see that in both models all the variables have highly significant coefficients and that results confirm, together with other models as those cited in Neira and Guisan(1999) and (2002), the importance of education for industrial development.

This influence is greater than usually thought, and it is very important to insist upon this because the influence of education on industry and development acts in many ways, generally improving freedom, peace, cooperation, trust, and all the institutional goodness that favours socio-economic development.

5.- A cross-country model of education and fertility reduction.

The fight against poverty demands improvement of international cooperation to help poorer countries to become richer and better organised, with better opportunities for people. They need help to be more productive in industry and services, and also to be less reproductive in population growth. Education helps in both ways.

Here we present some cross-country models that highlight the great importance of Education in reducing highly excessive fertility rates until they stabilise at moderate levels.

In several studies, both at macro and micro level, an negative relationship has been found between education and fertility, so, families with higher levels of education usually have, on average, lower fertility rates. On a dynamic perspective lower fertility contributes to more income per capita and that usually increases the level of education and then contributes to low fertility rates in future periods.

In the case of countries, the rate of growth of population depends not only on fertility rates but also on the age distribution of the population, so countries with a great share of young adults in total population will have higher rates of growth than others with the same fertility rates per woman but with a less youthful adult population.

Graph 3 shows the negative relationship between education, measured in this case in total average years of education of adult population in 1999 (Tyr99), and fertility or expected number of children per woman in 2000 (Fer00), taking into account data from Barro and Lee(1997) for education and Akal(2001) for fertility, in countries all over the World.

Although there are several factors which explain the deviations of each country from the regression line, the relation between education and fertility, on average, is clearly negative.

## Graph 3. Fertility and Total Years of Schooling

FER00 vs.TYR99

TYR99
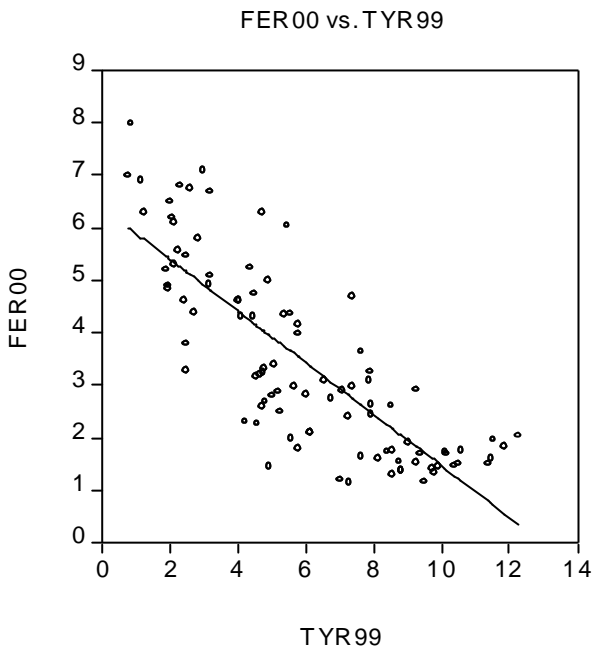
There are some countries that have special demographic policies to maintain fertility rates below the natural trends of population but in general the number of children per woman depends heavily on the educative level of population, so the higher the educative level of a country the lower the average fertility rate.

Of course there are some individual differences among families which depend upon religion, culture, and other criteria but the evidence is that generally the increase in the educative level of population reduces the average fertility rate.

On the other hand Graph 4 shows the positive relation between the Educative level of Population and the Expenditure on Education per inhabitant (Eduh). The relationship does not include private expenditure, which would make it complete, as the available

data only includes public expenditure information for the majority of countries. Nevertheless, the data are sufficient for showing the important positive impact of education expenditure.

Graph 4. Total Years of Schooling and Education Expenditure

TYR99 vs. EDUH
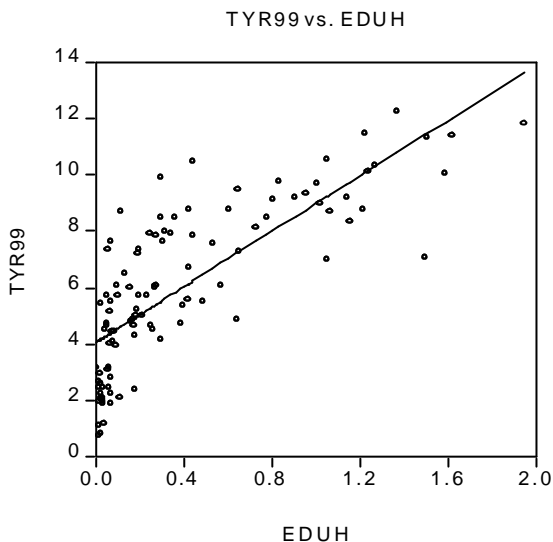
Tables 7 to 10 present the main data on population, education and fertility in some world areas that we have considered to make a geographic synthesis of this data. We have chosen examples of high, medium and low levels of fertility and the most populated areas.

Table 7. Education and Fertility in Africa

Area	Tyr99	Eduh	Fer00
North Africa	4.8	237	3.3
Sahel and Central Africa	2.5	21	6.6
South Africa	4.9	152	5.0
Total Africa	3.4	87	5.4
World	5.8	258	2.8

Note: Tyr is average total years of schooling in 1995, Eduh is Expenditure on education per inhabitant in 1995, Fer is fertility rate or average expected number of children per woman in 2000.

Table 8. Education and Fertility in Asia-Pacific

Area	Tyr99	Eduh	Fer00
Next East Asia	4.6	244	5.3
India and South Asia	4.5	46	3.4
China and NE Asia	6.2	149	1.8
Total Asia and South Pacific	5.3	113	2.7
World	5.8	258	2.8

Note: For definitions, see table 13

Table 9. Education and Fertility in America

Area	Tyr99	Eduh	Fer00
USA and Canada	12.1	1396	2.0
Latin America	5.7	260	2.8
Total America	8.1	704	2.5
World	5.8	258	2.8

Note: For definitions, see table 13

Table 10. Education and Fertility in Europe

Area	Tr99	Eduh	Fer00
Western Europe	8.6	995	1.5
Central Europe and East Med.	7.0	235	1.9
Russia and ex-Ussr	6.9	212	1.0
Total Europe and Central Asia	7.7	562	1.4
World	5.8	258	2.8

Note: For definitions, see table 13

The following models show the strong impact that education has in the reduction of fertility rates, although there are of course special policies of family planning and/or education that explain why some countries have fertility rates lower than those expected by the model, which seems to be the case for China, Brazil and Tunisia.

In some African countries, and to a lesser extent in other areas, fertility rates are a little higher than expected according to the educative level of their population. When this happens it is usually due to immigration from neighbouring countries, especially in areas of conflict, with a great number of adult women with high fertility rates.

The models fit very well, with high goodness of fit, and stability among countries. We do not find signification effects of other variables like religion, geography or other, when we include education.

This finding confirms the theories that relate religion to development through the educative level of population. In the past, many religions did not favour the spread of education among population in the same way Protestantism did. This explains the leadership of USA in world development as Goldin and Katz(2001) has pointed out, and the same has happened in many Western European countries.

Models 4, 5 and 6 were estimated with a sample of 96 countries worldwide.

Model 4 expresses the relation, in levels, between Fertility Rate in the year 2000, FER00, and the total average years of schooling of adult population, TYR99. We see that on average an increase of the explanatory variable per one unit implies a decrease in the explained variable of 0.49. This implies a reduction of approximately one child in the average fertility rate per woman for an increase of two years in average schooling of adult population.

Model 4. Fertility and Total Years of Schooling. Model in Levels

Dependent Variable: FER00				
Method: Least Squares				
Included observations: 96				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.364210	0.241919	26.30715	0.0000
TYR99	-0.491091	0.036485	-13.46021	0.0000
R-squared	0.658402	Mean dependent var		3.448333
Adjusted R-squared	0.654768	S.D. dependent var		1.795759
S.E. of regression	1.055124	Akaike info criterion		2.965807
Sum squared resid	104.6489	Schwarz criterion		3.019230
Log likelihood	-140.3587	F-statistic		181.1773
Durbin-Watson stat	1.667611	Prob(F-statistic)		0.000000

Model 5 is expressed in the form of a mixed dynamic model, with levels, in the explained variable and their lag, and in increases of the exogenous variable. DTYR4 expresses the increase of total average years of schooling of each country during the 4-year period 1995-99.

Model 5. Fertility and Total Years of Schooling. Mixed Dynamic Model

Dependent Variable: FER00				
Method: Least Squares				
Included observations: 94				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
FER95	0.939152	0.012916	72.71504	0.0000
DTYR4	-0.474521	0.153352	-3.094325	0.0026
R-squared	0.958057	Mean dependent var		3.447660
Adjusted R-squared	0.957601	S.D. dependent var		1.797347
S.E. of regression	0.370092	Akaike info criterion		0.870919
Sum squared resid	12.60109	Schwarz criterion		0.925031
Log likelihood	-38.93318	Durbin-Watson stat		2.041497

The estimated value of the coefficient of DTYR4 is very similar to the coefficient of TYR99 in Model 4 and, besides that, the model results indicate that the coefficient of FER95 is lower than one, implying that there is also a small trend in reduction of fertility due to other causes besides education, that could have relation with age structure of population and/or cultural changes not exclusively linked to the educative level.

Model 6 was fitted including dummies for explaining differences in intercepts among continents. The results only include the cases where the effect of these variables was significant: DEU is a dummy for European Union countries, which show a rate of fertility a little lower than that expected according to their educative level, and DAF is a dummy for African countries, which show a rate of fertility a little higher than that expected according to their educative level.

Model 6. Fertility and Education. Model in Levels with Dummies.

Dependent Variable: FER00				
Method: Least Squares				
Included observations: 96				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.262049	0.295248	17.82248	0.0000
TYR99	-0.344188	0.042067	-8.181886	0.0000
DEU	-0.632581	0.272452	-2.321806	0.0225
DAF	1.217535	0.251024	4.850266	0.0000
R-squared	0.743228	Mean dependent var		3.448333
Adjusted R-squared	0.734855	S.D. dependent var		1.795759
S.E. of regression	0.924677	Akaike info criterion		2.722028
Sum squared resid	78.66245	Schwarz criterion		2.828876
Log likelihood	-126.6574	F-statistic		88.76475
Durbin-Watson stat	1.416767	Prob(F-statistic)		0.000000

The goodness of fit was rather high in the three models, specially in the mixed dynamic model, and the negative impact of Education on Fertility is statistically significant in all the cases according to the t de student statistic.

We did not find a significant effect by differentiating between general population schooling and female education. Both seem to be important and the correlation between general and female years of schooling is so high at world level, with a few exceptions, that both variables get a similar result.

The results of the mixed dynamic model, that is the best of the three, indicate that an increase of one year in total average years of schooling of adult population implies almost an decrease of 0.5 in fertility rate, what means that two years of increase reduces the average fertility in one child.

It is very important, for an effective reduction of poverty and economic stagnation, to improve education in countries with excessive fertility rates as that policy would have a very important impact in fertility reduction and in increase in real income per inhabitant.

6.- Conclusions and suggestions for development policies

It is useful to take into account demand and supply sides of real GDP growth, as well as the structure of production and the relationships between production and external trade, as these variables are very important in explaining differences of growth between countries.

Both sides are very important, as Klein(1983) and (1997) has pointed out, especially in less developed countries where difficulties from the supply side are usually great. In this sense we will highlight the great importance that external trade generally has both from the demand side, as is usually thought, and from the supply side which usually receives less attention in applied econometric studies but which is very important in less industrialized countries.

Very often, especially in countries with moderate levels of industrialization, the causes of the most important cyclical changes are due to restrictions to industrial development related with external trade and/or investment. In particular the oil crisis from 1973 was a shock for all the areas and provoked many problems in Latin America and other areas which had experienced important progress in the period 1950-73.

Besides the 10 conclusions already presented in section 2, about economic evolution of great areas of the World during the 20th century, the analysis of data and models here presented let us stand out the following conclusions:

1) The main obstacle for reducing poverty and migration all over the world is the uneven evolution of production and population. Less Developed Countries usually have a need both of improving production rates of growth and of lowering demographic increase. If they do not lower the excessive fertility rates they will increase emigration to other areas with less economic problems.

2) Industrialized countries have reached their position mainly due to the improvement of education which have contributed to

increase production per inhabitant through two ways: improving real production growth and lowering population rates of growth.

3) Education is the main factor of development and international cooperation should be fostered to contribute to improve education in many areas of the world, as that is very important for improving real production per inhabitant and for getting real solutions to poverty and stagnation.

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