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Is Education the Cause for Iberian Economic Growth? A Study in Econometric History

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Abstract: Recent models of growth, such as Romer (1986, 1990) and Lucas (1988), following Arrow (1962) and Uzawa (1965), emphasise human capital investment as an important factor contributing to long-run growth. In the literature, human capital investment takes several forms (educational attainment, learning by doing, etc.). Our focus in this paper is on human capital accumulation through the formal schooling. It is our thesis that education is more an accompanying investment than a "driving force" behind growth. We test this argument with the concept of the causal relationship formulated by Granger. All the tests are performed on the basis of the aggregate series of public expenditures on education (EXPEDU), total public expenditures (EXPTOT), population (Population) and Gross domestic product (GDP) in Portugal and Spain before World War II.

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Introduction

In the last decades, a great deal of intensive research work has been done by economists and a number of historians seeking to explain the long-run development of public educational systems in relation to economic growth, to predict future trends, and to give advice to political decision makers. The search for the causes and mechanisms at work in the public sector (naturally placed in the context of the overall political-economic process) is still as fascinating as the endeavours of normative economics to establish criteria that allow to draw a clear dividing line between the private and the public sectors, to determine, first, the optimum allocation of resources to both and, second, an equilibrium of demand and supply for collective goods. Despite this laudable effort and the achievement of a certain amount of progress, we are still remote from a generally accepted positive and normative theory in this vitally important area of political economy. The flow of factual data and the volume of scholarly publications grow steadily, sometimes out of proportion, and, yet, our insights are still deficient, our body of knowledge very limited. For example, the models commonly used in modern growth theories have failed to recognise, before the endogenous growth revolution, the full importance of public activities. Also, positive and normative theories are kept apart by artificial barriers. In this respect, one question springs to mind immediately: what are the reasons for this slow-paced progress in devising better hypotheses and in finding more substantial evidence in support of secular trends of public activities? Among the most significant factors are: (I) the lack of a theoretical approach reflecting the basic pattern of state activity, expressing fundamental relationships, and describing in a useful way the various dependent and independent variables; (II) a weak or biased GNP concept that is unable to do full justice to the public sector; (III) the statistical material at hand which is often incomplete and therefore unfit to put theoretical analysis on a sound empirical basis; (IV) and methodological inadequacies acting as a bar to a (quantitative and qualitative) determination of causal connections.

Starting a this last point, this article is organised – in extension to our previous research (see Diebolt *et al.*) – into two parts. The first is devoted to the econometric methodology. In the second, causality is tested and possible cointegration relations are sought on the basis of the aggregate series of public expenditures on education (EXPEDU), total public expenditures (EXPTOT), population (Population) and Gross domestic product (GDP) in Portugal and Spain before World War II.

1. Testing Causality

Granger (1969) formulated the concept of the causal relationship in an explicit and statistically testable fashion. Testing for causality between two or more variables implies, first of all, the specification of the dynamic relationship which links them. This analysis advises to use a certain type of modelling: VAR (Vector Auto Regressive) model which permits to envisage all causality relationships between two variables without prejudicing the exogeneity of one of them. This involves certain hypotheses. First of all, it is necessary to work with stationary data.

In this article, we have therefore investigated their time series properties, first if they are stationary in levels or in first differences. Indeed it is dangerous to regress non-stationarity variables one on another, especially for the spurious regression problem (Granger & Newbold 1974).

A time series X_t is defined as weakly stationary or I(0) (i.e. integrated of order 0) if its mean and variance are time-invariant and its autocovariances are only dependent on the time span separating observations. Similarly, a series is defined as being integrated of order d if it is necessary to differentiate it d times in order to get a stationary I(0) series. The two sorts of non-stationary processes are Trend Stationary processes (TS) with deterministic non-stationarity and Difference Stationary processes (DS) with stochastic non-stationarity. Processes are stationarised respectively by a divergence from the trend and with first differences. In this case, series are integrated of order 1[1] and the existence of a cointegration relation is possible.

In order to test for the non-stationarity of a series X_t (i.e. testing for the presence of a unit root) we use the augmented Dickey-Fuller test. This procedure consists of estimating equation (1):

$$(1 - L)\, X_t = a_0 + a_1 T + b_0 X_{t-1} + \sum_{j-1}^{k} b_j\, (1 - L)\, X_{t-j} + u_t \quad (1)$$

where L is a lag operator, T is a trend and u_t is a disturbance term. Practicaly we reject the null hypothesis of non-stationarity (i.e. $b_0 = 0$) if b_0 is sufficiently negative. Critical value are obtained from Dickey and Fuller (1979) and Mac Kinnon (see Engle & Granger 1991).

Afterwards we must test if series are cointegrated or not. To test that two series X_t and Y_t, forming the vector Z_t, are cointegrated, we use the methodology developed by Johansen (1998, 1992, see also Engle & Granger 1991). This method is based upon an error correction representation of a VAR(p) model with a Gaussian error term:

$$\Delta Z_t\, \alpha + \sum_{k=1}^{p-1} \beta_k\, \Delta Z_{t-k} + \delta \Delta Z_{t-p} + \mu_t \quad (2)$$

[1] This means the variable is non-stationary in level but stationary after differentiation.

where Z_t is an m × 1 vector of I(0) variables (in our case, $m = 2$), β_k and δ are m % m matrixes of unknown parameters, and μ_t is a Gaussian error term.

This equation is estimated by a maximum likelihood procedure under the hypothesis of a reduced rank $r < m$ of δ,

$$H(r): \delta = - \Gamma\Omega' \quad (3)$$

where Γ and Ω are $m \times r$ matrixes. Johansen has demonstrated that under certain conditions these reduced rank condition of matrix implies that $\Omega' Z_t$ is stationary.

The problem induced by cointegration is the spurious regression due to the linear combination and so all cointegrated relations must first be eliminated. Moreover, the existence of cointegration between variables implies that the framework within which the causality is examined is modified with a VECM (Vector Error Correcting Model). The Johansen test is generally used to test cointegration. This test excludes altemative hypotheses concerning the number r of cointegration relations. First, one test of Ho: r = 0 against H_1: r >0. If Ho is accepted, the test stops; if not the next stages is H'o r = 1 against r > 1. This process continues along Ho is rejected. If testing Ho: r = k against r >k, and rejecting Ho, this means that the series are not cointegrated.

Finally, to test for causality between time series X_t and Y_t, components of the vector Z_t, we follow the classical procedures of Engle and Granger (1991).

The methodology applied differs whether time series are cointegrated or not. If they are not, we use the standard methodology developed by Granger (1969). This test is based on the estimation of dynamic relationships before first differentiated variables (if their levels are not stationary).

These relationships are:

$$(1 - L)\, X_t = \gamma_0 + \sum_{i=1}^{m} \lambda_i\, (1 - L)\, X_{t-i} \quad (4)$$
$$+ \sum_{k=1}^{p} \sigma_k\, (1 - L)\, Y_{t-k} + \nu_t$$
$$(1 - L)\, Y_t = \eta_0 + \sum_{i=1}^{n} \varphi_i\, (1 - L)\, Y_{t-i} \quad (5)$$
$$+ \sum_{k=1}^{q} \tau_k\, (1 - L)\, X_{t-k} + \mu_t$$

where (ν_t, μ_t) is a random vector with mean 0 and finite covariance matrix.

To ascertain the presence of one (or more) causal relationship(s), we have to test for the joint significance of the causal variables, i.e. lagged Y_t in equation (4) and lagged X_t in equation (5) by means of a classical F test. For instance, if $\sigma_k \neq 0$ and $\tau = 0$, we conclude that Y Granger-causes X. However, if the time series appear to be cointegrated, causality has to be investigated within the framework of an error correction model. The latter links short-run variations of the series to the disequilibrium error (i.e. the gap between actual behaviour and the long-run relationship given by the cointegrating vector).

The error correction model is given by:

$$(1 - L)\, Z_t = \alpha_0 + \sum_{i-1}^{p-1} b_i\, (1 - L)\, Z_{t-i} - \Gamma\Omega'\, Z_{t-p} + \nu_t \quad (6)$$

The existence of one cointegrating relationship between the two variables ensures that there exists at least on causality link between them. Testing for causality is therefore equivalent to testing for joint significance of the parameters on the assumed causal variables.

Consider the VAR model (with two variables):

$$\begin{bmatrix} y_{1,t} \\ y_{2,t} \end{bmatrix} = [Ao] + \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} y_{1,t-2} \\ y_{2,t-2} \end{bmatrix} + \dots + \begin{bmatrix} A_P & B_P \\ C_P & D_P \end{bmatrix} \begin{bmatrix} y_{1,t-P} \\ y_{2,t-P} \end{bmatrix} + [e_{i,t}]$$

The Granger test is divided into two steps:

- Ho: y_{2t} does not cause y_{1t}, that is to say the coefficients of matrix blocks 'B' are zero;
- H'o: y_{1t} does not cause y_{2t}, that is to say coefficients of matrix blocks 'C' are zero.

If H_1 and H'_1 are accepted, there is a feedback effect.

The variable Xt Granger cause Yt if forecasting Yt is improved using information about Xt and its past that is to say if past values of Xt contain information that are not contained in the past of Yt but which significatively improve its forecasting.

A causal relationship is accepted if the calculated statistic (F-statistic) is beyond the tabulated value, that is to say if the value of the first specie risk exceeds the value of the probability for a causal relationship.

2. Empirical Results

Our causality analysis pertains to two developed countries: Spain and Portugal before World War II. These countries have firstly been selected on data availability (see Appendix) and as an extension to our previous work (based especially on France and Germany).

2.1. Stationarity

The results of the augmented Dickey-Fuller (ADF) test for Spain are presented in Table 1.

The results of the ADF test for Portugal are presented in Table 2.

Table 1. Augmented Dickey Fuller Test for SPAIN

	Statistical Values	Critical Value	Decision
EXPEDUC	Tc = -3,99	-3,47	TS
	β -T stat = 4,01	1,96	
EXPTOT	T_6-stat = -1,99	-3,47	
	F6 = 3,33	[6,49 ; 6,73]	
	F5 = 2,99	[4,88 ; 5,13]	
	T_5-stat = 0,328	-2,9	
	F4 = 1,13	[4,71 ; 4,86]	
	M -stat = 191,38	1,96	DS
GDP	T_6-stat = -1,95	-3,47	
	F6 = 2,38	[6,49 ; 6,73]	
	F5 = 2,85	[4,88 ; 5,13]	
	T_5-stat = 0,55	-2,9	
	F4 = 1,8	[4,71 ; 4,86]	
	M -stat = 251,14	1,96	DS
POP	T_3-stat = 2,10	-3,47	
	F3 = 4,91	[6,49 ; 6,73]	
	F2 = 28,53	[4,88 ; 5,13]	
	β -T stat = 9,46	1,96	
	a -T stat = 5,09	1,96	Mixt process

Table 2. Augmented Dickey Fuller Test for PORTUGAL

	Statistical Values	Critical Value	Decision
EXPEDUC	T_6-stat = -1,56	-3,47	
	F6 = 1,87	[6,49 ; 6,73]	
	F5 = 1,94	[4,88 ; 5,13]	
	T_5-stat = -0,008	-2,9	
	F4 = 1,003	[4,71 ; 4,86]	
	M -stat = 5,33	1,96	DS
EXPTOT	T_6-stat = 2,17	-3,47	
	F6 = 2,81	[6,49 ; 6,73]	
	F5 = 2,42	[4,88 ; 5,13]	
	T_4 stat = 1,55	-2,9	
	F4 = 0,99	[4,71 ; 4,86]	
	M -stat = 26,92	1,96	DS
GDP	T_6-stat = -1,69	-3,47	
	F6 = 2,10	[6,49 ; 6,73]	
	F5 = 2,14	[4,88 ; 5,13]	
	T_5-stat = 0,06	-2,9	
	F4 = 1,05	[4,71 ; 4,86]	
	M -stat = 51,18	1,96	DS
POP	T_6-stat = -2,06	-3,47	
	F6 = 2,6	[6,49 ; 6,73]	
	F5 = 6,52	[4,88 ; 5,13]	
	β -T stat = 1,57	1,96	DS

2.2. Cointegration

The results derived from the application of the Johansen methodology are given in Table 3 and 4. The optimal number of lag for the VAR-model is 1 for the two countries.

Table 3. Johansen test for SPAIN

Sample(adjusted): 1864 1935 Series: EXPTOT GDP POP				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0,39	72,38	29,68	35,65
At most 1	0,35	36,37	15,41	20,04
At most 2	0,06	5,13	3,76	6,65

Table 4. Johansen test for PORTUGAL

Sample(adjusted): 1864 1935 Series: EXPEDU EXPTOT GDP POP				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None *	0,35	51,55	47,21	54,46
At most 1	0,14	20,46	29,68	35,65
At most 2	0,07	9,17	15,41	20,04
At most 3 *	0,05	3,98	3,76	6,65

Johansen test indicates the existence of two long-run relationship between variables for Spain (at 1% of critical value), and no long-run relationships for Portugal.

2.3. Causality

The Granger causality tests are given in Table 5 and 6. The results are shown in Figures 1 and 2.

Table 5. Pairwise Granger Causality Tests for SPAIN

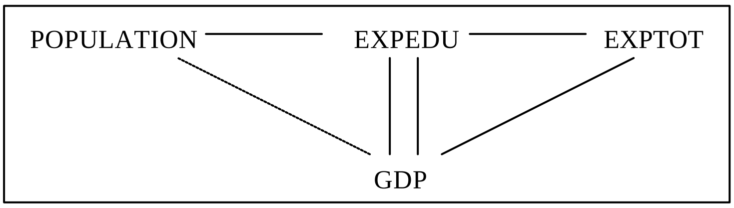
Sample: 1861 1935 Null Hypothesis:	Obs	F-Statistic	Probability
DEXPTOT does not Granger Cause DEDUC DEDUC does not Granger Cause DEXPTOT	72	1,29352 2,31368	0,25934 0,13281
DGDP does not Granger Cause DEDUC DEDUC does not Granger Cause DGDP	72	1,95214 0,00230	0,16683 0,96187
DPOP does not Granger Cause DEDUC DEDUC does not Granger Cause DPOP	72	0,09344 0,39493	0,76076 0,53179
DGDP does not Granger Cause DEXPTOT DEXPTOT does not Granger Cause DGDP	72	0,21334 0,02111	0,64561 0,88490
DPOP does not Granger Cause DEXPTOT DEXPTOT does not Granger Cause DPOP	72	4,47183 1,49748	**0,03807** 0,22522
DPOP does not Granger Cause DGDP DGDP does not Granger Cause DPOP	72	0,00081 6,42072	0,97735 **0,01355**

Table 6. Pairwise Granger Causality Tests for PORTUGAL

Sample: 1861 1935 Null Hypothesis:	Obs	F-Statistic	Probability
DEXPTOT does not Granger Cause DEDUC DEDUC does not Granger Cause DEXPTOT	72	1,55672 5,81002	0,21636 **0,01860**
DGDP does not Granger Cause DEDUC DEDUC does not Granger Cause DGDP	72	20,3561 3,91279	**2,6E-05** **0,05191**
DPOP does not Granger Cause DEDUC DEDUC does not Granger Cause DPOP	72	10,4560 1,41938	**0,00188** 0,23759
DGDP does not Granger Cause DEXPTOT DEXPTOT does not Granger Cause DGDP	72	43,3131 0,00092	**7,6E-09** 0,97585
DPOP does not Granger Cause DEXPTOT DEXPTOT does not Granger Cause DPOP	72	1,60428 1,39627	0,20956 0,24141
DPOP does not Granger Cause DGDP DGDP does not Granger Cause DPOP	72	0,40415 2,83679	0,52706 **0,09665**

Figure 1: Causality in SPAIN

Figure 2: Causality in PORTUGAL



Significance at 5 % level

Significance at 10% level

Conclusion: Education as an accompanying investment

To explain the causal relation between education and the economy in Portugal and Spain before World War II, we consider education as an investment. However, the allocation of resources to education as an investment raises the major problem of knowing the nature of this investment. Indeed, education can be considered either as a directly productive investment or as an investment in infrastructure.

In the first case, education incorporates in a person a kind of capital that increases the effectiveness of his/her work. Nevertheless, the possibility of investment induced by such an investment remains conditional. Indeed, we should not forget that material investment is considered as a driving force behind economic growth because it is performed with a view to production that should find outlets. In other words, production means are created with a reasonable prospect of their being used. As a result, it is not certain that an analogous forecasting calculation is performed for education. Indeed, is there a requirement for the economic use of the *products* of the education system, that is to say the adaptation of education to the absorption capacity of the economy?

In the second case, education is considered as an investment in infrastructure. This changes the perspective elaborated in the first case. Education appears more as a condition for development and no longer a driving force behind growth. Here we stress the complementary nature of education in relation to the labour factor, which is in turn complementary with regard to capital. Education then becomes a condition for the effectiveness of material means.

The problem of the economy's capacity to absorb the products of the educational system can now be approached using two notions.

The first notion sees the investment in infrastructure as a driving force behind investment. With regard to material investments, it leads to seeking a logical definition of the infrastructure corresponding to a given growth level (desired and attainable). We consider that this infrastructure encourages the adoption of a policy of technical operations that gives rise to new production activities and has a stimulating effect. Transposed to education, this analysis leads to recommending a certain education structure (levels and types of studies) corresponding to a certain professional structure suited to the level of economic growth desired. In these terms, the supply of trained persons produced by the educational system may have a stimulating effect insofar as the availability of qualified persons can encourage certain activities and form an incitement to use certain techniques. Nevertheless, such a stimulating effect is by definition delayed, random and partial. It includes the risk of not using qualified persons or using them badly. The investment in infrastructure thus becomes an investment not followed by production, that is to say economic waste.

The second notion considers investment in infrastructure as a simple accompanying investment. With regard to material investments, it leads to defining the infrastructure required by the prospects of economic growth related to directly productive investments. Unless there are differences in time lags inherent to the various investment operations, we can say that investment in infrastructure follows investment in production instead of preceding it. In other words, the former is modulated by the latter. Application of this reasoning to education means that the flow of the education system is adapted to forecastable future demand for labour with various levels and types of qualifications.

Finally, there must be economic use of the *products* of the educational system whether education is considered as a productive investment or as an investment in infrastructure. In the latter case, the results of our analysis lead us to considering that, in extension to previous publications (Diebolt, 1999-2002), for the case of Portugal and Spain, the investment is more in the accompanying category than a "driving force" investment.

Appendix

The sources for the data in section 2 are as follows.

- PORTUGAL: Maddison (1995), Nunes (2000).
- SPAIN: Carreras (1989), Comin (1992), Diebolt (2000a), Intervención General de la Administración del Estado (1891), Ministerio de Hacienda (1976), Ministerio de Hacienda (1979), Núñez (1991), Prados de la Escosura (1993).

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