Exploring the relationship between technology and growth: the spanish experience

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Abstract

The New Growth Theory has put the issue of endogenous technical change back into the center of attention. This paper explores the relationship between technical change and economic growth, from an empirical point of view. Although the statistical material available to the researcher wanting to investigate the economic influence of technological innovation is not very adequate, the aim of this paper is to analyse the impact of technological change on long run growth in Spanish regions by means of the statistical analysis. Using a panel data for spanish regions during 1987-1995, we apply some econometric exercises to assess the significance of the relationship between technology and growth.

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1.- INTRODUCTION.

The New Growth Theory stress the role played by technical progress as well as its determinants. In contrast to the traditional neoclassical growth model where technological progress is only the time trend, the new models take into account an endogenous determination of the sources of growth. In this sense, the empirical literature on the interaction between technology and growth has two main streams: the first consider that R&D activities can viewed as an additional production factor, a new production function argument. The second stream of literature tries to establish an empirical relation between knowledge accumulation and growth of output (Verspagen, 1994).

This work attempts to evaluate the R&D impact on the economic growth between 1986-1995 in Spanish regions. These study estimates an equation of growth accounts using panel data techniques in a framework, which takes into, account the specific characteristics of spanish regions.

Estimation is done using a panel data consisting of annual observations for the 15 spanish regions. The results show a big and statistically significant of regional gross product to technology indicators.

The structure of the paper is as follows. The theoretical model, which provides the framework for the empirical analyses, is presented in the section 2. Section 3 is devoted to presentation and discussion of the pooled time series/cross section data set, which is used in the estimation of econometric model. Finally, section 4 presents conclusions.

2.- THEORETICAL FRAMEWORK.

The empirical study of economic growth has produced a vast and diverse literature. This section reviews the empirical evidence on the effect of innovation on growth. The literature on technical progress and growth must start with the work of Solow who founded that technical change was the main responsible for the economic growth. The growth accounting approach was the dominant methodology for empirical studies of productivity after Solow's work. All the studies in the Solow tradition have a common problem: they produce an estimate of the rate of technical progress, but they do not shed any light on the causes of technical progress.

In the mid-1980s its appears a renewed interest in growth theory. This interest must be taken as a sign that an important change of perspective has been adopted as far as the sources of growth are concerned (Amable, 1994).

Dissatisfaction with the neoclassical growth theory assumption that technical progress is exogenous led to theoretical and empirical changes. On the theoretical side, recent theoretical work has tried to endogeneise the role of innovation in the growth process: In contrast to the traditional neoclassical growth model the new growth models take into account an endogenous determination of the sources of growth. From a neoclassical point of view, technical change is made endogenous because economic agents choose to allocate certain amount of resources to its development -R&D expenditure,...-. Certain models of economic growth have insisted on the particular role played by technological innovation and on the importance of the resources devoted to R&D. (Romer, 1990; Aghion y Howitt, 1992).

On the empirical side, researchers attempted to explicit the model the causes of

total factor productivity growth using different data on innovation (Cameron, 1996). But technology is not easy to measure: knowledge is an input into production other goods, but is also an output because knowledge itself is produced (Arrow, 1994). To resolve this problem, economists have followed two ways: One way is an indirect one, builds upon the concept of the production function. In this case the rate of technological change is approximated by the residual of output growth after subtraction of the growth rates of labour and capital input -weighted by their shares in income-. In this method, the residual measures not only technological progress, but also other sources not taken into account.

A second method of measuring technological change uses more direct indicators, such as expenditures on R&D, and patent statistics. Those indicators also have disadvantages. The R&D-process is subject to uncertain, and R&D is only an input-indicator. On the other hand patents are a direct measure of innovation output. Summarising, the statistical material available is not very adequate for research objectives.

3.- DATA AND ESTIMATION RESULTS.

The aim of this section is to investigate whether or not technology indicators are systematically related to growth of output. The data source used for all variables, except for the capital stock, is the Regional Account, constructed by the INE[**]. Data for most regions are available only for a shorter period: 1987-1995. In addition, data for Ceuta and Melilla are not included in the analysis. Hence, we use a balanced panel, which means that our sample contains 102 observations. The basic model used can be specified as follows:

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$$Y_{it} = A\,e^{\lambda t}\,K_{it}^{a}\,L_{it}^{b}\,R_{it}^{\alpha}$$

where Y denotes the gross industrial product, K is the private capital stock, L is the labour input. Technical change is assumed to be neutral, a function of the knowledge stock, R.

$$y_{it} = c_i + a\,lK_{it} + bl\,L_{it} + \alpha\,lR_{it} + \epsilon_{it}$$

Taking logarithms, it implies that equation (1) can be rewritten as:

where i= region; t= time; c_i: non-observable characteristics of each region, and ςit: a random error term.

This model includes country specific effects and we estimate two different models: a fixed-effect model, which assumes country effects are non-stochastic

$$y_{it} = c + al\,K_{it} + bl\,L_{it} + \alpha l\,R_{it} + \phi_i + \epsilon_{it}$$

and a random-effect model which can be formalised as follows:

where φ_i is a normally distributed random variable, with mean zero and constant variance.

Let us explain in detail each of the variables in the model. The dependent variable is the natural logarithm of real gross industrial product at factor cost in real terms (1990). The regression equation has 3 explanatory variables . The first one is L -labour-. It is measured with the average worked hours. The second variable is the logarithm of real investment R&D knowledge stock that is defined as a perpetual inventory. $R_{it+1} = G_{it-1} + (1-0,25)R_{i,t-1}$, where 0,25 is the depreciate rate assumed. The results obtained using the pooled time series/cross section panel data, with different estimation techniques are presented in table 1.

TABLE 1
Dependent variable: Gross Industrial Product in real terms

Variable	OLS	BETWEEN	WITHIN	RANDOM EFFECTS
Constant	2.51351 (6.41319)	2.29669 (0.002)		2.61063 (5.06178)
lR	0.140293 (4.78769)	0.105269 (1.91617)	0.121307 (2.20295)	0.155311 (4.83265)
lK	0.016491 (0.324193)	0.027201 (0.03803)	0.870754 (1.56995)	0.029603 (0.428649)
lL	0.836536 (11.7744)	0.105269 (1.91617)	0.152095 (0.244324)	0.800854 (8.90080)
NOBS= 102 ; N =17, T=6 R2 Hausman Test	0.9320 CHISQ(3)=5.12 P value [.1627]	0.9813	0.9530	0.9318

The results in column (1) correspond to ordinary least squares. The pooled model assumes that all provinces react in the same manner after a change in the values of the explanatory variables and that the non-observable characteristics are the same for all provinces. In column 2 are presented the results for the between-groups estimator. This estimator uses only the information between regions. Columns 3 and 4 differ in the assumptions concerning to the non-observable effects. In column 3, the individual effects are treated as fixed -fixed effect model- whereas in column 4 we are considered the error component model. Under the fixed effects assumption, the within estimator is the best unbiased estimator, while under the random effect hypothesis the most efficient unbiased estimator is the generalised least squares estimator, provided that the specific random effects, c_i, are uncorrelated with the explanatory variables. A way of detecting correlation between individual effects and regressors is the Hausman test, which measures the distance between the within and generalised least squares estimators. The

Hausman tests seem to indicate the RE-model perform better than the FE-model, chi-square statistic for the Hausman test is significant in comparison with the critical value of the chi-square. In addition it is evident from the significance of the estimated coefficients. Although the results for the capital variable are no longer significant, they are closer to their expected value. For the FE-model, only the catching-up term appears significant. For the RE-model as well as the model without any country-specific effects, the technology variable is also generally significant. With regard to the elasticities of the technology variable is significant.

Having selected the variance component model as the best, we discuss the elasticities estimated. Since the model is double-logarithmic, the estimated coefficients for the variables are elasticities. The results from the model supports the idea that the gross value added is more sensitive to changes in labour and technical change than to the capital.

Finally, it is remarkable that the evidence from the cross-regions estimates supports the hypothesis of a relationship between technological accumulation and growth of per capita GDP.

5. RESULTS AND CONCLUSIONS.

Using regional panel data for the period 1987-1995, an industrial production function has been estimated. The preferred equation has been obtained under the assumption that all regions respond in the same manner to given changes in each regressors, but in each region there are a set of non-observables characteristics which differs from one another.

The study has found R&D stock is an important predictor of economic growth, with an elasticity of 0.15. The estimates can be improved if we can improve the

panel data available.

The estimation is satisfactory, and this model is sufficient to explain growth differentials between spanish regions.

But the model uses a linear conception of technical change and neglects the specification of external effects. In further research we hope to account all the institutional factors affecting the relationship between technology and growth.

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