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## The New Growth Theories and Their Empirics after Twenty Years

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### **Abstract:**

In this work we update the reviews on endogenous growth theories, after two decades of theoretical and empirical contributions in order to explore whether recent empirical studies have become more supportive of their main predictions. Among the core topics studied in the growth econometric framework, namely, convergence, identification of growth determinants and factors responsible for growth differences in the data, the primary focus of this paper is on the last two. We will review, from macro growth regressions, studies that test primarily the performance of endogenous models in terms of significance and robustness of the coefficients of growth determinants. By highlighting methodological issues and critical discussion, we argue that: (i) causal inference drawn from the empirical growth literature remains highly questionable, (ii) there are estimates for a wide range of potential factors but their magnitude and robustness are still under debate. Our conclusion, however, is that, if properly interpreted, the predictions of endogenous growth models are increasingly gathering empirical support.

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## 1. Introduction

This survey updates the research program on the new growth theories (henceforth NGTs) after two decades of significant advancements in theoretical and empirical studies. In the last years many works have been published in which, differently from previous studies, evidence seems to be consistent with many predictions of the new theories. We shall update existing reviews since the focus has shifted from convergence issues to an assessment of the economic and statistical significance of the wide array of potential growth determinants.

The call for a further survey should be questioned, especially after the publication of the *Handbook of Economic Growth* edited by Aghion and Durlauf (2005), in which many determinants of growth are fully explored by leading economists in the field. This paper cannot be a substitute of the two-volume work just cited. Our motivation is to build a survey that presents in a single article an integrative view of the entire empirical debate and an assessment of where it stands today. The undertaking is not straightforward. The 87 variables identified as potential growth determinants in the 1999 survey by Durlauf and Quah, has increased to 145 in the more recent 2005 survey by Durlauf, Johnson and Temple. This figure is destined to further increase if the interaction between variables is considered. Is this large number of identified growth determinants supported by theoretical and empirical studies? We will search for salient growth determinants, even if not in the detail that would be possible if explorations were limited to one or few of them.

The appearance of the NGTs has generated an extensive literature characterised by two phases. The first focused on convergence *versus* divergence of per capita income and growth rates across countries and across time. The issue was considered relevant for an empirical assessment of the validity of the old and the new theories of growth. Whereas a key aspect of exogenous models of growth was the convergence of all countries to a common level of steady state per capita income, the implication of convergence in the NGTs may not occur at all. This seems to be consistent with the casual observation that poor countries are not able to catch up with the leading economies and to converge towards the same steady state as predicted by a

simple version of the traditional growth model. Following the empirical studies by Barro (1991), Barro and Sala-i-Martin (1991) Young (1991, 1995), Mankiw, Romer and Weil (1992), Jones (1995a, b), in which convergence among countries was measured conditional on factors that determine the steady-state, we have observed the weakness of the endogenous growth paradigm and the revival of the canonical Solow (1956) model. Subsequent studies have led to a wide array of empirical outcomes and to the failure of the original intention of using convergence as a test for the validity of competing growth theories. Convergence issues, even if they still capture the interest of many scholars, are by no means – as claimed by Durlauf, *et al.* (2005) – “the bulk of empirical growth studies”<sup>1</sup>.

In fact, the finding that poor economies converge to *their own steady states* does not provide an explanation for why these steady state levels are so low and fails to give useful devices to policy makers both in developing and developed countries<sup>2</sup>. Even if the prediction of convergence still remain as a testable hypothesis, the focus has shifted from convergence to the explanation of the growth mechanisms and the determinants of the steady state levels. Under this perspective it might be interesting to investigate, according to cumulate evidence, whether or not the predictions of the NGTs have become more robust and which problems still remain unresolved. Ironically, the growth debate, instead of getting a consensus, has assumed a new divergent path between those economists (Mankiw.Romer and Weil [1991] from a neo-classical perspective) who believe that international variation in income across countries are accounted for almost exclusively (80%) by differences in factor accumulation and those who attribute all the observed differences (90%) to total factor productivity (TFP) (Klenow and Rodriguez-Clare [1997], Easterly and Levine [2001], Henderson and Russell [2005], Caselli [2005], and Easterly [2005]). The diverse emphasis posed on these two factors, ideas gap against factor accumulation (A against K) in the recurring debate is lessened by the researches of scholars that distinguish

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<sup>1</sup> Convergence and identifications of growth determinants are closely related since their treatment requires the specification of a regression model of cross-country growth differences from which the effects on the growth of different factors may be identified (see Durlauf et al (2005)).

<sup>2</sup> See Islam (2004) for an interesting and updated survey on the convergence issue.

between these *proximate* sources of growth as opposed to *fundamental* sources. In a broader interpretation, fundamental determinants include economic institutions (Hall and Jones [1999], Acemoglu *et al.* [2001]), legal and political systems (La Porta *et al.* [1998, 1999]) as well as culture and social norms (Glaeser *et al.* [2004], Tabellini [2005]). Before discussing econometric outcomes and special features of the *institutions view*, it is indubitable that the new stylised fact that has emerged in recent years is the focus on factors, which go beyond the traditional ones.

This paper cannot be, for understandable reasons, a comprehensive review of all the approaches to the empirics of growth. Our proposal is to discuss the state of the general debate by reviewing empirical studies, from both journal articles and working papers, devoted to assess the robustness of the variables considered as salient sources of economic growth by the NGTs, in order to ascertain where we stand now and the context on which further research can be pursued<sup>3</sup>.

The main message of *a new theory* should have emphasised that growth does not depend on one factor only, but on a well-managed combination of several resources and their strategic complementarities. Unfortunately, this message does not emerge from a unified theoretical framework (see Galor [2005] who calls for a unified micro-founded model): each model of the NGTs captures only one factor and it alone is capable of generating sustained growth. Investigation of the NGTs from an empirical perspective can be considered the alternative to avoid this restriction. Empirical specifications of growth theories allow us to introduce more than one factor at a time and interactions among them. We examine the state of this literature without any pretence to be exhaustive.

The survey is not organised around the different approaches applied in growth empirics. Our choice is motivated by the fact that such a perspective has already been followed by Temple (1999) and Durlauf *et al.* (2005) in their outstanding reviews and also because our specific

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<sup>3</sup> The number of papers on this topic is immense. We will select the ones whose publication in leading journals have created motives of debate or have favoured further researches.

interest is to draw inferences from different studies that focus on the identification of leading growth determinants. The major weakness of the bulk of studies aimed at testing the NGTs is that econometric specifications capture poorly the mechanisms of growth stressed by these theories and the proxies used for measuring key determinants of growth are imprecise. Although there is lack of consensus on the methods used for distinguishing the NGTs empirically, we believe that a review structured around empirically useful categories of growth determinants may be a contribution to the current state of the literature. These categories include the evidence on factor accumulation *versus* research-based theories of growth as well as institutional factors.

The outline of the paper is as follows. Section 2 discusses the main criticisms to the empirics of growth and the substantial advances in the econometric tools developed over the decade. Section 3 (and subsections) shows from growth regressions the evidence on endogenous determinants of growth according to the most influential classes of models. By discussing the robustness of the estimates we will evaluate basic regression findings on initial conditions, broad capital and R&D. Section 4 introduces the evidence on public policy and institutions to gain insights on government activities and organizations and the way in which they affect country performance. The last section provides concluding remarks and proposes some possible directions for future research.

## 2. Methodological critiques on growth empirics

### 2.1. *Technical issues in testing the robustness of the determinants of growth.*

It is common knowledge that a non-marginal contribution to the success (at least in terms of interest by economists and papers written on the subject) of the NGTs has been the increasing use of econometrics to test their predictions. Growth is not a *natural* phenomenon but it is influenced by market forces, incentives and consequently by good policy choices.

Typically, the broad growth quantitative approach, to deal with these facts, is based on linear cross-country regressions. The motivation for the use of this approach has been twofold.

Firstly, second generation NGTs, and specifically those based on endogenous technological progress, should not rely on growth accounting since it fails to give precise estimates of TFP. Secondly, growth accounting attributes to physical capital and labour a weight that depends on their shares of GDP, while in regression analysis the significance and magnitude of the coefficients of each determinant of growth are left to data. Growth regressions, however, as economists unanimously agree, show how variables are correlated with the growth of nations, but are far from implying the direction of causation.

Although the econometrics of growth based on Barro (1991) and Mankiw-Romer-Weil (1992)'s basic framework, has been contested by many authors (i.e. Klenow and Rodriguez-Clare [1997], Dinopoulos & Thomson [2000], Brock and Durlauf [2001]), we agree with two opinions expressed by Temple (1999) in his worthy review article: (i) many interesting things have been learnt from these researches but, (ii) it is time to argue for a different, *non-neoclassical*, vision of growth.

It is worth mentioning, however, that the primary purpose of cross-country regressions was and still is the investigation of what determines growth differences in GDP per capita across countries in the long run. Growth empirics should explain if these differences were due to factor accumulation or to TFP, a combined effect of the two, or to other identified factors that can supplement the orthodox explanations. While some mechanisms pertain to the domain of neoclassical and endogenous growth theories, others, developed under the rubric of socio-political institutions, lie, at least partly, outside the field of theoretical models. The availability of standardised data sets<sup>4</sup>, have made it possible to test both mechanisms, but almost all the studies are exposed to severe criticisms.

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<sup>4</sup> Even if the more used set of data are the Penn World Tables (now updated, (PWT 6.2]) by Heston, Summers, and Aten (2005), many data on different variables have been made available by many growth scholars. The sites of the World Bank and NBER as well as those of many other institutions, such as the Centre of International Development (CID) provide interesting growth data. We still lack, however, the detailed data necessary to construct measures of TFP, R&D capital and other variables that are very useful for a direct test of second generation's growth models. Detailed data for EU countries are provided on-line by the Groningen Centre of Economic Development. Other set of data for specific growth issues are, Barro and Lee (1993, 2000), Beck *et al* (2000), Knack and Keefer (1995), Kaufman *et al* [2006], among many others.

One concern is the causality *versus* the correlation issue. Proponents of empirical studies based on this methodology share the belief that regression studies involve an implicit form of causality, otherwise they would not be suitable for growth investigations and for policy assessments. A researcher that wishes to explain the growth rate will introduce in the growth equation vectors of independent variables that he believes are the moving force of the former. But is this procedure appropriate? Regression techniques are appropriate only if the causal structure of the model is determined *a priori*. Typically, this does not occur if regressors are introduced arbitrarily into the analysis. Brock and Durlauf (2001) have pointed out that the extended set of variables used to explain growth patterns in cross-country regressions, such as democracy, rule of law, social capital, are of a socio-cultural nature and cannot be treated as if they were derived from an *a priori* specified structural model. The lack of agreed theoretical bases to apply in empirical work has motivated the practice of abandoning any *a priori* model and enables the data to show which variables are correlated with growth. This practice has led to unwieldy sets of explanatory variables (*model uncertainty*).

The concern about model uncertainty is at the centre of the recent empirical debate, but it is still in its infancy given the difficulties of finding accepted methods to deal with this issue. Among the enormous number of regressors that have been included in the empirical analysis, most have been found to be statistically significant according to conventional tests. This means that we have as many growth theories as the number of significant regressors and we cannot distinguish among them (model identification). To succeed the issue we need theoretical model that provide restrictions to this great number of regressors.

Other frequent motives of concern with conventional macroeconometric techniques refer to omitted variables, serial correlation in the disturbance terms, collinearity between the variables, and the presence of measurement errors, which may lead to violation of a set of conditions necessary for consistent coefficient estimates. Recently, the criticisms have intensified by emphasising concerns associated with parameter heterogeneity, and non-linearities. The argument raised is that conventional cross-country linear regressions impose

strong homogeneity among parameters, which lead to the implausible assumption that a change in a particular variable has the same effects across countries. Several studies (Liu and Stengos [1999], Kalaitzidakis *et al.* [2001]) find strong evidence of parameter heterogeneity that may arise from non-linearities in the production function, multiple steady-states and poverty traps. New empirical methods and tests have been performed to account for failures of standard growth regressions (Doppelhofer, Miller and Sala-i-Martin [2004] Easterly and Levine [2001], Lee, Pesaran and Smith [1997, 1998], Hansen [2000], Fernandez, Ley and Steel [2002], Masanjala and Papageorgiou [2005] among others).

Although a widespread discussion of these issues and methods to deal with are contained in Brock and Durlauf (2001) and Durlauf *et al.* (2005), what it is still lacking in the literature is a consensus on accepted methods to test the robustness of parameters and their importance in growth theories.

The most cited paper that has addressed the issue still remains Levine and Renelt's 1992 study (henceforth LR). Their method involves the identification of empirically robust determinants of growth that can explain observed differences in growth when the range of possible factors is large. Robustness consists of identifying a variable the importance of which is confirmed across different specifications. LR carried out the Leamer (1983) extreme bound-analysis (EBA), which involves estimating the upper and the lower extreme bounds of a coefficient of a variable of interest across different model specifications. If the signs of these extreme bounds are different (in the sense that they change their signs or their statistical significance when other variables are included) then the variable is considered to be fragile. The models are distinguished by alternative combinations of 1 to 3 variables taken from the following set: initial income, the investment share to GDP, secondary enrolment rates, population growth. According to LR the perspective to empirically find variables as robust sources of endogenous growth are very few. They report cross sectional studies conducted with over 50 different regressors, and only the share of investment, other than initial income, was found strongly correlated with growth. Durlauf *et al.* (2005), however, consider the EBA

methodology as an excessively conservative approach for policy evaluation since, from a “decision theoretic perspective, it corresponds to an extreme risk-averse way of responding to model uncertainty” (p.610). In other terms, the authors argue that the policy maker cannot decide on important matters on the basis of *t.statistics* and other similar mechanical criteria.

The same criticism applies to the alternative approach taken by Sala-i-Martin (1997). The method involves studying the entire distribution of estimators of a variable of interest. The robustness test is based on cumulative density functions to establish a ranking variable performance. A variable is robust, according to Sala-i-Martin's method, if, by averaging the statistical significance levels, it is significant and with a given sign in 95% of the different regressions estimated. Applying this methodology to 60 variables, Sala-i-Martin found, differently from LR, that 22 variables out of 59 appeared to be significantly linked to growth. The outcome depends on the less restrictive concept of robustness adopted. Nevertheless, also applying this procedure, there are many variables – theoretically expected to be important – that are not correlated significantly with growth. If we look at the list of variables reported by Sala-i Martin (1997), it is remarkable to note that, except for investment in equipment and initial income, the other robust variables include almost exclusively measures of geography, religion, rules of law, political rights and other institutional attributes. According to this evidence scholars should explain why institutional variables seem so robustly correlated with growth even if they are historically the same and do change very slowly in the growth process of developed countries. We expect to find a strong impact on growth for developing countries, but why in any regression with non significant coefficients, more robust estimates are obtained by simply introducing institutional variables as instruments for endogenous proximate factors? The answer may rely on the way these variables are constructed or on the fact that researchers include an exaggerated number of them, by simply arguing that they serve as good instruments being predetermined with respect to current growth rates in per capita income.

Alternative approaches have been proposed to solve the controversy over the selection of growth-regression models. One of these is the Hendry and Krolzig (2003, 2004) program for

selecting econometric models through an automatic procedure, which substitutes the data-based selection. Instead of millions of regressions, the authors just run one regression (choose one model) to individuate the determinants of growth based on a set of statistical tests. According to the *general-to-specific methodology* the “true” equation should be characterised by a general regression that includes all information about the effective determinants of growth but this general unrestricted model should be appropriately reduced to a more congruent representation (specific regression) which encompasses every other restricted regression of the general specification. The endeavour is to select among the different models the one that is consistent with some theoretical views. The authors claim that, in cases in which there are more potential candidate variables (as in growth theories) than available observations, it is still possible to run regressions by repeated applications. The model selected by the authors, out of the space of possible models based on a set of statistical tests, includes the rate of equipment investment, an index of openness and some institutional measures.

Hoover and Perez (2004), using the methodology associated with Hendry and Krolzig (2004), have re-examined LR and Sala-i-Martin’s conclusions by using, in a Monte Carlo experiment, a variant of the EBA. By comparing this approach with a version of the general-to-specific methodology, the authors conclude that the *modified* extreme-bound procedure used by Sala-i-Martin possesses higher power to detect potential significant regressors than the LR approach. The latter is able to reject important growth determinants as fragile and at the same time to consider spurious relationships with growth as robust.

Another prominent approach, advocated by many researchers, that can account for model uncertainty is the Bayesian Model Averaging Approach (BMA). This methodology has already been applied in the context of economic growth by Fernandez, Ley and Steel (2001), Brock, Durlauf and West (2003), and Doppelhofer, Miller and Sala-i-Martin (2004), among few others. The multiplicity of regressors introduced in growth equations is solved in classical econometrics by leaving it to data to sort out the significant ones. But when the number of regressors exceeds the number of countries in the data set the analysis becomes flawed. If we do

not know which model is the true one, we need to attach probabilities to different models and then use the Bayesian approach to average across models using some selection criteria. Model averaging seems to be a powerful tool that can help policy makers to gather more information than simply that offered by parameter estimates and other conventional summary statistics. The strategy of constructing posterior probabilities is considered appropriate to evaluate alternative policies without identifying a priori the best growth model. The application of this approach to sub-Saharan African countries, for example, helps to explain why ethnic heterogeneity affects growth in these countries but not in others (Brock and Durlauf [2001]). Fernandez *et al.* (2001) show the superiority of BMA over other techniques in selecting regressors to explain cross-country growth. Their findings, by comparing LR and Sala-i-Martin procedures, appear to favour the latter. The Sala-i-Martin procedure, even if not based on firm theoretical statistical methods, leads to the conclusion that a large number of variables are important for growth. However, independently of what Fernandez *et al.* claim, if we look at the table of results (Table 1, page. 181), many variables considered important by Sala-i-Martin show a lower posterior probability than the weighted average probability estimated with the previous method by Sala-i-Martin. The series of variables with a lower posterior probability are variables regarded as important growth determinants, such as rule of law, numbers of years an economy has been open, degree of capitalism, primary school enrolment in 1960, black market premium etc. The variables (for which there is also a correspondence with the average probability assigned by Sala-i- Martin) identified as strong explanatory variables are only the GDP levels in 1960, life expectancy, and equipment investment. Except for life expectancy, the other two variables are those found robust also by LR.

Doppelhofer *et al.* (2004), by averaging OLS coefficients of 68 variables across models for 88 countries, find that of 67 explanatory variables 18 are significantly partially correlated with long-term growth. But just four seem to be robustly associated with growth: the relative price of investment, initial GDP per capita, primary schooling and the number of years a country has been open.

Other non-parametric approaches to test the robustness of LR results have been performed by Kalaitzidakis *et al.* (2000). They propose a method in which auxiliary variables enter non-parametrically in the growth regression to ascertain if variables, considered fundamental determinants of growth, enter linearly and, hence, are valid candidates for a robustness assessment. Extending the sensitivity analysis of LR, they confirm the robustness of previous results concerning variables such as investment and initial GDP (for the period 1960-89). Differently from LR, however, they find government spending to be robust as well as some distortionary variables, such as standard deviation of gross domestic credit, inflation and real exchange rate distortion proxies.

## 2.2 Methodological advances in canonical growth regressions

Much of the discussion above typically refers to advanced tools in the empirics of long run growth that each researcher would like to possess when he faces model uncertainty. However, applications of some of these tools would require a change in the classical econometric approach. Even if the computational power available to researchers is enormously increased, we are not able to make predictions about widespread acceptance of Bayesian procedures among the generality of researchers.

However, also in performing canonical growth regressions, some progress has been made for parameter estimates to be more precise and consistent. Many scholars agree that dynamic panel data estimator is the right methodology to overcome the rather frequent endogeneity bias in the context of growth analysis.

It is common knowledge that in a cross section framework, in which data are averaged for periods of 40 years or more, the estimated regression should be of the following form:

$$g_i = \beta_0 + \beta_1 y_{i0} + \beta_2 X_i + u_i \quad (1)$$

where  $g_i$  denotes the growth rate of real GDP per capita (or per-worker) averaged 30-40 year period,  $y_{i0}$  is the initial level of real GDP per capita,  $X_i$  is a vector of explanatory variables

considered proximate determinants of economic growth,  $u_i$  indicates the error term (for the country index  $i = 1, \dots, N$ ), which contains unobserved country specific effects due to differences in initial conditions. Hence, in a pure cross-sectional regression the unobserved country-specific effect, being part of the error term, results in biased coefficient estimates.

To avoid endogeneity of regressors, simultaneity bias, as well as country-specific effects, recent empirical studies have used *time series* dynamic panel data approaches (Islam [1995], Caselli, Esquivel and Lefort [1996], Hoeffler [2000], Bond Hoeffler and Temple [2001]). To exploit the time series dimension of data, averages for shorter periods of 5 years are used in the regression. This allows to take into account unobserved country specific effects (country varying time invariant)  $\eta_i$ :

$$g_{it} = \beta_0 + \beta_1 y_{i,t-1} + \beta_2 X_{it} + \eta_i + v_{i,t} \quad (2)$$

where  $g_{it}$  indicates the average growth rate over a series of five year periods, and the error components include  $\eta_i$ , which is the country-specific effect as well as  $v_{i,t}$ , which reflects serially uncorrelated measurement errors.

Equation (2) has problem of its own. The term  $\eta_i$  may be correlated with  $X_{it}$  and standard estimators do not overcome the problem of endogeneity which requires estimating the equation in differences<sup>5</sup>. The problem has been addressed through the generalised method of moments estimator (GMM) of Arellano and Bond (1991). The general approach is to remove the country specific effects by using lagged levels of the regressors as instruments. In the empirics of growth this methodology was thought to solve many of the shortcomings of regression analysis. By eliminating the fixed effects, it avoids the problem raised by the omission of the initial level of technology and by using lagged instruments also avoids the problem of endogenous regressors. Since  $g_{it}$  is the logarithmic difference of GDP per capita, equation (2) can be rewritten as:

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<sup>5</sup> It is known that a technique which takes into account for country specific effects is the within group estimator. This method requires a transformation of variables by subtracting the time series variables from its mean for each country. The fixed effects are eliminated but the estimates of coefficients are biased downwards for fixed time periods.

$$y_{i,t} - y_{i,t-1} = \beta_0 + \beta_1 y_{i,t-1} + \beta_2 X_{i,t} + \eta_i + v_{i,t}$$

and taking differences:

$$y_{i,t} - y_{i,t-1} = \beta_1^* (y_{i,t-1} - y_{i,t-2}) + \beta_2 (X_{i,t} - X_{i,t-1}) + (v_{i,t} - v_{i,t-1}) \quad (3)$$

where  $\beta^* = (\beta + 1)$ .

Thus, moving to a panel approach and instrumental variables for all regressors, provides more precise estimates of the growth determinants, if moment conditions are satisfied. On the assumption that the error term is not serially correlated and that the explanatory variables ( $X$ ) are weakly exogenous (not correlated with future realisation of the error term) the following moment conditions should hold:

$$E[y_{i,t-s} (v_{i,t} - v_{i,t-s})] = 0 \quad \text{for } s = 2, \dots, T$$

$$E[X_{i,t-s} (v_{i,t} - v_{i,t-s})] = 0 \quad \text{for } s = 2, \dots, T$$

However, this approach raises a potential drawback that relates to the long run effect of the variables in the regression. Data averaged over five-year periods does not adequately proxy for steady-state relationships and it is possible that the coefficients capture the cyclical variability of the time series.

From a statistical perspective there are additional problems with the GMM difference estimator. When the time series of the explanatory variables are persistent, such as GDP, and the number of time series is small (observations averaged over 5-year periods) the *difference estimator* appears to produce unsatisfactory results in a growth context. The lagged levels of the variables are weak instruments for the variables in differences and this would cause large finite-sample biases in the presence of short panels. To address these problems the alternative *GMM system* estimator has been employed, which uses jointly lagged values of the explanatory variables ( $X_{it}$ ) in levels and lagged differences of the variables as instruments. Essentially the procedure results in the use of lagged first differences as instruments for equations in levels, in addition to the lagged levels of the variables in the equation in first differences (Arellano and

Bover [1995], Blundell and Bond [1998]). The first set of estimated equations is the same as above:

$$y_{i,t} - y_{i,t-1} = \beta_1^* (y_{i,t-1} - y_{i,t-2}) + \beta_2 (X_{it} - X_{i,t-1}) + (v_{i,t} - v_{i,t-1}) \quad (4)$$

and the second set of equations in the system are the level equations:

$$y_{i,t} = \beta_0 + \beta_1^* y_{i,t-1} + \beta_2 X_{it} + \eta_i + v_{i,t} \quad (5)$$

The equation in levels, still contain the country-specific effect. It is assumed, however, that  $X_{it}$  may be correlated with  $\eta_i$  but *changes* in  $X_{it}$  to be uncorrelated with  $\eta_i$ , which is clearly a more plausible assumption than that requiring the levels of  $X_{it}$  to be uncorrelated with the fixed effects (see Hoeffler [2000]). It is obvious that when the series are highly persistent the instruments used by GMM (DIFF) contain little information about the endogenous variables, but the extended use of GMM (SYS) is proven to produce more efficient estimates. To reduce the potential biases and imprecision associated with the difference estimator additional moment conditions for the regression in levels are:

$$E[y_{i,t-s} - y_{i,t-s-1})(\eta_i + v_{i,t})] = 0$$

$$E[X_{i,t-s} - X_{i,t-s-1})(\eta_i + v_{i,t})] = 0$$

These new conditions guarantee that the lagged first differences of the dependent variable is a valid instruments for equations in levels, being uncorrelated with the composite error term in the levels equation.

Although dynamic panel methodology applied to growth analysis is promising, it should be recalled that just in the last years it has begun to be applied for testing NGT hypotheses. Typically, it has been used to verify the neo-classical Solow model and the plausibility of the rate of income convergence to their steady state levels (see Bond, Hoeffler and Temple [2001]).

Two weaknesses emphasised in the literature of panel data must be recalled: (i) the use of differenced variables changes the interpretation of regression results, (ii) the range over which average of variables are computed (five years or more) is shorter with respect to cross section

studies and hence not adapted to capturing long run effects. In addition the problem of serial correlation in the errors needs to be further explored (see Lee, Pesaran *et al.* [1997], Phillips and Sul [2003]).

In our subsequent discussion we will not address statistical questions that have been extensively reviewed in the literature, even if concerns of divergent outcomes from econometric studies still remain. Why do some researchers find weak effects from physical and human capital accumulation in the process of growth whereas some others find a robust correlation? Why is the theoretical substantive role of externalities and the TFP stressed by the NGTs so difficult to take out from growth regressions? We firmly believe that, in the first case, a consensus would be attained if estimation were performed in strictly comparable conditions with the same period data, the same model-estimation techniques and the same sample of countries. In the second case our belief is that it is not the econometric methodology that is questionable but the difficulty of measuring accurately some crucial variables such as human capital, TFP and political-institutional variables.

### 3. Models and their empirical validation

#### 3.1 Evidence on initial conditions

We start reviewing the empirical analysis by looking at initial conditions. The empirical evidence is mostly based on convergence equations in which estimates of the sign of the coefficient of the initial level of per capita GDP (typically  $y_{i,0}$  in 1960) is considered the main test for endogenous versus exogenous models of growth<sup>6</sup>. We argued that the convergence issue no longer matters since it is unresolved either from a conceptual or statistical point of view. However, we cannot discuss initial conditions without linking their impact on convergence of income per capita across countries. Predicted convergence in the traditional model is based on

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<sup>6</sup> A convergence equation is a reduced form of a basic growth model and has been used to find not only evidence of convergence paths (the estimated coefficient of initial income), but also as an indirect test of how different variables are correlated with growth. The inclusion of such variables is appropriate to control for the steady state, since other variables can affect the growth rate of the economies under study, but is not satisfactory to draw inferences about the determinants of growth or to discriminate between alternative models. See the criticism of KRC (1997). Barro (1997) claims instead that the procedure is quite correct.

the assumption of a single worldwide production function featuring decreasing marginal returns to capital. In such a framework differences in growth rates may be justified by initial differences in capital intensities. Therefore, the disparities in growth performances that we observe across countries are determined by different levels of capital accumulation as demonstrated by Barro (1991, 1997) and by Mankiw Romer and Weil (1992). These studies have represented, according to Klenow and Rodriguez-Clare (1997) the "neoclassical revival" in the economics of growth. The augmented Solow model was considered suitable to explain almost 80% of the cross-country variance of output per-capita attributed to differences in steady state levels of physical and human capital. Is a model that stresses convergence and initial conditions the best approximation to the true model?

Even though it is very difficult to conclude in favour of one model or the other, the main results of this literature have been severely criticised. Bernard and Durlauf (1995), Quah [1995], Durlauf and Quah [1999], Phillips and Sul (2003) raised substantial criticisms by claiming that convergence patterns are too complicated to be captured by simple growth regressions.

The first challenge to the old model and its prediction of convergence comes from the application of panel data models. When controlling for differences in steady states by using country-fixed effects in panel regressions, the speed of convergence is much higher than the one implied by the classical studies, which is in the neighbourhood of two percent per year. The range of estimates found in studies using dynamic panel models (GMM approach) goes from zero to 30% a year (Canova and Marcer [1995], Caselli, Esquivel and Lefort [1996], Lee, Pesaran e Smith [1997], Islam [1995])<sup>7</sup>. These results are difficult to reconcile with the prevailing theoretical framework and with the earlier consensus on the convergence hypothesis. These estimates of the rate of convergence imply that the steady state is already here and the transitional dynamics is too short as an explanation of cross country productivity differences.

Recently the effort to apply the GMM system to an estimation of the Solow model has moved the rate of convergence across countries towards a more reliable value, which stays in

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<sup>7</sup> See Temple (1999) for a wider and critical discussion on the early literature on convergence.

the range of 1%-4% (see Bond, Hoeffler and Temple [2001], Doppelhofer et al. [2004]). However, there are other challenges against the prediction of the neoclassical convergence hypothesis and its theoretical implications.

One more challenge is the technology gap view, which moves a substantial and direct attack to the early literature on convergence and to the Mankiw-Romer and Weil (MRW) results, in which a consistent rate of convergence is obtained by adding human capital to the convergence regression. In fact, a by-product of the panel approach to convergence study is the estimated values of technology levels across countries. These levels according to Islam (1995, 2003) differ enormously across countries and the highest value is about forty times larger than the lowest. The claim that technological progress matters more than factor accumulation in the explanation of cross-country growth differences appeared firstly in a provocative way in the already cited Klenow and Rodriguez-Claire study (KRC, 1997) followed very rapidly by similar claiming by Prescott (1998), Hall and Jones (1999). KRC argue that the "ideas gap" is more important in explaining differences in output levels and growth rates than physical and human capital. Updating the data and adding primary and tertiary schooling, which were absent in the MRW study, they offer new evidence that technology-based models are more reliable in explaining income divergence across countries than differences in human capital. Since primary school attainments vary much less across countries than those of secondary school, the findings of MRW overestimate the effect of variation in human capital across countries. After the correction in the data, the earlier well-established outcome is reversed. Roughly, 90% of differences in per capita income growth between countries are attributable to technology differences. If, for comparison with MRW, we express the differences across countries in terms of per capita income *levels* then, human and physical capital are responsible for roughly 50% of cross country variations and the other 50% is attributable to changes in technology.

These new empirical studies on convergence were sufficient to shift the interest of researchers from the Solow model to the NGTs. A further strong support to the NGTs has appeared in a provocative paper by Easterly and Levine (2001), which complements the main

conclusion of KRC and offers new elements to the debate. The KRC and Easterly and Levine's findings are confirmed by Caselli (2005). Updating the sample and the period of analysis, the author tries to assess the performance of the *factors-only model*, and finds that this model explains from 0.35 to 0.40 of the variance of income across countries. This value is less than the value found by KRC. However, his basic message is that the differences in TFP, responsible for the majority of income differentials, may be the result of the different composition of GDP across countries and across sectors.

The consensus on the role of technology as a source of growth differentials is weakened by the work of Henderson and Russell (2005). The two authors using a non-parametric production function approach reverse the KRC outcome. Through the decomposition of productivity growth in shifts in the production frontier (technological progress), movements towards the frontier (technological catch-up) and movement along the frontier (capital accumulation), the authors find that on average shifts of the frontier account for only 8% while movement along the frontier accounts for 57%. This means that the majority of growth productivity in 52 countries is attributable to broad capital accumulation and only a small fraction of it to an increase in TFP.

A possible explanation of these conflicting findings is contained in some papers by Acemoglu and Zilibotti (2001) Ayrar and Feyrer ((2002), Banerjee and Duflo (2005). According to the first set of authors technology-skill mismatch could account for a large fraction of the observed output per worker differences across countries. They argue that many technologies used in LDCs, but discovered and implemented in OECD countries, are designed for the workforce skills of industrialised countries. Therefore, even if we assume that all countries have access to the same technology, the low skill supply of workers in poor countries can lead to sizeable differences in TFP.

Ayrar and Feyrer, in an attempt to reconcile different points of view, present evidence that shows how TFP differences are important in accounting for the cross sectoral (static) variation in GDP but that other factors (human capital in their work) are crucial in determining

the dynamic path of TFP. Beside human capital, other factors may include all kinds of spillovers from countries at the frontier towards developing countries, such as the degree of openness, the composition of a country's trade, FDI etc.. This means that studies should consider the possibility of interactions and spillovers between physical capital, human capital and TFP.

More articulated and abundant of extensive evidence, especially from the LDC, is the paper by Banerjee and Duflo. In order to solve the puzzle of non-convergence they re-propose an old criticism based on the use of an aggregate production function and its underlying assumptions of optimal resources allocation within each economy. In contrast to what the aggregate production function approach implies, they show evidence from micro-development literature of the wide range of rate of returns to a single factor in each economy and of how such heterogeneity parallels the one existing across countries. The authors argue that this striking evidence is a clear signal of factor misallocation, which can have different causes and to a lesser extent the one of overall technological backwardness. Various possible sources of inefficiencies, such as government failures, credit constraints, insurance failures, externalities, and the existence of large fixed costs in production, are all considered as potential explanations of cross-country growth differences.

On the same line of reasoning is the technical paper by Phillips and Sul (2003), which adds further arguments to the discussion. By allowing for parameter heterogeneity, not only across-countries but also over-time, and using filtered techniques to extract estimates of a transition parameter, they examine the evidence for growth convergence by testing whether or not the transition parameter converges. By eliminating the restriction that the growth rate of technical progress is the same across units and over time, they argue that a poor country may grow faster because its speed of technical learning or technological transfer is faster than the speed of technological creation in a rich country. When the rate of technological creation is higher than the rate of technological transfer, divergence in growth path is likely to occur. Applying their technique to Penn World Table (PWT) data set from 1960 to 1989 for 120

countries they find that transitional dynamics “reveal an elusive shadow” of conditional convergence in both the US regional and the OECD growth rates.

In what follows we discuss more extensively empirical studies for each variable considered a determinant of growth to investigate whether the empirical literature rejects or is supportive of competing NGTs. As stated at the outset, we believe that the interplay between factor accumulation, technological progress, and national policies and institutions are the driving force for long run growth. The bulk of the succeeding subsections consists of investigating the potential for improvements in the measurement of inputs such as physical and human capital as well as technology in order to better understand their specific role on cross-country income differences.

### *3.2. Evidence on broad capital*

There exists a substantial body of historical evidence on economic growth and investment. Although the traditional model does not recognise any long-run correlation between investment and growth rate because of diminishing returns, historical data in almost all countries show a tight relationship between the two<sup>8</sup>.

Cross-section regression analyses have evidenced a significant coefficient for the investment variable included in the regressions. DeLong and Summers (1991), who found physical investment in equipment and machinery to be significantly correlated with growth, have opened the debate on the role of investment as engine of growth. They examined investment across a sample that includes OECD and developing economies over the period 1960-1985. We have just recalled in the previous section the study by LR (1992) in which the authors found that the most reliable result in much econometric work is the stable and robust

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<sup>8</sup> Historical evidence shows that among the factors that have contributed to the economic success of East Asian economies, there has been the ability to keep the price of capital goods low relative to general price level. It is commonly held that this has favoured equipment investment. In Singapore, for example, the investment to GDP ratio increased from 10% in 1960 to 47% in 1984. Based on this evidence Young (1995) concluded that East Asian countries are an example of factors accumulation growth (more exactly an example of transitional dynamics of neoclassical type). It is similarly agreed that Latin American and African economies have displayed very low rates of investment per capita.

link between investment and growth. For a broad cross sectional sample based on Summers & Heston's (1991) data, the regression estimated by LR was the following:

$$GYP = -0.83 - 0.35RGDP60 - 0.38GPO + 3.17SEC + 17.5INV$$

where GYP is the growth rate of GDP per capita, RGDP 60 is real income per capita in 1960, GPO is the population growth rate, SEC is the secondary school enrolment rate, INV is the share of investment in GDP. The scope of many econometric studies was to test directly the predictions of NGTs of the AK type. Oulton and Young (1996), consider evidence from a wide range of countries from investment data in the Penn World Tables and data on the share of capital taken by OECD Economic Outlook. They found very different results for each country. The mean of a broad capital share for the period 1979-1990, of 23 OECD countries was 47% but it ranges from a minimum share of 38% for Switzerland to a maximum of 77% for Turkey. According to the two authors, who use different approaches for their investigation (cross section, panel data and time series) of the role of physical capital on growth and of how it is associated with externalities, no strong case has emerged that social return to physical capital exceeds the private return. In the absence of externalities, they conclude that the impact of capital on growth seems to be very modest.

A closer examination of regressions shows that, even if the coefficient for investment is the highest with respect to other variables, the most common value is only 17.5. This means that an increase in the rate of investment of 1% would raise the growth rate only by 0.17 percentage points. It also means that the gross rate of return to investment is just 17%, or less if instrumental variables are used. If we add the coefficient of human capital (0.3%) the growth rate will increase to 0.20%<sup>9</sup>. This finding is far from supporting the AK model, in terms of both the unitary elasticity of capital with respect to output and in terms of lack of convergence (the coefficient of the initial capital is not non-negative or equal to zero). The empirical result seems in line with the neo-classical model validating the presence of diminishing returns.

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<sup>9</sup> This commonly used interpretation of regression results is much contested. See, for example, KRC (1997)

The AK model has been highly criticised also by Jones (1995a). He tested the prediction of the model by comparing investment as a share of GDP and the growth rate for 15 OECD countries. By using time series methods in which growth is regressed on lagged investment rates, the estimated equation is:

$$g_{i,t} = A(L)g_{t-1} + B(L)x_{i,t-1} + \varepsilon_{i,t}$$

where  $x$  is the growth determinant (investment or other policy variables) and  $A(L)$  and  $B(L)$  are lag polynomials. Endogenous growth models predict that the sum of the coefficients on the lagged variables should be greater than zero whereas in exogenous growth models should be exactly equal to zero. Therefore if the sum of coefficients in the lag polynomial  $B(L)=0$ , then the variable has no long run effects on the growth rate<sup>10</sup>. Using data for the period 1950-1989, Jones argues that the AK model is inconsistent with the time series evidence. He notes that after the World War II there was a large increase in the investment-output ratio in all the countries included in the sample but growth rates in these countries was almost constant or fell. Jones focuses on investment on durables. Over the 40 year period the investment /output ratio nearly doubled in countries like the US and nearly tripled in Japan. In some countries an increase in investment coincided with decreasing growth rates.

Related studies such as Bloomstrom, Lipsey and Zejan (1996) tried to detect the direction of causation between investment and growth. The result of this causality test rejects the hypothesis that investment (and also equipment investment) is the anticipating factor of economic growth. What they found is that past growth has a significant effect on current capital formation, but capital formation does not induce subsequent growth.

Against the rejection of the AK model is the work by McGrattan (1998). Her benchmark model is a two-sector AK with human capital and with endogenous labour supply. The author reevaluates the AK theory from a different empirical standpoint by considering

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<sup>10</sup> The same method is used by Kocherlakota and Yi (1997) to estimate the effects of policy variables in the U.S and the UK by using time series data.

evidence over a longer time- period and numbers of countries than Jones does. Extending Jones' sample to include the data for a complete century (using Maddison's data for 1870-1989) she found that periods of high investment rates coincide with periods of high growth. For investment-output ratios, data are constructed using fixed domestic investment as a percentage of GDP valued in current prices. Regarding the growth rates, nine-year moving averages of per capita GDP growth were used in order to smooth out some of the large cycles that occurred during wars. Extending the analysis to many more countries than the Jones sample, and including some less developed countries, she is able to confirm a positive and robust association between investment and output growth. The slowest growing countries exhibit an average investment rate of around 7% whereas the fastest growing countries have an average rate of around 25%.

Cooley and Ohanian (1997) performed further estimates. Like McGrattan, they show that data for investment and growth in the UK are consistent with an extended version of the AK-type endogenous growth model. These new studies on long run data seem to support the main predictions of the AK model.

However, even if it is certain that investment has a positive effect on growth, this does not mean that capital is the only source of growth, as the model would imply. What these studies show is that the theory is consistent with available data and that the theory's quantitative implications are in line with the empirical observations. The main prediction of the model is to see if changes in investment rate would lead to permanent changes in the growth rate. The empirical estimates of the AK model concentrate quite exclusively on investment in physical capital but other influences, in particular human capital, are important in this model.

The debate on investment and growth remains open. Some arguments from prior studies refer to the endogeneity of the variable. Since investment is clearly endogenous it is necessary to use instrumental variables in a cross-country regression. It has been argued that if the endogeneity of investment could be correctly treated then the coefficient of investment would be very small.

This conclusion is not supported by recent empirical works, which control for the endogeneity of the variable. Dinopoulos and Thomson (2000) Xu (2000), Bond, Leblebicioglu and Schiantarelli (2004) contradict Jones' influential 1995 paper showing evidence of a positive and long lasting investment-growth relationship. These different results may depend on the definition of investment adopted, to the data sources (updated or not updated Penn-World Tables) and sample periods. Similarly, Xu (2000) finds that the rate of investment exerts a long run impact on growth for four of the five industrialised countries investigated in his study for the period 1870-1987 and in fourteen of the twenty-four OECD countries for the period 1950-1992. Bond *et al.* (2004) present evidence, using annual time series data) for 98 countries for the period 1960-1998, that an increase in the share of investment predicts a higher growth rate of output per worker in the steady state. The long run effect is quantitatively substantial and statistically significant. They conclude by arguing that the suggestion that capital accumulation plays a minor role in economic growth is "premature". In their study the authors allow for heterogeneity across countries in all regression coefficients, following the approach of Lee, Pesaran and Smith (1997), but the finding is strongly confirmed with pooling cross section regressions as well as five-year average panel estimations.

How can these divergent findings be reconciled? Many of the marked differences outlined above are due to distinct investment measures. Which measure is more appropriate to test NGTs? Some argue that total investment is a good proxy to test the AK model. Others, such as Bosworth and Collins (2003) assert that the change in the capital stock, not the investment rate, should be used to estimate the contribution of capital to output growth. They show by reviewing familiar results from regression analysis that  $R^2$  is higher when the capital stock is used while a very small correlation is obtained in their sample between the change in the capital stock and the mean investment rate. The argument of the authors is worth noting: it would be a good practice to use the correct measure, which reflects the specification of the true variable, to test theoretical models. If the capital stock is used, results over the relative importance of this factor are highly sensitive to the value of its share on GDP. A benchmark value of the capital

share around 1/3 would imply that most of the variation in income per-capita is still explained by TFP. As its share increases to 60%, instead, almost all of the cross-country income dispersion is explained by capital stock (see Caselli [2005]). Also Eaton and Kortum [2001]), well aware of the difficulties to take account of the great heterogeneity of capital stock, emphasises that once capital is correctly measured, augmenting for its quality across country, it reveals a strong impact on growth.

### *3.3. Estimated contribution from education*

The role of human capital has drawn considerable attention in the NGTs. It may be disappointing to realize that the original idea that capital stock should include human capital, as to justify high values of its share in national accounts, leads to the rejection of the AK model. Is the theoretical model wrong or the decomposition of capital into its constituent elements are very difficult to estimate? Unluckily this variable, even if carefully studied from a theoretical perspective, presents many problems of measurement. Wolff (2000) summarises the three paradigms that have dominated the current debate on the role of education on growth. Interpreting his arguments, we claim that these paradigms are linked with different human capital theories: (i) the general framework of Lucas (1988), (ii) the interaction hypothesis with technological change of Romer (1990), and the catch up hypothesis of Grossman and Helpman (1991). In Lucas' (1988) human capital is the only engine of persistent growth but also in other models the growth rate is predicted to monotonically increase with human capital levels. Despite the theoretical role assigned to human capital, the empirical results are highly unsatisfactory. With only some exceptions, both educational levels and growth in educational attainment are not significant and often their impact is negative.

Why this disappointing result, which continues to hold, despite the progress in the econometric tools and the different measures of schooling used in cross-country analysis?

In prior studies (Barro [1991], MRW [1992], LR [1992]) the proxy used as a measure of human capital was the schooling enrolment ratios of the labour force. This measure is defined as

the number of people (regardless of age) enrolled to different schooling levels over the population of the age group that officially corresponds to that level of education. Schooling enrolment rates, steadily increasing for all countries across time, were found positively correlated with growth. These data, although widely available, are flow variables that do not measure properly the stock of human capital effectively available for current production.

These earlier measures have been rapidly substituted with levels of educational attainment and average years of schooling. The data set constructed by Barro & Lee (1993, 2000) refers to adult population and the attainment levels of education are calculated as the proportion of the population aged 25 and over (or 15 and over which roughly corresponds to the labour force in developing countries) who have attained the indicated level of schooling. The figures were constructed at five year intervals by using benchmark data on attainment levels from UNESCO census-surveys and then updated on the basis of school enrolment flows in succeeding years for each country at all levels of education. Although these estimates provide a reasonable proxy for the stock of human capital, they perform poorly in the empirical analysis. One reason can be attributed to the complex characteristics that embrace the concept of human capital, which are difficult to quantify with precision. Another reason is the relative small number of observations on which these measures are calculated which does not provide a sensible basis for panel estimations. Further reasons have to do with comparison of educational measures across countries especially when one wishes to correct for schooling quality. Using average years of schooling as a measure of human capital means to assume perfect substitutability of workers across different attainment levels and across countries by giving the same weight to any year of schooling independently of the level and the quality already accumulated (Mulligan and Sala-i-Martin [2000] Wößmann [2004]).

Moreover, by looking at this data set, it is easy to find anomalies (such as the decrease of attainment levels also for some OECD countries) which are hard to justify, given worldwide increases in the enrolment rates and in the average years of schooling. In OECD countries the average years of schooling per person aged 25 have increased from 9.3 in 1990 to about 9.8

years in 2000, for middle income countries the increase is much higher: from 4.0 to 4.9 years in 2000. The same is true for poorer countries (see the discussion of Barro and Lee [2000], Wolff [2000]). Therefore, incongruity in the estimates of human capital figures is reflected in the unstable value of the coefficient of education in regression analysis. When attainment levels are used the coefficient for secondary and higher education, which was expected to be positive according to the predictions of the NGTs, has been found insignificant and often negative. Only primary education has exhibited a positive correlation with growth in both developed and developing countries. A one percentage point increase in primary school is estimated to lead to a 2% point increase in per-capita GDP growth rate. As expected, the impact has been found to be larger for LDCs<sup>11</sup>.

A related issue is whether other approaches to estimate human capital are more appropriate to capture its role in output growth. Many attempts have been made to improve international measurements of human capital, such as weighted estimations by rate of return (rather than years of schooling), the use of student international test-scores to correct for quality of education. The International Adult Literacy Survey is an attempt at measuring directly the skills of the work force for international comparison, but data availability is limited to OECD countries.

To date the most widely adopted measurement still remains the data set of Barro and Lee and it is on their human capital measures that the ensuing discussion is based.

Overall, for samples of non-OECD countries, the impact of education on growth seems to be negative (Nerhu *et al.* [1995]). In other studies the correlation is positive but not very significant (Barro [1997], Islam [1995], Benhabib and Spiegel [1994]). The Behabib & Spiegel analysis is important for two reasons. Firstly, they find a positive coefficient in their regression when level specifications of education are introduced but a small negative coefficient when education growth is considered. Secondly, they suggest that the divergence in growth rates across countries may not be due to differences in the rate of accumulation of human capital, as

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<sup>11</sup> See the reviews of Sianesi and van Reenen [2003] and that of Wößmann [2004].

the Lucas (1988) model predicts, but to differences in the *stocks* of human capital in each country. It is this latter measure that would affect the ability to innovate or catch up with the technologies of more advanced countries. The *level effect* of human capital has been criticised on a number of grounds by some authors (see Pritchett [2001]).

Empirical studies have produced no strong support for increasing returns to levels of education. Spillovers from human capital have been investigated recently by Acemoglu and Angrist (2000). They use instrumental variable techniques to determine if the high correlation in the USA between average schooling and wage levels is driven by social returns from education. The authors found that the precise private return to education is about 7%, while social returns (around 1%) are not significantly different from zero. However, the finding of lack of spillovers at macro-level is inconsistent with micro data in which a wage premium at the individual level for human capital investment is observed.

Pritchett (2001), trying to explain the micro-macro paradox of empirical evidence, has argued that the impact of human capital on growth “has fallen short of expectations” for at least three reasons:

- (i) a perverse institutional environment that lowered growth by using educated labour for socially counterproductive activities;
- (ii) a mismatch between an increasing supply of educated labour and a stagnant demand;
- (iii) a poor quality of education that is not capable of creating human capital at all.

Although the Pritchett analysis is very stimulating and indicates routes for future investigation, we believe that the concern with this large and upsetting piece of empirical evidence has much to do with the ability to construct an accurate measure of human capital. As stressed by Dinopoulos and Thompson (2000) this fact, together with the impossibility of treating properly non-linearity in econometric modelling, may lead to empirical rejection of important factors of growth even when the model is adequate.

An enhancement in measuring human capital goes in the direction of the work by Hanushek and Kimko (2000) who have constructed indexes of educational quality. The adjustments of years of schooling for variation in quality is obtained by the two authors for 38 countries and are based on international tests of students' performances in mathematics and science. In the estimation of the nexus between schooling quality and growth rates the authors found a positive and significant correlation. Hanushek and Woessmann (2007) confirm these findings in a more recent work. By applying quality-adjusted measures of human capital international comparison reveals much larger skill deficits in developing countries than just school enrolment and attainment.

Other studies augment years of schooling by a proxy of the health status of the labour force (Weil [2001]). It seems that there are large cross-country variations in nutrition and health status and accounts of these differences improve the explanatory power of human capital on growth.

Attempts at measuring human capital externalities at the aggregate and local levels have not led to appreciable results. Findings about their existence may explain the puzzle between the high correlation of human capital and income observed in the data and the micro evidence, which suggests diminishing (or low) returns to education. The estimated Mincerian return to schooling of about 10% most likely understates the true value of these returns because it fails to take into account positive externalities generated by more skilled workers. Specifically, as claimed by Banerjee and Duflo (2005), the human capital externalities should be in the order of 20-25% to explain the cross-country relationship between education and income. Unfortunately, this value is too high if we compare it with the true value estimated in some studies (in the order of 3 to 5 %). A way to reconcile these conflicting results is Duflo's study (2004) that shows evidence of the presence of negative externalities. The argument is that workers that increase their investment in education are able to "inflict" losses on the less educated workers. She estimates that an increase of 10% in the fraction of educated workers resulted in a decrease of 4

to 10% in the wages of the older workers. This would suggest that any positive externality may be compensated by the declining returns that affect all the workers in the labour market<sup>12</sup>.

Measurement errors are the basis of the criticisms by Krueger and Lindhal (2000) for the lack of a significant and satisfactory relationship between the change in years of schooling and the growth rate. Correcting for measurement errors, however, does not reverse the value of the coefficient and the impact of schooling remains very modest.

To reassess the robustness of human capital in empirical analysis, Papageorgiou and Chmelarova (2004) have followed a promising line of research. Using a cross section of 46 OECD and non-OECD countries, the authors test the hypothesis of non-linearity in capital-skill complementarity and find that the hypothesis is strongly verified for non-OECD economies. Conversely, in OECDs skills are complementary with technological progress. Additional testing of the hypothesis would also shed light on the controversy about the two competing determinants of economic growth: input accumulation and technological progress. Evidence in favour of complementarity between embodied-technical-progress physical capital and human capital would increase the relative importance of input accumulation. This implication emerges from works by Galor and Moav (2000) and Kalaitzidakis *et al.* (2001). The former develops a model characterised by ability-biased technological transition in which an increase in the rate of technological change raises the returns to ability but generates a series of collateral effects that can lead to a productivity transitory slowdown. The latter study uses semi-parametric estimation techniques to uncover non-linearities between human capital and growth and provides evidence of their existence.

Although recent studies are very promising and consistent with the view of many endogenous growth models, the correct estimation of human capital, at aggregate level, is a serious question, which has not found yet a satisfactory solution. If human capital is measured

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<sup>12</sup> For a discussion and methodological issues on human capital measurement at macro level see Sianesi and Van Reenen (2003).

with errors, the coefficient estimates will be biased downward yielding inconsistent predictions of the NGTs.

### *3.5. Evidence on research-based models*

In this section we consider evidence on the research-based theories of economic growth. The critical variable in these models is R&D and spillovers that derive from this activity. The empirical evidence focuses attention on the second model of Romer (1990), Aghion and Howitt [1992], Grossman and Helpman [1991]), Parente and Prescott (1994) in which innovations and research spillovers generate sustained endogenous growth. Even if old models assign to autonomous and disembodied technical change a prominent role as a source of productivity growth, they have never considered spillover effects of R&D as a systematic force for narrowing the gap in labour productivity across countries. In this class of models of the NGTs, the presence of R&D spillovers may be the underlying force behind convergence. From the empirical validation of this promising group of models we can infer whether the “ideas gap” may generate differences in per capita income more than the accumulation of traditional factors. It would be highly reductive, however, to mark this body of literature as a description of a theory that stresses innovations over factor accumulation. This is because in each of the models mentioned there are deep interactions between human capital and embodied technological content in capital equipments.

The empirical analysis very often oversimplifies theoretical modelling and uses proxies available in the data that give a rough picture of the complexities of growth processes. As Jaffe (1996) claims “A possible excuse for the delay between the time Alfred Marshall talked about spillovers and the time economists made serious efforts to measure them is that they are inherently difficult to observe” (p.13).

To make the empirics of these models tractable it is necessary to overcome a series of problems that involve developing a metrics for measuring technological similarities and geographic proximities among firms as well as economic relationships among firms and

between firms and consumers. As we shall see the literature aimed at measuring R&D and related spillovers is exposed to complexities which overwhelm those aimed at measuring human capital. This means that the assessment of the effects of R&D productivity and spillovers through empirical analysis, despite the rapid progress in the quality of studies and econometric techniques, remains a controversial subject.

The most interesting piece of evidence on the issue comes mainly from studies that estimate the productivity or profitability of research efforts at industry or firm-level data. What is controversial in these studies is not the relationship between R&D and productivity, since microeconomic evidence has always confirmed a positive and strong relationship between the two (Lichtenberg and Siegel [1991], Mairesse and Sassenou [1991], Griliches and Mairesse [1990]), but whether econometric studies can characterise such a relationship in a satisfactory way. Regression-based studies to measure productivity growth at firm and industry levels are often not comparable for practical measurement problems in estimating social and private returns from R&D. What is typically estimated is a gross rate of return from R&D in different industries. To make them comparable a net rate of return must be computed. The problem that emerges is that the rate of obsolescence is not a constant but may vary among firms and sectors depending on the type of investment. Thus, the contribution to productivity growth can be greatly affected when R&D intensities are not corrected for depreciation.

Current studies have tried to measure elasticity and rate of returns to R&D. R&D elasticity ranges from 5% to 25% and the rates of returns from 10 to about 80% depending on the econometric methodology: cross-section or time series estimations (Hall and Mairesse [1995] Mairesse and Mohnen [2002, 2003]. Cross sectional estimations yield higher and more significant values than time series estimations.

It is known, however, that the central tenet of the NGTs is that R&D investment not only affects the economic performance of the firms that undertake these activities but has also an impact on the performance of other firms. The various attempts at identifying different type of spillovers related to R&D have led to a wide range of estimates by different researchers for

different industries and countries. The effect of spillovers is to create a gap between the private rate of return to R&D (the return earned by the firm undertaking the research) and the social rate of return, which includes all the benefits that accrue to the other firms and to the consumers. There is a plausible basis for the belief that the magnitude of social returns to R&D is very high. In fact the importance and the speed of these spillovers will vary depending on the nature of the research and in particular the products or processes embodying the research results. The estimates depend also on the ability of price agency to capture gains from innovations that derive from quality changes. These last category of gains, even if lower than those obtained directly from R&D processes, are generally not recorded (Griliches 1994). There are also learning processes involved in the implementation of innovations not captured by conventional measures.

Among the studies developed in the spillover literature it is possible to distinguish:

- (i) Contributions aimed at measuring spillovers within a specific economy at various degree of aggregation (firm, industry or country levels);
- (ii) contributions that provide estimates of spillovers across countries. An assessment of this second category of spillovers is reviewed in the next section.

However, the evidence seems to indicate that the magnitude of R&D spillovers may be large, implying that social returns to R&D are higher than private returns. Indirect measurements show estimates that vary from positive and very high returns to negative ones<sup>13</sup>. Some studies document that the private rates of returns to R&D are between 20 and 30% whereas the social rate of return seems to be in the order of 50% (see Nadiri [1993]). Despite the econometric boundaries of this type of analysis, this finding suggests that there is a large gap between private and social rates of return.-(see Wieser [2005] for a survey). It is worth noting that the majority of these studies tends to measure in the data not only knowledge (technology) spillovers but also market spillovers (rivalry effect of R&D), which are conceptually different.

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<sup>13</sup> The possibility of different spillovers (in the NGTs) is well known. Besides the positive spillovers there are also negative ones (see Jones and Williams [1998]).

Whereas technology spillovers are beneficial to firms, market spillovers may have a negative impact. The main criticisms raised in this literature is that econometric estimates of spillovers do not distinguish adequately among different varieties of spillovers.

Bloom *et al.* (2005) develop a methodology to separate market and technological spillovers and implement it on a large panel of US firms for the period 1981-2001. They find that both types of externalities are present and quantitatively important and that social returns to R&D are positive and about 3.5 times the private returns.

The improvements in the econometric methodology and available data – one of the major constraints in the measurement of spillovers – have been substantial in the last few years. It is worth mentioning a recent work by Cincera (2005) in which the author improves the Jaffe (1986) methodology in the construction of R&D spillovers among 625 intensive R&D firms over the period 1987-1994. Technological spillovers have been modelled by weighting the firms R&D stock according to their technology space measured by patent distribution. The total spillover pool has been split into local and external components and both show a positive impact on productivity growth. The study also confirms that social returns are higher than the private ones. Significant and robust estimates are obtained also by Griffith *et al.* (2004) using a panel of industries across twelve OECD countries. Their opinion is that the low value of spillovers found in previous studies – based mainly on US firms (characterised also by negative spillovers) – is that they failed to take account of the R&D based absorptive capacity of a country.

On macroeconomic ground the first finding of output elasticity of internal R&D stock and the rate of return to R&D investment have been found in the same range of microeconomic evidence (respectively 0.3 and between 20 to 40%) even if a higher value was expected (Lichtenberg [1992]). In the study by Verspagen (1996) the role of R&D is investigated for Germany, France and UK since 1960. The author shows that R&D accounts for about 25% points of productivity growth in the first two countries whereas for the UK the author is not able to reject the null hypothesis of no impact on the growth rate.

More recent econometric studies have provided increasing support to R&D models. Most of the estimates are statistically significant at the standard 5% confidence level. Eaton and Kortum (1997) document that in some OECD countries (Germany, Japan, the U.S. and France) more than 50 percent of the growth in productivity is due to R&D innovations.

We believe that the evidence on R&D and spillovers at firm and country levels makes less imperative the criticisms of R&D-driven growth models by Jones (1995b). What Jones criticises is that the model implies that a doubling of the number of scientists engaged in R&D means a doubling of the growth rate and this prediction is not found in the data. In the OECD countries, for example, there has been an increase in the number of scientists and in resources devoted to R&D with little or no increase in the growth rate. What these research show is that the theory does not contradict empirical observations, even though quantitatively it does not fit perfectly with the available data. Furthermore, is it plausible that the increasing in the number of scientists in the R&D lab in the US has increased the growth rate a decade later.

The challenge for future research is to implement models and methodologies suitable to measure technological progress and spillovers with increasing precision. On this perspective runs the recent work by Klenow and Rodriguez-Clare (2005). Whereas cross-country growth regressions based over the last fifty years do not show significant effects of R&D spending on income growth rates, the effects seem to be strong when the dependent variable is TFP. However, regression analysis is inappropriate, according to the authors, to capture accurately the magnitude and the significance of R&D spillovers, while model calibration techniques should be more appropriate. By using quantitative analysis the authors demonstrate that the world's GDP would be only 6% of its current level or, as they explicitly claim, "on the order of \$3 trillion rather than \$50 trillion if countries do not share ideas".

In the next section we explore the possibility that R&D spillovers were channelled by international trade. A country can raise its productivity by investing directly in R&D and also indirectly by trading with research-intensive countries.

### 3.6. Evidence on international spillovers

The question of interest for economists is not only the relationship between R&D investment at firm, industry or country levels but how R&D spillovers explain cross country differences in growth rates. It is reasonable to believe that a country productivity growth depends not only on the accumulation of its R&D but also on the R&D performed by other countries. The literature on *international knowledge spillovers* has not a long tradition and has concentrated mainly on international spillovers driven by trade (Coe and Helpman [1995]), distance (Eaton and Kortum [1997]), as well as trade and foreign direct investment flows (Lichtenberg and van Pottelsberghe de la Potterie [1996]), foreign patenting (Nadiri [1993], Mohnen [1996]). But obviously the list can continue since there are other potential transmission mechanisms, such as licensing agreements, joint ventures, and the international migration of scientists and engineers, which have been less investigated in the current literature (see Bernstein and Mohnen [1998], Görg and Strobl (2005)).

Here, the emphasis is on spillovers driven by international trade, which are an important ingredient of the NGTs. Even if scholars generally agree that international trade may have positive effects on per capita income and on the level of productivity of an economy, they also claim that the reverse may be reasonable. In the NGTs there is an array of models which imply that great openness has growth effects, although the impact on growth rate remains ambiguous (Grossman and Helpman [1991], Matsuyama [1992]). In the Lucas model (1988), for instance, the economy can grow more rapidly, providing that its comparative advantage at the time of opening is in an industry with faster learning by doing. Along the same lines, however, there are models (Young [1991]), in which free trade could lead to a decline in growth rates of countries with no comparative advantages as often occur for LDCs.

In this section we review the most noticeable empirical studies based on the link between the degree of openness and the growth rate as well as the estimated magnitude of international spillovers from R&D, which can be transmitted through international trade. The widespread belief is that both domestic and foreign R&D act as engines of economic growth.

Eaton and Kortum (1997) show that even a technological leader such as the US would have grown less than half if it had been isolated.

The majority of existing studies of international R&D spillovers estimates simple Cobb Douglas production functions where for each country both domestic and foreign R&D enter as inputs. Much of the empirical work has been spurred by Coe and Helpman (1995)'s paper. They show that TFP growth during the period 1971-1990 in some OECD countries was affected by the increase in domestic R&D but also by foreign R&D and this impact is higher the more open is the economy. They construct for every country of their sample (21 OECD plus Israel) a stock of domestic knowledge based on R&D expenditure and a foreign R&D capital stock. The equation estimated is:

$$\log F_i = \alpha_i^0 + \alpha_i^d \log S_i^d + \alpha_i^f m_i \log S_i^f$$

where  $i$  is a country index,  $\log F$  is TFP,  $S$  with superscript  $d$  and  $f$  represent respectively domestic and foreign R&D capital stocks, the latter being defined as the import share weighted average of R&D capital stock of trade partners.  $m^i$  stands for the fraction of imports in GDP,  $\alpha$ , is the elasticity of TFP with respect to domestic and foreign R&D capital stocks. The main results are that smaller countries benefit from foreign R&D more than large countries, with the greatest impact on Belgium, followed by Ireland, the Netherlands and Israel. Estimates suggest also that international spillovers are very high and that R&D expenditure raises productivity in foreign countries as well as in the domestic economy.

International R&D spillovers are the focus of another paper by the same authors (Coe *et al.* [1997]). They provide quantitative estimates of international spillovers for a group of 77 countries over the period 1971-90 by examining the extent to which less developed countries, with low R&D of their own, benefit from R&D performed in industrial countries. The estimated equation differs from CH (1995), in which spillovers were studied among industrial countries, in three main respects: (i) the specification of the regression equation includes a proxy for human capital; (ii) only foreign R&D is included; (iii) the measure of openness to trade is

defined as the ratio of imports of machinery and equipment imported from industrial countries to GDP. The results imply that TFP of developing countries depends positively and significantly on all the factors mentioned.

Their model highlights the importance of trade as vehicle for technological spillovers and their estimates suggest that spillovers from industrial countries (the North) to developing countries (the South) are substantial. More precisely, on average an increase of 1% in the R&D capital stock in the US raises output in the developing countries by 0.06%, while a similar increase in R&D in other countries, namely Japan, France, Germany and the UK, increases TFP in the developing countries only by 0.004% to 0.008%.

Keller (1998) questions the results of CH that R&D spillovers are trade related. He runs the same regressions with the only difference that foreign knowledge stock is replaced by a random variable, which is computed on simulated import patterns. The estimated R&D international spillovers, based on simulated foreign knowledge stock, are larger than the coefficients based on the “true” foreign knowledge stock. This casts doubt on the reliability of CH’s results since counterfactual trade patterns generate a better empirical fit. The use of trade-weighted R&D capital stock implies that all international knowledge flows through imported goods. The criticisms are that the import composition of a country does not necessarily matter for growth in the way predicted by recent growth theory of openness and growth.

Other criticisms to the CH paper come from Lichtenbergh and van Pottelsberghe (1998) and Luintel and Khan (2004). Even if these authors question the econometrics in the paper of CH, such as the indexation scheme that biases the measurement of foreign spillovers (the first paper) or the modelling of dynamic heterogeneity of knowledge diffusion across countries which depends on the countries’ organisational structure and social capability for absorbing international technology (the second paper) both studies still confirm significant spillovers, although of reduced magnitude. The novelty of Luintel and Kahn’s study is that the US international R&D spillovers are significantly negative for total R&D data.

In all the previous literature the time lag structure of R&D spillovers has not been considered adequately. In CE, for example, diffusion of technology is instantaneous whereas some recent studies show that an estimated period of about four or five years is necessary for investment in R&D to impact on productivity and in specific cases for incorporating new technologies in both final goods and intermediates.

A distinctive further criticism in measuring the impact of externalities across borders is addressed in the paper by Meister and Verspagen (2005). The authors point to the important distinction between *knowledge* and *rent* spillovers. The former are externalities arising from the public good character of knowledge and do not require engagement in economic transactions. To separate both types of spillovers, in order to avoid measurement errors in attributing “productivity increase to wrong entities”, the authors suggest the use of technology flow matrices that use patent data. Patents are classified in terms of their technology class and a matrix represents the share of all patents generated in a sector that spillover to all other sectors. If a patent is classified in more than a single class which belongs to different industries, then this is taken as a spillover between sectors. Their exercise show that European TFP gaps relative to the USA would not be narrowed very much by an increase in R&D intensity according to the Barcelona target of a share of R&D of 3% for European countries.

Against the widespread character of knowledge flows is the paper by Maurseth and Verspagen (2002). They study the patterns of spillovers between European regions by using patent citations<sup>14</sup> and their findings support the hypothesis that there are relevant barriers to technology transfers. Spillovers occur between geographically close regions that belong to the same industry or the same country and are limited by language differences and country borders.

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<sup>14</sup> There is a body of empirical literature that uses patent citations as an indicator of knowledge spillovers. The rationale of patent citations is based on the argument that knowledge contained in the cited document has been useful for the development of the patent. Thus citations are an indicator of transmission of knowledge between inventors. We do not review this literature since the drawbacks of using patent data are quite large (see Griliches [1990]). The main concern is that the quality of patents varies widely and their effects are not comparable across countries. We believe however that patent citations may be quite useful in studying spillover from specific technologies.

Comparable conclusions were achieved in the paper by Nadiri and Kim (1996) in a different theoretical framework. They use a translog-cost function to capture spillovers for the highly industrialised G-7 economies. The rate of return to domestic R&D ranges between about 14 and 16% and the total return to R&D (private plus spillovers) is about 23 to 26%. The measurement of bilateral spillovers varies consistently among countries. While the R&D spillovers from the US to other countries are sizable, in Europe only Germany acts a source of spillovers while the other European countries were receivers of spillover benefits. Even if international R&D spillovers have contributed to narrowing the productivity gap between the US and the other G-7 economies, the evidence indicates that their magnitude is rather modest.

The works reviewed at micro and macro levels on research-based models indicate that, even if our knowledge and measurement of domestic and international spillovers is still rudimentary, there is no doubt that the phenomenon exists and is sizeable. Further researches are desirable for a clear understanding of modes of diffusion and appropriation of R&D spillovers across industries and across countries.

### **3. Evidence on Public policy and institutions**

The evidence on public policy, with some exceptions (Fisher [1993], Easterly and Levine [2001], Easterly [2005]) should be extracted by general regressions. There is a large literature on regressions of this sort. The impact on growth is obtained by looking at the sign of the coefficients of policy variables typically included among a broad number of other preference and technology parameters. The issue is now becoming an expanding area of research and public policy and institutions seem to dominate other more traditional growth factors in accounting for differences in per capita income and growth rates.

Before discussing empirical issues on public policy, it may be noteworthy to briefly summarise the major theoretical issues that have been raised by the NGTs with respect to the preceding literature. The main distinction between new and old theories of growth is not simply the modelling of non-convexity. This would be of limited importance if the predictions drawn

from these new models were roughly the same as the basic neo-classical one. Their peculiarity is the modelling of these non-convexities in such a way that the determinants of the growth rate are variables, which could be affected by government policy. That government policy influences the performance of an economy was well known by many economists but little progress in economic modelling took place in this direction. In the orthodox theory growth is an exogenous process and government policies have only level effects. The growth effects were limited to transitional phases. In the NGTs, on the contrary, government policies can affect the growth rate permanently.

In the NGTs the policies favouring R&D, education, saving rates, are all conducive to enduring productivity growth (Barro [1990], King & Rebelo [1990], Rebelo [1991], Jones & Manuelli [1990], Jones, Manuelli & Rossi [1991], DeLong and Summers [1991], Turnovsky [1996]). Policies capable of affecting growth also include, in a significant way, improvements in financial institutions, industrial relations, as well as law, order and justice. Some economists have stressed different degrees of democracy in developing countries to explain the differentials in growth rates that we observe. Further insights can be gained by focusing on some socio-cultural factors that have been revealed as historically important in case-study-growth processes.

Obviously, government policy is central to the NGTs, not only because of its focus on the determinants of growth which respond to incentives, but also because the externalities, involved in the growth process, create a general role for the government to correct the sub-optimal result generated by the market. The competitive result determines a level of saving that is too low relative to the social optimum because private agents do not take into account the effect of the externalities. Most of the models present non-optimal equilibria creating places for policies of different species. Furthermore, with increasing returns the theory is consistent with permanent maintenance of unequal growth. Increasing growth rates, as in the models of Romer (1990), Grossman and Helpman (1991), imply that there is a tendency to divergence across countries with different levels of income. Therefore, these models exhibit a multiplicity of

steady state growth paths. Again, with multiple equilibria economic policy really matters in choosing the more appropriate equilibrium path.

Unlikely, the wide variety of models, the multivarious sources of growth, and the highly aggregated content of the NGTs can lead to policy ambiguity and imprecisions (see Fine (2000)).

We will discuss dysfunctional tax policies in the next section but there is a piece of evidence that pertains to general discussion on public policy and growth as a whole, which deserves some reflections. Low persistence of growth rates observed empirically should imply that if public policies are central determinants of growth they should be themselves not persistent. Evidence by Easterly *et al.* (1993) shows, instead, that country characteristics and national policies are much more stable over time than growth rates and this finding suggests that policies account for income level effects more than for growth effects. Stability of policies and instability of growth rates are inconsistent with the AK model. The provocative title of the paper, "Good policy or good luck?" makes clear that some growth events may be driven by random shocks more than public policy.

In a more recent paper Easterly (2005), using variables that capture distinct dimensions of national policies, finds important growth effects. In particular, the author, by including in growth regressions bad policies (inflation, black market premium, real overvaluation index, budget balance) and good policies (financial depth and trade openness), provides evidence that all the coefficients of the six policy variables are stable and statistically significant. However, when extreme observations of policies (defined by the author) are excluded from the analysis all the six variables become insignificant. The result suggests that the effect of policy is significant only if countries undergo extreme national policies but there is no reason to expect significant growth effects from moderate changes. From these asymmetries of results the lesson that can be drawn is that bad policies may have a great potential for growth destruction whereas the potential of good policies for fostering long run development is rather modest.

Despite the interesting analysis in the paper just mentioned, we believe that models in which policies are important determinants of growth are worthy of the greatest attention. The

argument is explored by looking at the evidence on fiscal and monetary policies in the next subsections.

#### *4.1. Fiscal policy and growth*

The ambiguities delineated above can be found in the literature that has explored the effects of fiscal policy on growth. Models of the NGTs have stressed their role as a key determinant of long run growth. Using an extended AK model, Barro (1990) found that there is a fraction of government expenditure and a tax rate on output that maximises growth and welfare. The main hypothesis in Barro's model is that government expenditure is of the kind that increases productivity in the private sector of the economy (government consumption expenditure or more exactly unproductive government spending is missing from the analysis). However, since government expenditure must be financed, it requires distortionary taxation. If the size of government is small the positive effect of expenditure on private productivity dominates the negative effect of taxation.

Subsequently, many models have explored the link between taxation and growth. Rebelo (1991), Milesi Ferretti and Roubini (1998a,b), Devereux and Love (1994), Pecorino (1994), Turnovsky (2000), Devarajan *et al.* (1996), Kokerlakota and Yi (1997), Bleaney *et al.* (2001), Peretto (2003) are only some examples of an expanding literature. In an endogenous growth perspective these studies show that the equilibrium growth rate depends on the structure of taxes, which are generally growth reducing. All models imply that taxation has distortionary effects on growth and as is familiar from intertemporal Ramsey-type models (Chamley [1981, 1986]), these distortions are higher if it is physical capital income that is to be taxed. This is because a tax on capital income, in a growth setting, induces distorsions by reducing the incentives to save and invest with direct effects on the long run growth rate.

However, the standard outcome in public finance that taxation should be levied less on physical capital and to a greater extent on labour is no longer valid. In some classes of models in which both factors – physical and human capital – can be accumulated taxes levied on both

factors can have a negative impact on growth (Milesi-Ferretti and Roubini [1998a]). So the only taxes that are not growth-reducing are lump sums and on consumption (when in the model labour supply is exogenous).

A limit of the majority of these models is that they investigate the effects of taxes without taking into account its counterpart that is government expenditures. If expenditure is productive, such as expenditure on education, R&D, defence, and infrastructures, taxes are not necessarily growth reducing (Jones, Manuelli and Rossi [1993] Turnovsky [1996], Capolupo [2000]).

With endogenous labour supply, Turnovsky (2000, p.199), has shown that, since an increase in the tax-financed fraction of government consumption induces workers to devote a large fraction of their time to work, it can increase the long run growth rate. In a recent paper Peretto (2003) shows that taxation on labour income and on consumption has no impact on the steady state. Both kinds of taxes have only a *level effect* and the impact on growth rates comes mainly through taxes on assets and corporate income.

This brief summary of the literature makes it clear that the impact of policy is not yet well settled. Changing some assumptions of the model as well as modes of government financing can lead to different effects on the performance of the economy. Most of the empirical evidence on public policy is based on the use of Real Business Cycle techniques. The approach involves specifying explicit theoretical models which are then calibrated and parameterised so as to derive quantitative implications (see McGrattan and Schmitz (1999) for a review of evidence based on this approach). In general, however, what emerges from these studies is that the adverse effects of different taxes on the equilibrium growth rates rank in terms of distortionary impact according to the following sequence: tax on physical capital > tax on wages > tax on consumption > lump sum taxes (Turnovsky [2000]).

On the econometric side the findings are not more reliable than quantitative analyses with results that are extremely mutable. The econometric finding of Barro's seminal work, is in contrast with his theoretical result: government expenditure is negatively correlated with

growth. While some studies show a negative effects of government expenditure and taxation [Fölster and Henrekson [1999], others open the possibility that the effects may be positive, (Easterly and Rebelo [1993], Fisher [1993]). Yet, while some works reach agnostic conclusions (Agell *et al.* [1997]), others confirm *exactly* the prediction of Barro's (1990) model with public policy. We refer to the paper by Kneller *et al.* (1999). The authors show that if the budget constraint is specified correctly, which means that both expenditure and taxation must be considered properly, then Barro's predictions are accurate. Specifically, they find for a panel of 22 OECD countries (1970-1995) that: (i) distortionary taxation reduces growth while non-distortionary taxation does not; (ii) productive government spending enhances growth, whilst non-productive expenditure does not. Quite apart from robustness and significance of the results of this specific study, one point must be emphasised. When we want to evaluate the impact of taxation on growth, the regression must include expenditure variables otherwise the estimates will be biased by the omission of the variables, which might have positive effects on growth.

Bleaney, Gemmel and Kneller (2001) have replicated the results of the Barro model in a subsequent paper. They illustrate, without ambiguity, the positive long run effects of government policy on growth. However, more than other econometric tests, the estimate of the impact of government spending on growth is very problematic. First, different data quality may induce measurement errors in the estimating equation. Second, there are problems of endogeneity bias and omitted variables that can be correlated with the public sector. Some researchers have shown that when initial income is included in the regression the coefficient of government expenditure on GDP becomes positive. Third, there is a substantial identification problem, which derives from a two-way causation link between the size of the public sector and growth depending on supply and demand side relations. The first is crucial to identify the impact of public spending on growth but finding a set of instrumental variables that isolate the demand side effect seems quite impossible (Slemrod [1995], Agell *et al.* [1997]). This lack of robustness in the empirical findings adds to the negligible effects of taxation found in the quantitative method with calibration of theoretical models (Stokey and Rebelo [1995]).

Some robustness characteristics have emerged from time series studies. Kokerlakota and Yi (1996, 1997) provide evidence that tax measures significantly affect growth only if public capital expenditure is included in the regression. Their studies are worthy of further comments. The aim of the authors is at testing exogenous versus endogenous growth models using time series data. In the first study (1996), they regress GNP growth rates in the US, for the period 1917-1988, against lags of GNP growth rates, and seven policy variables, and test the hypothesis that the coefficients of the lags of these variables are zero. This should occur in the case of an exogenous growth model. The policy variables used are some measures of taxes, public physical investment and one measure of monetary policy (growth rate of  $M_2$ ). The sum of the slope coefficients for each policy variable was found to be non-zero, which implies that permanent changes in government policy have a permanent effect on growth rates. In the subsequent paper (1997) the two authors extended the analysis also to the UK using time series data up to 160 years and concluded that the results support endogenous growth models that emphasise constant return to reproducible factors at the aggregate level. The results therefore indicate, as theoretically expected, that policy variables exert a long and persistent effect on growth.

A final observation on cross-country regressions is that the majority of earlier studies reports non-robust correlation, either positive or negative, between tax – spending variables and growth and this did not allow any persuasive conclusion about the effects of government on growth.

However, successive empirical works have addressed the question of the impact of productive government spending (i.e., infrastructure, health, etc. ) on growth. Whatever the endogeneity problems are, the findings seem to be robust and crucial especially for developing countries (Batina [1999], Canning [1999]), Esfahani and Ramirez [2003]).

The observation that historically many development miracles have been spurred by good government policy suggests that the methodology of growth empirics should be improved so as to settle satisfactorily this controversial subject.

#### 4. 2. *Institutions and growth*

A general implication that arises from the studies reviewed is that institutions may have strong effects on the growth rate and on the level of per capita income. Their impact is not direct but can be substantial. As said at the outset, for some authors institutions are *deep* determinants of growth in contrast to the *proximate* growth factors that have been discussed at length in the previous sections. According to the *institutions view*, pioneered by Acemoglu *et al.* (2005), neither the neoclassical framework nor that of the NGTs informs us much about the ultimate sources of differences in economic performance. The observation that one country is poorer than another, because of worse technology or capital accumulation, does not explain why this is so. It is very likely that these differences should be caused by other, more fundamental, factors.

The argument recently debated in the context of the empirics of growth is whether institutions dominate over other traditional factors (Dollar and Kraay [2002, 2003], Rodrick, Subramanian and Trebbi [2004]). Not all researchers agree on the use of proxies for institutions in the empirical growth framework by arguing that their qualitative characteristics cannot be transferred in a quantitative index. Indeed, econometrically the quality of institutions is measured by different indices of accountability, property rights, rules of law, religion, degree of contract enforcement, government effectiveness, social capital etc. Commonly, these indices are built in a point of time through surveys or are collected at five-year periods. The series are very short and typically start from the 1980s. This means that their contribution to the cross sectional variation of income levels or growth rates can only be vaguely tested. Moreover, like other factors, institutions are endogenous and it is necessary to find appropriate instruments to test their impact on growth rates.

There is already considerable empirical work that suggests that a crucial aspect for countries to grow at different rates is the extreme diversity in institutions and public policies that establish the socio-economic environment in which people produce and exchange goods and services. Economic institutions determine the incentives as well as the constraints on

individuals and groups in the society by affecting the distribution of resources. As pointed out by Easterly and Levine (2001), divergence is inconsistent with growth that is driven by factor accumulation. If returns are diminishing then factor returns should converge across countries. Differences in institutions and other country-specificity may prevent factor convergence by reducing physical and human capital accumulation. Countries with secure property rights, rules of law and a good quality of political institutions should exhibit high growth, whilst countries whose environment is characterised by corruption, expropriation, limited democracy, and insecure physical and intellectual property rights discourage growth of output and generate a diversion of resources. Institutions that may affect the efficiency of an economy refer to aspects of government and political reforms that are related to the possibility to carry out profitable economic transactions. To a larger extent, it is possible to include in the institutional variables also those that have been treated separately in the previous part of this section. Country policy variables may include schooling, openness to trade, the size of government, credit and financial variables, tax policy etc. All of these are in many instances institutional variables. If so, then, institutions and policy variables have a potent role in the growth process. If a distinction is to be made between the *institutions view* and the *policy view*, the former with respect to the latter, holds that geographic and historical conditions produce lasting effects “ by shaping economic development today” (Easterly [2005], p. 1054). A further problem rises on testing the institutions view. As claimed by Durlauf *et al.* (2005) empirical evidence on the consequences of democracy may not permit any progress simply because the past century does not provide examples of stable democracies among poorer countries.

Here, however, we examine institutions as a set of social arrangements including indices of democracy, rules of law, trust among individuals, which a vast number of empirical studies have shown to affect growth.

By considering different institutional variables, simple indexes of democratic rights do not seem to be significant in the regressions performed so far. Once the other explanatory variables are held constant, variations in democracy are not systematically linked to the rate of

economic growth (see Barro [1997], Acemoglu *et al.* [2001]). It must, however, be pointed out that this variable may operate indirectly from democracy to other independent variables, which have proven to affect growth.

Like democracy, also the political instability variable defined as an average of revolutions and political assassinations (civil disturbance), affects growth, but not significantly. Not surprisingly, the estimated coefficient is negative (an increase in political instability by 0.12 in the period 1965-1975 lowers the growth rate by 0.4 percentage points per year) but, because of difficulties in collecting data for many countries, the proxy used for the variable is open to criticism. Data for political rights are those collected by Gastil (1987). However, this data set does not refer specifically to aspects of government accountability that affect economic transactions and property rights. In the growth regressions, data from Knack and Keefer (1995) have, in fact, been widely used. Other criticisms refer to potential identification problems: if omitted variables determine institutions and income we would spuriously infer the existence of a causal relationship from biased regression coefficients.

Even though evidence should be regarded with caution, a growing literature has documented the importance of institutions for growth. If one asks whether institutions have been inserted in the theoretical framework of the NGTs, the answer is no. However, Acemoglu *et al.* (2005) claim that it is crucial in the future agenda of the research program of the NGTs to go beyond models that focus exclusively on proximate determinants of prosperity. As already stated we need a theory, which explain why different countries have different economic and political institutions and a theoretical framework that includes them (p.463). Scholars such as Hall and Jones (1999) and Acemoglu *et al.* (2000, 2001, 2005) seem to believe firmly that the explanation of comparative growth is due to differences in institutions. It is reasonable to infer that weak institutions may have a negative impact on economic performance. As claimed by Solow (2005) the emphasis on the role of institutions opens up the possibility of connecting growth theory with theories of economic development in which issues of institutional change

are central (p.6). But the same author expresses scepticism about firm conclusions on this theme.

Other proponents of this view include, La Porta *et al.* (1998), Shleifer and Vishny (1993), Sachs and Warner (1995, 1997), Knack and Keefer (1995, 1997), Perotti (1996), Dollar and Kraay (2003), Tabellini (2005).

The studies just cited take a broad view of institutional variables. Institutions are considered as a collection of laws, government policy, regulations and so on. Hall and Jones (1999), for instance, include in their econometric framework the language spoken in a country as a measure of good institutions, so that countries that inherited the English language are assumed also to inherit English institutions. Moreover, they included in their study different indexes of government, (such as laws and regulations favouring production, private ownership). The finding is that differences in these institutional variables are fundamental to capital accumulation. In particular:

- Differences in institutions are associated with a large fraction of the variation of GDP per capita across countries;
- Institutions affect GDP per worker strongly. A low institutional index reduces capital stock, the accumulation of skills, and TFP.

Sachs and Warner (1995) use an index of institutional quality taken as an average of sub-indexes for rule of law, bureaucratic quality, and corruption available in data in the *International Country Risk Guide*<sup>15</sup>. The estimated cross-country regression coefficient of the institutional quality index found (for the period 1965-1990) is about 0.32 (*t statistics*: 3.8) which is the highest value among the coefficients of all other independent variables included in the

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<sup>15</sup> This Guide is a publication that provides data on the quality of political institutions with respect to the riskiness of investment. The data are available for 111 countries. Knack and Keefer have constructed five measures of institutional quality: rule of law, corruption in government, quality of the bureaucracy, expropriation risk, repudiation of contract by government. These indexes can take values from 0 to 6 with the maximum value indicating the most favourable environment. Other institutional indices are: Jagers and Marshall (2000) known as Polity IV Project and Kaufman *et al* (2003). Another recent set of data is from Gwartney *et al* (2002).

regression. The estimate is robust to the inclusion of several other variables suggested in the literature.

There are many other studies that measure through growth regressions the impact of various institutional indexes on growth rates. The work of Barro (1997) suggests higher priority in exploring the impact of these factors on growth performances.

But the main novelty in this approach comes from the work of Acemoglu, Johnson and Robinson (2001). They propose a careful econometric treatment of instruments to solve the endogeneity problem of institution quality in cross-country regressions, by using “exogenous” mortality rates amongst early European settlers in the New World as instruments. The idea starts from the observation that European colonizers erected solid institutions and rule of law in places in which they encountered relatively few health hazards and where they settled in large numbers (the US, Canada, Australia and New Zealand) whereas in less healthier areas their interest was limited to exploiting resources. Therefore the crucial determinant of whether Europeans chose the colonization strategy of extractive institutions with no interest in building solid institutions was based on their settlement. The decision to settle was dependent on the widely different mortality rates they encountered in these colonies. These potential settler mortality rates constitute the exogenous sources of variation of institutions that explain economic development. They show that colonial origin is strongly correlated with current economic performance. From an econometric point of view, colonial origin, measured by mortality rates used as instruments in growth regressions, are adequate to solve endogeneity problems. AJR (2002) focus on another important aspect, besides mortality rates, to explain differences in institutions and their effect on per capita income. The authors document that in more densely settled areas, Europeans were more likely to introduce extractive institutions because of the large benefits for them of exploiting both the work force of the indigenous population and the existent system of collecting taxes and tributes. These candidates as sources of exogenous variation in institutions may not influence output directly but, by affecting institutional development, they may have a strong influence on economic growth.

The recent paper by Dollar and Kraay (2003) examines the effects of a composite indicator of institutional quality (as well as trade) on per-capita income and found that property rights and rule of law cannot be measured properly because of endogeneity problems and collinearity with other growth variables. Generally, countries are perceived to have good institutions because they are rich (Dollar and Kraay, p. 138). Results are non robust and the positive correlation between institution quality and growth vanishes when a few countries are dropped from the sample (the US, Canada, Australia and New Zealand). In short, it is not possible to disentangle the partial effect of institutions by other variables. A comment by Pritchett (2003) on this paper argues that the weak significance of the institutional coefficient may be due to the method of IV used and to the choice of an instrument that is not appropriate to produce good information about the coefficient of interest.

Particularly attractive is the paper by Rodrick *et al.* (2004). Using a new data set collected by Kaufman *et al.* (2003) their institutional variable is a composite index of government effectiveness. Their results show the supremacy of institutions over other growth determinants, such as geography and trade openness. However, the authors point out that, although property rights are extremely important, nothing can be said about the proper form that they should take to boost growth. The recent experiences of China, which still retains a socialist legal system, and the private property rights system in Russia, offer examples that what matters for institutions is the possibility to spur incentives which are conducive to desirable economic behaviour.

Another historical example, the different patterns of growth of North and South Korea, has motivated the paper by Glaeser *et al.* (2004). They re-examine the debate (institutional view against development view) on whether political institutions cause growth and conclude that it is education (human capital promoting institutions) and wealth that lead to institutional evolution. They argue that: (i) the majority of institutional quality indexes are "conceptually unsuitable" to test the institution-growth nexus, (ii) the instrumental variable techniques used to control for endogeneity are conducive to flawed regressions. The suggestive conclusion of their paper is

that poor countries can get out of poverty traps even if are dictators to pursue good policies (i.e. the case of South Korea which started with dictatorship) mostly those which promote human capital accumulation and consolidate pro-market mechanisms devoted to assure property rights and rule of law.

An analogous view on the importance of human and social capital in determining the evolution of institutions, is expressed in the paper by Djankov *et al.* (2003).

Since the term institutions means different things to different people, the specific institutions and channels through which these institutions positively influence market growth are still unsettled but the topic is gaining growing interest by economists.

The emphasis has been argued should be about the role of the state and its quality: It is not important the size of the government but its effectiveness in encouraging good habit and behaviours of its citizens, build new capacity in the public administration and create regulatory regimes that influence positively investments, innovations and competition. We plot some of the worldwide governance indicators recently updated by Kaufman *et al* (2006) (now measured yearly) against economic performance measured by the average growth rate of the countries in the international data set of Heston *et al.* (2004). The correlation seems positive but simple visual correlation is not sufficient to show any causal link between the two. In Fig 1 the indicator used is Voice and Accountability that measures to what extent a country's citizens are able to participate in selecting their government, while in Figure 2 government effectiveness indicates the quality of public services and the degree of credibility of government's commitment to quality policies. It is worth noting in the inspection of the graphs that global averages of governance display no marked trends during 1996-2005. The impact is more evident if average GDP levels are considered (Fig. 3 and 4).

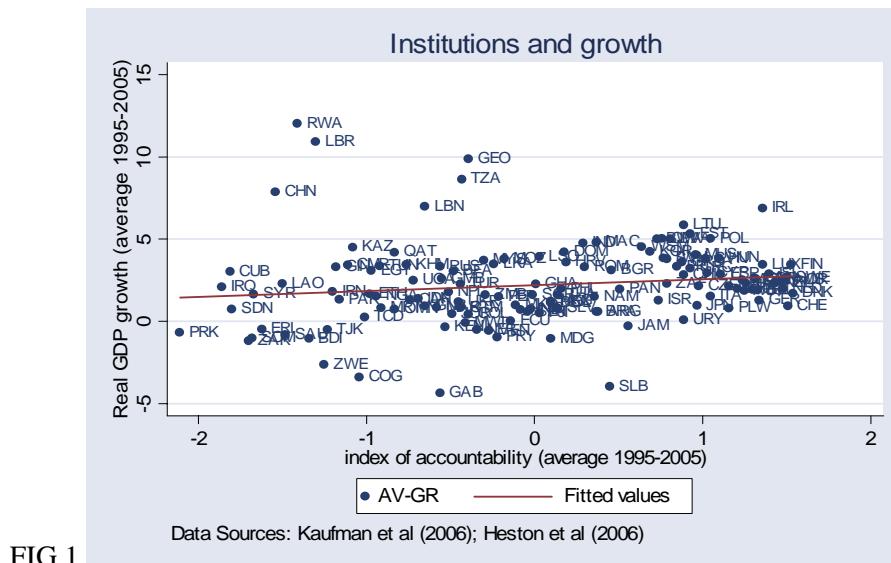


FIG 2

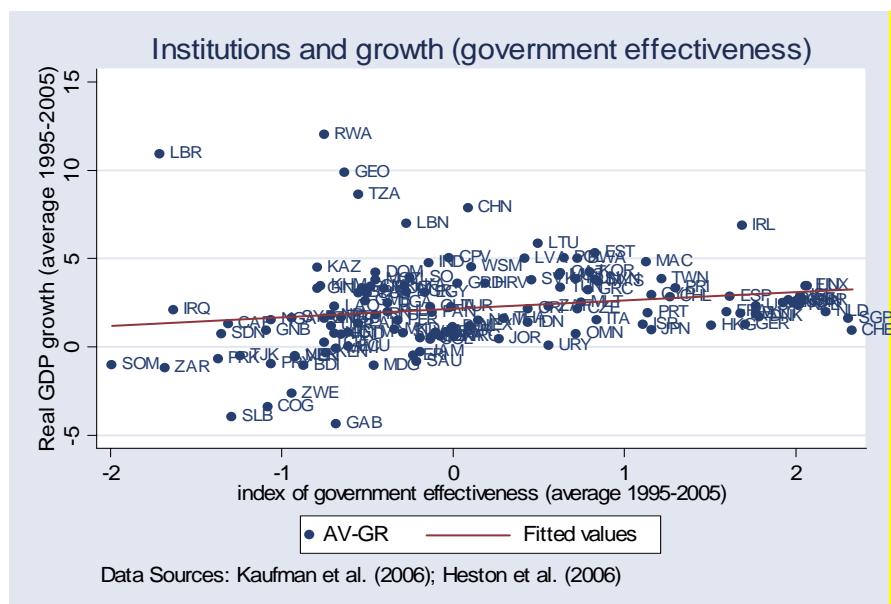


Fig. 3

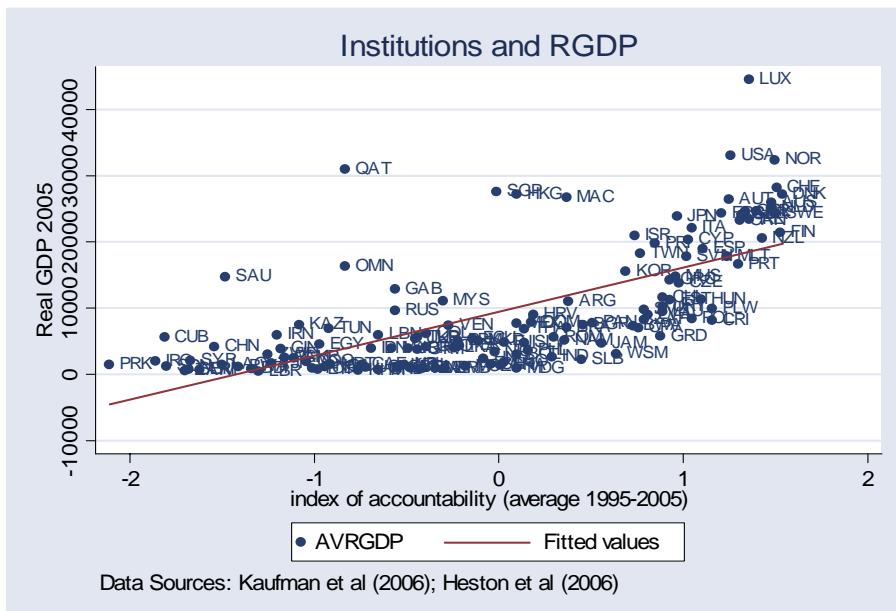
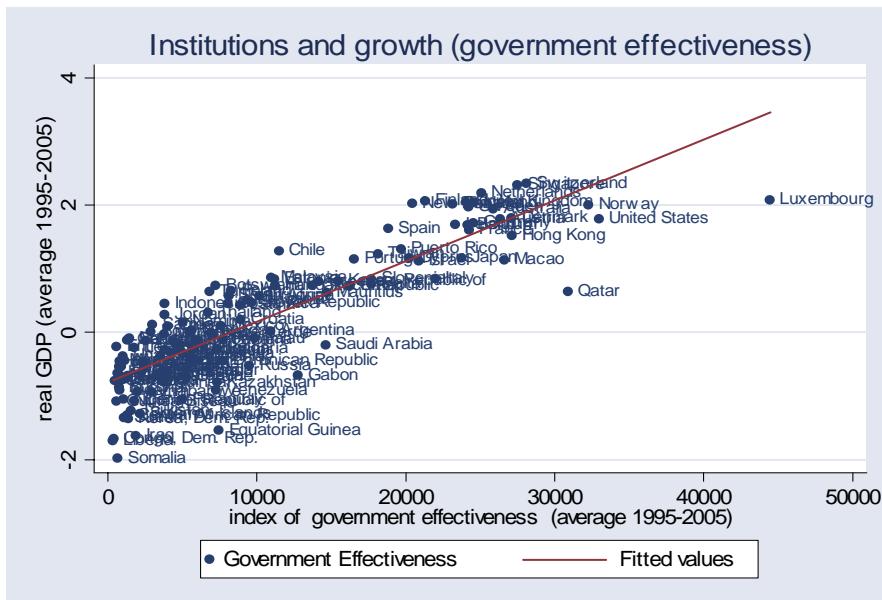


Fig. 4



Whatever the empirical evidence, it should be recognised that the predictions that appropriate outward looking government policy and institutional reforms may help in strengthening long run growth performances, is not only appealing to the profession and to policy-makers, but is also historically founded. However, also the view of Djankov *et al.* that

institutions have only a second order effect on economic performance and that human and social capital predominate over institutions, needs further investigations.

Before concluding it is worth noting the rise of some controversies in this field of research between economists that join the *institutions view* against those that join the *culture view*.

Quoting Acemoglu (2006), there are two major differences which establish different roles in economic performances:

“First in the institutions view, it is the social organization of the society, which at least in theory is changeable, that is responsible for prosperity. Instead in the culture view, culture or social capital, to a first approximation, cannot be changed. Second, the institutions view emphasizes much more the importance of conflict between different groups or individuals as a determinant of social outcomes, whereas there is a more cooperative undertone to the culture view (especially in the social capital version of this view). Finally, many versions of the culture view, such as those of Max Weber or Landes, emphasize religion or other predetermined factors as crucial determinants of individual’s approach to life and economic success” (p.88)

The role of social capital on the growth rate, therefore, according to Acemoglu, pertains to the culture view and it is treated briefly in the next section

#### 4.3. *The role of social capital*

Indeed, an additional important piece of evidence on institutions and growth is represented by the role of social capital on country-performance. In an influential paper, Knack and Keefer (1997) present evidence that the main determinant of social capital, proxied by indicators such as TRUST and CIVIC NORMS, characterise the institutional structure of a country. These two indicators are stronger in countries with higher and more equal incomes, with institutions that restrain predatory actions and prevent government from acting arbitrarily. Based on survey data for a sample of 29 countries the finding is that a 1 standard deviation change in Trust is associated with a change in growth of more than one half (0.56) of a standard deviation, almost as large as the coefficient of primary education. Since countries in Western Europe form half of the sample, the two authors infer that these variables may have a larger impact in poorer economies, if backwardness is explained by lack of mutual confidence. More surprisingly, it seems that social capital measured by horizontal networks (membership in groups) is unrelated

to growth. These results are in contrast with the findings in Putnam (1993), Helliwell and Putnam (1995) and Narayan and Pritchett (1997).

An interesting line of inquiry to test the importance of social capital in growth performance is pursued by Guiso *et al.* (2004) in their paper aiming at investigating the effects of social capital on financial development. By measuring social capital differences (through blood donation and electoral participation in referenda) in Northern and Southern Italy, they find that social capital is more important in areas where there is a weakness of both legal enforcement and educated people. In developed areas, households make more use of formal credit than taking advantages of membership in a certain community. According to their measures, social capital is very low in the South and this could partly explain also a weak impact of their unusual<sup>16</sup> measure of financial development on economic performance.

We cannot conclude on the role of social capital without mentioning the works by Durlauf (2002), Durlauf and Fafchamps (2005). The latter is a survey of the majority of researches on the issue in which the authors highlight a number of conceptual and statistical problems that flaws the empirical results of this literature. They argue that norms, trust and expectations, usually obtained from survey data, are not suitable for a rigorous empirical analysis. Moreover this literature, especially at aggregate level suffers to a larger extent from endogeneity and identification problems. In the first case social capital is a choice variable and in the second case it is hard to distinguish social capital from the presence of other group effects such as information spillovers or other common factors such as legal or political institutions. They believe that further exploration of this issue should come from micro-level studies, provided that typical econometric problems (identification and endogeneity) can be addressed adequately. We believe that the recent work by Tabellini (2005) goes in this direction and also in the direction of integrating culture and institutions as joint determinants of regional economic prosperity. The author, by collecting historical data on variables such as trust, respect, and

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<sup>16</sup> The access by households to formal and informal credit is based on data drawn from the Survey of Household Income and Wealth of the Bank of Italy.

confidence in individuals of European regions, identifies some mechanisms of development and their dependence on historical institutions and their propagation over time. An implication of this study is that there is no primacy of formal institutions over culture even if this last determinant is still a “black box” and more work is necessary to understand how individual beliefs and social norms are formed and transmitted and how they interact with the economic and the institutional environment. In fact, as pointed out by the author, the same formal institutions can operate differently in various cultural environments. In terms of the length of investigations the judicial system works differently in the South and the North of Italy even though the two parts of the country have shared the same legal system since the unification of the country over 150 years ago.

As discussed at length in this section, even if institutional measures do not fit well with the empirical framework of growth, certainly most of them matter for growth and a research effort in this direction should produce major benefits in our understanding of the growth mechanisms.

## 5. Concluding Remarks

In this paper we have discussed the NGTs and their empirical evidence based on the role of dynamic internal forces as sources of sustained economic growth. Theoretically, there exist two broad classes of models with different predictions in which diverse variables may contribute to long run growth. One group continues to consider capital accumulation as the driving force behind economic growth. The alternative group assigns a prominent role to technological change, which is made endogenous through substantial investment in R&D or is driven by international trade. Finally, even if not inserted yet in a strictly theoretical framework, there is the group of works that assign to economic institutions a fundamental role for achieving economic prosperity.

The theoretical structures of these models are known and have gained much ground in the last two decades in becoming part of mainstream growth economics. However, they differ

widely both in their positive and normative implications and it is significant to distinguish among them empirically.

Scholars through their empirical studies have evaluated the NGTs both directly and indirectly but there is still a gap between the complexity of mechanisms stressed by formal theoretical models and the indiscriminate use of explanatory variables included in growth regressions. This has produced a number of empirical models that greatly exceed the theoretical ones. We have discussed at length this important issue and reviewed the evidence on the sources of economic growth, the ones considered theoretically founded as well as those about which model's guidance is less obvious.

The *first* piece of evidence was obtained by looking at the convergence issue that has been the main empirical topic in the first wave of the growth debate. Even if subsequent analyses on cross sectional growth have adjusted for the predicted pattern of the conventional model (*conditional convergence*), it must be recognised that convergence is not the central issue for assessing the validity of the NGTs. However, if we interpret convergence as a way of asking whether initial conditions are robustly correlated with growth, we should admit that initial GDP is one of the few growth candidates that passes different tests of robustness. But the convergence issue with its implications is crucial also to shed light on the controversy of ideas gap *versus* factor accumulation.

In fact, the *second* piece of evidence considers the possible explanations of cross-country differences in output levels and growth. Many scholars, using a variety of techniques, agree that human and physical capital cannot explain all the divergence we observe. Even if there is compelling evidence that factors-only models increase productivity, the majority of the observed cross-country differences in output levels and growth rates are most likely due to differences in TFP as well as the quality of economic and political institutions. In this work we have re-examined critically the tests of robustness on growth variables drawing mainly, but not exclusively, on the latest researches. Although these studies are much less contested than the previous ones, the econometric results are still the object of many criticisms. The existence of

an impressive number of empirical studies has not been sufficient to settle down all the debates on growth's determinants, their consistency and significance. However new problems are emerging in the growth empirics, such as how to cope with model uncertainty, the adequacy and availability of data to test competing endogenous growth theories, and how to face the problem of non-linearity in growth econometrics.

Aside of these issues, if we ask what emerges from the empirical evidence concerning the relative role of growth factors, three facts stand out that require a major research effort.

First, the weakest results are related to models based on human capital. The empirical analysis on the role of this factor has not produced a strong and robust correlation with output growth as expected. Part of this result undoubtedly comes from measurement issues. It is known that official country statistical agencies do not include the value of human capital in their national statistic accounts and measures of this factor are available only for a small number of advanced countries. Moreover, by focusing just on education, as a measure of human capital, most studies fail to capture other level of knowledge embodied in individuals, which can contribute to an extended and more robust estimate of the human capital stock. All the discussion in our review on this issue shows that the impact of human capital has been understated by previous work but gradual advancements in the specification of human capital and in the quality of data seem to be very promising.

Second, more interesting results regard the role of spillovers, which have been found prevalent at firm and industry levels, but much rests to be done to measure the consistency of the phenomenon at the international level. Also the mechanisms by which R&D generates spillovers may be much larger than those already captured by existing empirical studies. However, the majority of prevailing studies lead to the conclusion that both domestic and foreign spillovers have significant positive effects in promoting productivity growth. Even if strong empirical evidence from human capital and R&D is problematic to obtain, this does not mean that the models that highlight spillover benefits from R&D and human capital do not matter for growth. There are promising signs that their influence on growth is substantial as

predicted by the NGTs but measurement problems and the availability of quality data still prevent a correct analysis of these crucial factors.

Third, more robust results are obtained for traditional factors like investment, degree of openness as well as other factors never considered as determinants of growth, in the old theories, such as institutional variables. The problem with most of these variables is that they are not strictly model-determined and it is necessary a theoretical effort by economists aimed at incorporating important socio-cultural features in the endogenous growth paradigm.

In conclusion, we reported empirical studies that confronted with data the main theoretical predictions of the NGTs. While some results are well established other important factors need further tests. However, since the empirics of growth is continuously improving its statistical tools and methods of analysis, we feel confident that further advances on all the fronts highlighted in this review may be substantial and may help the NGTs to collect stronger support in the near future.

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