THE NEW GROWTH THEORIES AND THEIR EMPIRICS

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Abstract

The aim of this paper is to update the reviews on endogenous growth theories in order to explore whether recent empirical studies are more supportive of their main predictions. Among the core topics studied in the growth econometric framework, namely, convergence, identifications of growth determinants and factors responsible of growth differences in the data, the primary focus of this paper is on the last two. Since the use of econometrics was originally motivated by convergence issues, in this work we will review econometric studies that test primarily the relevance of endogenous models in terms of significance and robustness of growth's determinant coefficients. 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. Overall, however, if properly interpreted, endogenous growth models' predictions are increasingly gaining empirical support.

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1. Introduction

This paper updates the research program on the new growth theories (NGTs hereafter) after almost 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 range of potential growth determinants.

The appearance of the NGTs has generated an extensive literature characterised by two phases. The first focused on convergence *versus* divergence of income per capita and growth rates across countries and across time. The issue was considered relevant for an empirical verification 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 income per capita, in standard models of the NGTs convergence should not occur at all. This seemed to be consistent with the casual empirical observation that poor economies are not able to catch up the leading economies and to converge to the same steady state as predicted by simple versions of the traditional growth model. Following the empirical studies by Barro (1991), Barro e Sala-i-Martin (1991) Young (1991, 1995), Mankiw, Romer and Weil (MRW,1992), Jones (1995 a, b), in which convergence among countries has been measured conditional on factors that determine the steady-state, we witnessed the weakness of the endogenous growth paradigm with respect to the older model. The importance of the earlier debate was overstated and the real issue not well posed. Among the range of definitions of convergence the possibility to show empirically the existence of the phenomenon depends on economic hypotheses and statistical models adopted. Even the Solow model can explain the stylized fact of differences in GDP per capita across country and across time by arguing that what we observe in the data is transition dynamics towards the steady state. But convergence issues, even if still capture the interest of many researches, in not by no means – as claimed by

Durlauf, *et al* (2004) - "the bulk of empirical growth studies"(p.73)[1]. The interest of economists has shifted to methodological and political issues that can help to analyse growth processes and their determinants more deeply. In fact, even economists who raised criticisms towards growth econometrics recognise that, as a whole, this empirical phase has been productive in terms of progress in econometric modelling and data availability (see Durlauf and Quah [1999], Temple [1999, 2000, 2003] Klenow and Rodriguez-Clare [KRC, 1997], Brock and Durlauf [2001]). Since the growth debate is far from over it might be interesting to investigate, according to cumulated evidence, whether or not the predictions of the NGTs have become more robust and which problems still remain unsettled. Inasmuch as the explanation of the growth mechanisms has become the main challenge for macroeconomics, the crucial questions for economists as well as policy-makers are related to the variables that can be considered sources of sustainable growth and how public interventions may enhance it. It is to some extent ironical to notice how many scholars, in summarising the growth debate, attribute to the neo-classical model results and policy implications that are properly of the new theories. This practice has not been generated by searching for a synthesis between the two approaches, which could help either to analyse growth in a unified framework or to disentangle normative issues and explanatory power of models, but by some forms of empirical confusion [2]. The search for a consensus has become necessary since the controversy on growth and its determinants has assumed a new divergent path between those economists (MRW, [1991] from a neo-classical perspective) who believe that differences in income across countries originate almost exclusively (80%) by factor accumulation and those who attribute all the observed differences (90%) to total factor productivity (TFP). Diverse emphasis on these two factors, A against K, describes the new

[1] Obviously both convergence and identifications of growth determinants are strictly related since their treatment requires the specification of a regression model of cross-country growth differences from which the effects on growth of different factors may be identified (see Durlauf et al (2004).

[2] Only recently have been conducted some tentative analysis in this direction (Bernanke and Gurkain A.K [2001]), Bleaney and Nishiyama (2002).

phase of the growth debate (Klenow and Rodriguez-Clare, [KRC, 1997], Easterly and Levine [2001], Henderson and Russell [2004]).

To answer to these and others opened questions we need to redirect our study to the empirical methods of growth and measurement issues, trying to highlight their merits and their weaknesses.

The first widely growth quantitative approach, which has substituted growth accounting exercises, is typically based on cross-country regressions. The motivation for the use of this approach has been twofold. Firstly, second generation's NGTs, specifically those based on endogenous technological progress, should not rely on growth accounting since it fails to give precise estimates of TFP. Regression analysis is, as an alternative, considered a general methodology, typically based on cross-country sample, able to measure the impact of different factors, including decomposition of TFP, on growth. Secondly, growth accounting attributes to the determinants of growth (physical capital and labour) a weight that depends on the shares of the factors on GDP, while in regression analysis the significance and magnitude of the coefficients of each determinant of growth are left to data. The implementation of this technique was spurred by the expansion of data availability on country-specific measures of human capital, physical capital, R&D expenditure as well as indexes for measuring institutional and political systems[3]. Regression analysis, however, as economists unanimously argue, shows how variables are correlated with the growth of nations but is far from implying the direction of causation. Although the econometrics of growth, typically based on the Barro (1991) and MRW (1992) basic framework, has been contested by many authors (i.e. KRC [1997], Dinopoulus & Thomson [2000], Brock and Durlauf [2001]), we associate with two opinions stated by Temple

[3] Even if the more used and useful set of data are the Penn World Tables (now updated, [PWT 6.1]) by Summers, Heston, and Aten [2002] many data on various variables have been made available by many authors who have conducted research on growth. The sites of World Bank and NBER as well those of many other institutions, such as the Centre of international Development (CID) provide interesting growth data. We still lack, however, data constructed to measure TFP, R&D expenditure and other variables very useful for a direct test of the second generation growth models. For EU countries interesting data are provided on line by the Groningen Centre of Economic Development and cover many industrialized countries. Other set of data extremely important for particular growth issues are, as known, Barro and Lee (1993, 2000), Beck et al [2000] Knack and Keefer (1995).

(1999) in his worthy review article: (i) we have learned many interesting things from these researches but (ii) it is time to argue for a different, *no-neoclassical*, vision about growth.

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 on the potential capability of the NGTs in explaining growth processes. We attempt to do it by reviewing empirical analyses devoted to assess the robustness of the variables considered growth determinants by the new theories. The main message of *a new theory* should have emphasised that growth does not depend on one factor only, but on a *happy* combination of many factors that interact to each other. Unfortunately, this message does not emerge by a unified theoretical framework. Each model captures only one factor and it alone is able to generate sustained growth. As an alternative, the empirics of growth should avoid this restriction. Empirical specifications of growth theories allow introducing more than one factor at a time and interactions among them. Indeed, lessons from history of country performances and from classical economists teach us that capital accumulation and technical progress interact in fostering long run economic growth. Technological improvements are embodied in new capital goods creating interactions that do not allow to separate out movement along the production function and shifts due to TFP growth.

What seems to be a clear advancement in the empirical literature is that cross-country differences are due mainly to differences in technologies but growth in a specific country continues to be predominantly driven by factor accumulation. Empirical work, encouraged by theoretical developments, has still much to say on the average influences of variables across countries *(cross section analyses*) as well as on the historical growth experience of individual countries (*time-series studies*). Therefore, it is still beneficial to revise the evidence, even with all the concerns about the empirics of growth that we will discuss later in the paper.

Our review is not organised around the different econometric approaches applied in empirical studies. The different perspective is motivated by the fact that this line of

investigation has been already followed by Temple (1999) and Durlauf *et al* (2004) in their excellent reviews and also because our specific interest is an assessment of the NGTs. 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 measures used as proxies of important determinants of growth are not accurate. Commonly, human capital is proxied by average years of schooling and TFP either is not measured at all or is measured with imprecision. Therefore, the structure of this review is based on the evidence on factor accumulation versus research-based theories of growth and other influential factors.

The remainder of the paper is as follows. In the section 2 we discuss the main criticisms that have been moved to this literature and the advances in the econometric tools applied to growth empirics. Then, we use growth regressions to examine in section 3 (and subsections) the evidence on endogenous determinants of growth according to the most influential classes of models. We will evaluate regression findings on initial conditions, broad capital, R&D spillovers. In section 4 we discuss the evidence on public policy and institutions as potential growth determinants. The last section concludes by indicating the main issues that still remain unsolved.

2. Methodological critiques on growth empirics

2.1 General technical issues

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 policy variables. We summarise recent evidence, most of it based on the standard growth regressions aimed at testing directly and indirectly the NGTs, beginning with the relationship between growth and initial conditions and then with investment rates in physical and human capital, government

expenditure, R&D, trade openness, finance and institutional variables. The impact of these factors, some of them considered *proximate* sources of growth, and others indirectly linked to long run growth, have been proved to date to be empirically relevant.

Before discussing the empirical studies, it should be meaningful to address the question of the critiques that have been moved to *cross-section* regression analysis. It is worth mentioning, however, that the primary purpose of cross-country regressions was and still remain the investigation of what determine growth differences in GDP per capita across countries in the long run. Regression analysis should explain if these differences were due to factor accumulation or TFP or a combined effect of the two. Following the seminal work of Barro (1991) and the availability of standardised data sets, as the Penn-World Tables (PWT) by Summers & Heston (1991), Heston *et al* (2002), the amount of studies which have tested growth theories has become immense but almost all the studies are exposed to severe criticisms.

Among the main concerns there is the causality versus correlation issue. This problem remains central and cannot be satisfactorily solved in the empirical framework of both cross-section and panel data growth regressions. One must argue that if regression analysis can be trusted, then a significant and positive coefficient value of a variable should indicate to *policy makers* the means to stimulate growth. We know that this is unlikely to be the case if inference from regressions would not imply causality. Proponents of the huge number of empirical studies based on this methodology share the belief that regressions involve an implicit form of causality, otherwise it should not be suitable for growth investigation and for policy assessments. The researcher wishes to explain the growth rate by introducing vectors of independent variables that are believed to be the moving force of the first one. But is this procedure appropriate? Regression techniques are suitable only if the causal structure of the model is a priori determined. Typically, this does not occur if arbitrary regressors are introduced into the analysis. In a recent work Brock and Durlauf (2001) have pointed out that many of the standard variables which are used to explain growth patterns, such as democracy, rule of law,

social capital etc., are of a socio-cultural nature and, hence, cannot be treated as if they were derived by a structural model a priori specified. The lack of agreed theoretical bases for empirical work and established reduced form to apply in empirical analysis has motivated subsequent researchers to abandon any a priori model and let the data show which variables are correlated with growth (*model uncertainty*).

The problem of model uncertainty (or *openendedness* of theories as termed by Brock and Durlauf [2001]) is at the centre of the recent empirical debate, but it is still at its infancy given the difficulties of finding accepted methods to deal with this complicated issue. Among the huge number of regressors that have been included in the empirical analysis – Durlauf et al (2004) count up 145 variables- the majority of them have been found to be statistically significant according to conventional tests. The meaning of these findings is that we have as many growth theories as the number of significant regressors and we cannot distinguish among them.

Other frequent motives of concern with conventional macroeconometric techniques are the questions of 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, criticisms have been intensified by emphasising issues linked to parameter heterogeneity, model identification and non-linearities. It is argued that conventional cross-country linear regressions impose strong homogeneity among parameters (countries share the same production function) which means that a change in a particular variable has the same effects across countries. This is clearly an implausible assumption. Several studies (Liu and Stengos (1999), Kalaitzidakis *et al* (2001) find strong evidence of parameter heteogeneity that may arise from non linearities in the production function, multiple steady-states, poverty traps. New empirical methods and tests have been performed to account for failures of standard regression analysis (Doppelhofer, Miller and Sala-

i-Martin [2004] Easterly and Levine [2001], Lee, Pesaran and Smith [1997, 1998), Fernandez, Ley and Steel [2002] Masanjala and Papageorgiou [2004], Hansen [2000] among others).

Although a brilliant and widespread discussion of these issues and methods to deal with are contained in Brock and Durlauf (2001) and Durlauf et al [2004], what it is still unsolved is to find a consensus on accepted methods to assess the robustness of parameters and their importance on growth theories[4].

The most cited paper testing the statistical robustness of growth's coefficients still remains Levine and Renelt (LR, 1992)'study. 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. They carried out the Leamer (1985) extreme bound-test, which consists of estimating the upper and the lower extreme bounds of a coefficient of a variable of interest. If the signs of these extreme bounds are different (in the sense that they change their signs when other variables are included) then the variable is considered to be fragile. Robustness consists of identifying variable whose importance is confirmed across different specifications. In the context of the EBA this requires that the sign of the coefficient must remain constant across a set of regressions, which represent different combinations of the variables. Following 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 just the share of investment, other than initial income, has been found strongly correlated with growth.

The alternative approach performed by Sala-i-Martin (1997) consists of studying the entire distribution of estimators of a variable of interest. In particular the test of robustness is based on cumulative density functions to establish a ranking variable performance. If, for example, 95% of the density function for the coefficient of the variable 1 lies to the right of zero, and only 50% of the coefficient of the variable 2 lies to the right of zero it is more likely

that 1 is more correlated with growth than the other variable. In other words a variable is robust according to the less restrictive Sala-i-Martin's method if, by averaging the statistical significance level of the variable, 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. These different results depend on the different notion of robustness adopted. Nevertheless, also applying this procedure there are many variables that are not significantly correlated with growth. If we look at the variables reported by Sala-i Martin (1997), it is remarkable to note that, except for investment in equipment, the other robust variables include almost exclusively measures of geography, religion, rules of law, political rights and other institutional features.

Recently, alternative approaches have been proposed to solve the controversy over the selection of growth regressions. 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 million of regression, the authors just run one regression (choose one model) to individuate determinants of growth based on a set of statistical tests. The mean idea of the general-to-specific methodology is that 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 aim is to select among the different models the one that is consistent with some theoretical views. 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 regression analysis by repeated applications. The model selected by the authors includes the rate of equipment investment, an index of openness (the years in which an economy has been opened) and some institutional measures.

[4] Brock and Durlauf (2000)claim that this problem has been excessively discussed in the literature while the

Hoover and Perez (2004) using the methodology associated with Hendry and Krolzig (2004) have re-examined analyses of LR and Sala-i-Martin using in a Monte Carlo experiment a variant of the extreme bound analysis. 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 in detecting potential significant regressors than the LR approach. The latter is able to reject as fragile important growth determinants and at the same time to consider as robust spurious relationships with growth.

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 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 can attach probabilities to different models and then using Bayesian approach to averaging 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 the ones offered by coefficient variables and other conventional summary statistics. Fernandez *et al* (2001) show the superiority of BMA over other techniques in selecting regressors for explaining cross country growth. Their finding by comparing LR and Sala-i-Martin procedures favours the latter. The Sala-i-Martin procedure even if not based on firm theoretical statistical methods brings to the conclusion that a large number of variables are important for growth. In fact when the same variables are analysed under a formal statistic framework, namely the BMA, the "optimistic conclusion" of Sala-i-Martin is confirmed by the analysis of the two authors. However, independently of what Fernandez *et al* claim, if one look

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problem of openendedness deserved an analogous attention (p. 7)

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 which have a lower posterior probability are variables considered important growth determinants such as rule of law, numbers of year 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 seem to be: GDP levels in 1960, life expectancy, equipment investment.

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 have been used to test the robustness of LR results. It is worth mentioning the study 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 fundemental growth'determinants enter linearly and, hence, are valid candidates for a robustness assessment. Extending the sensititvity 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 distortion 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 general advances in the empirics of long run growth that every researcher hopefully would like to possess among his tools when he

faces model uncertainty. But applications of some of these tools should require a changing in the classical econometric approach. Even if the computational power is enormously increased we are not able to make predictions about general acceptance of Bayesian procedures.

However, also in performing canonical growth regressions some progress has been done to make parameter estimates more precise and consistent. Many researchers agree on the advantages offered by panel data estimators in the context of growth analysis. In this section we well review new dynamic panel methods. 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 is of the following form:

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

where g_i denotes the growth rate of real GDP per capita (or per-worker) averaged 30-40 year period, y_i is the initial level of real GDP per capita, X_i is a vector of regressors considered proximate or deep determinants of economic growth, u_i indicates the error term (for the country index i= 1,…, N) which likely 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 some of the problems described (endogeneity of regressors, simultaneity bias, 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 period of 5 years are used in the regression. This allows to take account for unobserved country specific effects (country varying time invariant) η_i:

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

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

Therefore, equation (2) has problem of its own. The term η_i may be correlated with X_{it} and standard estimators do not solve the problem of endogeneity which requires to estimate the equation in differences[5]. The way used to address the problem has been through the generalised method of moments estimator (GMM) of Arellano and Bond (1991). The general approach is to remove the country specific effects and 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, avoids the problem raised by the omission of the initial level of technology and by using lagged instruments avoids the problem of endogenous regressors. Since g_{it} is the logarithmic difference of GDP per capita equation (2) can be rewritten as:

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

and taking differences:

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

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

The procedure proposed by Arellano and Bond (1991) solves the country-specific effect problem but introduces a correlation between the new error term $(v_{i,t} - v_{i,t-1})$ and the lagged dependent variable $(y_{i,t-1} - y_{i,t-2})$. The two authors propose using lagged values of the explanatory variables (X_{it}) in levels as instruments. 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. Under 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 held:

$$E[y_{i,t-s}(v_{i,t} - v_{i,t-s})] = 0 \qquad \text{for s = 2,} \quad \text{t= 3,…,T}$$

$$E[X_{i,t-s}(v_{i,t} - v_{i,t-s})] = 0 \qquad \text{for s = 2,} \quad \text{t= 3,…,T}$$

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* has been employed which use jointly lagged 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 are the same as above:

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

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

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

[5] 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.

The equations in levels, still contain the country-specific effect. It is assumed, however, that X_{it} may be correlated with η_I but *changes* in X_{it} to be uncorrelated with η_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 instrument for equations in levels, being uncorrelated with the composite error term in the levels equation.

The econometric methodology applied to growth analysis is promising. However just in the last years it has begun to be applied for testing some NGT's 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 reminded: (i) the use of differenced variables changes the interpretation of regression results, (ii) the construction of time series averaged five years or more should be considered arbitrary and not apt to capture long run effects. In addition the problem of serial correlation in the errors needs to be further explored (see Lee *et al* [1997], Phillips and Sul [2003]).

In our subsequent discussion we will not address statistical questions that have been extensively and well discussed in the literature. Yet remains the question of divergent outcomes from econometric studies. Why some researchers find weak effects from physical and human

capital accumulation in the process of growth whereas others find a robust correlation? Why the theoretical substantive role of externalities and TFP of the NGTs is so difficult to take out from growth regressions? We firmly believe that there are at least two reasons. Firstly, estimation should be performed in strictly comparable conditions with the same data, the same model and the same sample. Secondly, it is not the econometric methodology to be 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 looking at initial conditions. In some of the new endogenous models, growth is not correlated with initial conditions. The majority of the empirical evidence is based on the estimation of *convergence equations* relating the growth rate of income per capita to the level on income of some initial year. These equations can be considered reduced form of basic growth models and have 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 inference about the determinants of growth or to discriminate between alternative models[6].

The central investigation of the empirical literature has been the estimate of the sign of the coefficient of the initial level of per capita GDP ($y_{i,0}$ in 1960) as a test of endogenous versus exogenous models of growth. The aim was to provide an explanation for differences in growth rates across countries and over time. At a point in time, given identical levels of x_i – the growth of technological progress - a significant and negative sign for $y_{i,0}$ has been considered

supportive of exogenous growth theory. It would imply the existence of convergence in growth rates and level of income per capita and the existence of diminishing returns to capital (Barro [1991], MRW,[1992], Sala-i-Martin [1995] Barro [1997]). Given the dependence of the growth rate from many factors determining the steady state (the rate of investment, the level of efficiency, the rate of population growth and the depreciation rates), convergence has been defined as *conditional.* Therefore, the disparities in growth performances that we observe were justified by the transitional dynamics implied by the traditional model. These studies have represented, according to Klenow and Rodriguez-Clare(1997) the "neoclassical revival" in growth economy. The augmented Solow model was considered suitable to explain almost 80% of the cross country variance of output per-capita due to differences in steady state levels of physical and human capital as well as population growth.

The main results of this literature have been severely criticised. Bernard and Durlauf (1995), Quah [1995, 1996], Durlauf and Quah [1999], and more recently Phillips and Sul (2003) raised substantial criticisms other than claiming that convergence patterns are too complicated to be captured by simple growth regressions. A better method to estimate convergence and coefficient parameters should require time series regressions for each country. Assuming that an economy's per capita income possesses a unit root, evidence of *time series convergence* is obtained when the unit root is rejected, that is when the log per-capita income relative to that of the economy as a whole is stationary about zero. When this definition is applied, evidence shows that convergence fails to hold across most countries, included the set of OECD economies. Indeed, in previous analyses (MRW, [1992]) the rate of conditional convergence has been obtained by adding human capital to the original model so that the share of capital is augmented in a way to generate a common annual rate of convergence (2-3%) consistent with data. 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

[6] See the criticism of KRC (1997). Barro (1996) claims instead that the procedure is quite correct.

studies on convergence. The range of estimates found in studies using panel models (difference GMM approach) goes from zero to 30% a year (Canova and Marcet [1995], Caselli, Esquivel and Lefort [1996], Lee, Pesaran e Smith [1997], Islam [1995])[7] These results are difficult to reconcile with prevailing theoretical framework and with earlier consensus on the convergence hypothesis.

Recently, the application of system GMM to estimation of the Solow model has reported the rate of convergence across country towards the previous more reliable value. The work by Bond, Hoeffler and Temple (2001) indicates that the rate of convergence is in the range of 2%-4% a year, which is not very dissimilar from the standard cross-section result. The treatment of the investment ratio and of the population growth rate as potentially endogenous variables and the use of an extended instrument set have been sufficient to reconcile different estimates of the rate of convergence within plausible values. The authors point out that their estimates may be imprecise. They controlled for unobserved heterogeneity in the intercepts (country-specific effects) but there may be heterogeneity in the slope parameters (growth rates) as argued by Lee, Pesaran and Smith (1997) which invalidate the use of lagged values of serially correlated regressors as instruments. As is widely recognised, the diagnostic tests are not very powerful in detecting serial correlation in this context.

In a different econometric context, by applying Bayesian averaging approach, Doppelhofer et al (2004) show that the posterior probability of the hypothesis that initial income is part of the linear growth model is exactly one, with a point estimate of the convergence rate of 1,3 % per annum. This rate of convergence is lower than the finding of previous literature and fit better observed cross-country growth.

The idea that technological progress matters more than factor accumulation in the explanation of cross country growth differences appeared in the already cited KRC (1997)' article. It represents a substantial and direct attack to the first literature on convergence and to

[7] See Temple (1999) for a wider and critical discussion on the first literature on convergence.

the MRW results. The two authors argue that "ideas gap" are 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 secondary school, the finding of MRW overestimates the effect of variation in human capital across countries. After the correction in the data, the earlier well established result is completely reversed. Roughly 90% of country differences in income per capita growth are attributable to technology differences. If for comparison with MRW, we express the differences across countries in terms of income per capita *levels* then, human and physical capital are responsible for roughly 50% of cross country variations and the other 50% is attributable to change in technology.

These new empirical studies on convergence were sufficient to shift the interest of researchers from the Solow model to the NGTs. A more recent criticism has appeared in a very provocative paper by Easterly and Levine (2001) which complements the main conclusion of KRC and offers new elements to the debate. Along the same line of reasoning, however, Henderson and Russell (2004) using a non-parametric production function approach reverse the KRC outcome. Decomposing 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 to 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 a paper by Acemoglu and Zilibotti (2001) who show that technology-skill mismatch could account for a large fraction of the observed output per worker differences across countries. The authors 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 workes in poor countries can lead to sizeable differences in TFP.

On the same line of reasoning is the technical paper by Phillips and Sul (2003). It sheds some light on the controversy. 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 converge. 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 PWT for 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 OECDs growth rates.

In what follows we discuss more extensively empirical studies for each variable considered a determinant of growth to investigate whether empirical literature rejects or is supportive of competing NGTs. It is worth noting, however, that the validity of one theory of growth that stresses a particular factor as source of growth does imply neither the validity nor the falsity of others, which should focus on a different factor. As stated at the outset we believe that the interplay between factor accumulation and technological progress is the driving force of long-run growth.

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 correlation between investment and growth rate because of diminishing returns, historical data in almost all countries show a tight relationship between the two. Cross-section regression analysis has evidenced a significant coefficient for the investment variable included in the regressions. DeLong and Summers (1991) who find 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. The conclusion is 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 common opinion that this has favoured equipment investment. Historical evidence also shows that Latin American and African economies have displayed very low rate of investment per capita, whereas East Asian countries have invested over the period 1960-1990 more than 30% of their GDP.

On the econometric side, we have just reminded the study by LR (1992). The authors found that the most reliable result in much econometric work is the stable and robust 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 other statistically significant coefficient found by LR was the negative correlation of growth rate with the level of income per capita in the 60s (convergence hypothesis). More recently the scope of some 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 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 how it is associated with externalities, no strong case has emerged that social return to physical capital exceeds the private return. The impact of capital on growth seems to be very modest.

Some authors suggest that, despite the strong link between investment and growth found in the majority of studies, the AK model is not supported by these studies. A closer examination of regressions show 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% should 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%[8]. This does not support the AK model either in terms of unitary elasticity of capital with respect to output or 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.

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. The time series method used to test the prediction of the AK model is based on regressing growth on lagged investment rates. Formally:

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

where *x* is the growth determinant (investment or other policy variables) and A(L) and B(L) are lag polinomials. 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 polinomial B(L)=0, then the variable has no long run effects on the growth rate[9]. 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 has been a large increase in the investment- output ratio in all the countries included in the sample but growth rates in these countries have been almost constant or have fallen. Jones focuses on investment on durables. Over the 40 year period the investment /output ratio nearly doubled in countries like US and nearly tripled in Japan. In some countries an increase in investment coincides with decreasing growth rates.

Related studies such as Blomstrom, Lipsey and Zejan (1996) tried to study the direction of causation between investment and growth. The result of this causality test reject 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 revaluates the AK theory from a different empirical standpoint by considering evidence over longer time periods and number of countries than Jones does. Extending the sample of Jones to one century's data (using Maddison data from 1870-1989) she found that periods of high investment rates coincide with period of high growth. For investment-output ratios, data are constructed using fixed domestic investment as a percentage of GDP valued in current prices. For the growth rates were used nine-year moving averages of per capita GDP

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[8] This interpretation, commonly used, of regression results is much contested. See, for example, KRC (1997)

[9] 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.

growth in order to smooth out some of the large cycle 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 around 7% whereas the fastest growing countries have an average rate 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 prediction of the AK model.

However, even if it is certain that investment has 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 not inconsistent with available data and that theory's quantitative implications are in line with the empirical observation. The main prediction of the model is just to see if changes in investment rate would lead to permanent change in 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 still remains opened. 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 if we want to estimate consistently its coefficient. It has been argued that if the endogeneity of investment could be correctly treated then the coefficient of investment should be very small.

Even if further work is auspicious, 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. Different results should 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 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 time series annual 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 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 results are confirmed also with pooling cross section regressions as well as five-year averages panel estimations.

How to reconcile these divergent results? Many of the marked differences in results 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) show 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 through familiar results from regression analysis that R^2 is higher when the capital stock is used while a very little correlation is obtained in their sample between the change in the capital stock and the mean investment rate. Even if not necessarily this is the case for the different outcomes found in the literature, it should be a good practice to use the correct measure to test theoretical models. It is common knowledge that is not possible to construct measures of the capital stock without incurring in arbitrary measures for the initial capital stock. It should be added that once capital is correctly measured, augmenting for its quality across country should reveal a stronger impact on growth (see Eaton and Kortum [2001])

As known another means to reconcile the results is to assume that returns might be diminishing but then there should be some kind of externalities that makes investment significant for growth. This issue will be discussed in the following section.

3.3. Evidence on spillovers from physical capital

Empirical analysis has not produced a firm and definitive response on the importance of externalities as a source of growth. The amount of evidence is still limited, even if it has increased in the last years. Basically, the evidence is of two different types. The first one examines returns to scale directly through the production function. This kind of test should address the issue posit by basic NGTs, which focus on spillovers from the accumulation of physical and human capital. Only if scale economies are very large they can offset decreasing returns and explain accelerating growth. The empirical direct test of endogenous growth model with spillovers are very few, and even so the existing evidence shows that the exponents of capital in the production function is not consistent with spillover models.

Romer (1987) has estimated the coefficient of labour and capital using time series and cross section data and found that the elasticity of capital is bigger than the value of 1/3 predicted by the Solow model. In Romer's the elasticity is lying in the range between 0.7 and 1.0. This result appeared, at the beginning, to be consistent with existence of externalities to capital accumulation.

Caballero and Lyons (1990) estimated scale economies in European manufactures and their finding is that these economies are in the range 0.35 to 0.48. The same range of values (0.32 to 0.49) seems to characterise the US economy (Caballero and Lyons, 1992). These values are greater than the share of capital in the national income accounts but less than the value required justifying the assumption of the basic model with externalities.

The study, much debated, that seems to rule out spillovers is MRW (1992). The authors augment the Solow model introducing human capital and infer that a production function, such

as: $Y = K^{0.33} H^{0.33} L^{0.33}$, fits very well the international growth experience. This finding is inconsistent with NGTs because the exponents of K and H sum less than unity. In addition the low exponent for physical capital suggests an absence of substantial externalities from capital accumulation.

More recently, Hamilton and Monteagudo (1998) submit to further analysis the framework used by MRW. Their study supports some key conclusions of MRW but with two troubling results. First, even if the coefficient for physical capital is of the right sign and robustly correlated with growth, regression estimates attribute a slightly bigger share for the factor than the one justified by national income accounts. Rightly, the authors conclude that the reasons for the importance of physical capital on growth are not fully captured by the augmented Solow model. Second, and more importantly, in contrast with MRW, investment in human capital has no role in explaining changes in growth rate over time. The proxy for human capital investment is statistically significant but correlated with slower, not faster, economic growth. Other studies by Oulton and O'Mahony (1994), applied to manufacturing in Britain in the period 1954-1986, found that there was no evidence both of spillovers and of higher social returns.

However, there are several problems in estimating the elasticity of output with respect to capital. It is known that there can be a simultaneity bias in estimating a production function. Any shock to output, such as improvement in technology is likely linked to accumulation of inputs as well. This means that the regressors are correlated with the error term and estimation will be biased. Investigations of this kind by Benhabib and Jovanovic (1991) failed to confirm significant externalities in explaining the high variability of growth rate across economies.

The majority of these works is based on Cobb Douglas type production functions with some parameters that determine the value of the externality and aggregate returns to scale. Generally, the parameter to be estimated corresponds to capital's share of income. Only if α (the

capital share) is constrained to be 1/3 then the exponent of knowledge capital becomes positive and significant. Obviously this is a small peace of evidence in favour of spillovers.

Other studies (Cole and Ohanian [1999]) suggest that many investigations on returns to scale are imprecise. Large standard errors and wide confidence intervals are common in measuring aggregate returns to scale. Overall, however, there seems to be little empirical support for high spillover's effects. The empirical studies of the last years have not made substantive progress on this route to test the validity of NGTs.

3.4 Estimated contribution from education

The NGTs put a great emphasis also on the role of human capital. In a recent work Wolff (2000) summarises the three paradigms that have dominated the current debate on the role of education on growth. Interpreting differently his arguments, we state that all three 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 processes of Grossman and Helpman (1991). In Lucas' (1988) and Romer's (1990) models the growth rate is predicted to monotonically increase with level variables. 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 procedures adopted and the different measures of schooling used in cross-country analysis?

In prior studies (MRW [1991]) the proxy used for human capital has been schooling enrolment rates of the labour force. This measure is defined as the number of people (regardless of age) enrolled to different schooling levels over population of the age group that officially corresponds to the level of education indicated. Schooling enrolment rates, steadily increasing

for all countries, were found positively correlated with growth. These data, although widely available, do not measure properly the stock of human capital effectively available for current production.

These earlier results have been successively modified by using attainment rates by levels of schooling, a data set constructed by Barro & Lee (1993, 2000). This data set, refers to adult population and attainment levels of education, is calculated as the proportion of the population aged 25 years and over (or 15 years and over which corresponds to labour force in developing countries) who have attained the indicated level of schooling. The figures were constructed at five years interval by using benchmark data on attainment levels from census-survey from UNESCO and then updated on the basis of school enrolment flows in succeeding years for each country at all levels of education. These estimates, although provide a reasonable proxy for the stock of human capital, perform poorly in the empirical analysis. One reason should be attributed to the complex characteristics that embrace the concept of human capital, which are difficult to measure with precision. Other reasons have to do with comparison of educational measures across countries especially when one wishes to correct for the quality of schooling. By looking at this data set, it is easy to find anomalies (such as decreasing of attainment levels also for some OECD countries) which are difficult to justify, given worldwide increase 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 reflects 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 would be expected to be positive according to the predictions of the NGTs, has been found insignificant and often negative. Just primary education has been found positively correlated with growth in both developed and

developing countries. A related issue is whether other approaches to measure human capital are more appropriate to capture its role on output growth. Many attempts have been done in improving international measures 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 to measure directly the skills of the work force for international comparison, but data availability is limited to OECD countries.

To date the widely adopted measures still remain the data set of Barro and Lee and on this data set is based the following discussion.

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 should not be due to differences in the rate of accumulation of human capital, as the Lucas (1988) model predicts, but to differences in the *stocks* of human capital in each country. This measure would affect the ability to innovate or catch up 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 between average schooling in the USA and wage levels is driven from social returns to 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 individual level for human capital investment is observed.

Pritchett (2001), in the attempt 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 al 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 to create 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 peace 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 to treat properly non-linearity in econometric modelling could 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.

Other studies augment years of schooling by a proxy of the health status of the labour force (Weil [2000]). It seems that there are large cross-country variations in nutrition and health status and taking account for these differences improves the explanatory power of human capital on growth. Attempts to measure human capital externalities at the aggregate level have not given appreciable results.

On measurement errors are based the criticisms by Krueger and Lindhal (2001) 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, do not reverse the value of the coefficient and the impact of schooling remains very modest.

Overall the relationship between per capita growth and human capital attributable to educational attainments has been found to be very week, and often negative. A positive role of human capital is found only when it interacts with other growth factors.

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 a satisfactory solution. To reassess the robustness of human capital in empirical analysis, Papageorgiou and Chmelarova (2004) have followed a promising line of research. The authors, using a cross section of 46 OECD and non-OECD countries, 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 should be a clear advancement also to shed light on the controversy about the two competing determinants of economic growth: input accumulation and technological progress. Evidence in favour of complementarity between physical 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 develop 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 use semiparametric estimation techniques to uncover non-linearities between human capital and growth providing evidence of their existence.

3.5. Evidence on research-based models

To take the argument further, 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 the attention on the second model of Romer (1990), Aghion and Howitt [1992], Grossman and Helpman [1991]), in which innovations and research spillovers generate endogenous growth.

Two measures of innovation activity are used in empirical studies: the output elasticity of the stock of R&D and the rate of return to R&D investment. The capital stock of R&D is constructed through the perpetual inventory method for the series of R&D expenditure. Both measures are typically based on a Cobb-Douglas production function that includes R&D capital as a factor of production. All the studies aiming at measuring the effects of capital knowledge that rely on innovation inputs (R&D investment) can be only imperfectly measured. Better measures are considered the direct output of R&D such as the number of patenting purchases license costs, scientific publications etc. Indeed both measures, generally based on innovation surveys, are imperfect estimations of the innovation activity, since expenditure in R&D, even if deliberately aimed at obtaining innovations, not necessarily is conducive to new products and processes which are economically significant. Analogously, a new patent not necessarily is suitable to spur productivity growth. 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, remain a controversial subject.

There are grounds for believing that such research spillovers constitute an unambiguous positive externality and generally productivity is increased by R&D investment. But the same studies also document the existence of negative externalities. Important negative externalities are present in the model of Aghion and Howitt (1992) since innovations create shumpeterian effects of "creative destruction".

The major peace of evidence on the issue comes mainly by studies at industry or firm-level data. What is controversial in these studies is not the relationship between R&D and productivity, since evidence confirms a positive and strong relationship (Lichtenberg-Siegel, 1989), but whether econometric studies can characterise such a relationship in a satisfactory and effective way. Regression-based studies to measure spillovers and productivity growth at firm and industry levels often are 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. Some studies have tried to measure social return to R&D. Also the computation of the social return of an innovation depends on the industry structure and on the ability of price agency to capture gains from innovations that derive from quality changes. These last types of gains, even if lower than those obtained from R&D processes, generally are not registered (see Griliches 1994) in growth accounting. There are also learning processes involved in the implementation of innovations that are not captured by conventional measures. However the evidence seems to indicate that the magnitude of R&D spillovers may be quite large, implying that social returns to R&D are higher than private returns. The various attempts to identify different type of spillovers related to R&D have lead to a wide range of estimates by different researchers for different industries and countries. Social returns on research must take into account external returns measuring its potential spillovers for the other firms in the same industry or in similar industries, in the same country and in other countries and this becomes extremely difficult to carry out. Indirect measurements show estimates that vary from positive and very high returns to negative ones[10]. Other studies document that the rates of returns to R&D for some firms are

[10] The possibility of different spillovers is well known in the NGTs. Besides the positive spillovers there exists

between 20 and 30% If one considers private rates of returns and adds spillover returns, the social rate of return to R&D seems to be in the order of 50% (see Nadiri [1993]). If this estimate is realistic the implication is that too few resources are devoted to research.

On macroeconomic level output elasticity of R&D stock and the rate of return to R&D investment are in the same range of microeconomic evidence (respectively 0.3 and between 20 to 40%). Lichtenberg (1992) has estimated the impact of R&D on income levels and growth rates over a sample of 74 countries. The finding is that the cross-country correlation between R&D and growth is significant. More recent econometric studies have provided slight support to R&D models. Most of the estimates are statistically significant at the standard 5% confidence level. In the study of Hall and Mairesse (1995) in a sample of 197 firms and Mairesse and Mohnen (2003) R&D elasticity ranges from 5% to 25% and the rates of returns from 10 to about 80% depending on the cross-section or time series estimations. Cross sectional estimations yields higher and more significant values than time series (longitudinal) estimations. They applied the methods to the same panel of firms with the same data and the same model.

In the study by Verspagen (1996) the role of R&D is investigated for Germany, France and UK since 1960. The findings are that R&D accounts for about 25% points of productivity growth in the first two countries. For the UK the author is not able to reject the null hypothesis of no impact on the growth rate in this country. Eaton and Kortum (1997) document that in some OECD countries (Germany, Japan, U.S. and France) more than 50 percent of the growth in productivity is due to innovations in R&D.

By the way of contrast, it is needed to mention a paper by Jones (1995b) for his theoretical and empirical criticism to R&D-driven growth models. The main quantitative concern for this type of model has been their scale effects. The larger the economy the higher will be the growth rate. If we identify scale effect with the size of population, empirical evidence shows that this effect is not supported by data. However, if we think at the world as a

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negative ones (see Jones and Williams [1998]).

single unit of production, and at the scale effect as the way innovations can be used in a *nonrival* manner, then as Kremer (1993) has claimed, since ideas flow across borders, the positive correlation with the growth rate may be correct. What Jones criticises is that the model imply 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 there has been an increase in the number of scientists and in resources devoted to R&D with no or little increase in the growth rate. Jones has taken too seriously the scale effect in the model. What is important is that the theory does not appear to be inconsistent with observations, even though quantitatively does not fit perfectly with available data.

Empirical tests of R&D-based models of growth present other specific problems not easily solvable. Investment that takes the form of new machinery implies by itself change in scale and technological innovation as well as improvement in human capital. Therefore, is extremely difficult to break up increasing returns as an independent resource of growth and quantify their effect on productivity. The econometrics of research-based approach ignores many of potentially negative externalities associated with innovations and stressed by the theoretical literature, such as congestion externalities and creative destruction. Perhaps, the challenge for future research is to implement models suitable to measure spillovers and technical progress (see, i.e., Mairesse and Mohnen 2003]). To date we cannot account for many studies that explore the quantitative links between growth and R&D but knowledge of this issue has greatly increased irrespective of measurement difficulties. In the next section we explore the possibility that R&D spillovers are 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 (Branstetter [2001]).

3.6. Evidence on trade and growth

It is known that the remarkable growth of East Asian countries has been associated with various factors: high accumulation of physical (high investment rates) and human capital, high total factor productivity (TFP) (Young [1995] Lau and Kim [1992]). But, among all elements that have been responsible of these growth miracles, a relevant role should be attributed to export oriented policy followed by this group of countries. The Asian experience has generated a literature that explores the linkages between international trade, human capital accumulation, and technology transfer. To put it in a right perspective all these factors have been important for growth but some factors may have a greater impact if the country possesses a high degree of openness to the rest of the world. Even if economists generally agree that international trade may have positive effects on income per capita and on the level of productivity of an economy, the same economists claim that the reverse should also be true. In the NGTs there is an array of models which imply that great openness has not level effect but growth effect, 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 advantage as often occur for less developed countries.

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 in the economic profession is that openness to trade, generally, generates positive consequences for growth. Relevant empirical papers on the issue are Coe and Helpman (CH, 1995), Coe *et al* (1997), Sachs and Warner (1995), Harrison [1996], Edwards (1998), Keller (1998), Frankel and Romer [1999], Alcalà and Ciccone [2004], Dollar and Kraay [2002], Branstetter (2001) among others.

Coe and Helpman (1995) show that TFP growth during the period 1971-1990 in some OECD countries has been affected not only by 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, α, 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 largest impact on Belgium, followed by Ireland, the Netherlands and Israel. Estimates suggest also that international spillovers are very high and R&D expenditure raises productivity in foreign countries as well as 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 that is 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 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 R&D spillovers, measured by the elasticity of TFP with respect to foreign R&D, are large and significant. 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 UK, increases TFP in the developing countries by 0.004% to 0.008%.

Keller (1998) questions the results of Coe and Helpman that R&D spillovers are trade related. He runs the same regressions of CH, with the only difference that foreign knowledge stock is replaced by a variable, which is computed on simulated import patterns. The estimate spillovers are the average of a Monte-Carlo test with coefficients based on the simulated foreign knowledge stock. The value of these coefficients reveals larger R&D international spillovers than the coefficients based on the "true" foreign knowledge stock. These results hold for all the specifications used by CH. This cats doubt on the reliance of CH's results since counterfactual trade patterns generates a better empirical fit. The implication is that not necessarily import composition of a country matter for growth in the way predicted by recent growth theory of openness and growth.

It is worthy noting in this expansive strand of empirical literature to distinguish other two types of investigations. The first one tests the relationship between some variables of trade and their impact on growth rates. Openness is considered in the general meaning of imports and exports on GDP or other more general indices constructed on trade variables (Dollar [1992], Sachs and Warner [1995], Harrison [1996], Edwards [1998], Frankel and Romer [1999], Irwin and Tervio [2002]).

The second one includes cross-country regressions that test the implications of trade policy on growth. There is not a strict division in the literature between measures of openness as trade shares and policy oriented indices, since almost all works use both kinds of measures. Old

evidence on this issue shows that results in different period and across countries are ambiguous. But almost all the recent studies exhibit a positive and significant correlation between trade liberalisation and growth. These findings have been challenged by a paper of Rodriguez and Rodrick [2001] which shows that the evidence on the impact of policies affecting the openness of countries to trade do not conduct to faster growth.

Even though they focus primarily on *trade policy*, it is possible to infer that the empirical literature, reviewed by the authors, is under debate and suffers of many shortcomings. The results of Dollar (1992), Sachs and Warner (1995) and Edwards (1998) are re-estimated by the two authors and the results now are quite different from the original findings. The authors argue that the positive link found in these studies may depend on indicators of openness used by researcher as well as the methodology adopted. The Sachs and Warner zero-one dummy variable of openness for 79 countries in the period 1970-89 is shown to be not robust. Three of the other five indicators[11] loose their significance and the other two are not only dependent on trade policy of a country. In particular it is shown that if the measure of openness used is trade barriers there is little evidence that lower barriers, in the sense of lower tariffs to trade, are significantly associated with positive growth. Also the paper by Edwards (1998) and his openness index of nine variables is re-examined by Rodriguez and Rodrick and the robustness of the results vanishes when the two authors apply White's method to correct for heteroskedasticity or when data are updated.

There are papers that address the question of causality as Frankel and Romer (1999). They rightly posed the question of endogeneity of trade share with GDP and growth rate of income. The novelty in this paper is the attempt to deal with endogeneity by using geographic variables as instruments of the relationship bearing out the positive effect of trade. Also this paper, however, is criticised by Rodriguez and Rodrick on the basis that their geographic

[11] The openness indicator of Sachs and Warner (1995) includes .(i) average tariff rates over 40% on capital goods and intermediates, (ii) non tariff barriers that cover 40% of imports in capital goods or

variables are not valid instruments. Geography may affect income and productivity along many channels and not only trade.

Another study that controls for geographic factors and institutional quality and finds significant and robust correlation between openness and trade is the paper by Alcalà and Ciccone (2004). The two authors use a measure of *real openness* and a proxy for tradable GDP openness. They find that the effects of international trade on labour productivity and income per capita at country level are highly significant and robust (a 1 percent increase in real openness raises average labour productivity by 1.45 percent). The same robust effect is found when tradable GDP openness is used.

The regression analysis in the paper of Dollar and Kraay (2002) focuses on changes in growth rates and changes in the volume of trade by controlling for common shocks. Their results show a significant and positive link between the two variables. However, they observe that is extremely difficult to isolate the effects of trade from other variables, for the lack of adequate instruments in the regression.

The positive link, stressed in the Grossman and Helpman theoretical model (1991), depends not just on trade on goods but on whether or not the forces of comparative advantage push the economy resources in the direction of activities that generate long run growth (externalities, quality upgrading, expanding variety of products). The majority of the empirical studies have documented positive R&D spillovers from trade as well as positive links between more traditional measures of trade and growth. The econometric critiques both to the measures of openness and the instruments introduced in the regressions are, however, very pertinent. A further study, which highlights some features of the relationship between trade and growth, has been published recently by Vamvakidis (2002). Looking at historical evidence from 1870 to the present the regression results show evidence of a positive correlation only during the period

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intermediates (iii) a socialist system, iv) a state monopoly for major exports of the country, (v) a black market premium on exchange rate over 20% in the period.

starting in 1970 and a negative correlation for the period 1920-1940, suggesting that the positive correlation is a recent phenomenon.

Presumably, trade has becoming more important in the last decades but its role dates at least from mid the 1950's. The literature on trade and growth remains ambiguous and more empirical analysis is necessary to shed light on this important link.

4. Evidence on Public policy and institutions

The evidence on public policy should be extracted by general regressions, looking at the sign of the coefficients of policy variables typically included among infinity of other variables that economists think are predominant determinants of growth. The issue is becoming, now, an expanding area of interest and public policy and institutions seem to dominate on other more traditional growth's factors.

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 a way that 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 the 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 in a permanent way.

In the NGTs policies favouring R&D, education, saving rates, are all conducive to permanent 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 include also, in a significant way, improvements in financial institutions, industrial relations, as well as law, order and justice. Some economists have stressed different degrees of democracies 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 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 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.

Unlucky, as claimed by Fine (1999), the wide variety of models, the multivarious sources of growth, the highly aggregated content of the NGTs, can lead to policy ambiguity and imprecision.

We will discuss different policies in the next section but there is a piece of evidence that, although not very recent, pertains to general discussion on public policy as a whole, which require 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 are highly stable and this finding suggests that policies account for income level effects more than growth effects. The provocative title of the paper, "Good policy or good luck?" makes clear that some growth events should be driven by random shocks more than public policy. Despite the interesting analysis of the paper, we believe that models in which policies are important determinants of are worthy of the greatest attention. Also in the paper just cited economic policy should explain 60% of the variance of the growth rate and only a lesser part remains unexplained. This is a good argument to explore further recent econometric evidence on this issue.

4.1. Fiscal policy and growth

The ambiguities delineated before can be easily found in the literature that has explored the effects of fiscal policy on growth. Recent models of the NGTs have stressed its role as a key determinant of long run growth. Barro's (1990) using an extended AK model 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 is that government expenditure is of the kind that increases productivity in the private sector of the economy (government consumption expenditure is skipped 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.

Since then, many models have explored the link between taxation and growth. Rebelo (1991), Lucas (1990), Milesi Ferretti and Roubini (1998), Devereux and Love (1994), Pecorino (1994), Turnovsky (2000), Devarajan et al (1996), Kokerlakota e Yi (1997), Bleaney et al (2001), Peretto (2003) are only some examples of an expanding literature. In an endogenous growth context these studies show that the equilibrium growth rate depends on the structure of taxes which are generally growth reducing. All models imply that taxation have distortionary

effects on growth and these distortions, how is familiar from intertemporal Ramsey-type models (Chamley [1981,1986]), are higher if it is physical capital to be taxed. This is because a tax on capital, in a growth setting, reduces 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 not levied on physical capital but on labour at a greater extent is no longer valid. In some class of models with physical and human capital, in which labour is no more a fixed factor, taxes on both factors can have negative impact on growth (Milesi-Ferretti and Roubini [1998a]) Consequently, in the long run both factors must be untaxed. So the only tax that can be levied are lump sum and taxes 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 take into accounts its counterpart that is government expenditures. If expenditure is productive, such as expenditure on education, R&D, defence, infrastructures, not necessarily taxes are growth reducing (see Jones, Manuelli and Rossi [1993] Turnovsky [1996], Capolupo [2000]).

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

This brief summary of the main literature on the effects of fiscal policy makes 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 has been performed using Real Business Cycle techniques. The approach consists of specifying explicit theoretical models, calibrate and parameterise them and then derive quantitative implications. McGrattan and

Schmitz (1999) present a review of the evidence based on this approach. In general, however, what emerges from these studies is that the adverse effects of different distortionary taxes on the equilibrium growth rates rank 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 changeable. Starting with the seminal work of Barro, his econometric finding 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 should 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. The last reference is at the paper by Kneller *et al* (1999). The authors show that by specifying correctly the budget constraint, 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 and (ii) productive government spending enhances growth, whilst non-productive expenditure does not. Quite apart from robustness significance of the results of this specific study, a 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.

In a subsequent paper, Bleaney, Gemmel and Kneller (2001) have replicated the econometric results by Barro in a subsequent paper. They show 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 researches 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 derive from a two-way causation link between the size of the public sector and growth depending on supply and demand side relations. Just 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 has been found in time series studies. Kokerlakota and Yi (1996, 1997) show 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 to test 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 imply 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 UK using time series data up to 160 years and conclude 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 to cross-country regressions is that the majority of earlier studies report non-robust correlation, either positive or negative, between tax and spending variables

and growth and this did not allow any persuasive conclusion about the effects of government on growth. When econometric problems are dealt with properly the relation from negative becomes positive. It is worth noting that earlier studies, such as Barro, did not included productive government spending in his regressions (expenditure on education and defence). More recent empirical work have addressed the question of the impact of productive government spending (i.e., infrastructure) on growth. Whatever the endogeneity problems are, the findings seem to be robust and crucial for developing countries, (Batina [1999], Canning [1999]). Esfahani and Ramirez (2003) develop a structural model of infrastructure and output growth and the cross-country estimates of the model, controlling for endogeneity, indicate that the impact of infrastructures on growth is substantial.

The historical observation that many development miracles have been spurred by good government policy suggests that the econometric studies should improve their methodology to settle adequately this controversial issue.

4.2 Money, finance, and growth

Even if empirical analysis has crossed all the growth models, some factors of growth have been tested more extensively than other factors. This is the case for the empirical evidence on the nexus finance-growth. Whereas this conclusion about ambiguity of outcomes applies to money and monetary policy the same seems not to be true for financial variables. Money and financial factors have not been explicitly introduced in the theoretical framework of endogenous growth if we exclude some exceptions (Bencivenga and Smith [1991], Bencivenga *et al* [1995], King and Levine [1993 a, b], Greenwood and Smith [1997], Acemoglu and Zilibotti [1997]). Perhaps, this is due to the complexity of the financial structure, which is arduous to sketch in a theoretical model. According to most of these papers, however, financial intermediaries reduce information asymmetries, improve corporate governance, and channel funds to most productive uses. As a consequence it leads to faster economic growth. As we shall see the empirical

literature is supportive of this view. Even if money supply is a measure of the size of the financial sector, it is important to distinguish econometric studies on money and monetary policy from those on financial development.

Some econometric studies have tested the effects of an increase in money supply on the growth rate. These studies, conducted in the Barro-style regression analysis, in which financial variables are regressed on a proxy of economic development, have shown that inflation is negatively correlated with growth (De Gregorio [1993], Barro [1997]). With inflation resulting from an increase in money supply, agents should decrease saving with negative effects on growth rates. Inflation is viewed as a primary cause of poor economic performance. Agents perceive inflation as a tax on future income with an incentive to consume in the present. According to Barro's (1997) estimates the negative coefficient in convergence regressions is found also when the growth rate of M_1 or M_2 is included. The two coefficients (growth rate of money supply and the rate of inflation) are roughly similar (significantly negative).

A criticism that can be moved to the majority of these studies is that they estimate the role, inevitably negative, of high inflation on the growth rate. But what about the role of expansionary monetary policies that do not give rise to inflation? The growth theorists of the '60 emphasised the positive impact of inflation on capital accumulation as a result of the portfolio adjustment effect when agents substitute money, whose returns has fallen, with financial assets. The number of econometric studies that explore this link is very modest. Evans (1996), using data from IMF for 27 countries over the period 1960-1992 shows results, which are consistent with exogenous model of growth and with neutrality of money both in the short and in the long run. Fisher (1993) tries to allow for possible nonlinearities in the effects of inflation. A spline regression for growth, capital accumulation and productivity were estimated using inflation variables which break into three categories: low inflation at 15% or less, moderate inflation between 15 and 40% and high inflation for values above 40%. The results show that the effects are nonlinear but the negative impact is stronger at the low and moderate level than at high level

of inflation. Other interesting recent studies are Rousseau and Wachtel (1998, 2000) and Rousseau and Sylla (2001). In the first study the financial variable is M_3, among others. By controlling for initial real GDP in a sample of 84 countries, regression results show that financial variables are significantly positive. The effect disappears at high inflation rates. Rousseau and Sylla use a broad money variable relative to GDP in a sample of 17 countries from 1850 to 1997. The innovative part in their study consists not only of the long time span of the analysis but of having shown the remarkable role played by financial institutions in the first stages of development. Such importance diminishes after the Second World War. The channels of transmission of financial variables on growth appear to operate through promotion of international trade.

The literature on finance and growth is typically referred to the relationship between variables of financial development (intermediaries and equity markets): This approach, that is gaining approval, is linked to Shumpeter's idea that to finance innovations is not necessary a previous act of saving. Schumpeter reverted the smithian sequence that accumulation would precede technical progress. Following this line of thought many papers have tried to estimate the role of financial variables on growth. The positive and strong effect of the state of financial development on growth as has been documented by King and Levine (1993 a, b), Levine and Zervos (1996, 1998) Levine *et al* (1999), Arestis and Demetriades (1997), Rioja and Valev (2004 a, b), Beck and Levine (2004)[12], among others. After the reviews of Ross Levine (1997, 2003) on the finance-growth nexus and the availability of financial data compiled by the World Bank, research in this area has grown steadily. Despite this, however, it should be recognised that data on financial structure for comparison purposes are still insufficient; they are not harmonised, cover short period of time (from 1960 for bank data and from mid 1970 for stock

[12] For a review of this literature see Levine [1997].

market data) and the sample of countries is small. The exploration of the finance-growth linkage requires long cross-country time series. Moreover, the methodological pitfalls of cross-country regressions apply also to this kind of evidence, at least at the first wave of empirical researches. In particular, the documentation of a positive link between some indicators of financial development and growth does not imply causality. Reverse causality running from growth to higher demand of financial services is equally probable, although King and Levine (1993) interpret their results, of the impact of financial variables at the beginning of the period on the growth performance of the entire period, as evidence of causality. To confirm the finding other studies (Rousseau and Watchel [1998] and Beck, Levine and Loyaza[2000] exhibit a one way causality from finance to real GDP growth .

Overall the literature provide broad empirical evidence of a *positive finance-growth* link. In the majority of the papers, the proxy for the state of intermediary finance, that can promote investment and growth, is the ratio of liquidity liability as percent of GDP. Liquid liabilities are the sum of currency held outside the banking system plus interest-bearing liabilities of banks and non-bank financial intermediaries. This is a typical measure of the *overall size* of the financial sector. The other common financial development measures are Private credit (credit issued to the private sector of the economy as a percentage of GDP) and the Bank variable that is a measure of the relative importance of intermediaries in allocating saving in the financial sector (commercial bank assets divided by commercial bank plus central bank assets).

A typical regression used at aggregate level is of the kind:

$$growth_i = \alpha + \beta\, FINANCE_i + \gamma\, [conditioning\ set]_i + \varepsilon_i$$

where FINANCE includes the three measures mentioned. In the paper by Levine *et al* (2000) the coefficients for these measures are the following: 2.515 (private credit, [*t statistics* 3.09]), 10.861 (commercial central bank, [*t statistics* 2.041]), 1.723 (liquid liabilities, [*t statistics* 3.52].

The recent line of investigation (Levine [1999], Levine *et al* [2000], Beck *et al* [2000]) improves over previous researches on the effects of finance and growth using larger data set (of about 70 countries over the period 1960-1995) and dynamic panel estimators, to control for endogeneity and simultaneity biases. Results are consistent with theoretical models that predict that more efficient financial intermediaries accelerate economic growth.

A note of ambiguities in previous results is detected by Rioja and Valev (2004a). Using a broad sample of 74 countries during the 1965-1995 period and implementing GMM dynamic panel techniques, the authors find that the effects of finance on growth is not uniformly positive. The main result is that finance development exerts a strong positive effect on growth only if the country has reached a certain threshold of development. Below this threshold the impact is uncertain. The declining effects of financial variables is documented for countries with high level of development while financial development seems to benefit more countries in an intermediate phase of development. In a ensuing paper (Rioja and Valev [2004b]) the authors, taking into account the different growth strategies between LDCs and developed countries, test the effects of finance on the *sources of economic growth*. The results, based on a country relative position, show that financial development has a large effect on capital accumulation in LDCs and a large impact on TFP growth in developed countries.

Other papers, by Levine (1996), Levine and Zervos (1996, 1998), Arestis and Demetriades (1997), Singh (1997), examine the relationship between growth and different measures of equity market activity. Levine and Zervos (1996), using data or 41 countries covering the period 1976-1993 find significant correlation between economic growth and stock market indicators for many countries, including the less developed ones. By including in the regression measures of both stock market and bank-based financial indicators the authors show that all measures are robustly correlated with the rate of economic growth for the set of countries.

In a more recent work Beck and Levine (2004) have investigate the impact of both stock market and banks using a panel data set for the period 1976-1998 applying GMM estimators. Previous finding are confirmed: stock markets and bank positively affect the growth rates. These results seem robust and cannot be questioned by biases induced by classical econometric problems.

The evidence at the aggregate level is complemented by industry-level findings. There are many recent empirical studies on the finance growth nexus at the industry and firm levels. Some recent papers have been able to yield more tight and positive relations between financial variables and growth. Rajan and Zingales (1998) Demirgüç-Kunt and Maksimovic (1996,1998, 2002) show that industries, which make use of external finance in countries with well-developed financial systems, grow relatively faster than other industries. In contrast, in countries with less developed financial systems, industries that depend on external finance grow relatively slowly. Similarly, Carlin and Mayer (2004) document that countries with high accounting standards exhibit high growth of firms depending on external finance (equity and bank loans). Among the dependent variables R&D seems to be more robustly correlated with finance than investment share. A further study by Cetorelli and Gamberra (2001) show that growth of real value added in manufacturing industries is positively and significantly correlated with financial variables (private domestic credit to GDP, stock market capitalisation). Finally there are some papers that investigate the relationship between banking and economic growth by constructing some indices of efficiency of the banking sector Also under this aspect the analysis shows a positive impact of the efficiency of the banking sector on growth (Lucchetti, Papi *et al* [2001].

In this section on money, finance and growth, we have mentioned results from a related theoretical debate that deals with the optimal financing structure in promoting economic growth. Whether financial markets or financial intermediaries provide better financial services to spur growth remains an open question to which empirical evidence has not given a definitive

response. What is certain is that there are theoretical plausible arguments in favour of both financial markets and banks in providing funds for innovations and investment. The analysis of the arguments both at micro and macro level which favour one of the other financial structure should require a paper by itself. From an empirical point of view, however, there is no solid evidence of the superiority of *market-based* versus *bank-based* financial systems. What emerges is that the two financial systems reinforce each other so that a complementarity exists between the two.

For a more insightful and incisive analysis, it will be highly informative the recent survey by Levine (2003) who suggests more theoretical studies on the topic and from an empirical perspective a more deeply investigation of political, legal, and cultural institutions underlying financial development.

4. 3. Legal 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 income per capita. Their effect is not direct but should be substantial. For some authors institutions are *deep* determinants of growth in contrast to the *proximate* growth factors that have been discussed so far. We have already noticed that institutions interact with factors such as finance, intensity of openness, public policy. An argument recently debated in the context of the empirics of growth is whether institutions dominate over these and other factors (Dollar and Kraay [2002, 2003], Rodrick, Subramanian and Trebbi [2004]). Not all researchers agree on the use of proxies for institutions in the growth empirical framework and the main reason is that their qualitative characteristics cannot be transferred in a quantitative index. Indeed, econometrically the quality of institutions is measured by different indices of property rights, rules of law, religion, degree of contract enforcement, social capital etc. Generally they are constructed in a point of time trough surveys

or collected at five-year periods. The series are very short and typically start from the 80s. The aim is to test their contribution to the cross sectional variation on income levels or growth rates.

There is already some deal of empirical work that suggests that the primary reason 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. As pointed out by Easterly and Levine (2001), divergence is inconsistent with growth driven by factor accumulation. If returns are diminishing then factor's returns should converge across countries. Differences in institutions may prevent factor convergence by reducing physical and human capital accumulation. Countries with secure property rights, rules of law and good quality of political institutions should exhibit high growth, whilst countries whose environment is characterised by corruption, expropriation, low democracy, and insecure physical and intellectual property rights discourage growth of output generating diversion of resources. Obviously, 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.

Here, however, we examine institutions as a set of social arrangements including indices of democracy and rules of law that have been shown to affect growth. The policy variables just cited should be considered as channels via which institutions affect economic outcomes. It is reasonable to infer that weak institutions may have a negative impact on economic performance. However, simple indexes of democratic rights do not seem to be significant in the regressions performed. 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.

Similar to democracy, also the political instability variable, as an average of revolutions and political assassinations (civil disturbance), does affect 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 under criticism. Data for political rights are those collected by Gastil (1987). However, this data set does not refer specifically to aspects of the government that affect economic transactions and property rights. In the growth regressions, in fact, data from Knack and Keefer (1995) have been more widely used.

Even though evidence should be regarded with caution, a growing literature has documented the importance of institutions for growth. Proponents of this view include, among others, Hall and Jones (1997, 1999), La Porta *et al* (1998), Shleifer and Vishny (1993), Sachs and Warner (1995, 1997), Knack and Keefer (1995, 1997), Perotti (1996), Acemoglu *et al.* (2000, 2001) Dollar and Kraay (2003), Rodrick, Subramanian and Trebbi (2004).

The studies just cited take a broad view of institutional variables. Institutions are considered as a collection of law, government policy, regulations and the like. 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 English language is assumed also to inherit English institutions. Moreover, they included in their study different indexes of government, (such as law 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, reduces 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 from data in the *International Country Risk Guide*[13]. The estimated cross-country regression coefficient of the institutional quality index (for the period 1965-1990) found is about 0.32 (*t statistics*: 3.8) which is the highest value among the coefficients of all others independent variables included in the 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. With appropriate interventions the growth rate might be appreciably increased. The issue is particularly relevant for the development in poor countries.

The work of Acemoglu *et al* (2001) proposes a careful econometric treatment of instruments to solve the endogeneity problem of institution quality in cross-country regressions, by using mortality rates of colonial settlers. They state that European colonizers erected solid institutions and rule of law in places in which encountered relatively few health hazards, while in less healthier areas their interest was limited to exploit resources with little or not interest in building solid institutions.

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

[13] This Guide is a publication that provide data on the quality of political institutions with respect to implication for riskness 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: Jaggers and Marhall (2000) known as Polity IV Project and Kaufman et al (2003). Another recent set of data is from Gwartney et al (2002).

rule of law although important 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 some few countries are dropped from the sample (US, Canada, Australia and New Zealand). In short is not possible to disentangle the partial effect of institutions by other variables. A comment by Pritchett (2003) to this paper argues that the weak significance of the institutional coefficient should 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 interesting 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 experience of China, which still retain socialist legal system, and Russia private property rights regime offers an example 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, La Porta et al (2004). They re-examine the debate (institutional view against development view) on whether or not political institutions cause growth and conclude that it is education (human capital accumulation) and wealth that lead to institutional evolution. They argue that: (i) the majority of indexed of institutional quality 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 exciting (but also obvious) conclusion in their paper is that poor countries can get out of poverty traps even when good

policies are pursued by dictators (the case of South Korea which started with dictatorship) that promote human capital accumulation and pro-market mechanisms devoted to assure property rights.

The same view about the importance of human and social capital in determining the evolution of institution is stated in the paper by Djankov et al (2003). Whichever the empirical evidence, it should be recognised that the predictions that appropriate outward looking government policy and institutional reforms may help to strengthen long run growth performances, is not only appealing for the profession and policy-makers, but 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 is appealing and needs to be further investigated.

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, represent 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 itself to act 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, mainly 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 should 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) are 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 on 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 electoral participation to referenda and blood donation) 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 to a certain community. According to their measures, social capital results to be very low in the South and this could partly explain also a weak impact of their unusual[14] 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 (2004). The latter is survey of the majority of researches on the topic 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 on this interesting issue should come from micro-level studies, provided that typical econometric problems (identification and endogeneity) can be addressed adequately.

Therefore, on these crucial issues more researches are necessary before achieving established conclusions. However, even if institutional measures do not fit well with the empirical framework of growth, certainly some of them matter for growth.

[14] access by households to formal and informal credit based on data drawn from Survey of Household Income and Wealth of the Bank of Italy.

5. Summary and 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 prediction values 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.

The theoretical structures of these models are known and have gained much ground in the last decade in becoming part of the mainstream growth economics. However, they differ widely both in their positive and normative implications and is meaningful to distinguish among them empirically.

Scholars through their empirical studies have evaluated indirectly the new growth theories but still there is 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. Then, also with all concerns about the empirics of growth, we have reviewed the evidence on each source of economic growth, which is considered theoretically founded. The first piece of evidence was obtained by looking at the convergence issue that has been the main empirical topic in the last decade. Lack of *absolute* convergence was considered a puzzle for the standard model (a non-augmented Solow model), which predicts that poor countries grow faster in per capita terms than rich ones. 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. It is still possible, even in models of endogenous growth, with endogenous technological progress and transitional dynamics to find

place for convergence. Countries can catch up the leaders when imitation and implementation of discoveries are cheaper than the original innovation. This mechanism tends to generate convergence even if diminishing return to capital or to R&D are completely absent. Alternatively, also in Solow-type models divergence is possible. However the issue of convergence from an econometric point of view has become very complex and our purpose was do not enter in it. If we interpret convergence, asking whether initial conditions are robustly correlated with growth, we should recognise that initial GDP is one of the few growth candidate that pass different test of robustness.

The second peace of evidence consists of possible explanation of cross–country differences in output levels and growth. Many scholars using a variety of techniques have shown that human and physical capital cannot explain the divergence we observe. Fixed effects, interpreted as differences in TFP have been considered responsible of the majority of the observed cross-country differences in output levels and growth rates. In this work we have re-examined critically the tests of robustness on growth variables drawning mainly, but not exclusively, from latest researches. Although these studies are much less contested than the previous ones, econometric results are still object of many criticisms. The existence of an impressive number of empirical studies has not been sufficient to settle down all the debates around 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 reviewed concerning the relative role of growth factors, the weakest results are related to models based on spillovers and human capital. More robust results are obtained for factors like investment, finance, as well as various aspects of law enforcement and property rights. 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 signals that their influence on growth is substantial but measurement problems still prevent a correct analysis of these factors.

Advances on the econometric techniques used to test growth theories have been relevant: Since the empirics of growth is continuously improving its statistical tools and methods of analysis, we should expect further advances on this front

Overall, however, while earlier empirical studies found a fragile correlation with many determinants of growth, indicated by the new theories, more recent studies are becoming increasingly supportive of the NGTs. Even if further developments are expected for more definitive results, the improving on the methodological ground, as recent advances seem to predict, and better quality of data, especially on R&D, financial variables, trade, and institutions, may help the NGTs to collect a stronger support in the near future.

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