Empirics of Growth and Development

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1. Introduction

For much of the postwar period, empirical work on economic growth focused on accounting exercises whose goal was to understand the relative roles of factor accumulation and technical change in explaining growth trends. This approach was initiated in Solow's seminal (1957) article; work by Denison (1974) represents a particularly sophisticated version of this approach. In contrast, modern growth empirics largely attempt to address issues of *cross-country* economic differences using regression or other statistical methods which permit the consideration of a host of different growth determinants. This new work has been facilitated by the availability of data for a broad cross-section of countries for the period 1960-2000 due to Summers and Heston (1988,1991) and Heston, Summers, and Aten (2002).

What sorts of broad facts has the new growth empirics uncovered? Durlauf, Johnson and Temple's (2005) extended survey suggests three classes of empirical findings that are especially salient:

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1. Over the forty-year period from 1960-2000, most countries have grown richer, but vast income disparities remain and substantial heterogeneity exists across countries. The major countries of Western Europe have either maintained (UK) or substantially improved (Germany, Italy, France) their position relative to the US. East and Southeast Asia have unprecedented sustained growth rates. The weakest performers are predominantly located in sub-Saharan Africa, where many countries have barely grown at all, and some have become poorer. The record in South and Central America is distinctly mixed, with high output volatility and periodic output collapses.

2. The international distribution of GDP per worker exhibits an emerging bi-modality. While the distribution has shifted rightwards to reflect overall growth, there has been a noticeable thinning in the middle of the distribution. Further, when one explores the location of individual countries as the cross-section distribution evolves, there is little evidence of churning across the emerging twin modes so that poor countries from the left mode are extremely unlikely to "transition" into the right mode (and vice versa).

3. There exist a host of factors that appear to affect growth beyond the factor accumulation and exogenous technical change that drive the Solow model. These determinants include a range of economic, political, geographic, and social factors. There also appears to be significant evidence of nonlinearity and parameter heterogeneity in the way these factors enter into growth regressions.

These new classes of stylized facts have led growth economists to pose three major sets of formal statistical questions. The first revolves around the question of convergence. That is, are contemporary differences in aggregate economies transient over sufficiently long time horizons, or are these differences, in fact, permanent? If they are permanent, does that permanence reflect structural heterogeneity or the role of initial conditions in determining long-run outcomes? The second set of questions considers the properties of the cross-section income distribution. What probability density describes current incomes and how is this density evolving? The third set of questions surrounds the identification of growth determinants. Which factors seem to explain observed

differences in growth? Can these growth determinants be organized into theoretically and empirically useful categories: what are the *fundamental* (as opposed to *proximate*) determinants of growth?

The field of growth econometrics has emerged through efforts to interpret and understand the above stylized facts in terms of simple statistical models, and in the light of predictions made by alternative statistical structures. For questions of convergence and the determination of which growth factors are salient, these alternative statistical structures usually represent variations on a baseline linear cross-country growth regression pioneered by Barro (1991), Kormendi and Meguire (1985), and Mankiw, Romer, and Weil (1992). For questions on the cross-section income distribution, the methods involve various techniques related to density estimation. The plethora of statistical methods that has been employed to study growth is examined in Durlauf, Johnson, and Temple (2005).

Our review of the empirical growth literature will focus on growth differences between countries, as opposed to differences across individuals. For this reason, many of our claims concerning the evolution of the international inequality and changes in the world distribution will mask how differences across individuals have evolved; in our analysis China and India will be given the same weight as countries with small populations such as Cyprus. Our reason for this focus is that our goal is to understand growth facts in the contexts of growth theories, theories which are defined at the country level. While individual level incomes presumably matter more for normative evaluations, they are not required for the questions we address. Examples of individual-specific studies of world inequality include Sala-i-Martin (2002a,b).

2. The convergence hypothesis

Much of the empirical growth literature has focused on the question of whether contemporary income differences between countries are transitory or permanent. Unconditional convergence is said to occur if the differences are transitory. Conditional convergence is said to occur if the differences are permanent and solely due to cross-

country structural heterogeneity, cf. Galor (1996). The neoclassical (Solow) model predicts that once structural heterogeneity, such as exogenous differences in technology, population growth rates, and the population's willingness to save are controlled for, long-run economic outcomes are independent of initial values of state variables and so predicts conditional convergence. On the other hand, if the differences are permanent and initial conditions determine, in part at least, long-run outcomes, then convergence clubs are said to arise.

Attempts to translate these economic notions of convergence into testable restrictions on cross-country growth data have given rise to a number of popular statistical approaches.

i. β-convergence

The most common statistical approach towards convergence relies on the properties of the coefficient of the logarithm of initial income in linear growth regressions. A general panel data growth regression for growth over *K*-year intervals is

$$g_{i,t} = k + \beta \log y_{i,t} + \gamma Z_{i,t} + \varepsilon_{i,t} \tag{1}$$

where $g_{i,t}$ is real per capita growth between time *t* and *t+K*, $y_{i,t}$ is initial income at *t*, $Z_{i,t}$ is a set of additional control variables and $\varepsilon_{i,t}$ is an error. β-convergence in per capita means that $\beta < 0$. β-convergence is readily interpretable in the context of the Solow growth model, since the property is implied (at least locally) by the dynamics of the model. The economic intuition is simple: when the marginal product of capital is decreasing, per capita growth becomes slower as per capita output rises, assuming constant savings and population growth rates. In turn, β-convergence is commonly interpreted as evidence against endogenous growth models of the type studied by Romer (1986) and Lucas (1988), since a number of these models specifically predict that high initial income countries will grow faster than low initial income countries, once differences in saving rates and population growth rates have been accounted for.

Findings of conditional β-convergence (i.e. β-convergence in the presence of control variables typically including saving and population growth rates) are common in the cross-country growth literature. While this statistical evidence seems robust to the choice of control variables (Doppelhofer, Miller and Sala-i-Martin (2004) and Fernandez, Ley and Steel (2001)), there is a conceptual problem with the conditional β-convergence literature: namely the absence of a tight theoretical relationship between β-convergence and the notion of convergence as an economic concept.

This problem can be seen initially when one considers the use of β-convergence as a test between the Solow model and a model with multiple stable steady states. Multiple stable steady states in a model clearly violate the economic idea of convergence, since long-run behavior in the model depends on the initial capital stock. A standard example of the latter type of model is due to Azariadis and Drazen (1990). In this model, there is a discontinuity in the aggregate production function for aggregate economies. This discontinuity means that the steady-state behavior of a given economy depends on whether its initial capital stock is above or below this threshold. Bernard and Durlauf (1996) show that it is possible for data generated by economies that are described by the Azariadis-Drazen model to exhibit β-convergence even when multiple steady-states are present. The reason for this is that even if economies are converging to distinct steady states, those economies that are converging to a low steady state may still be growing faster than those converging to a higher one. More generally, the finding of β-convergence provides no insight as to whether the cross-section of countries exhibits growth and development differences that are, in fact, transient.

ii. σ-convergence

Other studies have focused on changes in the dispersion of income differences across time. σ-convergence is said to occur if the cross-sectional standard deviation of per capita income is falling over time. The key finding, however, is that there is no evidence of σ-convergence when one examines a full cross-section sample of countries

(Sala-i-Martin (1996)). In contrast, when one restricts the analysis to developed economies, σ-convergence appears to be present.

Some studies relate σ-convergence with β-convergence. One common assertion in the literature is that the finding of β-convergence implies σ-convergence, so that the finding of the former actually results in strong predictions regarding the diminishing dispersion of cross-country growth experiences with time. There is, however, in fact, no clear relationship between the two concepts. These two convergence notions do not have any necessary implications for one another, i.e. one may hold when the other does not. For our purposes, what is important is that σ-convergence is not an implication of β-convergence and so does not speak directly to the question of the transience of contemporary income differences. The erroneous assertion that β-convergence implies σ-convergence is known as Galton's fallacy and was brought into the convergence debate by Friedman (1992) and Quah (1993a). One should also note that there is no well-defined notion of conditional σ-convergence, which renders the use of this convergence concept to adjudicate growth theories essentially impossible.

iii. time series approaches to convergence

A third approach to convergence based on time series ideas has been developed by Bernard and Durlauf (1995, 1996) and extended by Evans (1998), and Hobijn and Franses (2000) among others. Bernard and Durlauf (1995) define time series convergence in output in two economies to be the equality of their long-run output forecasts taken at a given fixed date. In practice, forecast convergence is tested by looking for unit roots or deterministic trends in the difference in per capita output between two countries, either of which implies long-run forecastability of output differences. As argued by Bernard and Durlauf (1996), these tests carry strong economic implications. Specifically, they assume that first differences in output for each country may be described as a process with a time invariant autocorrelation function. This is inconsistent with economies that are still in their initial stages of development and

converging towards a steady state. As a result, time series convergence tests are only appropriate for developed economies that are near their steady states.

In general, time series approaches have rejected convergence. For example, Bernard and Durlauf (1995) find that time-series forecast convergence can be rejected across all OECD economies based on long time series data due to Maddison (1982,1989). However, they find that some individual country pairs such as Belgium and the Netherlands do display such convergence. Hobijn and Franses (2000) similarly find little evidence of convergence across 112 countries taken from the Penn World tables for the period 1960-1989. Pesaran (2004) confirms the findings of little convergence for both Maddison and Penn World data sets.

Taken as a whole, the convergence literature is difficult to interpret. There is good evidence of conditional cross-sectional convergence given the β definition and some evidence of convergence given the σ definition. However, these definitions do not provide strong discriminatory power when one is comparing models with unique versus multiple steady states, and so do not speak to many of the fundamental questions that motivate endogenous versus neoclassical growth theory. Further, time series tests typically conclude that convergence is not present and so represent a challenge to cross-section and panel findings of convergence. While Michelacci and Zaffaroni (2000) propose a clever reconciliation of cross-section and time series evidence which supports convergence, the analysis requires that output levels obey long memory processes, which has far from been established as empirically correct. We therefore conclude that the convergence question is far from resolved.

3. The world income distribution

A second strand of empirical research has focused on the world income distribution. This work is motivated by interest in the question of whether this distribution exhibits bimodality, which is suggestive of permanently high degrees of cross-section inequality, as well as whether the distribution reflects multiple mixture

components, which is suggestive of the presence of either multiple steady states or multimodality in certain growth determinants.

In terms of bimodality, a range of studies have described how the distribution of relative per capita income has changed from a unimodal shape to a bimodal ("twin-peaked") distribution from 1960 to 1989. Quah (1993b,1996,1997) studies the evolution of the entire cross-country income distribution by modeling the cross-section density as a dynamic process Quah finds that the estimated transition probabilities imply a bimodal steady state. While Kremer, Onatski, and Stock (2001) have questioned the robustness of Quah's methodology, his general conclusions have been confirmed by a number of authors using different methods. Bianchi (1997) uses kernel density estimations to construct statistical tests for multi-modality in the international distribution of income. Paap and van Dijk (1998) analyze the distribution of real GDP per capita using a parametric two-component mixture model. Using the estimated mixture distributions, they analyze intra-distribution mobility to find that the main source of mobility occurs from rich to poor while the 'middle' group between poor and rich disappears.

Recently, Anderson (2003) has shifted the discussion from the analysis of multimodality and the twin peaks debate to polarization, i.e. the extent to which gaps between the rich and poor are increasing. Using stochastic dominance techniques to construct measures of polarization of the income distribution, Anderson finds that between 1970 and 1995 polarization between rich and poor countries increased throughout the time period. An important methodological advantage of Anderson's approach is that it is nonparametric.

One important implication of the work on the evolution of the cross-section income distribution is that it implies that even if aggregate production functions exhibit decreasing marginal productivity of capital, other growth factors are sufficiently strong to produce increasing international inequality. What such findings cannot say is whether these other factors are themselves permanent or transitory.

4. Growth model determination

The major empirical effort in modern growth research consists of efforts to identify the relative importance of various growth determinants. As such, this work represents an extension of the original objective of empirical growth research to understand the respective roles of technological change and capital accumulation.

i. growth accounting revisited

One strand in the literature has attempted to quantify the extent of various sources of convergence or divergence. The aim of growth accounting is to estimate the relative portions of variation in cross-country output per worker, or growth, which can be assigned to variation in factor accumulation rates and that which accrues to total factor productivity (TFP). As such, the literature extends the approach pioneered in Solow (1957).

The recent TFP literature produces two important claims. First, the bulk of cross-country variation in per capita income levels or in growth rates appears to derive from differences in TFP. Klenow and Rodríguez-Clare (1997) find that only about half of the cross-country variation in the 1985 level of output per worker is due to variation in human and physical capital inputs while a mere 10% or so of the variation in growth rates from 1960 to 1985 reflects differences in the growth of these inputs. These findings are consistent with Easterly and Levine (2001) who also find that differences in inputs are unable to explain observed differences in output.

Second, divergence in the form of the "twin peaks" phenomena described in stylized fact 2 above is more likely to be attributed to cross-country divergence in TFP than to factor accumulation rates. Feyrer (2003) finds that the long-run distributions of both output per capita and TFP are bimodal while those of both the capital-output ratio and human capital per worker are unimodal. Feyrer's findings suggest that models of multiple equilibria that give rise to equilibrium differences in TFP are more promising than models that emphasize indeterminacy in capital intensity or educational attainment. Johnson (2004), however, shows that certain aspects of Feyrer's analysis are not robust and that robust approaches to this decomposition suggest the presence of bimodality in

the long-run distributions of both the capital-output ratio and TFP as well as in the long-run distribution of output per capita.

A key assumption of most TFP studies is that the aggregate production function is concave. Graham and Temple (2003), however, show that the existence of multiple steady states can increase the variance and accentuate bimodality in the observed cross-country distribution of TFP. It seems likely, therefore, that the imposition of a concave production function in this case will tend to exaggerate the measured differences in TFP and so confound inferences about the importance of TFP variation in explaining cross-country variations in output per worker or growth. Extension of TFP analyses to richer specification of production functions appears to be an important next step.

Another problem of most TFP studies is that they ignore the possibility of spillovers between physical and human capital accumulation and productivity. These spillovers can take the form of technology spillovers from countries at the frontier to developing countries facilitated by human capital stocks, rule of law, openness, etc. Aiyar and Feyrer (2002) analyze the causal links between human capital accumulation and growth in TFP. They find that TFP differences explain most of the cross-sectional (static) variation in GDP but at the same time they find that human capital plays a substantial role in determining the dynamic path of TFP. Their findings suggest the importance of further work on identifying the channel through which human capital affects productivity.

ii. growth determinants

The evidence of the importance of TFP in growth outcome may be linked to the general search for salient growth determinants in regression models. From the perspective of growth regressions, such as (1), many different candidates have been proposed for *Z*. The set of growth regressors that have been proposed as candidate growth determinants is large and growing. In a 1999 survey, Durlauf and Quah listed a total of 87 such potential growth determinants studied in the literature. By the time of Durlauf, Johnson, and Temple's 2005 survey, the number had risen to 145.

Recently, the growth literature has also begun to distinguish between determinants that are viewed to be "fundamental" as opposed to being "proximate" to growth. Many such fundamental determinants of growth have been proposed including economic institutions (North (1990), Knack and Keefer (1995), Hall and Jones (1999), Acemoglu, Johnson and Robinson (2001)), legal and political systems (La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1999), La Porta, Lopez-de-Silanes, Pop-Eleches and Shleifer (2004)), climate (Gallup, Sachs and Mellinger (1999), Masters and McMillan (2001)), geographic isolation (Radelet and Sachs (1998), Frankel and Romer (1999)), ethnic fractionalization (Easterly and Levine (1997), Alesina, Devleeschauwer, Easterly, Kurlat, and Wacziarg (2003)), and culture (Barro and McCleary (2003), Knack and Zak (2001), Tabellini (2005)).

This shift in the literature towards fundamental explanations of divergence is motivated in part by the desire to identify variables that are slow-moving and can be argued to be predetermined with respects to current growth rates in per capita income. The idea is that these fundamental determinants may not only provide interesting reduced form explanations for divergence, but may constitute valid instrumental variables for (statistically) endogenous proximate causes. However, as Durlauf (2000) points out, predetermined variables are not necessarily valid instruments. The difficulty is that with so many potential explanations for growth, it is hard to argue that simply because a variable is predetermined, that it is also uncorrelated with omitted growth factors in growth regressions. Glaeser, La Porta, Lopez-de-Silanes, and Shleifer (2004) have also questioned the direction of causality between certain fundamental determinants of growth and proximate factors of growth. They point out that some measures of economic institutions are themselves in reality choice variables of policymakers who are in turn constrained by proximate factors such as the average level of initial human capital in the population.

The presence of so many potential growth regressors is unsurprising given the nature of new growth theories. As argued by Brock and Durlauf (2001), new growth theories are inherently *open-ended*. By theory open-endedness, Brock and Durlauf refer to the fact that typically the a priori statement that a particular theory of growth is relevant does not preclude other theories of growth from also being relevant. As a result,

there is a great need for robust procedures that deal with model uncertainty by assessing the sensitivity of coefficient estimates and standard errors to choices of covariates.

An early attempt to develop ways to identify empirically salient growth determinants is Levine and Renelt (1992) who employed Leamer's (1983) extreme bounds analysis (EBA) to conclude that the only robust growth determinant among the set of growth determinants is the share of investment in GDP. However, from a decision-theoretic perspective, the extreme bounds approach is a problematic methodology. As discussed in detail in Brock and Durlauf (2001) and Brock, Durlauf and West (2003), EBA corresponds to a very risk averse way of responding to model uncertainty.

The limitations of EBA have led to a range of efforts to develop new tools for identifying robust growth determinants. Attempts to deal with the problem of model uncertainty include Sala-i-Martin's (1997) variants of extreme bounds analysis and the general-to-specific model selection approaches of Hendry and Krolzig (2004) and Hoover and Perez (2004). While these approaches avoid the implicit risk aversion found in extreme bounds analysis, they do not possess conventional statistical or decision theoretic justification.

An alternative approach has emerged that accounts for uncertainty in choice of growth regressors by systematically addressing the dependence of model-specific estimates on a given model. This method, known as model averaging was suggested by Leamer (1978) and has reemerged in recent work in statistics; see Hoeting, Madigan, Raftery, and Volinsky (1999) for a survey. The idea of model averaging is to construct estimates of parameters of interest by aggregating information across all elements in a space of possible models. As such, the method accounts for the fact that the true model is not known to the researcher, but rather presupposes the true model is known to lie within some set. Model spaces can be constructed based on the choice of regressors as well as the way in which nonlinearities or heterogeneity may appear in the growth process. Model averaging has been applied to cross-country growth data by Brock and Durlauf (2001), Brock, Durlauf, and West (2003), Doppelhofer, Miller and Sala-i-Martin (2004), Fernandez, Ley, and Steel (2001) and Masanjala and Papageorgiou (2004), among others

In terms of findings, these various approaches to identifying robust growth determinants conclude that at least two of the four canonical Solow variables; i.e., initial

income and the rate of physical capital accumulation, are robust determinants of growth. There is also some evidence that human capital accumulation as measured by secondary school education (Sala-i-Martin (1997)) and life expectancy (Fernandez, Ley, and Steel (2001)) may be robust as well. Other variables that have been found to be relatively robust include measures of political stability (Hendry and Krolzig (2004), Hoover and Perez), proxies for trade openness (Doppelhofer, Miller, and Sala-i-Martin (2004)), as well as measures of culture as captured by the percentage of the population that is Confucian (Hendry and Krolzig (2004), Hoover and Perez (2004), Doppelhofer, Miller, and Sala-i-Martin (2004), Fernandez, Ley, and Steel (2001)), and the percentage of the population that is Protestant (Hendry and Krolzig (2004), Hoover and Perez (2004)). These last variables are difficult to interpret in terms of causality and indeed may reflect the absence of attention to parameter heterogeneity across countries.

iii. nonlinearities and parameter heterogeneity

Another body of empirical growth analyses deals with the problems of parameter heterogeneity and nonlinearities relative to the canonical cross-country growth regression (1). By nonlinearity we mean that the determinants of economic growth enter the regression in a nonlinear way, while by parameter heterogeneity we mean that the parameters of the model are explicitly allowed to vary across countries. The modeling assumptions of parameter heterogeneity can take various forms. The parameters can be assumed to vary in a systematic and/or non-systematic (random) fashion. When parameter heterogeneity is modeled in a systematic way, the parameters are thought to be parametric or nonparametric functions of dummy variables (e.g. a dummy for Sub-Saharan countries) or more generally a subset of the determinants of economic growth (e.g. initial conditions). In this situation, one may view parameter heterogeneity as an interesting special case of nonlinearity.

Concerns over nonlinearity and parameter heterogeneity naturally arise when one considers theoretical growth models with multiple steady states. A range of analyses have provided microfoundations for the emergence of multiple steady states and convergence clubs. Examples include human capital externalities (Azariadis and Drazen

(1990)) or liquidity constraints (Galor and Zeira (1993)) in the accumulation of human capital and physical capital. More recently, several papers give a technological explanation for these growth anomalies. Howitt and Mayer-Foulkes (2005) show that a Schumpeterian approach that includes both innovation and technology implementation can give rise to convergence clubs. Acemoglu, Aghion and Zilibotti (2004) show that institutional barriers can prevent a group of countries from using the same production function potential thereby keeping each country in the group inside the group-level production possibility frontier. The equilibrium growth paths of these types of models are not well approximated by the linear growth model (1) in the way the neoclassical Solow growth model, or its Cass-Koopmans variation, is.

One approach to allowing for growth nonlinearities is to use semiparametric models. Liu and Stengos (1999) estimate a partially linear model to identify nonlinear growth patterns. This approach allows one or more regressors in (1) to have additive but nonlinear effects on growth. One of their findings is that the convergence hypothesis only holds for countries in the middle to upper range of initial income. Banerjee and Duflo (2003) use this same regression strategy to study nonlinearity in the relationship between changes in inequality and growth. They find an inverted U shape between the growth rate and the change in the Gini coefficient.

Durlauf, Kourtellos, and Minkin (2001) extend this search for nonlinearity to one for parameter heterogeneity and estimate a Solow growth model that allows the parameters for each country to vary as functions of initial income. In effect, this varying coefficient approach defines a distinct Solow regression at each initial income level. This approach reveals considerable parameter heterogeneity especially among the poorer countries. This work is extended in Kourtellos (2005) who finds parameter dependence on initial literacy, initial life expectancy, expropriation risk, and ethnolinguistic fractionalization. The varying coefficient approach is also employed in Mamuneas, Savvides, and Stengos (2004) who analyze annual measures of TFP for 51 countries. One important finding is that, in general, the estimates of the elasticity of human capital with respect to output are positive and largest for high income countries while the estimates for low income countries are small and in some cases zero.

A conceptually different approach to modeling parameter heterogeneity and nonlinearities has been taken by Bloom, Canning, and Sevilla (2003), Canova (2004), Durlauf and Johnson (1995), Masanjala and Papageorgiou (2004), and Tan (2005). These papers have employed statistical learning (specifically, sample splitting and threshold regression) approaches that emphasize pattern recognition in order to uncover evidence of multiple steady states or "convergence clubs" across countries. Durlauf and Johnson find evidence for convergence clubs that depend on initial values for state variables such as initial adult literacy rates and initial income. Papageorgiou and Masanjala find similar results using models that these findings by estimating growth models that allow for constant elasticity of substitution (CES) production function. Further evidence of multiple regimes is also found by Bloom, Canning and Sevilla using mixture distribution methods and Canova using a Bayesian approach that differentiates multiple regimes and parameter heterogeneity. Most recently, Tan employs classification methods to adjudicate divergent claims on the importance of different fundamental growth determinants and finds strong evidence that measures of institutional quality and ethnic fractionalization define convergence clubs across a wide range of countries.

This discussion suggests that the assumptions of linearity and invariant parameters such as found in (1) are likely to be inappropriate in the analysis of cross-country growth data. That being said, no consensus yet exists on which types of nonlinearity and heterogeneity are empirically most important, and so researchers will need to exercise judgment as to how to allow for these when analyzing a particular data set.

5. Summary and conclusion

Modern growth economics has led to a rich and wide-ranging empirical literature replete with many new methodologies and many new findings. Yet in comparing the modern empirical literature to the traditional growth accounting analyses of the 1960's and 1970's, one cannot help but be struck by the relative lack of progress on substantive conclusions. The critical role of TFP found in recent work is consistent with claims as

far back as Solow. Evidence of statistical notions of convergence represents a new set of stylized facts but suffers from a lack of connection to economically interesting notions of convergence. The search for empirically successful growth models has provided a range of candidate growth determinants that lie far outside the domain of the neoclassical growth model, but efforts to search for robust determinants have had mixed results, outside of the finding that physical capital accumulation affects growth, which is no surprise given the earlier literature. Evidence of nonlinearities and parameter heterogeneity is suggestive of multiple steady states and richer growth dynamics than neoclassical theories, but this evidence has yet to be integrated into a consistent whole. Together, this suggests that the next step in empirical growth research should be the unification of the vast array of statistical claims into a unified growth picture combined with efforts to link this picture more tightly with growth theories.

References

Acemoglu, D., Aghion, P., and F. Zilibotti, (2004), "Distance to Frontier, Selection, and Economic Growth," forthcoming, *Journal of the European Economic Association*.

Acemoglu, D., S. Johnson, and J. Robinson, (2001), "The Colonial Origins of Comparative Advantage," *American Economic Review*, 91, 5, 1369-1401

Aiyar, S. and J. Feyrer (2002), "A Contribution to the Empirics of Total Factor Productivity," mimeo, Dartmouth College.

Alesina, A., A. Devleeschauwer, W. Easterly, S. Kurlat and R. Wacziarg, (2003), "Fractionalization," *Journal of Economic Growth*, 8, 2, 155-194..

Anderson, G., (2003), "Making Inferences About the Polarization, Welfare, and Poverty of Nations: A Study of 101 Countries 1970-1995," *Journal of Applied Econometrics*, 19, 5, 537-550.

Azariadis, C. and A. Drazen, (1990), "Threshold Externalities in Economic Development," *Quarterly Journal of Economics*, 105, 2, 501-526.

Banerjee, A. and E. Duflo, (2003), "Inequality and Growth: What Can the Data Say?" *Journal of Economic Growth*, 8, 3, 267-300.

Barro, R. J. (1991), "Economic Growth in a Cross-Section of Countries," *Quarterly Journal of Economics*, 106, 2, 407-443.

Barro, R. and R. McCleary, (2003), "Religion and Economic Growth," *American Sociological Review*, 68, 760-781.

Bernard, A. and S. Durlauf, (1995), "Convergence in International Output," *Journal of Applied Econometrics*, 10, 2, 97-108.

Bernard, A. and S. Durlauf, (1996), "Interpreting Tests of the Convergence Hypothesis," *Journal of Econometrics*, 71, 1-2, 161-73.

Bianchi, M., (1997), "Testing for Convergence: Evidence from Nonparametric Multimodality Tests," *Journal of Applied Econometrics*," 12, 4, 1997, 393-409.

Bloom, D., D. Canning and J. Sevilla (2003), "Geography and Poverty Traps," *Journal of Economic Growth*, 8, 355-378.

Brock, W. and S. Durlauf, (2001), "Growth Empirics and Reality," *World Bank Economic Review*, 15, 2, 229-272.

Brock, W., S. Durlauf, and K. West, (2003), "Policy Evaluation in Uncertain Economic Environments (with discussion)," *Brookings Papers on Economic Activity*, 1, 235-322.

Canova, F. (2004), "Testing for Convergence Clubs in Income Per Capita: A Predictive Density Approach," *International Economic Review*, 45, 1, 49-77.

Denison, E. F. (1974), *Accounting for United States Growth, 1929-1969*, The Brookings Institution, Washington DC.

Doppelhofer, G., R. Miller, and X. Sala-i-Martin, (2004), "Determinants of Long-Term Growth: A Bayesian Averaging of Classical Estimates (BACE) Approach," *American Economic Review*, 94, 4, 813-835.

Durlauf, S. and P. Johnson, (1995), "Multiple Regimes and Cross Country Growth Behaviour," *Journal of Applied Econometrics*, 10, 4, 365-84.

Durlauf, S., (2000), "Econometric Analysis and the Study of Economic Growth: A Skeptical Perspective," in *Macroeconomics and the Real World*, R. Backhouse and A. Salanti, eds., Oxford: Oxford University Press.

Durlauf, S., P. Johnson, and J. Temple (2005), "Growth Econometrics," in *Handbook of Economic Growth*, P. Aghion and S. Durlauf, eds., Amsterdam: North Holland, forthcoming.

Durlauf, S., A. Kourtellos, and A. Minkin, (2001), "The Local Solow Growth Model," *European Economic Review*, 45, 4-6, 928-40.

Durlauf, S. and D. Quah, (1999), "The New Empirics of Economic Growth," in *Handbook of Macroeconomics*, J. Taylor and M. Woodford, eds., Amsterdam: North Holland.

Easterly, W. and R. Levine, (1997), "Africa's Growth Tragedy: Policies and Ethnic Divisions," *Quarterly Journal of Economics*, 112, 4, 1203-50.

Easterly, W. and R. Levine, (2001), "It's Not Factor Accumulation: Stylized Facts and Growth Models," *World Bank Economic Review*, 15, 177-219.

Evans, P., (1998), "Using Panel Data to Evaluate Growth Theories," *International Economic Review*, 39, 2, 295-306.

Fernandez, C., E. Ley and M. Steel (2001), "Model Uncertainty in Cross-Country Growth Regressions," *Journal of Applied Econometrics*, 16, 5, 563-76.

Feyrer, J., (2003), "Convergence By Parts," mimeo, Dartmouth College.

Frankel, J. and D. Romer, (1999). "Does Trade Cause Growth?," *American Economic Review*, 89, 3, 379-399.

Friedman, M., (1992), "Do Old Fallacies Ever Die?" *Journal of Economic Literature*, 30, 2129-2132.

Galor, O., (1996), "Convergence? Inferences from Theoretical Models," *Economic Journal*, 106, 1056-1069.

Galor, O. and Zeira, J., (1993). "Income Distribution and Macroeconomics," *Review of Economic Studies*, 60, 1, 35-53.

Graham, B. and J. Temple, (2003), "Rich Nations, Poor Nations: How Much Can Multiple Equilibria Explain?" mimeo, University of Bristol.

Gallup, J., J. Sachs, and A. Mellinger, (1999), "Geography and Economic Development," *International Science Review*, 22, 179-232.

Hall, R., and C. Jones, (1999), "Why Do Some Countries Produce So Much More Output Per Worker Than Others?," *Quarterly Journal of Economics*, 114, 83-116.

Hendry, D. and H.-M. Krolzig, (2004), "We Ran One Regression," *Oxford Bulletin of Economics and Statistics*, 66, 5, 798-810.

Heston A., R. Summers and B. Aten (2002), *Penn World Table Version 6.1*, Center for International Comparisons at the University of Pennsylvania (CICUP).

Hobijn, B. and Franses, P. H., (2000), Asymptotically Perfect and Relative Convergence of Productivity," *Journal of Applied Econometrics*, 15, 59-81.

Hoeting, J. A., Madigan, D., Raftery, A. E., and Volinsky, C. T. (1999), "Bayesian Model Averaging: A Tutorial (with Discussion)," *Statistical Science*, 14, 382--401. Correction: vol. 15, pp. 193-195.

Hoover, K. and S. Perez, (2004), "Truth and Robustness in Cross-Country Growth Regressions," *Oxford Bulletin of Economics and Statistics*, 66, 5, 765-798.

Howitt, P. and Mayer-Foulkes, D., (2005), "R&D, Implementation and Stagnation: A Schumpeterian Theory of Convergence Clubs," *Journal of Money, Credit and Banking*, 37, 147-77.

Johnson, P., (2004), "A Continuous State Space Approach to 'Convergence by Parts'," mimeo, Vassar College, and forthcoming, *Economic Letters*.

Klenow, P. and A. Rodriguez-Clare, (1997), "The Neoclassical Revival in Growth Economics: Has it Gone Too Far?" in *Macroeconomics Annual 1997*, B. Bernanke and J. Rotemberg, eds., Cambridge: MIT Press.

Knack, S. and P. Keefer, (1995), "Institutions and Economic Performance: Cross Country Tests Using Alternative Institutional Measures," *Economics and Politics*, 7, 3, 207-27.

Knack, S. and P. J. Zak, (2001), "Trust and Growth," *The Economic Journal*, 111, 470, 295-321.

Kormendi, R. and P. Meguire, (1985), "Macroeconomic Determinants of Growth: Cross-Country Evidence," *Journal of Monetary Economics*, 16, 2,141-163.

Kourtellos, A., (2005), "Modeling Parameter Heterogeneity in Cross-Country Growth Regression Models," mimeo, University of Cyprus.

Kremer, M., A. Onatski, and J. Stock, (2001), "Searching for Prosperity," *Carnegie-Rochester Conference Series on Public Policy*, 55, 275-303.

La Porta, R., F. López-de-Silanes, A. Shleifer and R. Vishny, (1999), "The Quality of Government," *Journal of Law, Economics and Organization*, 15, 222-279.

La Porta, R., F. López-de-Silanes, C. Pop-Eleches, and A. Shleifer, (2004), "Judicial Checks and Balances," *Journal of Political Economy*, 112, 445-470.

Leamer, E., (1978), *Specification Searches. Ad-Hoc Inference with Non-Experimental Data.* New York: John Wiley.

Leamer, E., (1983), "Let's Take the Con Out of Econometrics," *American Economic Review*, 73, 1, 31-43.

Levine, R. and D. Renelt, (1992), "A Sensitivity Analysis of Cross-Country Growth Regressions," *American Economic Review*, 82, 4, 942-63.

Liu, Z. and T. Stengos, (1999), "Non-Linearities in Cross Country Growth Regressions: A Semiparametric Approach," *Journal of Applied Econometrics*, 14, 5, 527-38.

Lucas Jr., R., (1988), "On The Mechanics of Economic Development," *Journal of Monetary Economics*, 22, 3, 3-42.

Maddison, A., (1982), *Phases of Capitalist Development*: New York: Oxford University Press.

Maddison, A., (1989), *The World Economy in the 20th Century*, OECD: Paris.

Mankiw, N. G., D. Romer, and D. Weil (1992), "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, 107, 2, 407-437.

Mamuneas, T., A. Savvides, and T. Stengos, (2004), "Economic Development and Return to Human Capital: A Smooth Coefficient Semiparametric Approach," mimeo, University of Guelph and forthcoming, *Journal of Applied Econometrics*.

Masanjala, W. and C. Papageorgiou, (2004), "Rough and Lonely Road to Prosperity: A Reexamination of the Sources of Growth in Africa Using Bayesian Model Averaging," mimeo, Louisiana State University.

Masters, W. and M. McMillan (2001), "Climate and Scale in Economic Growth," *Journal of Economic Growth*, 6, 167-186.

Michelacci, C. and P. Zaffaroni (2000), "Fractional (Beta) Convergence", Journal of Monetary Economics 45:129-153.

North, D. C. (1990), *Institutions, Institutional Change and Economic Performance*, Cambridge University Press.

Paap, R. and H. van Dijk, (1998), "Distribution and Mobility of Wealth of Nations," *European Economic Review*, 42, 7, 1269-93.

Pesaran, M. H., (2004), "General Diagnostic Tests for Cross-Section Dependence in Panels," mimeo, University of Cambridge.

Quah, D., (1993a), "Galton's Fallacy and Tests of the Convergence Hypothesis," *Scandinavian Journal of Economics*, 95, 427-443.

Quah, D., (1993b), "Empirical Cross-Section Dynamics in Economic Growth," *European Economic Review*, 37, 2-3, 426-34.

Quah, D., (1996), "Empirics for Economic Growth and Convergence," *European Economic Review*, 40, 6, 1353-75.

Quah, D., (1997), "Empirics for Growth and Distribution: Stratification, Polarization, and Convergence Clubs," *Journal of Economic Growth*, 2, 1, 27-59.

Radelet S. and J. Sachs (1998), "Shipping Costs, Manufactured Exports, and Economic Growth," mimeo, HIID.

Romer, P. M. (1986), "Increasing Returns and Long-run Growth," *Journal of Political Economy*, 94, 5, 1002-1037.

Sala-i-Martin, X., (1996), "The Classical Approach to Convergence Analysis," *Economic Journal*, 106, 1019-1036.

Sala-i-Martin, X., (1997), "I Just Ran 2 Million Regressions." *American Economic Review*, 87, 2, 178-83.

Sala-i-Martin, X., (2002a), "The Disturbing "Rise" of Global Income Inequality," *National Bureau of Economic Research Working Paper no.* 8904.

Sala-i-Martin, X., (2002b), "The World Income Distribution," *National Bureau of Economic Research Working Paper no.* 8933.

Solow, R. M. (1957), "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics*, 39, 312-320.

Summers, R. and A. Heston, (1988), "A New Set of International Comparisons of Real Product and Price Levels Estimates for 130 Countries, 1950-1985," *Review of Income and Wealth*, 34, 1-25.

Summers, R. and A. Heston, (1991), "The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988," *Quarterly Journal of Economics*, 106, 2, 327-368.

Tabellini, G., (2005), "Culture and Institutions: Economic Development in the Regions of Europe," mimeo, IGIER, Bocconi.

Tan, C. M. (2005), "No One True Path: Uncovering the Interplay between Geography, Institutions, and Fractionalization in Economic Development", Tufts University, Dept. of Economics Working Paper No. 2005-12.