

# From Growth Theory to Policy Design

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## 1 Introduction

One indicator of a good theory, is the extent to which the predictions delivered by the theory can be validated or falsified by the available evidence. New growth theories can potentially qualify on that ground, as they deliver predictions on the relationship between growth and a series of micro- and macro-economic variables that can be confronted by cross-country, cross-industry, or cross-firm (panel) data series. In this paper, we put growth theory to another test, namely that of delivering relevant growth policies across various types of countries. For example, imagine a policy adviser, who faces a disappointing growth performance (in particular growth has been persistently slow in the EU, with less than 2% a year against 3% in the US between 1995 and 2006). Or imagine the policy adviser having to explain why Latin American countries, which had comparable or higher per capita GDP levels than their Asian counterparts in the early 1960s, have grown at a much slower rate ever since: thus while Latin American countries have grown at less than 3% on average between 1960 and 2000, Singapore has grown at 7%, South Korea at 6.5%, Hong Kong at 6%, Thailand at 5%, and China now grows at annual rates beyond 10%.

Disappointingly, classical growth models, in which growth is primarily driven by (physical and/or human) capital accumulation, do not appear to have much to tell us on this question. The neoclassical growth model would try to explain the lower growth rate in Europe by comparing its savings rate or the capital-labor ratio to those in the US. But savings rates tend to be higher in Europe and the same is true for capital-labor ratios, and this has been the case for more than one decade and even during times where per capita GDP in Europe was growing either faster than or at the same rate as in the US. Similarly, capital output ratios are about the same in the big Latin American countries as in the OECD countries, namely at .31.

Also, at first sight the standard textbook innovation-based model(s) cannot account for the recent growth gap between Europe and the US, given that the property rights and innovation subsidies stressed by these models are reasonably well established in Europe, and that Europe invests almost as large a fraction of GDP on R&D as the US (2% versus 2.5%). Moreover, these models do not seem to explain why European labor productivity growth was much higher than

US growth during the sixties and seventies (3.5% versus 1.4% on average during the 1970s), given that R&D investments were higher in the US than Europe throughout this period. Nor can R&D investments fully explain the divergence between Asia and Latin America: the former have grown at a very high rate long before they invested in R&D.

In this paper we argue that modern growth theory can in fact provide relevant tools to analyze the determinants of growth in different types of countries, and that it generates a systematic approach to growth policy design. In Section 2, we offer a summarized presentation of new growth theory. In Section 3 we discuss how growth theory can be used to design policy. In particular we contrast the growth diagnostic approach by Hausmann, Rodrik and Velasco (2005), with an alternative approach based on growth regressions suggested by the theory, and we build on this approach to draw some guidelines of comprehensive growth policy packages for Europe or Latin America. Section 4 concludes.

## 2 What can we learn from new growth theory?

In this section we present a very brief overview of new growth theory paradigms, and of the policy lessons each of those can deliver. A natural starting point for growth analysis, is to specify an aggregate production function which describes how domestic output flow is generated from a given stock of production factors. Thus we can write:

$$Y = AF(K, L)$$

where  $K$  is the capital stock,  $L$  is the stock of labor, and  $A$  is a productivity factor which reflects the existing stock of knowledge and the resulting efficiency of capital and labor in producing final output.

Growth in output thus results: (i) from the accumulation of production factors  $K$  or  $L$  (one could also include human capital  $H$  on top of  $K$  and  $L$ ); (ii) from increases in the productivity factor  $A$ , that is, from *productivity growth*.

If the production function  $F$  is homogeneous of degree one, one can rewrite the above equation as:

$$y = AF(k, 1) = Af(k),$$

where  $y = \frac{Y}{L}$  is the per capita output flow and  $k = \frac{K}{L}$  is the stock of capital per capita, and  $f$  displays decreasing returns to capital accumulation, that is: the more capital has already been accumulated, the smaller the increase in per capita output generated by accumulating one more unit of capital.

The seminal contribution by Solow (1956) was, first to show that, absent technical progress, that is, in the absence of growth in  $A$ , per capita output  $y$  might grow in the short run but not in the long run: eventually, accumulating more capital will entail more capital depreciation than what it can bring in terms of added output. The history of the past fifty years offers a perfect illustration of that view: for example, the Soviet Union grew fast during the post-war period where growth was primarily driven by factor accumulation, itself financed by (forced) domestic savings. But as of the late 1960s, growth tapered off.

Similarly, factor accumulation facilitated by the Marshall Plan, explains part of the growth miracle of the "Trente Glorieuses" in Western Europe. However, Western Europe ceased to grow fast as of the mid-1970s.

The contribution of new growth theory is to explain productivity growth, that is, the growth in  $A$  as resulting from innovations. The first version of endogenous growth theory was the so-called AK theory. In AK models, sustained productivity growth results from contemporaneous or intertemporal externalities between individuals who accumulate physical or human capital. Thus in effect these models lump together the physical and human capital whose accumulation is studied by neoclassical theory with the intellectual capital that is accumulated when technological progress is made. Indeed Lucas's (1988) influential contribution followed Uzawa (1965) in explicitly assuming that human capital and technological knowledge were one and the same. When this aggregate of different kinds of capital is accumulated there is no reason to think that diminishing returns will drag its marginal product down to zero, because part of that accumulation is the very technological progress needed to counteract diminishing returns.

According to the AK paradigm, the way to sustain high growth rates is to save a large fraction of GDP, some of which will find its way into financing a higher rate of technological progress and will thus result in faster growth. Thrift and the capital accumulation are the keys, not novelty and innovation. AK theory thus formalizes the ideas behind the World Bank consensus policies after WWII, according to which the problem of economic development was underaccumulation of capital and the cure was to subsidize and give aid to large investment projects.

The second wave of endogenous growth theory consists of so-called "innovation-based" growth models, which themselves belong to two parallel branches. One branch is the model of Romer (1990), according to which aggregate productivity is a function of the degree of product variety. Innovation causes productivity growth in the product-variety paradigm by creating new, but not necessarily improved, varieties of products. This paradigm grew out of the new theory of international trade, and emphasized the technology spillovers according to which the productivity of resources devoted to developing new product varieties was greater the greater the variety of products that have already been developed.

The other branch of innovation-based theory, developed in Aghion and Howitt (1992) and subsequently elaborated in Aghion and Howitt (1998), grew out of modern industrial organization theory, and is commonly referred to as "Schumpeterian" growth theory, because it focuses on quality improving innovations that render old products obsolete, and hence involves the force that Schumpeter called "creative destruction."

This second wave of endogenous growth models puts the investment side at the heart of the growth process. In particular, economic policies and institutions influence growth by influencing entrepreneurs' incentives and/or ability to make innovative investments.

## 2.1 The AK paradigm

The AK paradigm is neoclassical growth theory without diminishing returns. The theory starts with an aggregate production function, which, in the case where knowledge externalities among firms exactly compensate for the diminishing returns to capital accumulation by individual firms, ends up being linear and homogeneous in the stock of capital:

$$Y_t = AK_t \quad (1)$$

with  $A$  a constant. Output is in turn divided between consumption and investment:

$$Y_t = C_t + I_t \quad (2)$$

and net investment is investment minus depreciation at the fixed rate  $\delta$ :

$$\dot{K}_t = I_t - \delta K_t \quad (3)$$

Thus the growth rate of output is the same as the growth rate of capital, which in turn depends on thrift.

In early versions of the theory,<sup>1</sup> thrift is represented by a fixed saving ratio:  $s = 1 - C_t/Y_t$ , in which case the economy's growth rate is:

$$g = sA - \delta.$$

Alternatively, Romer's (1986) version<sup>2</sup> represented thrift as intertemporal utility maximization à la Ramsey, in which a representative household maximizes:

$$\int_0^{\infty} e^{-\rho t} \frac{C_t^{1-\sigma}}{1-\sigma} dt$$

subject to the production function (1), the law of motion (3), and an individual version of the resource-balance constraint (2):

$$Y_t = C_t + (1 - \tau)I_t + T_t,$$

where  $\tau$  is an investment subsidy (or tax, if negative) financed by the lump-sum tax  $T$ . The Euler equation implied by this problem determines immediately the economy's growth rate as:

$$g = \frac{\dot{C}}{C} = \frac{\frac{A}{1+\tau} - \delta - \rho}{\sigma} = g.$$

An immediate implication of this model is that a higher saving rate  $s$ , or higher investment-subsidy rate  $\tau$ , encourages capital accumulation and therefore growth.

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<sup>1</sup> See Frankel (1962).

<sup>2</sup> See also King and Rebelo (1993, 1994).

There are several problems with AK theory. First, it constitutes a “one size fits all” approach to the growth process. It applies equally to countries that are on the leading edge of the world technology frontier and to countries that are far behind. Like the neoclassical theory of Solow and Swan, it postulates a growth process that is independent of developments in the rest of the world, except insofar as international trade changes the conditions for capital accumulation.<sup>3</sup> In particular, the theory is not helpful in understanding how the institutions and policies that were so successful in promoting growth immediately following WWII, when Europe was far below the frontier, turned out to produce relatively poor performance since the 1990s. Second, in AK models growth here is primarily driven by the savings side of the economy: policies affect growth by affecting aggregate savings which are equal to aggregate investment. This view becomes problematic, for example when discussing the relationship between macroeconomic volatility and growth. Third, AK models cannot explain convergence. Indeed, a country’s or region’s growth rate is independent from its current capital stock which in that model measures its stage of development. Thus, countries with low levels of capital stock do not grow faster than more advanced countries. Thus, compared to the Solow model, AK models can “explain” long-run growth, however at the expense of losing convergence.

## 2.2 The Schumpeterian paradigm

Schumpeterian theory begins with a production function specified at the industry level:

$$Y_{it} = A_{it}^{1-\alpha} K_{it}^{\alpha}, \quad 0 < \alpha < 1 \quad (4)$$

where  $A_{it}$  is a productivity parameter attached to the most recent technology used in industry  $i$  at time  $t$ . In this equation,  $K_{it}$  represents the flow of a unique intermediate product used in this sector, each unit of which is produced one-for-one by capital. Aggregate output is just the sum of the industry-specific outputs  $Y_{it}$ .

Each intermediate product is produced and sold exclusively by the most recent innovator. A successful innovator in sector  $i$  improves the technology parameter  $A_{it}$  and is thus able to displace the previous innovator as the incumbent intermediate monopolist in that sector, until displaced by the next innovator. Thus the first key implication that distinguishes the Schumpeterian Paradigm from the AK and product-variety models, is that *faster growth generally implies a higher rate of firm turnover, because this process of creative destruction generates entry of new innovators and exit of former innovators.*

Although the theory focuses on individual industries and explicitly analyzes the microeconomics of industrial competition, the assumption that all industries are ex ante identical gives it a simple aggregate structure. In particular, it is easily shown that aggregate output depends on the aggregate capital stock  $K_t$  according to the Cobb-Douglas aggregate per-worker production function:

$$Y_t = A_t^{1-\alpha} K_t^{\alpha} \quad (5)$$

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<sup>3</sup>See for example Acemoglu and Ventura (2002).

where the labor-augmenting productivity factor  $A_t$  is just the unweighted sum of the sector-specific  $A_{it}$ 's. As in neoclassical theory, the economy's long-run growth rate is given by the growth rate of  $A_t$ , which here depends endogenously on the economy-wide rate of innovation.

There are two main inputs to innovation; namely the private expenditures made by the prospective innovator, and the stock of innovations that have already been made by past innovators. The latter input constitutes the publicly available stock of knowledge to which current innovators are hoping to add. The theory is quite flexible in modeling the contribution of past innovations. It encompasses the case of an innovation that leapfrogs the best technology available before the innovation, resulting in a new technology parameter  $A_{it}$  in the innovating sector  $i$ , which is some multiple  $\gamma$  of its pre-existing value. And it also encompasses the case of an innovation that catches up to a global technology frontier  $\bar{A}_t$  which we typically take to represent the stock of global technological knowledge available to innovators in all sectors of all countries. In the former case the country is making a leading-edge innovation that builds on and improves the leading edge technology in its industry. In the latter case the innovation is just implementing technologies that have been developed elsewhere.<sup>4</sup>

For example, consider a country in which in any sector leading edge innovations take place at the frequency  $\mu_n$  and implementation innovations (or imitations) take place at the frequency  $\mu_m$ . Then the change in the economy's aggregate productivity parameter  $A_t$  will be:

$$A_{t+1} - A_t = \mu_n (\gamma - 1) A_t + \mu_m (\bar{A}_t - A_t)$$

and hence the growth rate will be:

$$g_t = \frac{A_{t+1} - A_t}{A_t} = \mu_n (\gamma - 1) + \mu_m (a_t^{-1} - 1) \quad (6)$$

where:

$$a_t = A_t / \bar{A}_t$$

is an inverse measure of "distance to the frontier."

The second term reflects the existence of knowledge spillovers across countries: the further below the frontier a country is, that is the smaller  $a_t$ , the faster the country can grow as by imitating or adapting leading-edge technologies. Thus the theory incorporates Gerschenkron's "advantage of backwardness"<sup>5</sup>, in the sense that the further the country is behind the global technology frontier (i.e., the smaller is  $a_t$ ) the faster it will grow, given the frequency of implementation innovations. As in Gerschenkron's analysis, the advantage arises from the fact that imitations allow the country to make larger quality improvements

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<sup>4</sup>This flexibility of the Schumpeterian framework, does not lead to a theory in which anything can happen. For example, in Aghion et al (2005a), the effect of competition on growth in the Schumpeterian paradigm, is either monotonic or inverted-U shaped, but cannot be of any other form. Similarly, the effect of entry at the frontier on productivity growth is always more (and not less) positive in sectors initially closer to the frontier.

<sup>5</sup>See Gerschenkron (1962).

the further it has fallen behind the frontier. Thus the Schumpeterian paradigm can explain convergence, but one primarily based on knowledge spillovers, rather than on diminishing returns to capital accumulation as in the neoclassical model.

The above growth equation also illustrates the fact Schumpeterian theory provides a framework in which the growth effects of various policies are highly context-dependent. In particular, the Schumpeterian apparatus is well suited to analyze *how a country's growth performance will vary with its proximity to the technological frontier  $a_t$ , and what kinds of policy changes are needed to sustain convergence as the country approaches the frontier.*

We could take as given the critical innovation frequencies  $\mu_m$  and  $\mu_n$  that determine a country's growth path as given, just as neoclassical theory often takes the critical saving rate  $s$  as given. However, Schumpeterian theory goes deeper by deriving these innovation frequencies endogenously from the profit-maximization problem facing a prospective innovator, just as the Ramsey model endogenizes  $s$  by deriving it from household utility maximization. This maximization problem and its solution, will typically depend upon institutional or policy characteristics of the economy such as property right protection, product market competition, education policy and the composition of education spending, financial development and the financial system, market size, the organization of labor markets, trade policy,...., in a way that may or may not vary with the country's distance to the technological frontier  $a$ .

Thus, quite independently from a country's level of development the theory clearly predicts that innovation and therefore productivity growth and convergence should be fostered by: (i) better protection of (intellectual) property rights, as this will improve the extent to which successful innovators can appropriate the rents from their innovation; (ii) better financial development, as tight credit constraints will limit individuals' ability to finance a new innovative idea<sup>6</sup>; (iii) a higher stock of educated labor, as this will improve individuals ability to imitate more advanced technologies or to innovate at the frontier building on giants' shoulders<sup>7</sup>; (iv) macroeconomic stability: by ensuring low (risk-adjusted) equilibrium interest rates, it will encourage individuals to engage in long-term growth-enhancing investments.

However, the effects of product market competition, trade policy, the composition of education spending or the organization of labor markets or that of financial systems turn out to depend heavily upon a country's or region's or sector's level of development as measured by  $a_t$ . Typically, the closer a country or sector is to the technological frontier, the more growth-enhancing are the effects of: (i) product market competition<sup>8</sup> and entry<sup>9</sup>; here the idea is that competition and entry encourages innovation by firms that are already sufficiently

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<sup>6</sup> See Durlauf and Johnson (1996) and Aghion-Howitt-Mayer (2005) for analyses of club convergence. In the latter, club convergence results from the interplay between credit constraints and knowledge spillovers.

<sup>7</sup> See Nelson-Phelps (1966), Benhabib-Spiegel (1994), and Krueger-Lindahl (2001).

<sup>8</sup> See Aghion-Bloom-Blundell-Griffith-Howitt (2005).

<sup>9</sup> See Aghion-Blundell-Griffith-Howitt-Prantl (2006).

advanced that they can escape competition by innovating; (ii) higher education, which is more important for frontier innovation than for imitation, and therefore becomes increasingly important for growth as a country approaches the world technology frontier<sup>10</sup>; (iii) stock market finance, which is particularly adapted for innovative projects that are highly uncertain and do not necessarily carry collateral; (iv) democracy, which favors entry which in turn is growth-enhancing in advanced sectors as discussed above<sup>11</sup>; (v) more decentralized firms: delegating initiative to managers downstream is important when a firm introduces new frontier technologies on which information upstream is limited.<sup>12</sup>

Now, given that the institutions or policies that favors implementation innovations (that is, that lead to firms emphasizing  $\mu_m$  at the expense of  $\mu_n$ ) are not the same as those that favor leading-edge innovations (that is, that encourage firms to focus on  $\mu_n$ ) then, to sustain a high growth rate as it develops (i.e as  $a_t$  increases) a country will have to shift from implementation-enhancing institutions to innovation-enhancing institutions. As formally shown in Acemoglu-Aghion-Zilibotti (2006), failure to operate such a shift can prevent a country from catching up with the frontier level of per capita GDP. AAZ refer to this as a non-convergence trap phenomenon. In Sapir et al (2003) we argued that this failure largely explains why Europe stopped catching up with US per capita GDP since of the mid 1970s.

How about growth rates? Suppose that the global frontier grows at the exogenous rate  $\bar{g}$ .<sup>13</sup> Then equation (6) implies that in the long run a country that engages in implementation investments (with  $\mu_m > 0$ ) will ultimately converge to the same growth rate as the world technology frontier. That is, the relative gap  $a_t$  that separates this economy from the technology frontier will converge asymptotically to the steady-state value:

$$\hat{a} = \frac{\mu_m}{\bar{g} + \mu_m - \mu_n (\gamma - 1)} \quad (7)$$

which is an increasing function of the domestic innovation rates and a decreasing function of the global productivity growth rate. The economic force underlying this convergence in growth rates is again Gerschenkron's advantage of backwardness, according to which a country that is growing slower than the frontier rate  $\bar{g}$ , and which is therefore falling further behind the frontier, will therefore experience an increase in its growth rate.

Now, can we explain why, since the mid 1990s, the EU is growing at a lower rate than the US? A plausible story, which comes out naturally from the above discussion, is that the European economy caught up technologically to the US following WWII but then its growth began to slow down before the gap with the US had been closed, because its policies and institutions were not designed to

<sup>10</sup>See Vandenbussche-Aghion-Meghir (2006) and Aghion-Boustan-Hoxby-Vandenbussche (2006).

<sup>11</sup>See Aghion-Alesina-Trebbi (2007).

<sup>12</sup>See Acemoglu-Aghion-Lelarge-Van Reenen-Zilibotti (2007).

<sup>13</sup>Howitt (2000) shows how the global growth rate can be endogenized as a function of innovation rates in sectors and all countries.

optimize growth when close to the frontier. That by itself would have resulted in a growth rate that fell down to that of the US but no further. But then what happened was that the IT revolution resulted in a revival of  $\bar{g}$  in the late 1980s and early 1990s. Since Europe was as not well placed as the US to benefit from this technological revolution the result was a reversal of Europe's approach to the frontier, which accords with the Schumpeterian steady-state condition (7), and the fact that Europe is not adjusting its institutions in order to produce the growth maximizing innovation policy, acts as a delaying force on growth convergence towards the US.<sup>14</sup> Neo-classical theory might explain the convergence phase of Europe towards the US, but not the reversal that occurred since.

### 2.3 The product-variety paradigm

The other branch of innovation-based growth theory is the product-variety model of Romer<sup>15</sup> (1990), which starts from a Ethier-Dixit-Stiglitz production function<sup>16</sup> of the form:

$$Y_t = \sum_0^{N_t} K_{it}^\alpha di$$

in which there are  $N_t$  different varieties of intermediate product. By symmetry, the aggregate capital stock  $K_t$  will be divided up evenly among the  $N_t$  existing varieties equally, which means we can re-express this production function as:

$$Y_t = N_t^{1-\alpha} K_t^\alpha. \quad (8)$$

According to (8), the degree of product variety  $N_t$  is the economy's labor-augmenting productivity parameter, and its growth rate is the economy's long-run growth rate of per-capita output. Product variety raises the economy's production potential in this theory because it allows a given capital stock to be spread over a larger number of uses, each of which exhibits diminishing returns.

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<sup>14</sup>Endogenizing  $\mu_m$  can also generate divergence in growth rates. For example, human capital constraints as in Howitt and Mayer-Foulkes (2005), or credit constraints as in Aghion, Howitt and Mayer-Foulkes (2005), make the equilibrium value of  $\mu_m$  increasing in  $a$ , which turns the growth equation (6) into a non-linear equation. That  $\mu_m$  be increasing in  $a$ , in turn follows from the assumption that the cost of innovating is proportional to the frontier technology level that is put in place by the innovation, (Ha and Howitt (2005) provide empirical support for this proportionality assumption.) whereas the firm's investment is constrained to be proportional to current local productivity. Then, countries very far from the frontier and/or with very low degrees of financial development or of human capital will tend to grow in the long run at a rate which is strictly lower than the frontier growth rate  $\bar{g}$ . However, our empirical analysis in this paper shows that this source of divergence does not apply to EU countries.

<sup>15</sup>The semi-endogenous model of Jones (1995), in which long-run economic growth depends uniquely on the rate of population growth, might be thought of as a fourth paradigm, but it has nothing useful role to say about growth policy, since it predicts that long-run growth is independent of any policy that does not affect population growth. It does imply that innovation affects growth during the transition to the long-run but in that context it behaves just like the product-variety model that we discuss in this section.

<sup>16</sup>See Dixit and Stiglitz (1977).

The driving force of long run growth in the product-variety paradigm is innovation, as in the Schumpeterian paradigm. In this case however innovations do not generate better intermediate products, just more of them. Also as in the Schumpeterian model, the equilibrium R&D investment and innovation rate result from a research arbitrage equation that equates the expected marginal payoff from engaging in R&D to the marginal opportunity cost of R&D. But the fact that there is just one kind of innovation, which always results in the same kind of new product, means that the product-variety model is limited in its ability to generate context-dependent growth, and is therefore of limited use for policy makers in Europe.

In particular, the theory makes it very difficult to talk about technology frontier, distance to the frontier, and convergence. Thus, it has little to say about how the kinds of policies appropriate for promoting growth in countries near the world's technology frontier may differ from those appropriate in technological laggards, and thus to explain why Asia is growing fast with policies that depart from the Washington consensus, or why Europe has grown faster than the US during the first three decades after WWII but not thereafter.<sup>17</sup>

In addition, nothing in this model implies an important role for exit and turnover of firms and workers; indeed increased exit in this model can do nothing but reduce the economy's GDP, by reducing the variety variable  $N_t$  that uniquely determines aggregate productivity according to the production function (8). As we argue in Aghion-Howitt (2006), these latter implications of the product variety model are inconsistent with an increasing number of recent studies demonstrating that labor and product market mobility are key elements of a growth-enhancing policy, particularly in sectors or countries near the technological frontier.

### 3 From growth theory to growth policy

In a recent and influential paper entitled "Growth Diagnostics", Hausmann-Rodrik-Velasco (2005), henceforth HRV, have proposed an attractively simple methodology to design growth-enhancing policy. In this section, we will first summarize the methodology, then point at some of its potential limitations, and then propose an alternative approach based which uses growth regressions that are themselves suggested by the theory, particularly the Schumpeterian paradigm outlined above..

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<sup>17</sup>For example, Helpman (1993) uses the product-variety approach to construct a 2-country model in which innovation takes place only in the North and imitation only in the South. But although policies would then have different growth effects depending on whether implemented in the North or South, there is nothing in this analysis that links a given country's position as imitator or innovator to any productivity gap; instead it is just assumed that some countries cannot imitate and some cannot innovate. Thus there is nothing in the approach that would imply a change in appropriate institutions or policies as the country closed the gap, let alone allow for one country to leapfrog another.

## 3.1 The HRV approach to growth diagnostics

### 3.1.1 The approach

HRV start from the relevant observation that growth-enhancing policies should vary from one country or region to another. For example, while growth in the US and other industrialized countries over the past ten years, appears to have benefited from market deregulations and privatizations, in Asian countries including China high growth rates have been promoted under limited competition or limited privatizations. The next question then is: can one use existing new growth theory to provide a flexible guide to growth policy making, one that fully takes cross-country into account? HRV provide a positive and attractively simple answer to this question.

They start from the Euler equation in graduate textbooks which expresses the growth rate  $g$  of an economy as:

$$g = \sigma[r(1 - \tau) - \rho],$$

where  $\sigma$  is the intertemporal elasticity of substitution,  $r$  is the rate of return on capital,  $\tau$  is the tax rate and  $\rho$  is the individual rate of time preference taken to be equal to the world rate of interest.

The rate of return on capital  $r$  is itself endogenous and depends in particular upon the country's TFP level  $a$ , the degree of externalities in production  $\theta$ , the tax rate on capital  $\tau$ , and the availability of complementary factors  $x$ :

$$r = r(a, \theta, x).$$

These two equations narrow down the set of potential suspects to be considered when designing growth policy. The next question is: how can one identify the most binding constraint to growth, that is the *actual* suspects? Here HRV propose a simple solution which avoids any use of econometrics, namely to use price comparisons to infer the importance of each potential constraint to growth. To illustrate their methodology, HRV consider a few Latin American examples, including Brazil and El Salvador.

In Brazil, returns to capital are high (with a net interest margin equal to 11.5 in 2001). This leads HRV to point at the low level of local savings (with very negative public savings) and the high tax rates as the main constraints on growth (the importance of the former is further supported by the positive and significant correlation between the interest rate and the current account deficit over time). The rate of return on education is also high in Brazil, which suggests that the rate of return on capital, and thereby growth, could be further increased by investing more on education; however, the argument goes, the already high rate of return on capital suggests that investing in education may not be a priority in Brazil.

In El Salvador, interest rates are low (a net interest margin equal to 3.7 in 2001), but so is the tax rate on capital. Is the lack of education responsible for the rate of return on capital? The HRV answer is no, given that the rate of return on education in El Salvador is low. Nor is there a lack of contractual enforcement

that would reduce profitability. Lack of savings cannot be the binding constraint either, otherwise the interest margin would be high. Having failed to identify true obstacles to growth in El Salvador, HRV mention the "absence of profitable investment opportunities" as yet another potential suspect to consider.

Now suppose we used the same growth diagnostic approach to deal with the slow EU growth problem. The return to education is lower in the EU than in the US, which HRV would interpret as an indication that education is the most binding constraint to growth. Rather, they would presumably point at the high European tax rates as the main suspect, and thereby follow Prescott (2006) in advocating lower tax rates as the primary cure to the growth problem in the EU.

### 3.1.2 Discussion

The simple and ingenious approach proposed by HRV, raises a number of questions, first on individual country cases and then at a more fundamental level on the methodology itself. Looking first at examples, do we really believe that education is not a binding constraint for growth in the EU and that the main problem there is taxation? A recent study (see Aghion, Azkhenazy, Cetto (2007)) based on cross-country panel regressions of growth on education, regulation indexes, and their interactions with countries' levels of technological development, suggests that higher education investment is a main source of increase of the growth potential of France and other EU countries at similar levels of productivity.

At a more fundamental level, we see at least two problems with the HRV methodology. First, equilibrium prices do not necessarily reflect a constraint on growth. Consider first interest rates. A low interest rate does not mean that the local credit market is not constrained. In fact, low interest rates may reflect a high degree of credit rationing, as shown by Aghion and Bolton (1997). Indeed, the more restricted the access to credit (that is, the more individuals are barred from undertaking their own projects), the more supply of loanable funds there will be in the economy, as all credit-rationed individuals will end up lending to a few entrepreneurs. But this in turn should result in a lower domestic equilibrium interest rate. Next, consider the rates of return on labor, which are measured by the so-called Mincerian wages, that is by the foregone wage income of one more year in education at different levels of education. Mincerian wages of course provide some useful indication on the marginal value of private investments in education in different fields and at different levels of education. However, a big shortcoming of the Mincerian approach, is that the Mincerian wage does not account for externalities, and in particular for the intertemporal knowledge externalities that lie behind the positive relationship between education and growth. That intertemporal externalities matter, is evidenced by the large effects of education on growth (see Aghion et al (2006)), in comparison to the recent study by Acemoglu and Angrist (2004) which pointed at the absence of significant contemporaneous externalities in education.

More generally, current price reflect a current state of the economy. They

do not inform directly about the growth dynamics that would result for various types of policies.

A second problem with the HRV approach, is that it cannot lead to growth prescriptions that would affect the demand side and the supply side of markets simultaneously. Thus, for example HRV would never recommend that a country invests in education (thereby increasing the supply of research labor) and at the same time invests in structural reforms that increase the profitability of innovations (thereby fostering the demand for R&D labor by firms).<sup>18</sup>

## 3.2 Use new growth theory and growth regressions instead

A natural alternative to the above methodology, is to use the theory outlined in Section 2 to construct growth regressions which are meant to inform us directly about the impact of different institutions or policies on growth.

### 3.2.1 Some main issues in using growth regressions

In this section, we discuss some issues that arise when using growth regressions to evaluate policies. In our sequel paper, Aghion and Durlauf (2007), we provide a systematic discussion of the use of growth regressions in policy evaluation. The emphasis in that paper will be the development of a set of proposals to modify the use of these regressions to render them more appropriate for policy analysis. While our sequel paper will suggest that the empirical results we describe can be augmented in two important ways. First, it is important that policy analyses account for the model uncertainty inherent in any growth regression. Second, we argue that empirical evidence is generally not presented in ways that are appropriately decision-theoretic. Our goal here is more modest. We describe the baseline cross country regression and identify some interpretation issues that naturally arise when the model is considered against the background of economic theory.

The basic cross country growth regression, as developed by Barro (1996), may be written as

$$g_i = X_i\beta + Z_i\gamma + \varepsilon_i, \quad (9)$$

where  $g_i$  is real per capita growth across some fixed time interval,  $X_i$  is a set of regressors suggested by the Solow growth model (population growth, technological change, physical and human capital savings rates transformed in ways implied by the model),  $Z_i$  is a set of additional control variables suggested by new growth theories, and  $\varepsilon_i$  is an error. The distinction between  $X_i$  and  $Z_i$  is important in econometric practice because while variables are essentially constant across empirical studies, there is no consensus on which  $Z_i$  variables should be included.

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<sup>18</sup>Incidentally, HRV would never recommend more active competition policies whose effect in the simple growth paradigm they consider is simply to reduce the rate of return on capital.

The use of cross-country growth regressions has been criticized at several levels. Here, we note four criticisms that are germane to the empirical work we wish to discuss and which flow naturally from the use of these regressions to make substantive claims. First, the regressors in (1) may be endogenous, so that the interpretation of OLS regressions using this structure begs the question of whether the regression coefficients reflect causality or correlation. From the perspective of economic theory, this worry is an obvious one. Variables such as the savings rate or population growth rate are (aggregations of individual) choices and so a theory that treats them as exogenous is not only incomplete but susceptible to classical simultaneous equations bias. The natural solution to this problem is the use of instrumental variables.

The determination of appropriate instrumental variable choices is difficult because of the fact that many candidate instruments are themselves possible growth determinants. For example, geographic variables are used as instruments for international trade in some studies while the variables are treated as growth determinants in others. Another example is ethnic diversity. This issue should not be interpreted as a general rejection of instrumental variables methods in growth regressions. Rather it suggests that there are difficult judgments involved in their use. Brock and Durlauf (2001) and Durlauf, Johnson and Temple (2005) provide an extensive discussion.

A second problem concerns interactions. Linear specifications treat each growth determinant as acting separately from the others. This is inconsistent with the essentially nonlinear structure of new growth theories, in which the different determinants interact. This problem has often been addressed using products of variables as additional regressors.

This use of products of variables is, we believe, a sensible way to begin to understand interactions. That said, we believe an important outstanding question is how to develop richer conceptions of interactions. The addition of products of variables may be understood as a step towards a second-order Taylor series approximation of a general nonlinear growth model. It is unclear as to whether, for the sorts of interactions that theory suggests exist, this approximation is accurate. While there has been some interest in using semiparametric methods to allow for richer structures, Durlauf and Johnson (1996), Liu and Stengos (1999) are early examples, the focus of this literature has been on the modeling of heterogeneity in the coefficients in (1). The one systematic evaluation of interactions between theories using semiparametric methods that we know of is Tan (2006). We note that semiparametric and nonparametric methods requires larger data sets than are conventionally available for growth contexts.

A third problem concerns the appropriate level of aggregation. New growth theories such as the innovations models focus on interactions that are defined with respect to firms and industries, not aggregate economies. For this reason, identification of these effects is problematic when the exclusive focus is on aggregate data. The reason for this is that the endogeneity of those aggregates that produce spillovers (e.g. human and physical capital) is difficult to disentangle from the effects of other aggregate determinants, e.g. the saving rate.

In our view, the use of disaggregated data is a key to making progress on

many of the empirical questions in growth. It is surprising that so little interaction exists between the growth literature as it relates to spillovers and the literature on social interactions, in which similar phenomena are studied and a host of identification issues have been analyzed since Manski's seminal (1993). See Brock and Durlauf (2001) for a synthesis of much of the literature and Brock and Durlauf (2007) for recent partial identification results. One message of the social interactions literature is that disaggregated data is not a panacea as issues of self-selection and unobserved aggregate variables make the development of persuasive claims about spillovers difficult. Durlauf's (2002) criticisms of the use of aggregate data to identify spillovers was based on the relative strength of the necessary assumptions relative to those that are needed in disaggregated studies; substantive assumptions are still needed

A final problem is residual heterogeneity. Economic theory does not impose any natural homogeneity on the residuals in the model (1). The reason for this, using a term of Brock and Durlauf (2001), is that new growth theories are opened in the sense that different theories are logically compatible. From the perspective of the substantive information that a researcher brings to a problem, the key issue concerns the requirement that the  $\varepsilon_i$ 's in the growth regression are exchangeable, which in essence means that given the specification chosen for (1), a researcher is willing to assume that he has no basis for distinguishing the residuals of one country versus another. This is problematic given the knowledge that is available to a researcher about each country. Is it appropriate to disallow the possibility that, over the last  $\frac{1}{2}$  century, that there is a component of South Africa's growth that is country-specific in the sense that it is not captured by any of the controls one introduces? One solution to this problem which has been widely adopted is to generalize the analysis to a panel context, so that country-specific fixed effects may be allowed for.

The limitations imposed by the incorporation of fixed effects in a panel analysis are well known. Differencing of panel data to eliminate the fixed effects makes inference difficult if the controls in the model only move slowly over time. And there are cases where these methods may not be available. As argued by Durlauf, Johnson, and Temple:

The fixed-effects identification strategy cannot be applied in all contexts. Sometimes a variable of interest is measured at only one point in time. Even where variables are measured at more frequent intervals, some are highly persistent, in which case the within-country variation is unlikely to be informative. At one extreme, some explanatory variables of interest are essentially fixed factors, like geographic characteristics or ethnolinguistic diversity. Here the only available variation is "between-country", and empirical work will have to be based on cross-sections or pooled cross-section time-series.

In the remaining part of this subsection, we consider particular growth regressions and ways to address some of the issues raised above.

### 3.2.2 Cross-country regressions and beyond

Barro (1991), Barro and Sala-i-Martin (1995) and Barro (1996) regress the average growth rate of (per capita) GDP across countries over potential growth determinants suggested by endogenous growth theory such as education spending, government expenditure, democracy measures, ..., measured on average over the period under consideration. As discussed above, this type of regressions raises several issues. In particular, are we capturing the causality from policy variables to growth, or instead the reverse causality from growth to the level of these variables? For example, if more education is growth-enhancing, at the same time a faster growing country can afford to invest more on education as it becomes wealthier.

To address this endogeneity problem in the relationship between growth and education, Aghion-Boustan-Hoxby-Vandenbussche (2006) use political economy variables (membership in appropriation committees for research education, existence of two-year or four-year colleges in the district of state's education head,...) as potential instrumental variables for education spending or attainment. Similarly, to deal with the endogeneity problem in the relationship between growth and competition, Aghion et al (2005) use policy variables such as the implementation of the single market program in the EU, or the extent of privatizations.

A second problem with cross-country regressions, is that they do not control for country fixed effects. To deal with this latter criticism, one needs: (i) to move from pure cross-sectional to panel regressions, that is, regressions where growth over a succession of limited subperiods (typically between one and five years) is regressed over a set of policy variables averaged over the same subperiods, or over the values of these variables at the beginning of the subperiod; (ii) to control for country fixed effects. The problem is often that the cross-country panel data are too sparse for regression results to hold with the same degree of significance once one controls for country fixed effects. For example Vandenbussche-Aghion-Meghir (2005) show that the positive correlation between education and growth in the cross-country OECD panel regression becomes insignificant once we fully controlled for country fixed effects. Similarly, the positive correlation between democracy and growth in Barro (1996) is not robust to the inclusion of country fixed effects, as pointed out by Acemoglu et al (2006). Another example is Easterly (2005) who shows that once we control for institutions (or for the macroeconomic policy in the country being reasonable), the correlations between growth and policy variables such as inflation, openness, black market premium,..., may also become insignificant.

A natural way out of this second problem, is to move from cross-country to more disaggregated cross-industry or even firm-level data. Yet, they are policies such as education or market regulations that are often uniform across sectors within a given country. This, in turn implies that to assess the effects of such policies, one cannot completely disregard cross-country regressions. But, then, as discussed above, one way out is to interact the policy variables with other state variables, for example the country's distance to the technological frontier, or the country's level of financial development, or other institutional

characteristics of the economy.

For example, consider the relationship between volatility and growth. While no significant relationship would survive the restriction to "reasonable" countries (as in Easterly (2005)), introducing the interaction between volatility and financial development restores the significance of the right hand side coefficients (see Aghion-Angeletos-Banerjee-Manova (2006)): namely, in a country with low financial development macroeconomic volatility is clearly detrimental to growth whereas this is no longer true in countries with high degrees of financial development

### 3.2.3 Using cross-sectoral variations

We have just seen that introducing interaction terms on the right hand side of the growth regression can help restore the significance of correlations coefficients between some policy variables and growth. But this may not be enough. In particular, if a policy variable (e.g financial development or the degree of democracy) does not vary much over time in the various countries in the sample, then it is hard to obtain correlations between this variable and growth that are robust to controlling for country fixed effects.

An ingenious way out, suggested by Rajan and Zingales (1998), is to interact that variable with a sectoral characteristic (in RZ it is the degree of dependence upon external finance in the corresponding sector in the US) which reflects the extent to which the policy variable (e.g financial development) affects investment and growth in that particular sector.

Thus, using the RZ method, Aghion-Alesina-Trebbi (2007) show that democracy is more growth-enhancing in sectors that are both, more dependent on external finance and closer to the technological frontier. Also using the RZ method, Aghion-Fally-Scarpetta (2006) regress the post-entry growth of firms (measured here by firms number of employees after six years of existence since entry, divided by the number of employees upon entry) over financial development and labor market regulations, respectively interacted with the sector's dependence upon external finance and the sector's capital labor ratio (the idea being that a section with lower capital labor ratio is more vulnerable to labor market regulations). Their main conclusion is that financial development, both bank credit and stock market finance, beats labor market regulations as a determinant of post-entry growth of firms.

### 3.2.4 Using cross-firm variations

One can go even further and look at firm-level data when data are too sparse at country or even sectoral level. Thus, when analyzing the relationship between credit constraints, volatility and the growth-enhancing nature of investment using cross-country panel data, Aghion-Angeletos-Banerjee-Manova (2006) would only get significant results by using structural investment as a proxy for growth-enhancing investment. One problem there is that R&D panel data are not available for more than a handful of countries. However, once we move to firm-level

data, one can get more precise results. Thus, using a firm-level French panel data set, Berman et al (2007) could look at the relationship between macroeconomic volatility, R&D investments and growth. Their main result is that R&D investments become more pro-cyclical the more credit constrained the firm is. Moving from country-level to firm level data here has two additional virtues besides the fact that we can take advantage of detailed firm-level R&D panel data. First, we have more observations which in turn allows us to control for more variables without losing the significance of main coefficients. Second, instead of using private credit over GDP at country level as the measure of financial development, one can construct a more precise and firm-specific measure of credit constraint: namely, the amount of unpaid trade credits by the firm, an information which in France is available to banks and affects directly to the firm's ability to obtain new bank loans.

### **3.3 Europe versus the US and Latin America versus Asia**

#### **3.3.1 How can we foster growth in Europe?**

Since the past ten years, we observe persistently slow growth in the EU 15 (less than 2% a year against 3% in the US between 1995 and 2006). This is in sharp contrast with the 1945-1975 period where labor productivity growth was much higher in Europe than in the US (for example the EU was still growing at an average of 3.5% per year on average during the 1970s versus 1.4% in the US).

How can we explain this reversal of fortune? The model in Section 2 suggests an explanation, namely that Europe has exhausted the growth potential generated by factor accumulation and imitation and needs now to adapt its institutions so as to foster innovation.

**Innovation has increasingly become a priority** In 1945, Europe's stock of physical capital had been largely destroyed and its technological knowledge as reflected by its average level of per capita GDP was far behind per capita GDP in the US. So, what it would take to grow at that time, was for Europe to accumulate capital and to imitate or adapt technological innovations made elsewhere. And this is what Europe did quite successfully during the "trente glorieuses", with the support of economic institutions and policies that were adapted to those goals, in particular: limited competition in the product market; large firms financed by banks and by government subsidies; educational systems emphasizing primary, secondary, and specialized undergraduate education; rigid labor markets that would privilege human capital investment within firms over mobility.

However, by the late 1980s Europe had largely caught up with the world technology frontier in terms of its capital labor ratio and also in terms to its per capita GDP level. This in turn implied that Europe had largely exhausted capital accumulation and technological imitation as its main sources of growth, and had to turn to an alternative source, namely innovation, that is, the ability for firms and workers to move rapidly into new activities or to improve produc-

tion processes. In the meantime the IT revolution resulted in a revival of US growth in the late 1980s and early 1990s. Since Europe did not have the institutions and policies to benefit from this technological revolution, the result was a reversal of Europe’s approach to the frontier, and the fact that Europe is not adjusting its institutions in order to produce the growth maximizing innovation policy, acts as a delaying force on growth convergence towards the US.

A first way to foster innovation is to invest more in R&D. As we all know, EU countries invest less than 2% of their GDP in R&D whereas the US invests between 2 and 3%. That R&D investment becomes more essential when industries move closer to their technological frontier, can be evidenced by looking at the correlation between distance to frontier and research and development (R&D) intensity at the industry level using data from the OECD sectoral database previously analyzed by (among others) Griffith et al. (2004).

A natural (inverse) proxy for distance to frontier is “proximity to frontier” for an industry,  $PTF_{ict}$ , defined as TFP (total factor productivity) in industry  $i$  in country  $c$  at time  $t$  divided by the highest TFP in industry  $i$  at time  $t$  in the sample. We obtain estimates of proximity to frontier as well as data on R&D intensity,  $RD_{ict}$  (R&D divided by sales) for the years 1974–1990.

Table 1 in Acemoglu-Aghion-Zilibotti (2006) reports the correlation between these two measures with or without controlling for country and industry effects. The first three columns use a measure of  $PTF_{ict}$  without correcting for differences in skills and hours, while the last three columns use a measure that corrects for these differences (see Griffith et al. 2004). All columns show the same pattern of a statistically significant positive correlation between proximity to frontier and R&D intensity: industries closer to their respective frontier are more R&D intensive. Moreover, as an industry approaches the world technology frontier more rapidly than others it becomes relatively more R&D intensive. These results are consistent with the view that R&D is more important in industries or countries closer to the world technology frontier. So, the lesson is: now that they moved closer to the world technological frontier, EU countries should invest more in R&D. There is this naive view, however, that R&D subsidies would be sufficient to foster innovation and productivity growth: just invest more in R&D here and there and the economy will grow faster. In the remaining part of this note we will point at five indirect sources of innovation and growth: competition/entry, education, financial development, labor market regulations, and the conduct of macroeconomic (particularly fiscal) policy over the business cycle.

**Competition and entry** As stressed by the Sapir report (see Sapir (2003)), competition policy in Europe has emphasized competition among incumbent firms, but paid insufficient attention to entry. Entry, as well as exit and turnover of firms, are more important in the United States than Europe. For example, 50% of new pharmaceutical products are introduced by firms that are less than 10 years old in the United States, versus only 10% in Europe. Similarly, 12 percent of the largest US firms by market capitalization at the end of the 1990s

had been founded less than twenty years before, against only 4 per cent in Europe, and the difference between US and Europe turnover rates is much bigger if one considers the top 500 firms.

That the higher entry costs and lower degree of turnover in Europe compared to the US are an important part of the explanation for the relatively disappointing European growth performance over the past decade has been shown in empirical work by Nicoletti and Scarpetta (2003).

However, as shown by Aghion-Bloom-Blundell-Griffith-Howitt (2005) and Aghion-Blundell-Griffith-Howitt-Prantl (2006), entry and competition are more growth-enhancing for industries that are closer to their technological frontier. Thus, the following figure, where we look at patenting rates within a panel of UK manufacturing firms over the period 1973-1992 as a function of the degree of competition in the industry ,

*FIGURE 1 HERE*

shows that if we restrict the set of industries to those that are closer to their world frontier than the median, the upward sloping part of the inverted-U relationship between competition and innovation is steeper than we consider the whole sample of industries.

What is true for competition is also true for entry. The following figure shows that entry has a more positive effect on growth in industries that are close to the technological frontier than in those that are not.

*FIGURE 2 HERE*

During the immediate post-WWII period the European firms were predominantly the technological laggards, whose innovation rates would have been diminished by very intense competition. Thus for some time the relatively non-competitive nature of Europe was favorable to innovation and productivity-growth by European firms. However, as Europe approached closer to the global technological frontier, competition and entry have become increasingly important catalysts for innovation and productivity growth.

**Education** Is the European education system growth-maximizing? A first look at the US versus the EU in 1999-2000 shows that 37.3% of the U.S. population aged 25-64 have completed a higher education degree, against only 23.8% of the EU population. This educational attainment comparison is mirrored by that on tertiary education expenditure, with the US devoting 3% of its GDP to tertiary education versus only 1.4% in the EU. Is this European deficit in tertiary education investment a big deal for growth?

Recent analyses by Vandenbussche-Aghion-Meghir (2005), in particular the cross-country regression in Table 2 above, and more recently the cross-US state analysis by Aghion-Boustan-Hoxby-Vandenbussche (2006), ABHV, suggests it is. Namely, as Europe has moved closer to the world technological frontier, it should invest more in tertiary education in order to increase its innovative potential.

In particular the following figure, based on ABHV, shows that not investing in higher education is more damaging to growth, the closer a US state is to the world technology frontier.

*FIGURE 3 HERE*

What is true between countries is also true between regions within a country. For example, an additional \$1000 per person in research education spending, raises a US state's productivity growth rate by .27% if the state is at the frontier, whereas it raises it by only 0.09% if the state is far from the frontier.

For Europe to put the emphasis on primary/secondary education was fine as long as Europe was technologically far from the US and therefore relying more on imitation as a main source of growth, but that now that the growth potential of imitation is wearing out, it becomes more urgent to invest more in higher education in order to foster innovation. And further evidence shows that the IT and globalization waves of the 1980s, have further increased the growth potential of higher education investment. in *all* OECD countries.

**Credit constraints versus labor market regulations** Labor market rigidities are often presented as the main impediment to firms' entry, mobility and post-entry growth. As it turns out, financial constraints are at least if not more important. The study by Aghion-Fally-Scarpetta (2006) already mentioned above, shows in fact that credit constraints act as a main barrier to the entry and post-entry growth of small firms, whereas labor market regulations inhibit the entry of larger firms.

**Macropolicy** There is currently a debate on the conduct of macroeconomic policy in the Euro area. In a nutshell, it has been noticed that structural budget deficits and short-term interest rates fluctuate much less over the cycle in the EMU zone than in the US and the UK, and some policy makers have raised the concern that this in turn may inhibit growth in the Euro area. Are those concerns at all justified?

Mainstream macroeconomists would answer negatively to this question. Indeed, there is this common prejudice in macroeconomics, that there is a perfect dichotomy between, on the one hand macroeconomic policy (budget deficit, taxation, money supply) taken to affect primarily the short-run and whose primary aim is to stabilize the economy; and on the other hand, long-run economic growth, which is either taken to be exogenous or to depend only upon structural characteristics of the economy (property right enforcement, market structure, market mobility and so forth). The only link between macropolicy and long-run growth that most policy makers believe in, is that growth requires macroeconomic stability everything else remaining equal.

However, one might depart from that view. According to Schumpeter, recessions would provide a cleansing mechanism for correcting organizational inefficiencies and for encouraging firms to reorganize, innovate or reallocate to new markets. The cleansing effect of recessions is also to eliminate those firms

that are unable to reorganize or innovate. Schumpeter would summarize that view as follows; “[Recessions] are but temporary. They are means to reconstruct each time the economic system on a more efficient plan”. Now, if firms could always borrow enough funds to either reorganize their activities or move to new activities and markets, and the same was true for workers trying to relocate from one job to another, the best would be to recommend that governments do not intervene over the business cycle, and instead let markets operate.

However, things become quite different when credit market imperfections prevent firms from innovating and reorganizing in recessions. For example, suppose that the borrowing capacity of firms is proportional to their current earnings. In a recession, current earnings are reduced, and therefore so is the firms’ ability to borrow in order to innovate. But then, a countercyclical budgetary policy may foster innovation and growth by reducing the negative consequences of a recession (or a bad aggregate shock) on firms’ innovative investments. For example, the government may decide to increase the volume of its public investments, thereby fostering the demand for private firms’ products. Or the government may choose to directly increase its subsidies to private enterprises, thereby increasing their liquidity holdings and thus making it easier for them to face idiosyncratic liquidity shocks without having to sacrifice R&D or other types of longer-term growth-enhancing investments.

That countercyclical government support to the enterprise sector may be growth-enhancing, is suggested by the work of Berman et al (2006) already mentioned above, which uses a French firm-level data set to show that R&D investments are more hurt in downturns in firms that are more credit constrained. Recent work by Aghion-Marinescu (2007) provides consistent evidence to the effect that the correlation between countercyclical budgetary policy and growth is more positive the lower a country’s level of financial development. Interestingly, budgetary policies are currently far less countercyclical in the EU than in the US even though the US are more financially developed than the EU. Indeed, the ratio of private credit to GDP in the EU is equal 0.76 against 1.32 in the US, and this difference abstracts from differences in stock market and venture capital market development, both markets are also far more developed in the US than in the EU. As shown in Figure 4 below, both the structural deficit and the real interest rates vary much less over time in the Eurozone than in the US, and the above discussion suggests that the absence of an active (or reactive) macropolicy in the Eurozone is a potential source of growth deficit in this region.

*FIGURE 4 HERE*

### **3.3.2 Latin America versus Asia**

What can Latin American countries do to get closer to the high growth rates experienced by Asian countries? As we mentioned in the introduction, capital output ratios are the same in OECD countries. Yet, the framework in Section 2 suggests several complementary levers to foster growth in that region.

**Savings** In a recent paper, Aghion-Comin-Howitt (2006) argue that domestic savings can serve as collateral to attract foreign direct investment, and that foreign direct investment in turn is more growth-enhancing for countries that are not too close to the technological frontier as they bring knowledge from the frontier to those countries (in terms of the model in Section 2, they enhance the implementation rate  $\mu_m$ ). This prediction is tested using a cross-country panel regression where growth is regressed over the domestic savings rate and its interaction with the country's proximity to the frontier. The interaction coefficient between savings and proximity is found to be positive and significant, which in turn means that growth in middle-income countries such as those in Latin America would benefit from higher savings rate. To show how much growth potential can be gained on that front, it suffices to note that average private savings in Latin America over the period 2000-2002 were only at 7.8% of GDP, versus 28.1% in the Asian tigers including China.

**Education** Education is another lever of growth that has been largely underexploited or misexploited in Latin America. That education spending and attainment has substantial growth effects, is shown in several studies, including VAM and ABHV mentioned above. However, if we look at the Barro-Lee schooling data in 1985 for the population aged between 25 and 64 years old, we find a schooling index of only 3.49 in Brazil, 6.45 in Chile versus 11.79 in the US.

Not only do Latin American countries underinvest in education, they also misinvest in education. Indeed, the analysis in VAM suggests that given Latin American countries' distance to the world productivity frontier, they should invest more, not less in primary and secondary education than OECD countries, and they should invest less, not more, in tertiary education. However, if we look respectively at spending in primary, secondary and tertiary education in percentage of per capita GDP, we find that Brazil invests 10.8% in primary, 11.2% in secondary, and 48.87 in tertiary. By comparison, the US invest 21.6% in primary, 24.4% in secondary and 26% in tertiary. Thus, Brazil overinvests in tertiary education, which we take as resulting from a long history of excessive income and wealth inequality and of capture of the political system by the well-off who would enjoy almost exclusive access to higher education. We do not recommend that Latin American countries give up on higher education altogether, but that they emphasize more primary, secondary and undergraduate education.

**Competition** Existing growth analyses suggest that competition and entry tend to enhance innovation and growth, especially in sectors and countries that are not too far from the technology frontier. One may argue that Latin America is not so close to the frontier, and that the same argument that led us to advocate more emphasis on lower education, would also push for not emphasizing competition policy. However, if we look at the recent liberalization experience in India (see Aghion-Burgess-Redding-Zilibotti (2005)) we find that while liber-

alizing entry has enhanced productivity growth more in more advanced sectors than in sectors further below the frontier, overall this has enhanced growth in the Indian manufacturing sector. The same should presumably be true in Latin American countries which are, if anything, closer to the world productivity frontier than India was in 1985 or in 1991 when delicensing and trade liberalization reforms took place.

The so-called Frazer index (which ranks countries according to their levels of product market deregulations), suggests that much growth potential can be gained in Latin America by fostering competition and entry: Brazil is ranked 88th, Argentina is ranked 74th, Mexico is ranked 60th, only Chile does relatively fine, being ranked 20th.

**Financial development** There exists a large literature on the positive effects of finance on growth and convergence, also based on new growth theory. Here the idea is simply that financial constraints limit firms' ability to undertake innovative or implementation activities (See Levine(2005) for a first rate survey on the question). And here again, Latin American countries are dramatically lagging behind. If we look at the ratio of private credit to GDP as the measure of financial development, we find a ratio of only 0.345 in Brazil, 0.244 in Argentina, 0.184 in Mexico, whereas we find 0.683 in Chile which is close to 0.76 in the EMU zone but still far below 1.42 in the US.

## 4 Conclusion

In this paper we have argued that new growth theory combined with suitable growth regressions has the potential to deliver growth policy recommendations. In particular we have argued that growth in the EU should benefit from a more active competition and entry policy, a bigger emphasis on higher education and a more proactive macroeconomic policy over the cycle. Similarly, although more econometric work needs to be done in this case, we have argued that growth in Latin America should benefit from a combination of higher domestic savings, higher investments in education, starting with primary and secondary education, from opening up competition and entry (with complementary policies to help workers relocate from lagging sectors to more advanced sectors), and from higher financial development.

However, so far we have taken a Pigovian approach and ignored the political costs of implementing various reforms. A necessary next step is to look at more specific policy instruments and for each instrument calculate a ratio of the additional growth potential associated with this instrument with respect to the cost of implementing the corresponding policy. This in turn would enable us to "rank" the reforms, that is, to get a more precise view as to what should be undertaken first, or as to which reforms should be implemented jointly because of complementarities in their growth impacts.

Also, we have only briefly touched upon the difficult issues raised by the use of growth regressions. These are the subject of our companion paper. section.

## References

- [1] Acemoglu, Daron, Aghion, Philippe, and Fabrizio Zilibotti (2002), “Distance to Frontier, Selection, and Economic Growth”, NBER Working Paper No 9066
- [2] Aghion, Philippe, Alesina, Alberto, and Francesco Trebbi (2007), “Democracy, Technology, and Growth”, mimeo Harvard.
- [3] Aghion, Philippe; Angeletos, Marios; Banerjee, Abhijit and Kalina Manova (2005), “Volatility and Growth: Credit Constraints and Productivity-Enhancing Investment”, mimeo Harvard-MIT
- [4] Aghion, Philippe; Bloom, Nick; Blundell, Richard; Griffith, Rachel and Peter Howitt (2005), “Competition and Innovation: An Inverted-U Relationship”, *Quarterly Journal of Economics*
- [5] Aghion, Philippe; Blundell, Richard, Griffith, Rachel; Howitt, Peter and Susanne Prantl (2004), “Entry and Productivity Growth: Evidence from Micro-Level Panel Data”, *Journal of the European Economic Association, Papers and Proceedings*, 2, 265-276.
- [6] Aghion, Philippe; Blundell, Richard, Griffith, Rachel; Howitt, Peter and Susanne Prantl (2005), “Entry, Innovation, and Growth: Theory and Evidence from UK Firm-Level Data”, mimeo Harvard-UCL
- [7] Aghion, Philippe; Boustan, Leah; Hoxby, Caroline and Jerome Vandenbussche (2005), “Exploiting States’ Mistakes to Evaluate the Impact of Higher Education on Growth”, mimeo Harvard
- [8] Aghion, Philippe; Burgess, Robin; Redding, Stephen and Fabrizio Zilibotti (2005a), “Entry Liberalization and Inequality in Industrial Performance”, *Journal of the European Economic Association, Papers and Proceedings*
- [9] Aghion, Philippe; Burgess, Robin; Redding, Stephen and Fabrizio Zilibotti (2005b), “On the Unequal Effects of Liberalization: Theory and Evidence from Indian Delicensing Data”, mimeo LSE-Harvard-IIES
- [10] Aghion, Philippe, Fally, Thibault, and Stefano Scarpetta (2007), “Credit Constraints as a Barrier to the Entry and Post-Entry Growth of Firms”, mimeo Harvard.
- [11] Aghion, Philippe and Peter Howitt (1992), “A Model of Growth through Creative Destruction”, *Econometrica*, 60, 323-351.
- [12] Aghion, Philippe and Peter Howitt (1998), *Endogenous Growth Theory*, MIT Press
- [13] Aghion, Philippe; Howitt, Peter and David Mayer-Foulkes (2005), “The Effect of Financial Development on Convergence: Theory and Evidence”, *Quarterly Journal of Economics*, 120, 173-222

- [14] Aghion, Philippe and Peter Howitt (2006), "Appropriate Growth Policy", Schumpeter Lecture, *Journal of the European Economic Association, Papers and Proceedings*.
- [15] Aghion, Philippe and Ioana Marinescu (2007), Cyclical Budgetary Policy and Productivity Growth: What Do We Learn from OECD Panel Data?", mimeo Harvard.
- [16] Barro, R., (1991), "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics*, 106, 2, 407-43
- [17] Barro, Robert (1996), "Democracy and Growth", *Journal of Economic Growth* 1, 1-27.
- [18] Barro, Robert and Xavier Sala-i-Martin (2005), *Economic Growth*, MIT Press
- [19] Barro, Robert and Jong-Wha Lee (2000), "International Data on Educational Attainment: Updates and Implications", Working Paper No 42, Center for International Development at Harvard University.
- [20] Benhabib, Jess and Mark Spiegel (1994), "The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-Country Data", *Journal of Monetary Economics*, 34, 143-173.
- [21] Berman, Nicolas, Eymard, Laurent, Aghion, Philippe, Aszenazy, Philippe and Gilbert Cette (2007), "Credit Constraints and the Cyclicalities of R&D: Lessons from French Firm-Level Panel Data", mimeo Banque de France.
- [22] Bills, Mark and Peter Klenow (2000), "Does Schooling Cause Growth?", *American Economic Review*, 90, 1160-1183.
- [23] Blundell, Richard; Griffith, Rachel, and John Van Reenen (1995), "Dynamic Count Data Models of Technological Innovation", *Economic Journal*, 105, 333-344.
- [24] Brock, W. and S. Durlauf, (2001a), "Growth Empirics and Reality," *World Bank Economic Review*, 15, 2, 229-272.
- [25] Brock, W. and S. Durlauf, (2001b), "Interactions-Based Models," *Handbook of Econometrics*, J. Heckman and E. Leamer eds., Amsterdam: North-Holland.
- [26] Brock, W. and S. Durlauf, (2007), "Identification of Binary Choice Models with Social Interactions," *Journal of Econometrics*, forthcoming.
- [27] Burnside, C. and D. Dollar, (2000), "Aid, Policies, and Growth," *American Economic Review*, 90, 4, 847-868.
- [28] Durlauf, S., (2002), "On the Empirics of Social Capital," *Economic Journal*, 112, 459-479.

- [29] Durlauf, S. and P. Johnson, (1995), "Multiple Regimes and Cross-Country Growth Behavior," *Journal of Applied Econometrics*, 10, 4, 363-384.
- [30] Durlauf, S., P. Johnson and J. Temple, (2005), "Growth Econometrics," in *Handbook of Economic Growth*, P. Aghion and S. Durlauf eds., Amsterdam: North Holland.
- [31] Easterly, William (2005), "National Policies and Economic Growth: A Reappraisal", forthcoming in the *Handbook of Economic Growth*, edited by P. Aghion and S. Durlauf.
- [32] Frankel, Marvin (1962), "The Production Function in Allocation and Growth: A Synthesis", *American Economic Review*, 52, 995-1022.
- [33] Gerschenkron, Alexander (1962), *Economic Backwardness in Historical Perspective*, Harvard University Press.
- [34] Ha, Joonkyung and Peter Howitt (2005), "Accounting for Trends in Productivity and R&D: A Schumpeterian Critique of Semi-Endogenous Growth Theory", mimeo Brown University
- [35] Howitt, Peter (2000). "Endogenous Growth and Cross-Country Income Differences", *American Economic Review*, 90, 829-846.
- [36] Howitt, Peter and David Mayer-Foulkes (2005). "R&D, Implementation and Stagnation: A Schumpeterian Theory of Convergence Clubs", *Journal of Money, Credit and Banking*, 37, 147-177.
- [37] Jones, Charles (1995), "R&D-Based Models of Economic Growth", *Journal of Political Economy*, 103, 759-784.
- [38] King, Robert and Sergio Rebelo (1993), "Transitional Dynamics and Economic Growth in the Neoclassical Model", *American Economic Review*, 83, 908-931
- [39] Krueger, Alan and Mikael Lindahl (2001), "Education for Growth: Why and For Whom?", *Journal of Economic Literature*, 39, 1101-1136
- [40] Liu, Z. and T. Stengos, (1999), "Non-Linearities in Cross-country Growth Regressions: A Semiparametric Approach," *Journal of Applied Econometrics*, 14, 5, 527-38.
- [41] Lucas, Robert (1988), "On the Mechanics of Economic Development", *Journal of Monetary Economics*, 22, 3-42.
- [42] Manski, C., (1993), "Identification of Endogenous Social Effects: The Reflection Problem." *Review of Economic Studies*, 60, 3, 531-542.
- [43] Mankiw, Gregory; Romer, David and David Weil (1992), "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics*, 25, 275-310.

- [44] Nelson, Richard and Edmund Phelps (1966), "Investment in Humans, Technological Diffusion, and Economic Growth", *American Economic Review, Papers and Proceedings*, 61, 69-75.
- [45] Nickell, Steven (1996), "Competition and Corporate Performance", *Journal of Political Economy*, 104, 724-46
- [46] Nicoletti, Giuseppe and Stefano Scarpetta (2003), "Regulation, Productivity and Growth", *Economic Policy*, 36, 11-72.
- [47] Ramey, Garey and Valerie Ramey (1995), "Cross-Country Evidence on the Link Between Volatility and Growth", *American Economic Review*, 85, 1138-1151.
- [48] Rodrik, Dani (2005), "Growth Strategies", forthcoming in the *Handbook of Economic Growth*, edited by P. Aghion and S. Durlauf
- [49] Romer, Paul (1986), "Increasing Returns and Long-Run Growth", *Journal of Political Economy*, 94, 1002-1037
- [50] Romer, Paul (1990), "Endogenous Technical Change", *Journal of Political Economy*, 98, 71-102
- [51] Sapir, Andre et al. (2003), *An Agenda for A Growing Europe*, Oxford University Press
- [52] Solow, Robert (1956), "A Contribution to the Theory of Economic Growth", *Quarterly Journal of Economics*, 70, 65-94.
- [53] Tan, C. M., (2006), "No One True Path to Development: Uncovering the Interplay Between Geography, Institutions, and Ethnic Fractionalization in Economic Development," mimeo, Tufts University.
- [54] Vandenbussche, Jerome; Aghion, Philippe; and Costas Meghir (2004), "Growth, Distance to Frontier and the Composition of Human Capital", mimeo Harvard-UCL.