On Institutions and Growth[*]

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November 15, 2004

1 Introduction

A main development in growth economics in the recent years, has been to point at the fundamental role of institutions in the growth process, although few studies have led so far to precise policy recommendations beyond the general claims about the importance of property right enforcement. This is largely due to the difficulty in de&ning the term *institutions*. North and Thomas (1973) developed the notion that "social infrastructure" reduces uncertainty and diminishes transaction costs. This idea has been adopted by growth theorists in many different guises. Some authors have emphasized the importance of property right protection and its impact on entrepreneurship; others have concentrated on regulatory institutions in either &nancial, labor, or product markets; yet others have highlighted the importance of social insurance and con! ict management.

In this chapter, we use the Aghion-Howitt model of growth with quality-improving innovations, to look at some speci&c aspects of the relationship between institutions, institutional change, and productivity growth. The &rst section is devoted to the relationship between &nancial development and convergence, and argues that &nancial development is a main determinant of a country's ability to converge in growth rates and/or in levels of GDP per capita towards the technological frontier. The following section looks at the relationship between productivity growth and product market competition. It spells out the con! icting impacts that competition can have on innovation, and discusses the empirical evidence on this issue. The last section develops the notion of appropriate institutions, showing how different types of institutions or policies maximize growth at different stages of technological development.

2 Financial institutions and convergence

The history of cross-country income differences exhibits mixed patterns of convergence and divergence. The most striking pattern over the long run is the

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"great divergence" - the dramatic widening of the distribution that has taken place since the early 19th Century. Pritchett (1997) estimates that the proportional gap in living standards between the richest and poorest countries grew more than five-fold from 1870 to 1990, and according to the tables in Maddison (2001) the proportional gap between the richest group of countries and the poorest[1] grew from 3 in 1820 to 19 in 1998. But over the second half of the twentieth century this widening seems to have stopped, at least among a large group of nations. In particular, the results of Barro and Sala-i-Martin (1992), Mankiw, Romer and Weil (1992) and Evans (1996) seem to imply that most countries are converging to parallel growth paths.

However, the recent pattern of convergence is not universal. In particular, the gap between the leading countries as a whole and the very poorest countries as a whole has continued to widen. The proportional gap in per-capita income between Mayer-Foulkes's (2002) richest and poorest convergence groups grew by a factor of 2.6 between 1960 and 1995, and the proportional gap between Maddison's richest and poorest groups grew by a factor of 1.75 between 1950 and 1998. Thus as various authors[2] have observed, the history of income differences since the mid 20th Century has been one of "club-convergence"; that is, all rich and most middle-income countries seem to belong to one group, or "convergence club", with the same long-run growth rate, whereas all other countries seem to have diverse long-run growth rates, all strictly less than that of the convergence club. In this section we develop an explanation for this phenomenon.

2.1 A model of technology transfer

Consider one country in a world of h different countries. We assume that whenever an innovation takes place in any given sector in any country, the productivity parameter attached to the new product will match the global leading-edge technology. That is, let $\overline{A}_t$ be the maximum productivity parameter over all countries in the sector at the end of period t; in other words the "frontier" productivity at t, and suppose that the frontier grows at a constant rate $\overline{g}$ which here we take as exogenous for simplicity.

Then domestic productivity in the sector evolves according to:

$$A_t = \left\{ \begin{array}{ll} \overline{A}_t & \text{with probability } \mu \\ A_{t-1} & \text{with probability } 1-\mu \end{array} \right\} \quad (1)$$

where μ is the country's innovation rate. Let

$$a_t = \frac{A_t}{\overline{A}_t}$$

[1] The richest group was Western Europe in 1820 and the "Euopean Offshoots" (Australia, Canada, New Zealand and the United States) in 1998. The poorest group was Africa in both years.

[2] Baumol (1986), Durlauf and Johnson (1995), Quah (1993, 1997) and Mayer-Foulkes (2002, 2003).

denote the country's proximity to the technological frontier. Then, it follows immediately from (1) that the distance variable a_t evolves over time according to:

$$a_t = \mu + \frac{1-\mu}{1+g} a_{t-1}.$$

If $\mu > 0$, which in turn will depends upon underlying characteristics of the economy such as property right protection or the productivity of R&D, this difference equation has a unique &xed point

$$a^* = \frac{\mu(1+g)}{\mu+g}.$$

That is, as long as the country continues to perform R&D at a positive constant intensity its distance to the frontier will stabilize, meaning that its productivity growth rate will converge to that of the global frontier. But if $\mu = 0$ the difference equation has no stable rest point and a_t diverges to zero. That is, if the country stops innovating it will have a long-run productivity growth rate of zero because innovation is a necessary condition for the country to bene&t from technology transfer.

2.2 The role of &nancial development in convergence

The framework can be further developed by assuming that while the size of innovations increases with the distance to the technological frontier (due to technology transfer), the frequency of innovations depends upon the ratio between the distance to the technological frontier and the current stock of skilled workers. This enriched framework (see Howitt and Mayer-Foulkes, 2002) can explain not only why some countries converge while other countries stagnate but also why different countries may display positive yet divergent growth patterns in the long-run. Benhabib and Spiegel (2002) develop a similar account of divergence and show the importance of human capital in the process. The rest of this section presents a summary of the related model of Aghion, Mayer-Foulkes and Howitt (2004) (AMH) and discusses their empirical results showing the importance of &nancial development in the convergence process.

Suppose that the world is as portrayed in the previous sections, but that research aimed at making an innovation in t must be done at period $t-1$. If we assume perfectly functioning &nancial markets then nothing much happens to the model except that the research arbitrage condition (**??**) has a discount factor β on the right-hand side to re! ect the fact that the expected returns to R&D occur one period later than the expenditure.[3] But when credit markets are imperfect, AMH show that an entrepreneur may face a borrowing constraint that limits her investment to a &xed multiple (which we refer to as the credit multiplier) of her accumulated net wealth. In their model the multiple comes

[3] For simplicity we suppose that everyone has linear intertemporal preferences with a constant discount factor β.

from the possibility that the borrower can, at a cost that is proportional to the size of her investment, decide to defraud her creditors by making arrangements to hide the proceeds of the R&D project in the event of success.[4] They also assume a two-period overlapping-generations structure in which the accumulated net wealth of an entrepreneur is her current wage income, and in which there is just one entrepreneur per sector in each country. This means that the further behind the frontier the country falls the less will any entrepreneur be able to invest in R&D relative to what is needed to maintain any given frequency of innovation. What happens in the long run to the country's growth rate depends upon the interaction between this disadvantage of backwardness, which reduces the frequency of innovations, and the above-described advantage of backwardness, which increases the size of innovations. The lower the cost of defrauding a creditor the more likely it is that the disadvantage of backwardness will be the dominant force, preventing the country from converging to the frontier growth rate even in the long run. Generally speaking, the greater the degree of financial development of a country the more effective are the institutions and laws that make it difficult to defraud a creditor. Hence the link between financial development and the likelihood that a country will converge to the frontier growth rate.

More formally, the convergence equation becomes:

$$a_t = \widetilde{\mu}(a_{t-1}) + \frac{1 - \widetilde{\mu}(a_{t-1})}{1+g} a_{t-1},$$

where $\widetilde{\mu}(a_{t-1})$ is the innovation probability of credit-constrained firms in a country at proximity a_{t-1} from the technological frontier. That $\widetilde{\mu}(a_{t-1})$ should increase with a_{t-1}, stems from the fact that the innovation cost is proportional to the frontier productivity (recall that innovations bring sectors all the way to the frontier) whereas the amount of wage resources firms in the country can use as a basis for borrowing, are proportional the country's current level of productivity. Therefore the further below the frontier a country currently is, the tighter credit-constraints on innovative firms. This, in turn, captures what we call the "disadvantage of backwardness". In addition, for given a_{t-1} the innovation probability $\widetilde{\mu}(a_{t-1})$ increases with the borrowing/resource ratio (credit multiplier), which in turn increases with the cost of defrauding.

AHM test this effect of financial development on convergence by running the following cross-country growth regression:

$$g_i - g_1 = \beta_0 + \beta_f F_i + \beta_y \cdot (y_i - y_1) + \beta_{fy} \cdot F_i \cdot (y_i - y_1) + \beta_x X_i + \varepsilon_i \qquad (2)$$

where g_i denotes the average growth rate of per-capita GDP in country i over the period 1960 - 1995, F_i the country's average level of financial development, y_i the initial (1960) log of per-capita GDP, X_i a set of other regressors and ε_i a disturbance term with mean zero. Country 1 is the technology leader, which they take to be the United States.

[4] The "credit multiplier" assumed here is much like that of Bernanke and Gertler (1989), as modified by Aghion, Banerjee and Piketty (1999).

Define $\widehat{y}_i \equiv y_i - y_1$, country i's initial relative per-capita GDP. Under the assumption that $\beta_y + \beta_{fy} F_i \neq 0$ we can rewrite (2) as:

$$g_i - g_1 = \lambda_i \cdot (\widehat{y}_i - \widehat{y}_i^*)$$

where the steady-state value $\widehat{y}_i^*$ is defined by setting the RHS of (2) to zero:

$$\widehat{y}_i^* = -\frac{\beta_0 + \beta_f F_i + \beta_x X_i + \varepsilon_i}{\beta_y + \beta_{fy} F_i} \tag{3}$$

and λ_i is a country-specific convergence parameter:

$$\lambda_i = \beta_y + \beta_{fy} F_i \tag{4}$$

that depends on financial development.

A country can converge to the frontier growth rate if and only if the growth rate of its relative per-capita GDP depends negatively on the initial value $\widehat{y}_i$; that is if and only if the convergence parameter λ_i is negative. Thus the likelihood of convergence will increase with financial development, as implied by the above theory, if and only if:

$$\beta_{fy} < 0. \tag{5}$$

The results of running this regression using a sample of 71 countries are shown in Table 1, which indicates that the interaction coefficient β_{fy} is indeed significantly negative for a variety of different measures of financial development and a variety of different conditioning sets X. The estimation is by instrumental variables, using a country's legal origins, and its legal origins[5] interacted with the initial GDP gap $(y_i - y_1)$ as instruments for F_i and $F_i\,(y_i - y_1)$. The data, estimation methods and choice of conditioning sets X are all take directly from Levine, Loayza and Beck (2000) who found a strongly positive and robust effect of financial intermediation on short-run growth in a regression identical to (2) but without the crucial interaction term $F_i\,(y_i - y_1)$ that allows convergence to depend upon the level of financial development. AHM show that these results are surprisingly robust to different estimation techniques, to discarding outliers, and to including possible interaction effects between the initial GDP gap and other right-hand-side variables.

2.3 Concluding remark

Thus we see how Schumpeterian growth theory and the quality improvement model can naturally explain club convergence patterns, the so-called twin peaks pointed out by Quah (1996). The Schumpeterian growth framework can deliver an explanation for cross-country differences in growth rates and/or in convergence patterns based upon *institutional considerations*. No one can deny that

[5] See LaPorta et al. (1998) for a detailed explanation of legal origins and its relevance as an instrument for financial development.

such considerations are close to what development economists have been concerned with. However, some may argue that the quality improvement paradigm, and new growth theories in general, remain of little help for development policy, that they merely formalize platitudes regarding the growth-enhancing nature of good property right protection, sound education systems, stable macroeconomy, without regard to speci&cs such as a country's current stage of development. In the next two sections we will argue on the contrary that the Schumpeterian growth paradigm can be used to understand (i) why liberalization policies (in particular an increase in product market competition) should affect productivity growth differently in sectors or countries at different stages of technological development as measured by the distance variable d; and (ii) why the organizations or institutions that maximize growth, or that are actually chosen by societies, also vary with distance to the frontier.

3 Competition and growth

One particularly unappealing feature of most existing endogenous growth models is the prediction that product market competition is unambiguously detrimental to growth because it reduces the monopoly rents that reward successful innovators and thereby discourages R&D investments. Not only does this prediction contradict a common wisdom that goes back to Adam Smith, but it has also been shown to be (partly) counterfactual (e.g by Geroski (1994), Nickell (1996), and Blundell et al (1999))[6].

However, as we argue in this section, a simple modi&cation reconciles the Schumpeterian paradigm with the evidence on product market competition and innovation, and also generates new empirical predictions that can be tested with &rm- and industry-level data. In this respect the paradigm can meet the challenge of seriously putting IO into growth theory. The theory developed in this section is based on Aghion-Harris-Vickers (1997) and Aghion-Harris-Howitt-Vickers (2001), but cast in the discrete-time framework introduced above.

As before, there is a global technological frontier that is common to all sectors, and which is drawn on by all innovations. The model takes as given the growth rate of this global frontier, so that the frontier $\overline{A}_t$ at the end of period t obeys:

$$\overline{A}_t = \gamma \overline{A}_{t-1},$$

where $\gamma = 1 + \overline{g} > 1$.

In each country, the general good is produced using the same kind of technology as in the previous sections, but here for simplicity we assume a continuum of intermediate inputs and we normalize the labor supply at $L = 1$, so that:

$$y_t = \int_0^1 A_{it}^{1-\alpha} x_{it}^{\alpha} di,$$

[6] We refer the reader to the second part of this section where we confront theory and empirics on the relationship between competition/entry and innovation/productivity growth.

where, in each sector i, only one &rm produces intermediate input i using general good as capital according to a one-for-one technology.

In each sector, the incumbent &rm faces a competitive fringe of &rms that can produce the same kind of intermediate good, although at a higher unit cost. More speci&cally, we assume that at the end of period t, at unit cost χ, where we assume $1 < \chi < 1/\alpha < \gamma\chi$, a competitive fringe of &rms can produce one unit of intermediate input i of a quality equal to $\min(A_{it}, \overline{A}_{t-1})$, where A_{it} is the productivity level achieved in sector i after innovation has had the opportunity to occur in sector i within period t.

In each period t, there are three types of sectors, which we refer to as type-j sectors, with $j \in \{0, 1, 2\}$. A type-j sector starts up at the beginning of period t with productivity $A_{j,t-1} = \overline{A}_{t-1-j}$, that is, j steps behind the current frontier $\overline{A}_{t-1}$. The pro&t ! ow of an incumbent &rm in any sector at the end of period t, will depend upon the technological position of that &rm with regard to the technological frontier at the end of the period.

Between the beginning and the end of the current period t, the incumbent &rm in any sector i has the possibility of innovating with positive probability. Innovations occur step-by-step: in any sector an innovation moves productivity upward by the same factor γ. Incumbent &rms can affect the probability of an innovation by investing more in R&D at the beginning of the period. Namely, by investing the quadratic R&D effort $\frac{1}{2}\gamma A_{i,t-1}\mu^2$ incumbent an &rm i in a type-0 or type-1 sector, innovates with probability μ.[7] However, innovation is assumed to be automatic in type-2 sectors, which in turn re! ects a knowledge externality from more advanced sectors which limits the maximum distance of any sector to the technological frontier.

Now, consider the R&D incentives of incumbent &rms in the different types of sectors at the beginning of period t. Firms in type-2 sectors have no incentive to invest in R&D since innovation is automatic in such sectors. Thus

$$\mu_2 = 0,$$

where μ_j is the equilibrium R&D choice in sector j.

Firms in type-1 sectors, that start one step behind the current frontier at $A_{i,t-1} = \overline{A}_{t-2}$ at the beginning of period t, end up with productivity $A_t = \overline{A}_{t-1}$ if they successfully innovate, and with productivity $A_t = \overline{A}_{t-2}$ otherwise. In either case, the competitive fringe can produce intermediate goods of the same quality but at cost χ instead of 1. Then, as in Acemoglu et al (2003), the equilibrium pro&t can be shown to be equal to:[8]

$$\pi_t = A_t \delta(\chi),$$

[7] We thus depart slightly from our formulation in the previous sections: here we take the probability of innovation, not the R&D effort, as the optimization variable. However the two formulations are equivalent: that the innovation probability $f(n) = \mu$ is a concave function of the effort n, is equivalent to saying that the effort is a convex function of the probability.

[8] Imitation does not destroy the rents of non-innovating &rms. We assume nevertheless that the &rm ignores any continuation value in its R&D decision.

with

$$\delta(\chi) = (\chi - 1)(\chi/\alpha)^{\frac{1}{\alpha-1}}$$

increasing in χ.

Thus the net rent from innovating for a type-1 &rm is equal to

$$(\overline{A}_{t-1} - \overline{A}_{t-2})\delta(\chi)$$

and therefore a type-1 &rm will choose its R&D effort to solve:

$$\max_{\mu}\{(\overline{A}_{t-1} - \overline{A}_{t-2})\delta(\chi)\mu - \frac{1}{2}\gamma\overline{A}_{t-2}\mu^2\},$$

which yields

$$\mu_1 = (1 - \frac{1}{\gamma})\delta(\chi).$$

In particular an increase in product market competition, measured as an reduction in the unit cost χ of the competitive fringe, will reduce the innovation incentives of a type-1 &rm. This we refer to as the *Schumpeterian effect* of product market competition: competition reduces innovation incentives and therefore productivity growth by reducing the rents from innovations of type-1 &rms that start below the technological frontier. This is the dominant effect, both in IO models of product differentiation and entry, and in basic endogenous growth models as the one analyzed in the previous sections. Note that type-1 &rms cannot escape the fringe by innovating: whether they innovate or not, these &rms face competitors that can produce the same quality as theirs at cost χ. As we shall now see, things become different in the case of type-0 &rms.

Firms in type-0 sectors, that start at the current frontier, end up with productivity $\overline{A}_t$ if they innovate, and stay with their initial productivity $\overline{A}_{t-1}$ if they do not. But the competitive fringe can never get beyond producing quality $\overline{A}_{t-1}$. Thus, by innovating, a type-0 incumbent &rm produces an intermediate good which is γ times better than the competing good the fringe could produce, and at unit cost 1 instead of χ for the fringe. Our assumption $\frac{1}{\alpha} < \gamma\chi$ then implies that competition by the fringe is no longer a binding constraint for an innovating incumbent, so that its equilibrium pro&t post-innovation, will simply be the pro&t of an unconstrained monopolist, namely:

$$\pi_t = \overline{A}_t\delta(1/\alpha).$$

On the other hand, a type-0 &rm that does not innovate, will keep its productivity equal to $\overline{A}_{t-1}$. Since the competitive fringe can produce up to this quality level at cost χ, the equilibrium pro&t of a type-0 &rm that does not innovate, is equal to

$$\pi_t = \overline{A}_{t-1}\delta(\chi).$$

A type-0 &rm will then choose its R&D effort to:

$$\max_{\mu}\{[\overline{A}_t\delta(1/\alpha) - \overline{A}_{t-1}\delta(\chi)]\mu - \frac{1}{2}\gamma\overline{A}_{t-1}\mu^2\},$$

so that in equilibrium

$$\mu_0 = \delta(1/\alpha) - \frac{1}{\gamma}\delta(\chi).$$

In particular an increase in product market competition, i.e a reduction in χ, will now have a fostering effect on R&D and innovation. This, we refer to as the *escape competition effect:* competition reduces pre-innovation rents of type-0 incumbent &rms, but not their post-innovation rents since by innovating these &rms have escaped the fringe. This in turn induces those &rms to innovate in order to escape competition with the fringe.

3.1 Composition effect and the inverted-U relationship between competition and innovation

We have just seen that product market competition tends to have opposite effects on frontier and lagging sectors, fostering innovation by the former and discouraging innovation by the latter. In this section we consider the impact of competition on the steady-state aggregate innovation intensity

$$I = q_0\mu_0 + q_1\mu_1 \tag{6}$$

where q_j is the steady-state fraction of type-j sectors (recall that type-2 sectors do not perform R&D).

To get a non-trivial steady-state fraction of type-0 &rms, we need that the net ! ows out of state 0 (which corresponds to type-0 &rms that fail to innovate in the current period), be compensated by a net ! ow into state 0. We simply postulate such a ! ow into state 0, by assuming that at the end of any period t, with exogenous probability ε entry at the new frontier, that is by a type-0 &rm with productivity level $\overline{A}_t$, occurs in a type-2 sector after the incumbent &rm has produced. We then have the following ! ow equations describing the net ! ows into and out of states 0, 1 and 2:

$$\begin{aligned} q_2\varepsilon &= q_0(1-\mu_0); \\ q_0(1-\mu_0) &= q_1(1-\mu_1); \\ q_1(1-\mu_1) &= q_2\varepsilon; \end{aligned}$$

in which the left hand sides represents the steady-state expected ! ow of sectors that move into a state j and the right hand sides represent the expected out! ow from the same state, for $j = 0, 1$, and 2. This, together with the identity:

$$q_0 + q_1 + q_2 = 1,$$

implies that:

$$I = 1 - q_2(1 + 2\varepsilon),$$

where

$$q_2 = \frac{1}{1 + \frac{\varepsilon}{1-\mu_0} + \frac{\varepsilon}{1-\mu_1}}.$$

In particular, one can see that the overall effect of increased product market competition on I is ambiguous since it produces opposite effects on innovation probabilities in type-0 and type-1 sectors (i.e on μ_0 and μ_1). In fact, one can say more than that, and show that: (i) the Schumpeterian effect always dominates for γ sufficiently large; (ii) the escape competition effect always dominates for γ sufficiently close to one; (iii) for intermediate values of γ, the escape competition effect dominates when competition is initially low (with χ close to $1/\alpha$) whereas the Schumpeterian effect dominates when competition is initially high (with χ close to one). In this latter case, the relationship between competition and innovation is inverted-U shaped.

This inverted-U pattern can be explained as follows: at low initial levels of competition (i.e high initial levels of $\delta(\chi)$), type-1 &rms have strong reason to innovate; it follows that many intermediate sectors in the economy will end up being type-0 &rms in steady-state (this we refer to as the *composition effect* of competition on the relative equilibrium fractions of type-0 and type-1); but then the dominant effect of competition on innovation is the escape competition effect whereby more competition fosters innovation by type-0 &rms. On the other hand, at high initial levels of competition, innovation incentives in type-1 sectors are so low that a sector will remain of type-1 for a long time, and therefore many sectors will end up being of type-1 in steady-state, which in turn implies that the negative Schumpeterian appropriability effect of competition on innovation should tend to dominate in that case.

3.2 Empirical predictions

The above analysis generates several interesting predictions:

1. Innovation in sectors in which &rms are close to the technology frontier, react positively to an increase in product market competition;
2. Innovation reacts less positively, or negatively, in sectors in which &rms are further below the technological frontier;
3. The average fraction of frontier sectors decreases, i.e the average technological gap between incumbent &rms and the frontier in their respective sectors increases, when competition increases;
4. The overall effect of competition on aggregate innovation, is inverted-U shaped.[9]

[9] Although perhaps only the second part of the inverse U will be observable. See footnote **??** above.

These predictions have been confronted by Aghion-Bloom-Blundell-Grigffith-Howitt (2002) with UK firm level data on competition and patenting, and we briefly summarize their findings in the next subsection. The prediction we want to emphasize here is that the escape competition effect should be strongest in industries in which firms are closest to the technological frontier.

ABBGH considers a UK panel of individual companies during the period 1968-1997. This panel includes all companies quoted on the London Stock Exchange over that period, and whose names begin with a letter from A to L. To compute competition measures, the study uses firm level accounting data from Datastream; product market competition is in turn measured by one minus the Lerner index (ratio of operating profits minus financial costs over sales), controlling for capital depreciation, advertising expenditures, and firm size. Furthermore, to control for the possibility that variations in the Lerner index be mostly due to variations in fixed costs, we use policy instruments such as the implementation of the Single Market Program or lagged values of the Lerner index as instrumental variables. Innovation activities, in turn, are measured both, by the number of patents weighted by citations, and by R&D spending. Patenting information comes from the US Patent Office where most firms that engage in international trade register their patents; in particular, this includes 461 companies on the London Stock Exchange with names starting by A to L, for which we already had detailed accounting data. Finally, technological frontier is measured as follows: suppose a UK firm (call it i) belongs to some industry A; then we measure technological distance by the difference between the maximum TFP in industry A across all OECD countries (we call it TFP_F , where the subscript "F" refers to the technological frontier) and the TFP of the UK firm, divided by the former:

$$m_i = \frac{TFP_F - TFP_i}{TFP_F}.$$

ABBGH find that the effect of product market competition on innovation is all the more positive that firms are closer to the technological frontier (or equivalently are more "neck-and-neck"). Another interesting finding is that the Schumpeterian effect is also at work, and that it dominates at high initial levels of product market competition. This in turn reflects the "composition effect" pointed out in the previous subsection: namely, as competition increases and neck-and-neck firms therefore engage in more intense innovation to escape competition, the equilibrium fraction of neck-and-neck industries tends to decrease (equivalently, any individual firm spends less time in neck-and-neck competition with its main rivals) and therefore the average impact of the escape competition effect decreases at the expense of the counteracting Schumpeterian effect. The ABBGH paper indeed shows that the average distance to the technological distance increases with the degree of product market competition. The Schumpeterian effect was missed by previous empirical studies, mainly as a result of their being confined to linear estimations. Instead, more in line with the Poisson technology that governs the arrival of innovations both, in Schumpeterian and in patent race models, ABBGH use a semi-parametric estimation method in which the expected flow of innovations is a piecewise polynomial function of the Lerner index.

4 Appropriate institutions

4.1 From Schumpeter to Gerschenkron

By linking growth to innovation and entrepreneurship, and innovation incentives in turn to characteristics of the economic environment, new growth theories made it possible to analyze the interplay between growth and the design of policies and institutions. For example, the basic model developed in Section 2 suggested that long-run growth would be best enhanced by a combination of good property right protection (to protect the rents of innovators against imitation), a good education system (to increase the efficiency of R&D activities and/or the supply of skilled manufacturing labor), and a stable macroeconomy to reduce interest rates (and thereby increase the net present value of innovative rents). Our discussion of convergence clubs in Section 3 then suggested that the same policies or institutions would also increase a country's ability to join the convergence club.

Now, new growth theories may be criticized by development economists and policy makers, precisely because of the universal nature of the policy recommendations that appear to follow from them: no matter how developed a country or sector currently is, it seems that one should prescribe the same medicines (legal reform to enforce property rights, investment climate favorable to entrepreneurship, education, macrostability,..) to maximize the growth prospects of that country or sector.

However, in his essay on *Economic Backwardness in Historical Perspective,* Gerschenkron (1962) argues that relatively backward economies could more rapidly catch up with more advanced countries by introducing "appropriate institutions" that are growth-enhancing at an early stage of development but may cease to be so at a later stage. Thus, countries like Japan or Korea managed to achieve very high growth rates between 1945 up until the 1990s with institutional arrangements involving long-term relationships between firms and banks, the predominance of large conglomerates, and strong government intervention through export promotion and subsidized loans to the enterprise sector, all of which depart from the more market-based and laissez-faire institutional model pioneered and promoted by the US.

That growth-enhancing institutions or policies might change with a country's or sector's distance to the technological frontier, should not come as a total surprise to our readers at this point: in the previous section, we saw that competition could have opposite effects on innovation incentives depending on whether firms were initially closer to or farther below the fringe in the corresponding industry (it would enhance innovations in neck-and-neck industries, and discourage it in industries where innovating firms are far below the frontier). The same type of conclusion turns out to hold true when one looks at the interplay between countries’ distance to the world technology frontier and “openness”. Using a cross-country panel of more than 100 countries over the 1960-2000 period, Acemoglu-Aghion-Zilibotti (2002), henceforth AAZ, regress the average growth rate over a five year period on a country’s distance to the US frontier (measured by the ratio of GDP per capita in that country to per capita GDP in the US) at the beginning of the period. Then, splitting the sample of countries in two groups, corresponding respectively to a high and a low openness group according to Frankel-Romer’s openness indicator, AAZ show that average growth decreases more rapidly as a country approaches the world frontier when openness is low. Thus, while a low degree of openness does not appear to be detrimental to growth in countries far below the world frontier, it becomes increasingly detrimental to growth as the country approaches the frontier. AAZ repeat the same exercise using entry costs to new firms (measured as in Djankov et al (2001)) instead of openness, and they obtain a similar conclusion, namely that high entry costs are most damaging to growth when a country is close to the world frontier, unlike in countries far below the frontier.

In this section, we shall argue that Gerschenkron’s idea of “appropriate institutions” can be easily embedded into our growth framework, in a way that can help substantiate the following claims:

1. different institution or policy design affects productivity growth differently depending upon a country’s or sector’s distance to the technological frontier;

2. a country’s distance to the technological frontier affect the type of organizations we observe in this country (e.g, bank versus market finance, vertical integration versus outsourcing,..).

The remaining part of the section is organized as follows. We first describe the growth equation which AAZ introduce to embed the notion of “appropriate institutions” into the above growth framework. We then focus on the first question about the effects of institution design on productivity growth, by concentrating on the relationship between growth and the organization of education. Finally we briefly discuss the effects of distance on equilibrium institutions in a concluding subsection.

4.2 A simple model of appropriate institutions

Consider the following variant of the multi-country growth model of Section 3. In each country, a unique general good which also serves as numéraire, is produced competitively using a continuum of intermediate inputs according to:

$$y_t = \int_0^1 (A_t(i))^{1-\alpha} x_t(i)^{\alpha} \; di, \tag{7}$$

where $A_t(i)$ is the productivity in sector i at time t, $x_t(i)$ is the flow of intermediate good i used in general good production again at time t, and $\alpha \in [0, 1]$.

As before, ex post each intermediate good producer faces a competitive fringe of imitators that forces her to charge a limit price $p_t(i) = \chi > 1$. Consequently, equilibrium monopoly pro&ts (gross of the &xed cost) are simply given by::

$$\pi_t(i) = \delta A_t(i)$$

where $\delta \equiv (\chi - 1)\chi^{-\frac{1}{1-\alpha}}$.

We still let

$$A_t \equiv \int_0^1 A_t(i)\, di$$

denote the average productivity in the country at date t, $\overline{A}_t$ the productivity at the world frontier which we assume to grow at the constant rate g from one period to the next, and $a_t = A_t/\bar{A}_t$ the (inverse) measure of the country s distance to the technological frontier at date t.

The main departure from the convergence model in Section 3, lies in the equation for productivity growth. Suppose that intermediate &rms have two ways to generate productivity growth: (a) they can imitate existing world frontier technologies; (b) they can innovate upon the previous local technology. More speci&cally, we assume:

$$A_t(i) = \eta \bar{A}_{t-1} + \gamma A_{t-1}, \tag{8}$$

where $\eta \bar{A}_{t-1}$ and γA_{t-1} refer respectively to the imitation and innovation components of productivity growth. Imitations use the existing frontier technology at the end of period $(t-1)$, thus they multiply $\bar{A}_{t-1}$, whereas innovations build on the knowledge stock of the country, and therefore they multiply A_{t-1}.

Now dividing both sides of (8) by $\overline{A}_t$, using the fact that

$$\overline{A}_t = (1+g)\bar{A}_{t-1},$$

and integrating over all intermediate sectors i, we immediately obtain the following linear relationship between the country s distance to frontier a_t at date t and the distance to frontier a_{t-1} at date $t-1$:

$$a_t = \frac{1}{1+g}(\eta + \gamma a_{t-1}). \tag{9}$$

This equation clearly shows that the relative importance of innovation for productivity growth, increases as: (i) the country moves closer to the world technological frontier, i.e as a_{t-1} moves closer to 1, whereas imitation is more important when the country is far below the frontier, i.e when a_{t-1} is close to zero; (ii) a new technological revolution (e.g the ITC revolution) occurs that increases the importance of innovation, i.e increases γ.

This immediately generates a theory of appropriate institutions and growth: suppose that imitation and innovation activities do not require the same institutions. Typically, imitation activities (i.e η in the above equation (9)) will be enhanced by long-term investments within (large) existing &rms, which in turn may bene&t from long-term bank &nance and/or subsidized credit as in Japan or Korea since 1945. On the other hand, innovation activities (i.e γ) require initiative, risk-taking, and also the selection of good projects and talents and the weeding out of projects that turn out not to be pro&table. This in turn calls for more market-based and ! exible institutions, in particular for a higher reliance on market &nance and speculative monitoring, higher competition and trade liberalization to weed out the bad projects, more ! exible labor markets for &rms to select the most talented or best matched employees, non-integrated &rms to increase initiative and entrepreneurship downstream, etc. It then follows from equation (9) that the growth-maximizing institutions will evolve as a country moves towards the world technological frontier. Far below the frontier, a country will grow faster if it adopts what AAZ refers to as *investment-based* institutions or policies, whereas closer to the frontier growth will be maximized if the country switches to *innovation-based* institutions or policies.

A natural question is of course whether institutions actually change when they should from a growth- (or welfare-) maximizing point of view, in other words how do equilibrium institutions at all stages of development compare with the growth-maximizing institutions? This question is addressed in details in AAZ, and we will come back to it brie! y in the last subsection.

4.3 Appropriate education systems

In his seminal paper on economic development, Lucas (1988) emphasized the *accumulation* of human capital as a main engine of growth; thus, according to the analysis in that paper, cross-country differences in growth rates across countries would be primarily attributable to differences in *rates of accumulation* of human capital. An alternative approach, pioneered by Nelson-Phelps (1966), revived by the Schumpeterian growth literature[10], would instead emphasize the combined effect of the *stock* of human capital and of the innovation process in generating long-run growth and fostering convergence. In this alternative approach, differences in growth rates across countries would be mainly attributable to differences in *stocks* of human capital, as those condition countries□ability to innovate or to adapt to new technologies and thereby catch up with the world technological frontier. Thus, in the basic model of Section 2, the equilibrium R&D investment and therefore the steady-state growth rate were shown to be increasing in the aggregate supply of (skilled) labor L and in the productivity of research λ, both of which refer more to the *stock* and *efficiency* of human capital than to its rate of accumulation.

Now, whichever approach one takes, and the evidence so far supports the two approaches as being somewhat complementary, once again one may worry about growth models delivering too general a message, namely that more education is always growth enhancing. In this subsection we will try to go one step further

[10]For example, see Acemoglu (1996, 2002), Aghion-Howitt-Violante (2002) and Aghion (2002).

and argue that the AAZ speci&cation (summarized by the above equation (8), can be used to analyze the effects, not only of the total *amount* of education, but more importantly of the *organization* of education, on growth in countries at different stages of development..

This subsection, which is based on Vandenbussche-Aghion-Meghir (2003), henceforth VAM, focuses on one particular aspect of the organization of education systems, namely the mix between primary, secondary, and higher education. We consider a variant of the AAZ model outlined in the previous subsection, in which innovation requires highly educated labor, whereas imitation can be performed by both, highly educated and lower-skill workers.

A main prediction emerging from this a model, is that the closer a country gets to the world technology frontier, the more growth-enhancing it becomes to invest in higher education. The intuition follows directly from the Rybczynski theorem in international trade. Stated in the context of a two sector-two input economy, this theorem says that an increase in the supply of input in the sector that uses that input more intensively, should increase “output” in that sector more than proportionally. To transpose this result to the context of our model, consider the effect of an increase in the supply of skilled labor, keeping the supply of unskilled labor &xed and for given a. Given that skilled workers contribute relatively more to productivity growth and pro&ts if employed in innovation rather than in imitation, the demand for additional skilled labor will tend to be higher in innovation. But then the marginal productivity of unskilled labor should also increase more in innovation than in imitation, hence a net ! ow of unskilled workers should also move from imitation into innovation. This in turn will enhance further the marginal productivity of skilled labor in innovation, thereby inducing an ever greater fraction of skilled labor to move to innovation. Now the closer the country is to the technology frontier (i.e the higher a), the stronger this Rybszynski effect as a higher a increases the efficiency of both, skilled and unskilled labor, in innovation relative to imitation. A second, reinforcing, reason is that an increase in the fraction of skilled labor reduces the amount of unskilled labor available in the economy, hence reducing the marginal productivity of skilled labor in imitation, all the more the closer the country is from the frontier.

VAM then confront this prediction with cross-country evidence on higher education, distance to frontier, and productivity growth. The prediction that higher education has stronger growth-enhancing effects close to the technological frontier can be tested using cross-regional or cross-country data. Thus VAM consider a panel dataset of 19 OECD countries over the period 1960-2000. Output and investment data are drawn from Penn World Tables 6.1 (2002) and human capital data from Barro-Lee (2000). The Barro-Lee data indicate the fraction of a country’s population that has reached a certain level of schooling at intervals of &ve years, so VAM use the fraction that has received some higher education together with their measure of TFP (itself constructed assuming a constant labor share of .7 across countries) to perform the following regression:

$$g_{j,t} = \alpha_{0,j} + \alpha_1 dist_{j,t-1} + \alpha_2 \Lambda_{j,t-1} + \alpha_3 (dist_{j,t-1} * \Lambda_{j,t-1}) + u_{j,t},$$

where $g_{j,t}$ is country j's growth rate over a five year period, $dist_{j,t-1}$ is country j's closeness to the technological frontier at $t-1$ (i.e. 5 years before), $\Lambda_{j,t-1}$ is the fraction of the working age population with some higher education in the previous period and $\alpha_{0,j}$ is a country dummy controlling for country fixed effects. The closeness variable is instrumented with its lagged value at $t-2$, and the fraction variable is instrumented using expenditure on tertiary education per capita lagged by two periods, and the interaction term is instrumented using the interaction between the two instruments for closeness and for the fraction variables. Finally, the standard errors we report allow for serial correlation and heteroskedasticity.

VAM find a positive and significant interaction between our education measure and closeness to the frontier, as predicted by the theory in the previous subsection. This result demonstrates that it is more important to expand years of higher education close to the technological frontier.

5 Conclusion

In this chapter we argued that the endogenous growth model with quality-improving innovations provides a framework for taking a closer look at the relationship between institutions, institutional change, and economic growth.

Far from closing the field, the chapter suggests many avenues for future research. For example, on growth and convergence, more research remains to be done to identify the main determinants of cross-country convergence and divergence.[11] Also important, is to analyze the role of international intellectual property right protections and foreign direct investment in preventing or favoring convergence. On growth and industrial organization, we have restricted attention to product market competition among existing firms. But what can we say about entry and its impact on incumbents' innovation activities?[12] On institutions, we have just touched upon the question of how technical change interacts with organizational change. Do countries or firms/sectors actually get stuck in institutional traps of the kind described in the previous section? What enables such traps to disappear over time? How do political economy considerations interact with this process?

If we just had to select three topics for further thinking on the role of institutions and policy in the growth process using the Aghion-Howitt framework, we would suggest the following. First, on the role of basic science in generating (very) long-term growth. Do fundamental innovations (or the so called "general purpose technologies") require the same incentive system and the same rewards as industrial innovations? How can one design incentive systems in universities

[11] In Aghion, Howitt and Mayer-Foulkes (2004) we emphasize the role of credit constraints in R&D as a distinguishing factor between the countries that converge in growth rates and in levels towards the frontier, those that converge only in growth rates, and those that follow a divergent path towards a lower rate of long-run growth. Whether credit constraints, or other factors such as health, education, and property rights protection, are key to this three-fold classification, remains an open question

[12] See Aghion et al (2003a, 2003b) for preliminary work on entry and growth.

so that university research would best complement private research? A second aspect is the interplay between growth and volatility. Is R&D and innovation procyclical or countercyclical, and is macroeconomic volatility always detrimental to innovation and growth? Answering this question in turn opens up a whole new research topic on the macropolicy of growth[13] A third aspect is the extent to which our growth paradigm can be applied to less developed economies. In particular, can we use the new growth approach developed in this chapter to revisit the important issue of poverty reduction?[14] All these exciting questions are left for future research.

[13] See Aghion-Angeletos-Banerjee-Manova (2004).

[14] See Aghion and Armendariz de Aghion (2004) for some preliminary thoughts on this aspect.

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