S Modica, April 2005

• **Summary**

- Education matters for growth, quality as much as quantity
- It matters more when growth accelerates,
- and then you want it more general than vocational
- Teachers have a crucial role, but what determines their quality?

• **Origins of Growth Theory**

Solow (QJE 1956, Nobel 1986) is the first modern model of growth. Aggregate production function

$$Y = F(K, AL) = K^{\alpha}(AL)^{1-\alpha}, \quad 0 < \alpha < 1\,, \tag{1}$$

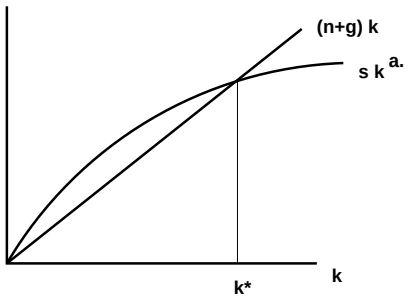
where Y, K, L are income capital and labour, and A is technological advancement; so AL are 'effective labour units'. **Assume** that L and A grow at constant rates n and g and that savings are a constant fraction sY of income, so that addition to capital $\dot{K}$ in equilibrium is given by $\dot{K} = sY$. Expressing variables in effective labour units,

$$y = Y/AL, \quad k = K/AL\,,$$

from (1) and $\dot{K} = sY$ one gets

$$y = k^{\alpha} \text{ and the rate of change of } k, \ \dot{k} = sk^{\alpha} - (n+g)k\,. \tag{2}$$

This dynamics implies that k globally converges to the steady state k^* given by $\dot{k} = 0$ in (2):



In this state also $Y/AL = y = k^\alpha$ is constant, so income per capita $Y/L = Ay$ grows at the same rate as A, that is g (which is *exogenous*). Moreover, from

$$sk^\alpha = (n+g)k, \quad \text{or} \quad s = (n+g)k^{1-\alpha}\,,$$

by taking logs one obtains $\ln s = \ln(n+g) + \frac{1-\alpha}{\alpha}\ln k^\alpha$, that is

$$\ln y = \frac{\alpha}{1-\alpha}[\ln s - \ln(n+g)]\,. \tag{3}$$

On the basis of *this* equation one can estimate income differences among different countries. But by plugging in realistic values of the relevant variables, it implies differences of around 60%. Since they are around 1000% in the real world, the model fails to explain income differences across countries.

• Introducing Human Capital

Mankiw–Romer–Weil (QJE 1992, MRW) augment the production function (1) to

$$Y = F(K,H,AL) = K^\alpha H^\beta (AL)^{1-\alpha-\beta}, \quad 0 < \alpha+\beta < 1\,, \tag{4}$$

where H is human capital, and adapt the Solow accumulation equation $\dot{K} = sY$ to the system

$$\dot{K} = s_K Y, \quad \dot{H} = s_H Y\,.$$

Going through the same steps as before one obtains an analogue of equation (3); plugging in realistic values in the new equation, the result is now that about 80% of real world income differences is explained by the model.

• Role of Human Capital: Level Vs Growth Rate

Benhabib–Spiegel (JMonEc 1994) discriminate between augmented Solow model of Mankiw–Romer–Weil (QJE 1992) and Nelson–Phelps (AER 1966) approach. In the former human capital is a productive factor, in the latter it affects the rate of innovation; so in MRW growth is determined, among other things, by **growth** of human capital; in NP by **level** of human capital. Policy difference is that in MRW education has only current benefits (growth unaffected by levels), while in NP benefits extend infinitely in time. BS '94 find that if human capital has a role, it is in the NP sense (fostering innovation).

Benhabib–Spiegel (2002, Handbook Economic Growth) generalize their '94 NP model, to allow for the possibility that in a multi-country model some

ones would not grow at the same pace as the leaders —because of insufficient human capital stock in the NP model. They test this club-convergence against global convergence, and find the former better supported by the data.

To sum up, BS find support for NP (human capital for innovation), and within it for club convergence; in the context of their results, building human capital stock may therefore be crucial for escaping poverty traps.

• Convergence Clubs

Howitt–Mayer-Foulkes (NBER 2002) refine clubs. If at some point in time there is an **acceleration** of the rate of technological progress, then clubs become three: the group of the leader, whose members have sufficient skills at acceleration time to keep up with faster technology-adotpion rate. A first group of followers, who find optimal to increase their skill to the point of being able to parallel the leaders; these grow at the fastest pace eventually but lose contact in the catch-up phase, so their GNP per capita is lower than in the first group. The final group contains those whose human capital is so low at the crucial moment that upgrading is subotpimal; they grow at a slower pace than the others asymptotically.

• What Kind of Education: General Vs Vocational

Kruegen–Kumar (JMonEc 2004) examine data on postwar OECD cuntries and **observe** an acceleration in technological innovation in the 90's compared to the previous 20 years, in terms of incidence of ICT equipment investment on investment totals. Both US and Europe accelerated, but the latter lagged behind.

They look closely at human capital needed for technological acceleration, and argue that **general** education, where you 'learn to learn', is more suited to adapting to continuous change than **vocational** education, where you 'learn one thing'. In practice general education is defined to be upper secondary non-professional plus university. In their model, at acceleration time advantage is to have larger general-education stock (because this lowers educated workers wages thereby enabling firms to take the risk of raising the innovation adoption rate).

Policy instrument relevant in this context is expressed by the ratio between subsidy to general and subsidy to vocational education. KK point out using OECD data that the US has a ratio of 2.5 while european countries' ratios are around 1. They also parametrize other policy variables which differ between US and Europe, namely those regarding distortions in the labour and products markets. In the calibrated model, the one variable that explains the difference in growth rates is education policy (Europe too vocational being

the culprit).

• Human Capital and Education: Quality Vs Quantity

The original MRW measure of human capital is proportional to average years of school in the population. But in the tradition of labour-market research (starting with Mincer in 1974) human capital is linked directly to earnings, through the *wage differentials* that schooling and on-the-job experience determine. Using this approach Bils–Klenow (AER 2000) find that of the observed correlation between schooling and GNP growth, less than a third can be explained by human capital growth; and problem is, as they point out, that the effect of schooling on growth, if any, should go through human capital. BK conclude that the observed relation between schooling and growth may be one of reverse causality: higher expected growth raises profitability of educational investment (cost is now when income is low and benefit later when income is higher), thus causing an increase in measured years of schooling.

Hanushek–Kimko (AER 2000) challenge the above conclusion by arguing that it is not so much school quantity, but school **quality** which should enter growth regressions; and for the first time they include results from international test scores in mathematics and science in estimating the education-growth causal relationship. They typically find that quality has very strong impact (for example, in a simple regression of GNP growth against Initial income, Population growth and Years of schooling, adding a measure of Educational attainment more than doubles R^2 making it jump from .3 to .7). And once quality is taken into account, they argue in favor of the education-to-growth causality relation by cleverly using Mincerian estimates on US immigrants.

Conclusion here is that quality of education matters at least as much as quantity. A policy problem however arises, because it not clear how strongly quality depends on **resources** invested in educational system (more on this below).

• Teachers and Education Quality (Hanushek et al. Em 2005)

When achievement gains are regressed against family bakground, school and teacher characteristics, and a student fixed (innate ability) factor, teachers' measured characteristics do not matter. On the other hand performances of any two cohorts of students are much more correlated when they have the same teacher (e.g. in same grade) then whey do not (e.g. in same academic year). Thus if teacher quality plays a role, it is not due to factors like teach-

ers' masters degrees or years of experience. Writing achievemnt gains directly as a sum of fixed effects, using a rich data set created in Texas Hanushek et al. find that teacher's quality has indeed a sizeable role in determining achevement variability.

We quote the authors' main policy indications: "Though it is tempting to tighten standards for teachers in an effort to raise quality, the results in this paper and elsewhere raise serious doubts that more restrictive certification standards, education levels, etc. will succeed in raising the quality of instruction. Rather the substantial differences in quality among those with similar observable backgrounds highlight the importance of effective hiring, firing, mentoring, and promotion practices... [through] closer links between rewards and performance."

• Suggestions for experiments

Young teachers might learn from experienced good ones by watching them at work (inside the class). For Mezzogiorno, also: more teaching in afternoon; and monetary rewards to pupils.

Caution: more thinking is needed about measuring education output (maths and science scores may not be the last word).

• Other Determinants of Growth: Education Is Not Everything

- Social Infrastructure, pioneered by Hall–Jones QJE 1999
- Development of Financial Sector, Aghion–Howitt–Mayer-Foulkes, QJE 2005
- Institutions, Acemoglou 2004