ECON4350: Growth and investment
Sketch of solution to exam

Autumn-term 2003

I: (50 percent)

a:

A qualified yes. Reference to reading list: Romer (1990). Ideas are in general non-rival, i.e. that one persons use of an idea does not in itself prevent some other person from (simultaneously) using the same idea. Thus they possess the most important attribute of a public good. Ideas can however be excludable, i.e. that one person can exclude some other person from actually being able/allowed to use the idea (secrecy, patents etc). Hence ideas are not always strictly public goods in the sense of being non-rival and non-excludable goods. The degree of excludability will depend on for example legal protection of patents. Examples can illustrate these properties well.

It is desired that the candidate mentions that ideas can be patented in their use for manufacturing specific goods (i.e. excludable in this use), but in general will be non-excludable in the production of new ideas (i.e. nonexcludable). Cfr. the R&D models discussed in the course.

b:

No. Reference to reading list: Lecture note 9. With a neo-classical production function (with constant returns to scale, CRS, to inputs labor and capital), there will be no long run growth unless there is technological progress (this is a standard result of the neo-classical growth model). However, if the upper Inada condition for the accumulated factor capital is violated (i.e. that the marginal product of capital approaches a positive limit when capital goes to infinity). This can easily be illustrated by a diagram in $(k, \dot{k}/k)$ space, or by going through the calculations done in class (cfr. lecture note). The violation of this Inada-condition implies that labor is inessential in production.

Alternatively, or preferable additionally, one can refute the claim by discussing the $Y = AK$ production function. Here we also have long run growth, but with CRS in the one input K. However, it should be clear that we here have suppressed the role of labor in production in order to maintain CRS.

c:

In the short run: Yes, in the long run: no. See for example chapter 2.6 in Romer's book. It is most natural to discuss this question in relation to the neo-classical growth model. Using the Solow model one can interpret more patient consumers as giving a higher saving rate. It should then be shown that this gives a higher steady state, with more rapid growth during the transition to this higher steady-state level, but with no effect on long run growth. Preferably, the same point can be illustrated in the Ramsey model. Here, the patient of consumers is reflected directly by the discount factor (although it is not entirely wrong also to discuss the intertemporal elasticity of substitution). A lower discount factor, ρ, shifts the Euler-equation for growth in consumption it is easy to use the Euler-equation to show that the $\dot{c} = 0$ line in the phase diagram shifts outward. This leads to a transitional phase with higher growth towards the new,m higher steady state level. Again there are no effects in the long run.

A fully satisfactory answer to this question should also mention that the conclusion concerning the long run effects will be different in models of endogenous growth. For example, in the Romer (1990) model, the expression for the long run growth rate ($g = \frac{\alpha BL - \rho}{\alpha + \theta}$) readily shows that the more patient are consumers the higher is g. This point can also be illustrated by the $Y = AK$ model. A full discussion along these lines is not expected.

II: (50 percent)

This exercise relates closely to Mankiw, Romer and Weil (1995), MRW, on the reading list. Points e)-g) also draws on Pritchett (2001).

a) See MRW p. 416-417.

b) See MRW p. 416-417.

c) One should relate equation (3) to the structural equation (2). First, $\gamma_1, \gamma_2, \gamma_3$ should all be positive according to the theory. Second, according to theory we should have $\gamma_1 + \gamma_2 = \gamma_3$, a testable parameter restriction. Third, from these estimated parameters one can derive the structural parameters α and β. These should have plausible values. One can test the plausibility of

these parameters by noting that α and β are the shares of income that physical capital and human capital respectively would receive if they enumerated at their marginal product. It is an empirical rule of thumb that α should be around 1/3. Finding empirical estimates of the share of human capital in income is more complicated, but guestimates based on comparisons with the (unskilled) minimum wage indicate values in the interval $(1/3, 1/2)$.

A fully satisfactory answer should briefly discuss the econometrical problems of using this equation. Most importantly, that cross country differences in levels of technology are included in the error term (i.e. is a neglected variable). It is of course doubtful whether such differences are uncorrelated with the explanatory variables, so there is a potential source of biases in the estimates. This problem can be avoided by use of panel-data methods, but discussion of such technicalities is not expected.

d) Note: Point d) and f) should be seen in reltion to each other.

The measure used by MRW is a crude proxy for s_h. First, it relies on an assumption that all education is equally productive. (The candidate should at some point here, or in f) discuss alternative measures based on Mincerian regressions). Second, it measures only the inflow, not the outflow of human capital (this point is somewhat problematic to relate to the theoretical model which assumes a fixed depreciation rate also of human capital). Third, by using secondary school enrollment one might be exaggerating cross-country differences in human capital since primary school enrollment differs much less.

An additional point to be made is that within this framework one could also formulate a model using h as an explanatory variable (cfr eq. (12) in MRW). Preferring to use s_h must be based on better data being available for capturing s_h than h. This is perhaps doubtful, as will also be discussed in f).

e) Take logs and differentiate.

f) One here needs data on changes in the stock of human capital. Such stock estimates can be found by first measuring the educational attainment of the workforce, and secondly by using micro-data evidence on the returns to eduction in order to try to capture the increased productivity of the work force due to eduction. Such micro evidence can be found in Mincer regressions. (Typically with one year of eduction implying 10 per cent increase in income, but with important differences for different different levels of education). On the basis of these stock data, the differences can readily be calculated.

A full answer should also discuss whether education captures all relevant

aspects of human capital. What about e.g. on the job training?

g) The most striking finding is the negative (though not statistically significant) effect of education on productivity. This is in sharp contrast to the quite substantial private returns to education. This micro-macro mismatch could result due to for example 1) The cognitive skills gained through education has not everywhere been put into socially productive activities (piracy), 2) In many countries there has (for structural reasons) been a much slower growth in the demand for educated labor than in the supply, thus leading to decreasing returns to schooling, 3) The education system has failed in providing the appropriate skills required to be a productive worker.