Lecture 2: Capital Accummulation and Returns to Capital

EC2303: Intermediate Development Economics

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Outlook for this week and beyond

- Today we'll get to know the Solow-Swan model, which attempts to explain income differences across countries based on how much *capital* (i.e. physical machines) a country has accumulated. We'll see that the model has decent explanatory power, but it does leave variance to be explained, and the evidence is correlational. We'll also introduce the idea of *poverty traps* when talking about the model.
- One assumption/prediction of the model is that the returns to capital in low-income countries are high. The paper you read for today, de Mel et al. 2008, is a classic study that demonstrates that returns to capital in Sri Lanka are in fact high.

Outlook for this week and beyond

- If returns to capital are high, there should be a market for providing this capital to entrepreneurs in low-income countries. And there is: microfinance. On Thursday, we will ask whether microfinance has similarly high returns as we saw in the de Mel et al. paper. The answer will be: No, for most people; perhaps, for some people. This illustrates the importance of *capital (mis)allocation:* one reason why countries are poor is that capital isn't allocated efficiently.
- Next week, we'll turn to another factor that may make entrepreneurs less productive than they could be: risk.

The Solow-Swan Model

- Developed in 1956, simultaneously by Robert Solow and Trevor Swan
- Goal: explain income differences, and differences in growth rates, across countries with physical capital
- Important note: all models are wrong, and any model that only focuses on one factor is definitely wrong. But the Solow model was an important step in thinking about which factors might matter for growth, and how we might learn about them.
- Starting observation: There is comparatively less physical capital in low-income countries compared to high-income countries (machines, factories, etc.). How did it get there, and is it perhaps responsible for their low income?

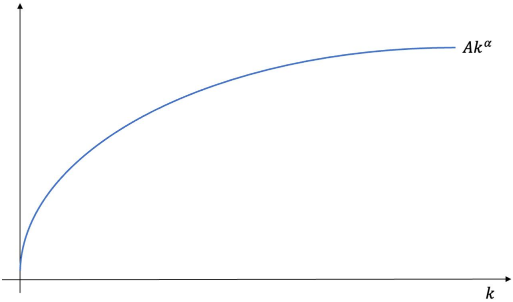
Assumptions

Production function in aggregate terms: $Y = F(K, L)$

1. Constant returns to scale: $zY = F(zK, zL)$
   Permits expressing the production function in per capita terms:
   $\frac{Y}{L} = F(\frac{K}{L}, \frac{L}{L}) = F(\frac{K}{L}, 1)$
   $y = f(k)$

Assumptions

2. Decreasing marginal returns (also called diminishing marginal product)
   Intuition: Capital is put to its most productive use first ("low-hanging fruit").
   Specifically, the model uses a Cobb-Douglas production function:
   $F(K,L) = AK^{\alpha}L^{1-\alpha}$
   α: Capital's share of national income. About $\frac{1}{3}$.
   $1-\alpha$: Labor's share of income. A: Total factor productivity.
   In per capita terms: $\frac{Y}{L} = A\left(\frac{K}{L}\right)^{\alpha}\left(\frac{L}{L}\right)^{1-\alpha} \Longrightarrow y = Ak^{\alpha}$



3. L and A are constant.

Investment and capital

- The economy is closed. How do we get the capital that we need for production?
  Answer: we produce it ourselves.
- Specifically, in each period, when we produce output y, we can consume it or invest it: $y = c + i$.
- In the next period, this investment becomes capital, which can then be used to produce output in that period.
- At the same time, some of our old capital will *depreciate* from this period to the next.
- This gives the *law of motion of capital*: capital in the next period, k_{t+1}, is this period's capital k_t, plus investment i, minus depreciation d:

$$k_{t+1} = k_t + i - d$$

Law of motion of capital

- Some more assumptions:
  - A constant share of output is invested in each period: $i = \gamma y$.
  - A constant share of capital depreciates in each period: $d = \delta k$
- Substituting this into the law of motion of capital from the previous slide, and using the fact that $y_t = Ak^\alpha$, gives us a more specific law of motion of capital:

$$\begin{aligned} k_{t+1} &= k_t + \gamma y_t - \delta k_t \\ &= k_t + \gamma A k_t^\alpha - \delta k_t \end{aligned}$$

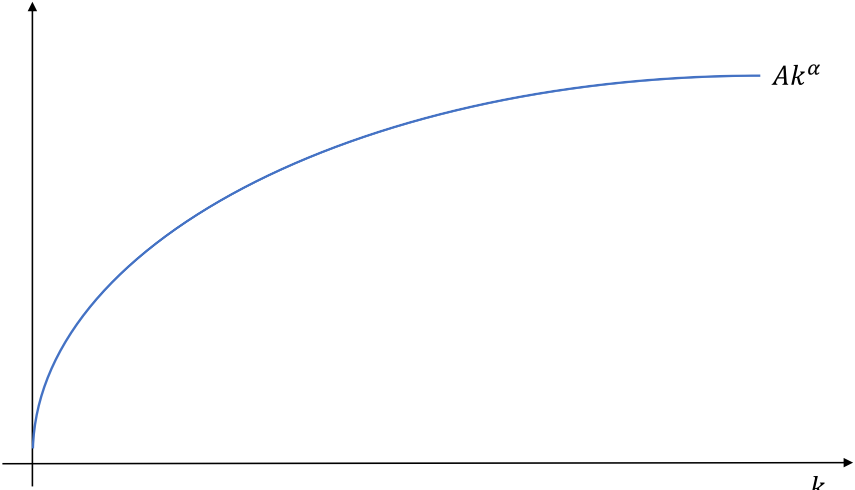
- Another way of writing this, defining $\Delta k = k_{t+1} - k_t$:

$$\Delta k = \gamma A k_t^\alpha - \delta k_t$$

This is the fundamental equation of the Solow model.

Solow model: graphical intuition

$$\Delta k = \gamma A k_t^{\alpha} - \delta k_t$$



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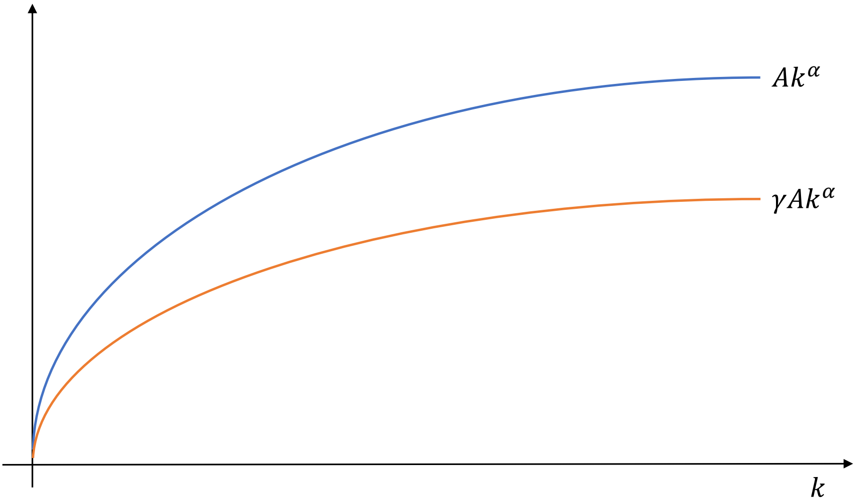

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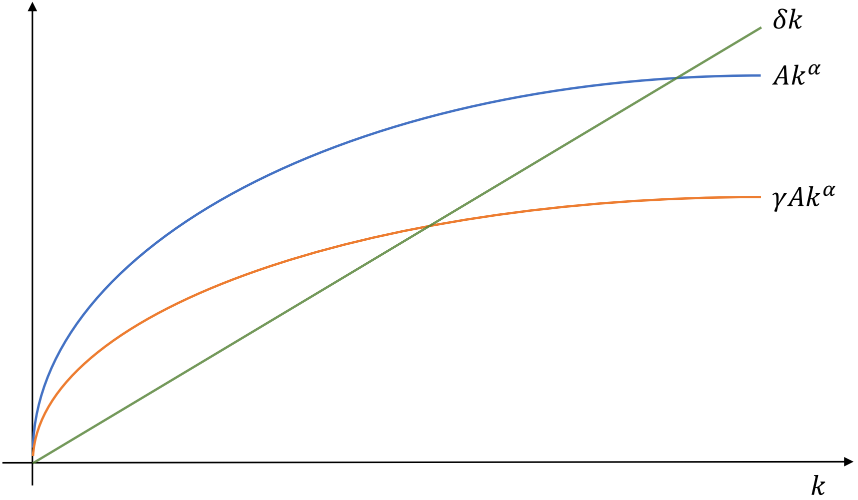

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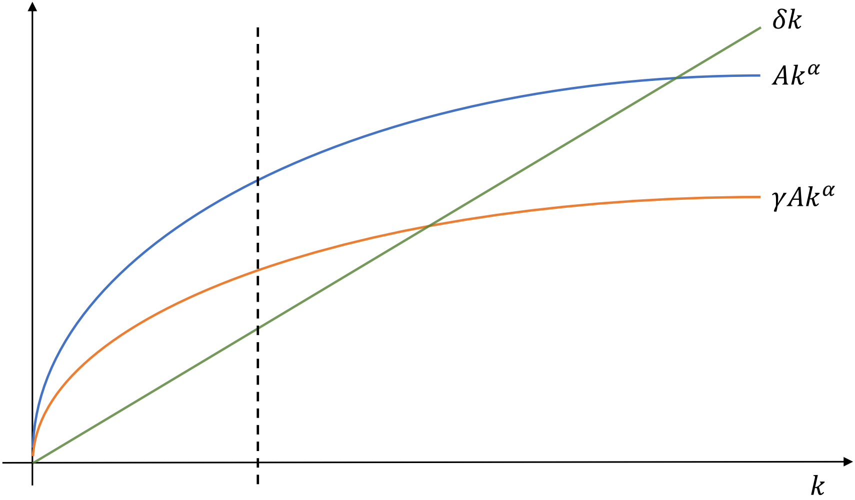

Solow model: graphical intuition

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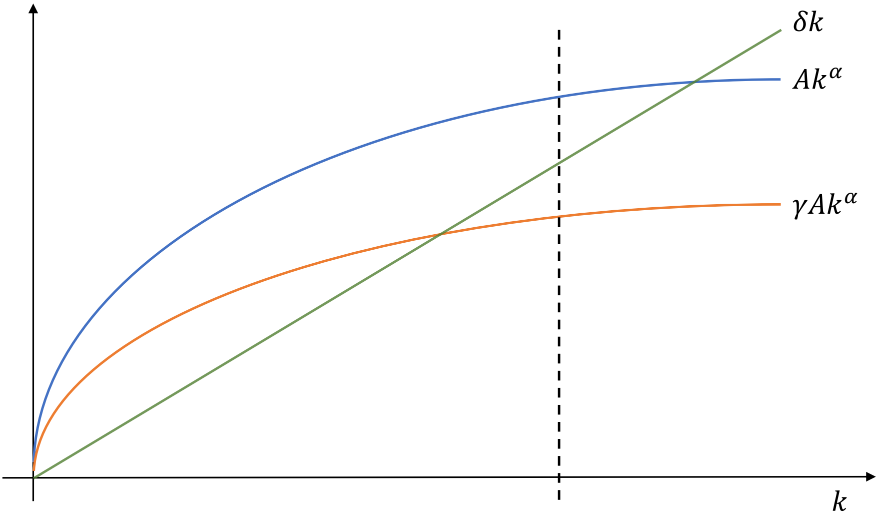

Solow model: graphical intuition

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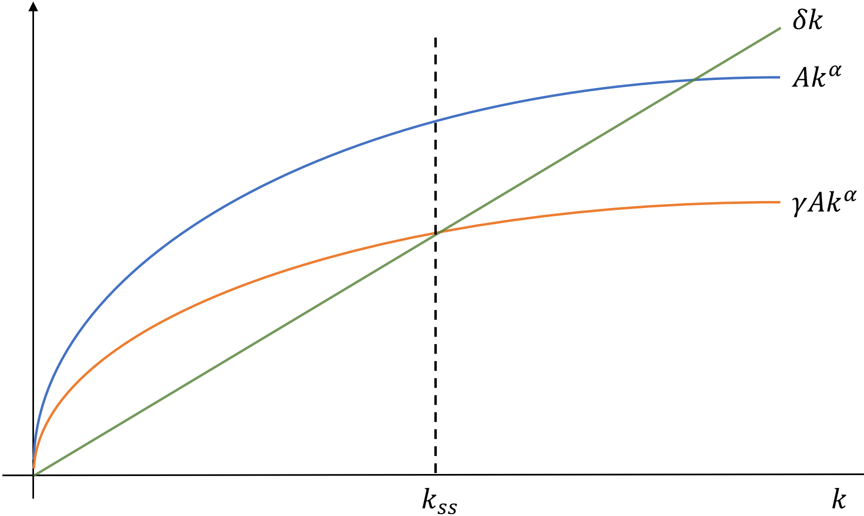


Solow model: Implications

- **Conditional convergence:** We can compute a single steady-state level of capital, k_{ss}. In steady-state, $\Delta k = 0$, i.e. capital does not change over time. We can then substitute this into our fundamental equation and solve for k_{ss}:

$$0 = \gamma A k_{ss}^{\alpha} - \delta k_{ss}$$

$$\delta k_{ss} = \gamma A k_{ss}^{\alpha}$$

$$k_{ss} = A \frac{\gamma}{\delta} k_{ss}^{\alpha}$$

$$k_{ss}^{1-\alpha} = A \frac{\gamma}{\delta}$$

$$k_{ss} = \left(A \frac{\gamma}{\delta} \right)^{\frac{1}{1-\alpha}}$$

Solow model: Implications

- Thus, the Solow model implies that a country will accumulate capital until it converges to a specific steady-state level of capital (and therefore, income) in the long run. That steady state is entirely determined by parameters (TFP, rates of investment & depreciation, and capital's share of income).
- Do all countries converge to the *same* steady-state level of capital? No: it depends on their values of A, γ, δ, and α. This is why it's called *conditional* convergence: conditional means "dependent on" in this context. Convergence happens, but the exact level is dependent on these parameters. (All countries converging to the exact same level of capital would be called *unconditional* convergence.)
- In addition, the model predicts that countries with lower income (that are farther away from the steady state) have higher growth rates. (Let's call this "prediction 2".)

Testing the model

- These are bold predictions! Do they describe reality?
- Mankiw, Romer, & Weil, 1992: income and growth in 98 countries, 1960–1985.
  - Regress income on investment (and depreciation + some other parameters in the full Solow model, like population growth, that we didn't consider here). Question: how well does investment explain differences in incomes across countries?
  - Answer: moderately well; $R^2 = 0.59$. An augmented Solow model that includes human capital is an even better description of the data: $R^2 = 0.79$, i.e. it explains about 80% of the variance in income levels.
  - In addition, they find that low-income countries indeed have higher growth rates than high-income countries, supporting prediction 2.
- So, the model fits the data relatively well. However, this is purely correlational – we can't be sure it reflects a causal relationship. It could be that some other variable increases the income of countries, and this then leads to investment in capital.
- How could we get a causal answer to the question whether investment in capital increases income?

Returns to capital

- Ideally, we'd like to run an experiment where we randomly allocate extra capital to some countries, but not to others.
- At the country level, that's hard to do. But it can be done for individual entrepreneurs!
- The paper you read, de Mel et al. 2008, is a classic. It estimates the returns to capital for micro-enterprises in Sri Lanka
- First author: Suresh de Mel, Professor of Economics, University of Peradeniya, Sri Lanka

From the Solow model to poverty traps

- The Solow model says returns to capital in low-income countries should be high, and de Mel et al. (2008) confirm this prediction for micro-entrepreneurs in Sri Lanka.
- But there also is reason to think returns might be lower than they could be: e.g. badly functioning credit markets, capital misallocation, integer constraints. If these problems disproportionately affect low-income households, this might give rise to *poverty traps*.
- You saw a simple demonstration of a poverty trap in Chapter 1 of *Poor Economics*; they call it "the S-shape curve". We will now see how the Solow model can be modified to produce such a poverty trap.

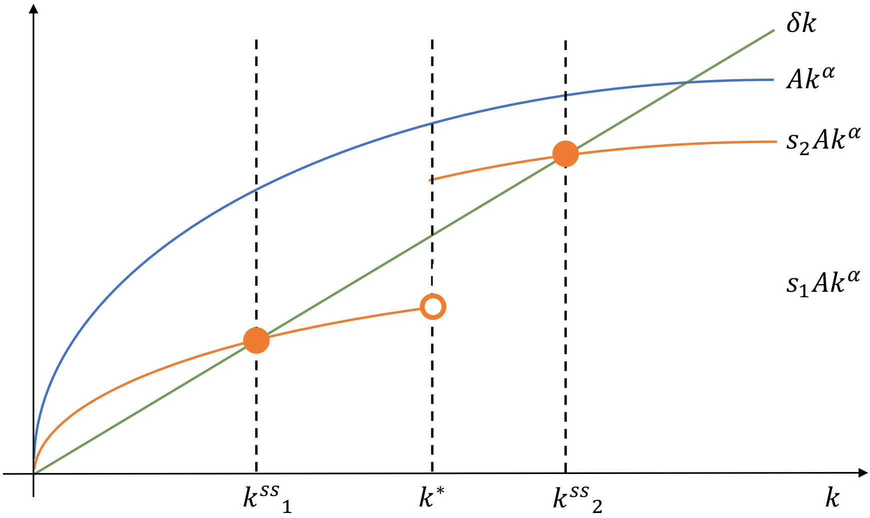
A modified Solow model

- A simple way to generate a poverty trap with the Solow model is to endogenize the rate of investment. Endogenous means that the rate is determined "within the model", rather than "taken as given" or "determined exogenously".
- For example, perhaps very poor individuals (or countries) have trouble investing much; they need money for subsistence instead. So we might have:

$$\gamma = \begin{cases} s_1 & \text{if } y \leq y^* \\ s_2 & \text{if } y > y^* \end{cases}, s_1 < s_2$$

- This generates a model with *three* steady-state levels of capital: a low one (stable); an intermediate one (unstable); and a high one (stable).
- Those who start with an initial level of capital below that which corresponds to y^* will always converge to the low steady-state; they're in a poverty trap.

A modified Solow model



Breakout rooms: Do you think poverty traps exist, and if yes, for which variables?

Next time

- With high returns like those observed by de Mel et al., there should be a market that provides credit to low-income microentrepreneurs to take advantage of their high returns to capital. This is the basic idea behind *microcredit*.
- On Thursday, we will ask whether microcredit can increase household income. The paper by Augsburg et al. is part of a special issue of the American Economic Journal: Applied Economics from 2015, that collected 6 randomized evaluations of microcredit. Have a look at some of them if you like: https://www.aeaweb.org/issues/360
- In contrast to what we might expect given the predictions of the Solow model and the results of de Mel et al., we'll see that microcredit has some positive impacts, but doesn't increase incomes a lot on average. We'll think a bit about why that might be the case (e.g. capital misallocation).
- Lecture 3: Thu 9/9 08:00–10:00, Auditorium 4, Södra huset hus B