Part I

Neoclassical Growth in an Open Economy

"Consider two countries producing the same good with the same constant returns to scale production function, relating output to homogeneous capital and labor inputs. If production per worker differs between these two countries, it must be because they have different levels of capital per worker: I have just ruled everything else out! Then the Law of Diminishing Returns implies that the marginal product of capital is higher in the less productive (i.e., in the poorer) economy. If so, then if trade in capital good is free and competitive, new investment will occur only in the poorer economy, and this will continue to be true until capital-labor ratios, and hence wages and capital returns, are equalized".

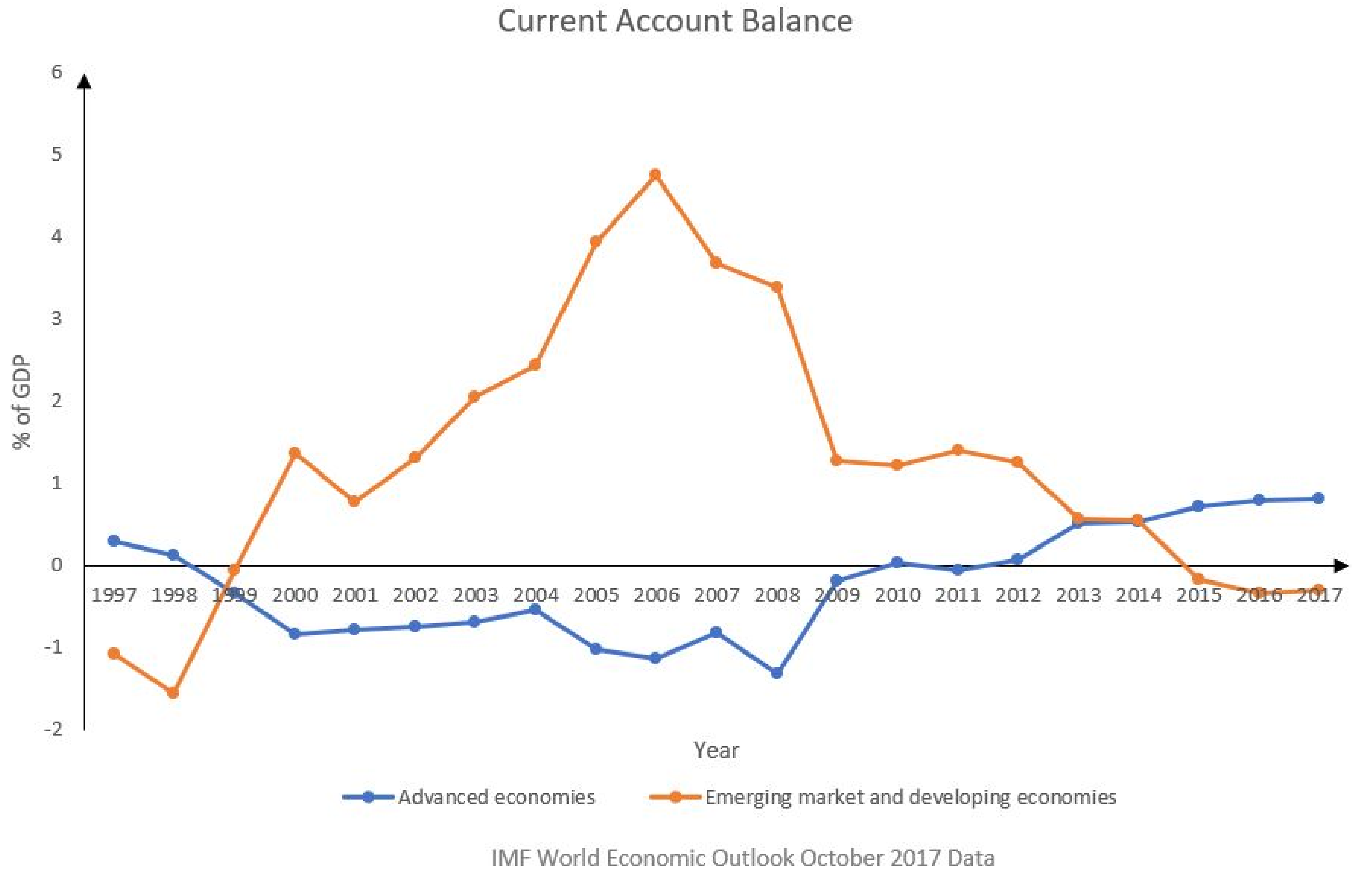
Robert E. Lucas Jr.

"Why Doesn't Capital Flow from Rich to Poor Countries?"

The American Economic Review, Vol. 80, No. 2, Papers and Proceedings of the Hundred and Second Annual Meeting of the American Economic Association (May, 1990)

1 Opening Up the Economy

The quote by Lucas's discussed above frames a puzzle for economy growth. It says that whenever GDP per capita, (output per capita) is lower in one country than the other, then this can only result from the poorer country having less capital, assuming that technologies are the same. Then, he proceeds to conclude that we should expect capital to move from rich to poor countries. Something that Lucas doesn't talk about is that the opposite flow should be present among workers: workers should move from poor to rich countries. Of course, this doesn't happen and in fact, there's more capital flowing across rich countries than between rich and poor countries. A first approximation of this phenomenon can be seen in the current account balance. If a country is running a positive current account, then this implies that it is running a capital account deficit. That is, it's using its savings to finance capital creation abroad. From the picture, you can see that emerging economies have historically run large current account surpluses, thus "exporting" capital abroad. On the other hand, advanced economies were running a current account deficit, thus importing capital.



Another figure shows that the flows among rich countries are much larger than from rich countries to poor. The picture is a representation of the capital account, that looks at changes in ownership in assets. A positive flow in the capital account occurs every time capital located in the country is bought by a foreigner (e.g.: Toyota building a factory in the US). A negative flow occurs when home investors are buying assets abroad (e.g.: a US national buying Volkswagen stocks). Keep in mind that the capital account measure only changes in a stock, while the current account is looking at flows.

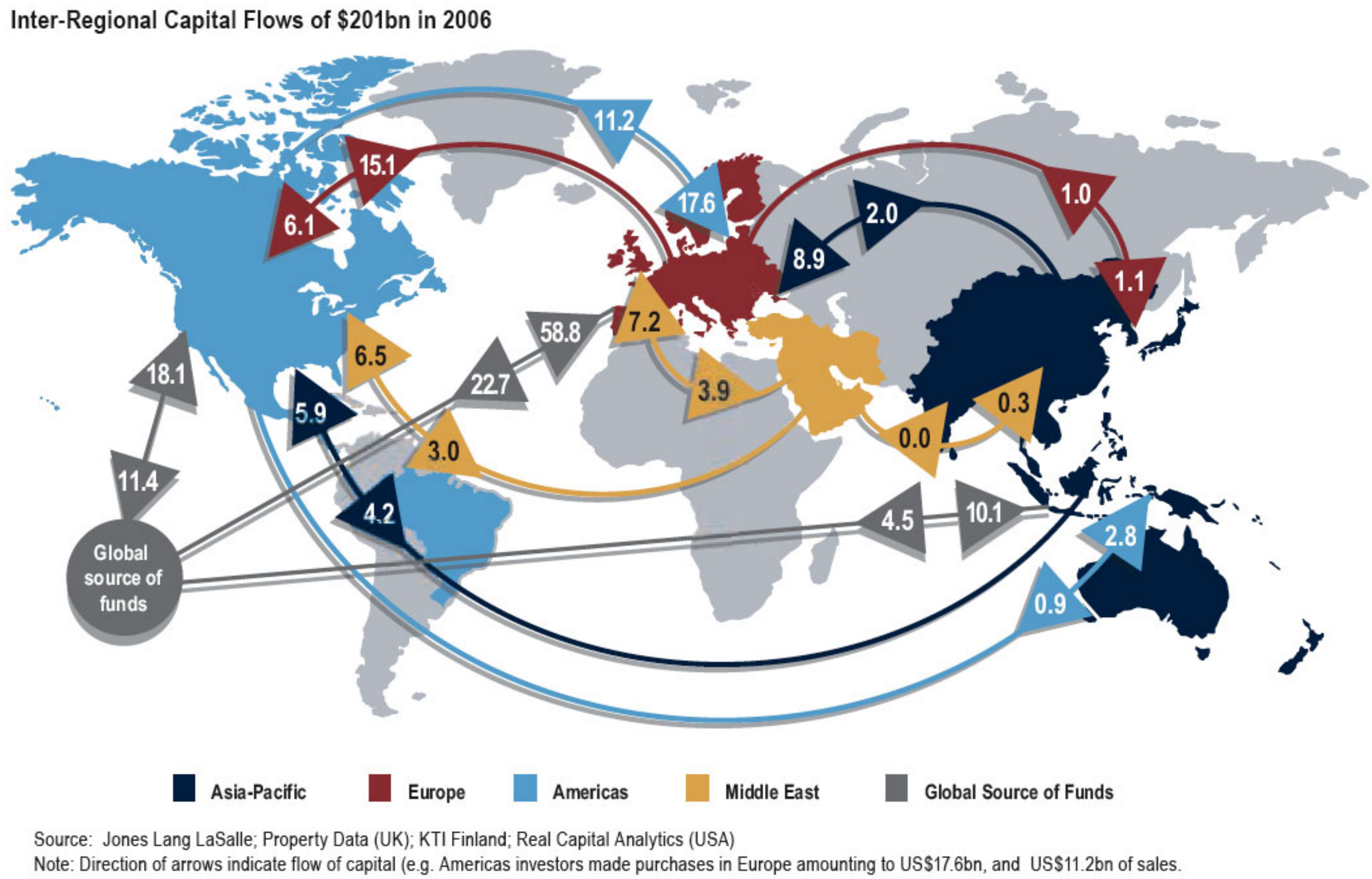


Figure 1: International Capital Flows

This means that the Neoclassical model predicts much faster capital accumulation than we see in practice. The lack of predictive success of the neoclassical model doesn't imply that we don't learn anything from it. Rather, we can use its failure to discuss what could go wrong. We can list a set of potential candidates for its lack of success:

1. Capital cannot flow across borders because of direct capital controls, or other frictions such as risk of expropriation (Aguiar and Amador, AER) or lack of capital markets (Moll, AER).

2. Labor doesn't flow because of policy migration controls, or mobility frictions (Porzio, ...)

3. Technology is not transferable across countries. See for example the Lucas's model of human capital (1988) accumulation.

4. Lack of technology adoption.

What we do next is present an extension of the Solow model with two countries, to describe how that benchmark economy would work. We will take it from there in subsequent lectures and talk about different potential deviations.

2 An Open Economy Version of the Model

We extend Solow's model to an open economy were capital can be transferred across two countries. In general, each country can have a different level of total-factor productivity. Both economies feature decreasing returns to scale in capital and labor. Also, they have potentially different savings rates. We want to ask questions such as where should the steady state of both economies end up. The key feature of the model is a non-arbitrage condition, the idea that rates of return to capital in both countries must be the same.

This framework serves as a basis for the models of balance of payments. The following table summarizes the parameters of the model we use:

	Country A	Country B
Technology Level	A^A	A^B
Savings Rate	s^A	s^B
Initial Capital	K_o^A	K_o^B
Demographics	L_A	L_B
Capital Share	α^A	α^B
Depreciation	δ^A	δ^B

Table 1: List of Model Parameters

Then we will need to solve for the following variables:

	Country A	Country B
Capital owned at t	K_t^A	K_t^B
GDP	Y_t^A	Y_t^B
Investment	I_t^A	I_t^B
Consumption	c_t^A	c_t^B
Wage	w_t^A	w_t^B
Rental Rate	r_t^A	r_t^B

Table 2: List of Model Variables

2.1 Inequality and a useful Benchmark.

To simplify the model, let's focus on two countries that differ only in their initial capital level. That is, assume $K_o^A < K_o^B$ and that all other parameters are constant (no technological or labor growth) and equal across the two countries.

Autarkic Solution. Consider the world in which neither country can move capital to the other country. Then, this model would simply behave as a standard Solow model, where capital would accumulate over time to reach the steady state value. Since country A starts from a lower capital level, then it would take longer to reach steady state and we would observe a growth rate higher than the one in country B.

2.2 The Market for Capital

Now let's allow capital to be freely traded across the two countries. The owner of capital in country A can either rent it to a firm in his own country and earn a rate r_t^A or rent it abroad to earn r_t^B. Thus capital owned by country A K_t^A can be divided in capital used domestically $K_t^{D,A}$ and capital sent abroad B_t^A. The same holds true for the owner of capital in country B. It must be the case that

$$\begin{aligned} K_t^A &= K_t^{D,A} + B_t^A \\ K_t^B &= K_t^{D,B} + B_t^B \end{aligned}$$

Clearly, any investor would choose to send the capital to the country that offers the highest rate.

Can an equilibrium with different rental rates exist? Suppose that $r_t^A > r_t^B$. Define the operational capital used in country A as

$$K_t^{O,A} = K_t^{D,A} + B_t^B$$

That is, the operational capital is the total capital used for production in a given country. By symmetry, the operational capital in country B is

$$K_t^{O,B} = K_t^{D,B} + B_t^A$$

Because $r_t^A > r_t^B$, everyone will want to invest in country A. Thus $K_t^{O,A} = K_t^A + K_t^B$and $K_t^{O,B} = 0$, with $B_t^A = 0$ and $B_t^B = K_t^B$. However, the profit maximization problem of the firm states that the rental rate must equal the marginal product of capital in each country.

$$\begin{aligned} r_t^A &= A\alpha \left(K_t^{O,A}\right)^{\alpha-1} L^{1-\alpha} \\ r_t^B &= A\alpha \left(K_t^{O,B}\right)^{\alpha-1} L^{1-\alpha} \end{aligned}$$

Since $0 < \alpha < 1$, $K_t^{O,A} = K_t^A + K_t^B$, and $K_t^{O,B} = 0$, r_t^A is finite, while r_t^B is infinite. Therefore $r_t^A < r_t^B$, which contradicts the initial assumption. Similarly, it can't be the case that $r_t^A < r_t^B$. The only possible equilibrium is obtained when

$$r_t^A = r_t^B.$$

That is, the owner of capital must be indifferent between renting the capital to firms in country A or country B. The condition is also called a non-arbitrage condition. Since the rates are equalized, it is impossible to rent capital in a country and lend it abroad to obtain a profit equal to the difference of the rental rates.

Because the model requires that this condition be satisfied, we have that used capital must be identical in both countries, or $K_t^{O,A} = K_t^{O,B}$. So the poorer country will borrow some capital from the richer country. What is borrowed by A must be lent by B. To determine how much capital is borrowed, equate the definitions for the operational capital in country A and B to obtain

$$B_t^B - B_t^A = \frac{K_t^B - K_t^A}{2} = B_t$$

Where B_t is the net capital transfer.

Question. Why $\frac{1}{2}$? What is the intuition behind the balance of capital?

An interesting feature of this model is that a version of the powerful Modigliani-Miller Theorem applies: it does not matter how are we financing B_t be it through foreign direct investment or directly through external debt of firms, the balance of payments will be the same. One implication of this model is the fact that the source of production does not really matter for the well being of domestic consumers. Their resources will be identical in either case unless, of course, there's autarky.

Total Output produced in country A will be given by:

$$Y_t^A = F\left(K_t^{O,A}, L\right) = A\left(K_t^{O,A}\right)^{\alpha} L^{1-\alpha}$$

and it is distributed according to the following function:

$$Y_t^A = w_t L + r_t K^{O,A} = w_t L + r_t K^A + rB_t$$

Recall that a share $1-\alpha$ of the output will be used to pay labor and the remaining share α goes to capital. The same decomposition holds true for country B. Also recall that GDP can be decomposed as the sum of consumption plus investment plus exports minus imports. That is:

$$Y_t^A = C_t^A + I_t^A + X_t^A - M_t^A$$

Country A does not import anything ($M_t^A = 0$) and exports the rent payment for the capital borrowed from B ($X_t^A = rB_t$). So the net flows to to borrowed capital ($X - M$) are equal to$-rB_t$, so this is the value of the current account. For country B the inverse is true. They import the rent payment $M_t^B = rB_t$ and export nothing ($X^B = 0$). Therefore the value of the current account in country B is equal to rB_t.

Obviously the worldwide Balance of Payments are net to 0, as we are just transferring resources from one country to the other. As in the standard Solow model, we have that investment is constant function of disposable income, and depends on the marginal propensity to save s:

$$
\begin{aligned}
I_t^A &= s\left(Y_t^A - X_t^A\right) \\
I_t^B &= s\left(Y_t^B + M_t^B\right)
\end{aligned}
$$

Here the disposable income has to include the current account values in each country. The amount exported by A will only be available in country B. Replacing for the current account values and the income decomposition we have that

$$
\begin{aligned}
I_t^A &= s\left(w_t L + r_t K^A + rB_t - rB_t\right) \\
I_t^B &= s\left(w_t L + r_t K^B - rB_t + rB_t\right)
\end{aligned}
$$

The level of investment in each country only depends on the amount of capital owned. Therefore, the evolution of capital we be an analog to the evolution of capital in the closed economy version of the model:

$$
\begin{aligned}
K_{t+1}^A &= (1-\delta) K_t^A + s\left(w_t L + r_t K_t^A\right) \\
K_{t+1}^B &= (1-\delta) K_t^B + s\left(w_t L + r_t K_t^B\right)
\end{aligned}
$$

Where the rental rate is equal to the marginal product of capital

$$
r = F_K\left(K^{O,A}, L\right) = F_K\left(K^{O,B}, L\right)
$$

and wages equal to:

$$
w = F_L\left(K^{O,A}, L\right) = F_L\left(K^{O,B}, L\right)
$$

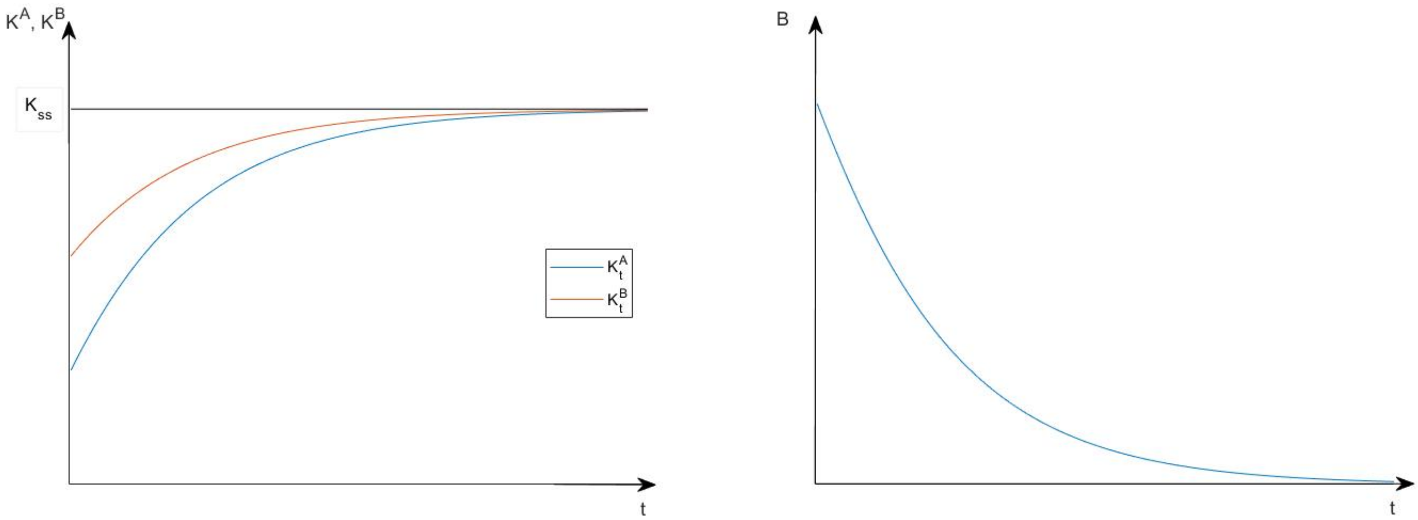
The steady state will be identical to the close economy version of Solow's Model, but the paths will present one of the economies lending the other economy through it's convergence path. To show that each country achieves the same long run outcome as the standard Solow model, guess that $K_{ss}^A = K_{ss}^B$. If that's the case, then in steady state we have that $B_{ss} = 0$ and $K_{SS}^{O,A} = K_{SS}^A = K_{SS}^B = K_{SS}^{O,B}$. Replacing these observations in the capital accumulations equations we get

$$
\begin{aligned}
K_{ss}^A &= (1-\delta) K_{ss}^A + s\left(w_t L + r_t K_{ss}^A\right) = (1-\delta) K_{ss}^A + s\left(A\left(K_{ss}^A\right)^\alpha L^{1-\alpha}\right) \\
K_{ss}^B &= (1-\delta) K_{ss}^B + s\left(w_t L + r_t K_{ss}^B\right) = (1-\delta) K_{ss}^B + s\left(A\left(K_{ss}^B\right)^\alpha L^{1-\alpha}\right)
\end{aligned}
$$

These capital accumulation equations are the same as the standard Solow model and return the familiar formula

$$K_{SS}^A = K_{SS}^B = \left(\frac{sA}{\delta}\right)^{\frac{1}{1-\alpha}}$$

Which also verifies our initial guess. The following pictures show what would happen to capital in the two countries and how the current account evolves. Note how the two countries converge to the same steady state, so a smaller and smaller current account is needed to equalize the capital used in production.



(a) Capital Accumulation

(b) Capital Flows