Teorías del Crecimiento Económico
Lecture Notes on Development in Open Economies

Guzmán Ourens
Tilburg University

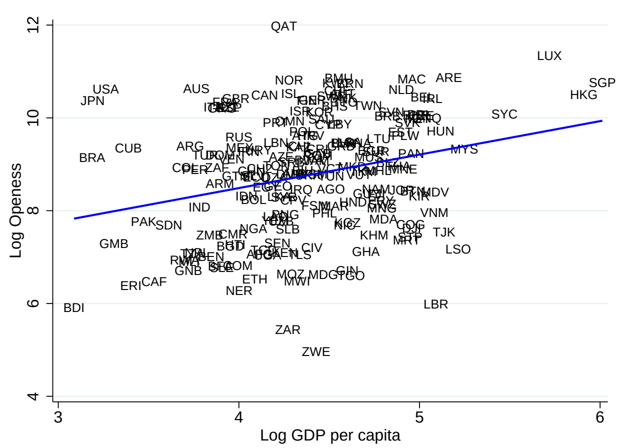
May 2019

Main Reference

Sections 19.4 to 19.7, in Acemoglu, D., Introduction to Modern Economic Growth, Princeton University Press, 2009.

1 Introduction

It is a robust fact that richer economies are more open to the world economy. The following figure shows the cross-country relationship between per capita GDP in real terms and degree of openness (measured as exports plus imports over GDP).



The figure highlights how even the raw data (no controls used) exhibit a clear positive relationship. The literature on the relationship between trade and welfare is not deprived of skeptics[1], but most of it finds positive effects of trade openness on growth, consumption possibilities and welfare.[2] In this section we highlight the importance of thinking the development process not in isolation, but rather considering the interactions that economies have with the rest of the world.

We start by exploring how trade can affect real income through relative price effects following the work of Acemoglu and Ventura (2002). We then move to cover the main ways in which trade can affect growth through product cylces as in Vernon (1966), following the setting in Krugman (1979). We conclude by showing canonical explanations for how trade can have positive effects on the endogenous growth rate. We present positive effects through spillovers following Grossman and Helpman (1991). Negative effects can also arise when sectors exhibit learning-by-doing externalities and there is resource reallocation, since regions with a comparative advantage in low growing sectors will typically reallocate resources towards them. To illustrate this possibility we follow the works of Young (1991) and Matsuyama (1992).[3]

2 Terms of trade effect-Acemoglu and Ventura (2002)

In a very influential work, Acemoglu and Ventura (2002) argue that, ignoring a few cases of growth miracles, the world income distribution remained surprisingly stable over the period 1960-1990 (see the figure below). What can explain such pattern? The paper makes the point that terms of trade (i.e. the price of exports over the price of imports) have moved to offset gains in output growth. The argument is based on the idea that, as long as the production of one country is not perfectly substitutable by that of any other country (i.e. a country's exports face a downward sloping demand) then economies experiencing fast output growth will increase their supply and reduce the price of their exports. At the same time, they increase their demand for imports potentially pushing their price up. The result is terms of trade falling for fast growing countries, and the counterpart is terms of trade improving for slow growing regions.

Moreover, when terms of trade are affected by an economy's exports, its factor prices will be affected as well.

Typical models of growth and trade attribute to international spillovers the role of homogenizing growth rates of the different integrated economies. How-

[1] See for example a critique of the empirical evidence based on growth regressions by Rodríguez and Rodrik (2001)

[2] See the canonical work by Frankel and Romer (1999) exploring macro evidence, and in Bernard et al. (2003) exploring firm level data.

[3] Galor and Mountford (2008) provide yet another way in which these negative mechanisms can operate: when richer countries have a comparative advantage in high skill tasks, freer trade will provide incentives to invest in education in those economies, while in the rest it would provide incentives to increase population reducing human capital accumulation. A recent and very neat exploration to how market driven reallocation of resources can harm growth can be found in Bustos et al. (2016).

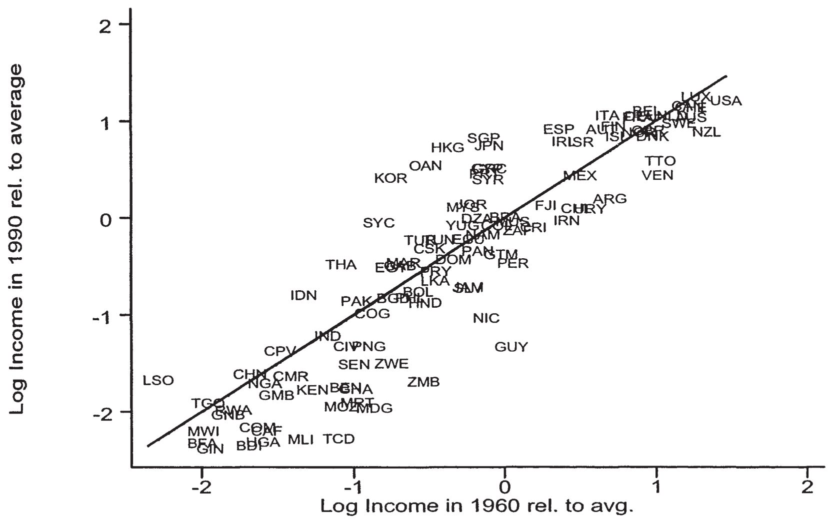


FIGURE I
Log of Income per Worker in 1990 and 1960 Relative to World Average from the Summers and Heston [1991] Data Set

ever, the model that is presented here shows that international trade alone (absent any technological spillovers) can generate sufficient interactions to ensure a common long-run growth rate for the integrated economies.

2.1 Setup

In what follows we develop a version of the model presented in Acemoglu and Ventura (2002). The world economy comprises J countries indexed by $j = 1, ..., J$, there is a continuum of intermediate products indexed by $\eta \in [0, N]$ and two final goods: consumption goods (C) and investment goods (I). Trade is free in intermediates and non-existent in final goods or assets.

Countries differ in their technology, impatience (savings) and economic policies (μ_j, ρ_j, ζ_j), where μ_j is an indicator of how advanced the technology of the country is, ρ_j is its rate of time preference, and ζ_j is a measure of the effect of policies and institutions on the incentives to invest. All of these characteristics potentially vary across countries with a given distribution but are constant over time. In addition, I assume that each country has a population normalized to 1 and there is no population growth, so aggregate consumption equals per capita consumption. All countries admit a representative household with logarithmic intertemporal preferences:

$$\int_0^\infty e^{-\rho_j t} \log C_j(t) dt \tag{1}$$

Here $C_j(t)$ is consumption of country j at date t. We also assume that

$K_j(0) > 0$, there is no depreciation, and we set the numeraire to be the ideal price index of intermediate goods. The budget constraint of the representative household in country j at time t is

$$p_j^I(t)\dot{K}_j(t) + p_j^C(t)C_j(t) = Y_j(t) = r_j(t)K_j(t) \tag{2}$$

where $p_j^I(t)$ and $p_j^C(t)$ are the prices of investment and consumption goods respectively (in terms of the numeraire). As usual, $K_j(t)$ is the capital stock, $r_j(t)$ is the rental rate of capital, and $w_j(t)$ is the wage rate. Finally $Y_j(t)$ is simply the value of total production in this economy.

Comparative advantage stems from technological differences between regions (Ricardian). Moreover, each country is perfectly specialized in the production of certain intermediates (Armington assumption). The latter assumption ensures that while each country is small in import markets, it affects its terms of trades by the amount of the goods it exports. Denoting the measure of goods produced by country j by μ_j , this assumption yields

$$\sum_{j=1}^{J} \mu_j = N$$

The previous expression implies that a higher level of μ_j corresponds with a country j having the technology to produce a larger variety of intermediates, so we can interpret μ as an indicator of how advanced the technology of the country is. All firms within each country have access to the technology to produce these intermediates, which ensures that all intermediates are produced competitively.

In each country there is free entry into the production of intermediates, which implies that production is competitive. The production technology of intermediates is such that one unit of capital gives one unit of a given intermediate. Together with perfect competitive markets, this means that the price of all intermediates in country j equal the returns to capital in that country

$$p_j(t) = r_j(t) \tag{3}$$

Both the consumption and investment goods are produced using domestic capital as well as a bundle of all the intermediate goods in the world (which are all traded freely). The production function for consumption goods in country j is

$$C_j(t) = \chi K_j^C(t)^{1-\tau} \left[\int_0^N x_j^C(t,\nu)^{\frac{\epsilon-1}{\epsilon}} d\nu \right]^{\frac{\tau\epsilon}{\epsilon-1}}$$

Notice the Cobb-Douglas structure of this production function with $0 < \tau < 1$ as the parameter driving shares, and factors used in production being the domestic capital used in the consumption goods sector $K_j^C(t)$, and a CES composite of all the intermediates used in the production of C in j, $x^C(t,\nu)$ with $\epsilon > 1$ as the elasticity of substitution among the intermediates.

Similarly, the production function of investment goods is:

$$I_j(t) = \frac{\chi}{\zeta_j} K_j^I(t)^{1-\tau} \left[\int_0^N x_j^I(t,\nu)^{\frac{\epsilon-1}{\epsilon}} d\nu \right]^{\frac{\tau\epsilon}{\epsilon-1}}$$

Notice that the only difference with respect to that of consumption goods is the term ζ_j representing economic policies (higher values of ζ correspond to policies reducing output of I). This allows differential levels of productivity, due to technology or policy, in the production of investment goods across countries.

All markets clear, which implies that $K_j^C(t) + K_j^I(t) + K_j^\mu(t) = K(t)$, where $K_j^\mu(t)$ is the capital used in the production of intermediates.

Finally, it can be shown that production functions for I and C are equivalent to the following unit cost functions:

$$\begin{aligned} B_j^C(r_j(t), [p(t,\nu)]_{\nu\in[0,N]}) &= r_j(t)^{1-\tau} \left(\int_0^N p(t,\nu)^{1-\epsilon} d\nu \right)^{\frac{\tau}{1-\epsilon}} \\ B_j^I(r_j(t), [p(t,\nu)]_{\nu\in[0,N]}) &= \zeta_j r_j(t)^{1-\tau} \left(\int_0^N p(t,\nu)^{1-\epsilon} d\nu \right)^{\frac{\tau}{1-\epsilon}} \end{aligned}$$

where the constant χ is chosen appropriately.

Notice that the $p(t,\nu)$ are not indexed by j, since there is free trade in intermediates and thus all countries face the same intermediate prices. The specification using the unit cost functions simplifies the analysis.

2.2 Equilibrium

A *world equilibrium* is defined by paths of prices, capital stock levels, and consumption levels $\left[[p_j^C(t), p_j^I(t), r_j(t), K_j(t), C_j(t)]_{j=1}^J, [p(t,\nu)]_\nu \in [0,N] \right]_{t\in[0,\infty]}$ for each country j, such that all markets clear and the representative household in each country maximizes utility given the paths for prices.

The Euler equation for optimal path of consumption obtained by maximizing (1) subject to (2) for each j is:

$$\frac{r_j(t) + \dot{p}_j^I(t)}{p_j^I(t)} - \frac{\dot{p}_j^C(t)}{p_j^C(t)} = \rho_j + \frac{\dot{C}_j(t)}{C_j(t)}$$

and the transversality condition is:

$$\lim_{t\to\infty} e^{-\rho t} \frac{p_j^I(t) K_j(t)}{p_j^C(t) C_j(t)} = 0$$

Remember that in this simplified model there is no labour income and $p_j^I(t)K_j(t)$ is household wealth at current prices. Then what the previous condition says is that when $t \to \infty$ accumulated wealth goes to zero relative to consumption.

Integrating the budget constraint and using the Euler and transversality conditions, we obtain a particularly simple consumption function:

$$p_j^C(t)C_j(t) = \rho_j p_j^I(t)K_j(t) \tag{4}$$

which can be interpreted as households spending a fraction ρ_j of their wealth on consumption at every instant.

The fact that we set the numeraire to be the price index of all intermediate goods implies:

$$1 = p = \left(\int_0^N p(t,\nu)^{1-\epsilon}d\nu\right)^{\frac{1}{1-\epsilon}} = \sum_{j=1}^{J}\mu_j p_j(t)^{1-\epsilon}$$

where the last equality uses the fact that country j produces μ_j intermediates, and each of the intermediates produced in j has the same price $p_j(t) = r_j(t)$. Since each country exports all the goods it produces and imports all goods then $p_j(t)$ also represents the term of trade of country j.

With the above normalization, unit cost functions reduce to:

$$p_j^C(t) = r_j(t)^{1-\tau} \quad \text{and} \quad p_j^I(t) = \zeta_j r_j(t)^{1-\tau} \tag{5}$$

To compute the rate of return to capital, we need to impose market clearing for capital in each country. In addition we also have a trade balance equation for each country. However, by Walras's Law, one of these equations is redundant. Here we use the trade balance equation, which can be written as

$$Y_j(t) = \mu_j r_j(t)^{1-\epsilon}Y(t) \tag{6}$$

where $Y(t) = \sum_{j=1}^{J} Y_j(t)$ is total world income at time t. Equations (2), (3), (4), (5), and (6), fully characterize the world equilibrium. We can combine them to obtain the low of motion of resources in each economy j:

$$\frac{\dot{K}_j(t)}{K_j(t)} = \frac{r_j(t)^\tau}{\zeta_j} - \rho_j \tag{7}$$

$$r_j(t)^\epsilon K_j(t) = \mu_j \sum_{i=1}^{J} r_i(t)K_i(t) \tag{8}$$

The first equation gives the law of motion of capital for each country, $K_j(t)$, for a given rental rate. The second equation gives, for a level of $K_j(t)$, the cross-section terms of trade (equal to the interest rates), which in turn feeds back into the previous equation to determine the evolution of capital.

We can now define a *steady-state world equilibrium* in the usual fashion, in particular, requiring that all prices are constant. This "steady-state" equilibrium involves balanced growth. Using the two equations above, we can show that there exist a unique steady-state world equilibrium where:

$$\frac{\dot{K}_j(t)}{K_j(t)} = \frac{\dot{Y}_j(t)}{Y_j(t)} = g^* \quad \forall j$$

and the world steady-state growth rate g^* is the unique solution to

$$\sum_{j=1}^{J} \mu_j [\zeta_j(\rho_j + g^*)]^{(1-\epsilon)/\tau} = 1$$

The steady-state rental rate of capital and the terms of trade in country j are given by

$$r_j^* = p_j^* = [\zeta_j(\rho_j + g^*)]^{1/\tau}$$

The results summarized in this proposition are remarkable. First, despite the high degree of interaction among the various economies, there exists a unique globally stable steady-state world equilibrium. Second, this equilibrium takes a relatively simple form. Third and most important, in this equilibrium all countries grow at the same rate g^*. This third feature is quite surprising, since each economy has access to an AK technology: thus without any international trade (e.g., when $\tau = 0$), each country would grow at a different rate (e.g., those with lower ζ_j or ρ_j would have higher long-run growth rates). The process of international trade acts as a powerful force keeping countries together, ensuring that in the long run they all grow at the same rate.

In other words, international trade, leads to a stable world income distribution. Why? The answer is related to the terms-of-trade effects encapsulated in (8). To understand the implications of this equation, consider the special case where all countries have the same technology parameter, that is, $\mu_j = \mu \forall j$. Suppose also that a particular country, say country j, has lower ζ_j and ρ_j than the rest of the world. Then (7) implies that this country accumulates more capital than others. But (8) makes it clear that this cannot go on forever, and country j, by virtue of being richer than the world average, will also have a lower rate of return on capital. This lower rate of return ultimately compensates the greater incentive to accumulate in country j, so that capital accumulation in this country converges to the same rate as in the rest of the world.

Intuitively, each country has "market power" in the goods that it supplies to the world: when it exports more of a particular good, the price of that good declines to ensure that world consumers purchase a greater amount of this good. So when a country accumulates faster than the rest of the world and thus increases the supply of its exports relative to the supplies of other countries' exports, it will face worse terms of trades. This negative terms-of-trade effect reduces its income and its rate of return to capital (recall 3), and slows down capital accumulation. This mechanism ensures that in the steady-state equilibrium all countries accumulate and grow at the same rate.

Naturally, growth at a common rate does not imply that countries with different characteristics have the same level of income. Countries with better characteristics (higher μ_j and lower η_j and ρ_j) grow at the same rate as the rest of the world, but will be richer than other countries. This is most clearly shown by the following equation, which summarizes the world income distribution. Let $y_j^* = Y_j(t)/Y(t)$ be the relative income of country j in steady state. Then (6) and (**??**) yield

$$y_j^* = \mu_j [\zeta_j(\rho_j + g^*)]^{(1-\epsilon)/\tau}$$

This equation shows that countries with better technology (high μ_j), lower distortions (low ζ_j) and lower discount rates (low ρ_j) will be relatively richer. The above equation also highlights that the elasticity of income with respect to ζ_j and ρ_j depends on the elasticity of substitution between the intermediates, ϵ, and the degree of openness (which is a function of τ). When ϵ is high and τ is relatively low, small differences in ζ_j's and ρ_j's can lead to very large differences in income across countries.

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