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ESTIMATING THE SPEED OF CONVERGENCE IN OUTPUT PER CAPITA FOR JORDAN AND ISRAEL

by

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Abstract

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This paper examines the convergence hypotheses in the Solow model. It shows that an augmented Solow model can be used to estimate the speed of convergence between Jordan and Israel. The data indicates that Israel has a higher steady state than Jordan. Moreover, the estimated speed of convergence for Israel is between 2% and 4% per year and for Jordan is between 1% and 2% per year.

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INTRODUCTION

After World War II, economists developed a number of growth models to study the long-run economics of countries. Exogenous and more recently endogenous growth models are used to explain the long-run determinants of output per capita and its growth rate. Growth models can be used in many ways to understand the growth experience of countries. Growth models can be used to study convergence among countries. This aspect has received a lot of focus and attention among economist. Convergence applies if poor economies tend to grow faster than rich economies, so that poor economies will catch up with rich economies in per capita output. In this paper, exogenous growth models will be examined in section one. This will be followed by an exposition of the endogenous, or new, growth theories in section two. The third section of this paper will examine the Solow model. In section four, the data and samples are discussed as well as the characteristics of the Jordanian and Israeli economies. The paper will end by section five that contains an exposition of the convergence hypotheses and the empirical work devoted to test for convergence and as a result estimating its speed.

SECTION 1: EXOGENOUSE GROWTH MODELS.

One-sector growth models formulate functions of output growth (usually defined as growth of real GDP) as depending on inputs into the production process, primarily being capital and labor. In more detailed models, other factors such as land and technical progress are included. A combination of three assumption typically form the basis of these models:

1- Labor supply is exogenously determined and it grows at a given rate, equal to the rate of growth of the population, i.e., constant participation rate.
2- A production function; $Y_t=F(K_t,L_t)$, is incorporated, in which capital and labor inputs transform at any given time, t, into output Y_t. The marginal product functions meet the Inada conditions, as we will see in the third section.
3- Saving equals to Investment.

Further assumptions (related to the production function) are also incorporated into these models. It is assumed that the marginal products of capital and labor are positive and decreasing as inputs increase, and the function is also assumed to be homogenous of the first degree in capital and labor, implying constant returns to scale. One-sector growth models further assume full employment with planned saving equal to planned investment.

Formalized growth models of this type include the Harrod-Domar model (Harrod, 1939 and Domar, 1946), The neo-classical-Solow growth model (Solow, 1956).

The Harrod-Domar model is a simple model of the determination of the rate of economic growth. They use a fixed-proportions production function[1]. The no substitution between labor and capital led them to conclude that the equilibrium point is characterized by continuous growth of unemployment of labor or machines (Barro and Martin, 1995). In other words, depending on the exogenously determined saving rate the economy has to go to either one of the following two equilibrium points:

1- Low enough saving rate results in permanent and increasing unemployment of labor and continuous decline in per capita income, i.e., per capita variables will approach zero.
2- High enough saving rate results in permanent and increasing unemployment of capital[2] and zero growth in per capita income.

The only time the economy can achieve an equilibrium point in which both capital and labor are fully employed is if the saving rate times the average product of capital equal to the growth rate of population[3]. If we accept this model and the saving rate is high enough, then the model predicts that there will be convergence among economies, even though the steady state to which economies will be converging is undesirable.

The neoclassical Solow growth models change the production function of the Harrod-Domar model, to allow for substitution between capital and labor. In this

[1] Also called Leontief production function. Mathematically, Leontief production function can be expressed as $Y= F(K,L)=\min(AK,BL)$.

[2] In this case even though the marginal product of capital is zero, households are assumed to keep their saving rate fixed.

[3] Assume that the depreciation rate of the capital stock is zero.

model, the growth of the labor force is exogenously given and the issue of technical progress is central in the neo-classical explanations of economic growth process. If countries are similar with respect to structural parameters of population growth rate, human capital accumulation rate, saving rate and technological progress, then countries with lower per capita income tend to grow faster than countries with higher per capita income. Thus, there is a force that promotes convergence in levels of per capita income across countries. This, however, does not necessarily imply a reduction in the dispersion of income levels if each country's level of income is continually subject to random disturbances. This model is used in this paper and its the analytical aspect and implication on convergence is presented in section three and five respectively.

All these models emphasize the importance of savings in determining levels of output and capital, and in shifting the trend growth path up or down, while maintaining the same growth rate as that before the change in the saving-rate occurred. According to one-sector growth models, optimal use of resources and factor inputs, saving and investment levels, the exogenous population growth and technical progress are considered to be the only factors affecting economic growth. Also, the neoclassical growth theory is known for its prediction that economies will converge in their levels of per capita income.

Two-sector models are based on the relationship between the modern (industrial) sector and the traditional (agricultural) sector. The basic model, as expounded by Lewis (1954), is based on the following assumptions: a surplus labor exists in an overpopulated agricultural sector where the marginal product of labor is very low, a gradual transfer or re-allocation of labor from the low productivity agricultural sector to the higher productivity industrial sector occurs, capitalists re-invest their profits, and wages are assumed to be higher in the modern sector, by a proportion high enough to induce the migration of labor from one sector to the other.

Overall, the Lewis model is very valuable in the analysis of the development process, with emphasis on the rate of capital accumulation in the modern sector, surplus rural labor, and relative factor shares in each sector as the key factors affecting economic growth. However, the model has been criticized for its restricting assumptions that do not seem applicable to today's developing countries. To begin with, there is the assumption of complete re-investment of profits by the capitalists creating modern sector employment at a rate proportional to that of capital accumulation. However, even assuming away the possibility of capital flight, it is likely that those capitalists would re-invest their profits in a more labor-intensive manner, as the real cost of labor could be relatively low if the productivity of labor is relatively low, rendering a labor-intensive process more lucrative.

Furthermore, the assumption of surplus rural labor but fully employed urban labor has been questioned, and evidence points to the reverse situation in many of today's less developed countries (Todaro, 1989). Finally, there is the tendency of modern sector wages to rise rapidly, rendering the assumption of a competitive modern sector labor market somewhat unreal. This is due to institutional factors and forces such as union power, multinational corporation hiring practices and civil service wage scales.

In the development process, some economists, such as Fisher (1933 and 1939) and Clarke (1940), have made the distinction between primary, secondary and tertiary production as a basis of a theory of development. Countries are assumed to start as primary producers, then, as the basic necessities of life are met, resources shift into manufacturing or secondary activities and, finally, due to rising income, more leisure and an increasingly saturated market for manufacturing, resources move into services or tertiary activities, producing commodities with a high income elasticity of demand. This corresponds to a move from being a less developed country to a mature developed economy with a high proportion of resources in the services sector.

The many-sector model is an extension of the Lewis-type model. It focuses on the transformation of the structure of production, moving from a traditional-sector-based economy to a more industrial and modern-sector-based one, as per capita incomes rise. However, unlike the Lewis model, increased saving and investment are considered necessary but not sufficient conditions for economic growth. In addition to the accumulation of both physical and human capital, "a set of interrelated changes in the economic structure of a country is required for the transition from a traditional to a modern system" (Chenery, 1979). These include changes in the composition of demand, international trade, socio-economic factors (for example, urbanization), and changes in resource use. Thus, the "Structural Change" economists emphasize that the growth and development of an economy depends on both domestic and external, or international, factors. The main concern of these models is to describe a linkage between the different sectors in the economy and how the interaction between them leads to economic development. Even though these models are not designed to study convergence, someone can think that these models predict that less developed economies will eventually grow to be a developed one. This can be thought of as convergence.

SECTION 2: ENDOGENOUS GROWTH THEORIES.

The mid- to late-1980s saw the emergence of a significant amount of literature on the subject endogenous growth. These theories were developed and pioneered by Romer (1986) and Lucas (1988), to interpret the economic growth process of developed and less developed economies, and to understand the disparities between countries at various stages of development. Their main preoccupation was with how to maintain sustainable growth and why it occurs, rather than with how to start it.

Endogenous growth theories suggest that differences in economic performance between countries are a function of a number of factors that are not explicitly explained in traditional neo-classical and other growth theories. Specifically, factors such as investment in human capital and technology are thought to play an important role in the development of an economy, equal in importance to that played by the "traditional" factors. Thus new growth theories attempt to endogenise the sources of growth, which are left out by the neo-classical growth models (investment in human capital and technology). These theories also attempted to get away from the traditional Solow-type conclusions that the majority of long-term growth in per capita incomes arose from exogenous technical progress.

Thus, proponents of endogenous growth models present them as alternatives to the neo-classical models, as the latter appear to fail empirically in explaining cross-country differences. However, Mankiw, Romer and Weil (1992), argue that an augmented Solow model, which includes accumulation of human as well as physical capital, provides a good description of cross-country data. In their model, which covers 98 countries over the period 1960-1985, they conclude "...the Solow model is consistent with the international evidence if one acknowledges the importance of human as well as physical capital. The augmented Solow model says that differences in saving, education, and population growth should explain cross-country differences in income per capita. Our examination of the data indicates that these three variables explain most of the international variation." (Mankiw et al, 1992). In their OECD sample, for instance, differences in saving, education and population growth explained 65% of the variation in income per capita. They further conclude that differences in tax, education policies and political stability will end up among the ultimate determinants of cross-country differences.

The AK model can give a good beginning to understanding endogenous growth theory[4]. The absence of diminishing returns to capital is key to endogenous growth in the AK model. The model predicts that all per capita variables grow at the same constant rate[5]. As a result, economies with similar structural parameters[6] will grow at the same rate regardless of their initial positions. Thus the model does not predict any convergence.

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[4] The production function in the AK model can be written as Y=AK, where K is a broad concept of capital that includes both physical and human components and A is the average and marginal product of capital.

[5] I am assuming a constant, exogenous saving rate, fixed depreciation rate of capital and fixed level of technology, such that sA>(depreciation).

[6] Saving rate, capital depreciation rate and average (marginal) product of capital.

In more advanced work the assumption of a non-convex aggregate production function was utilized in endogenous growth models. Individual production functions may be convex, but at the aggregate level of the economy, convexity fails to exist throughout the whole function, because of market failures and, more specifically, because of the existence of externalities in investments in human capital and technology, deriving from the public good nature technology. These externalities are mostly positive and thus lead to an increase in the overall productivity of an economy, causing increasing returns to scale to exist at the aggregate macroeconomic level, when the individual at the microeconomic level faces a constant returns to scale production function. The endogenous growth theory succeed in presenting a competitive equilibrium model in which knowledge enters the production function as an input with increasing marginal product, as a result the growth rate is driven by the accumulation of knowledge. With including increasing returns the model predicts that " the level of per capita output in different countries need not converge; growth may be persistently slower in less developed countries and may fail even fail to take place at all." (Romer, 1986).

SECTION 3: A NEOCLASSICAL GROWTH MODEL: SOLOW MODEL.

Mankiw, Romer and Weil (1992) argue that an augmented Solow model, which includes the accumulation of human as well as physical capital, provides a good description of cross-country data. This model can be used to understand the determinants of the steady state level of income and to test for convergence among countries. The first part of this section examines the model without human capital; the second part will deal with the inclusion of human capital. The neoclassical model of capital accumulation is a natural place to start studying economic growth and as you will find in the first part of this section it allows us to expose the basic mechanics and predictions of the model.

3.1 The Neoclassical Model of Capital Accumulation: Textbook Solow Model

3.1.1 Production and capital accumulation

The production function is given by[7]:

(1) $$Y_t = K_t^{\alpha}(A_tN_t)^{1-\alpha}$$

$$0 < \alpha < 1$$

This is a constant returns to scale Cobb-Douglas production function. Y_t is the total output produced at time t. A_t is a measure of labor efficiency at time t, which is a function of technology, as technology level improves labor efficiency improves. A_t is assumed to grow at a constant rate g ($A_t=A_0e^{gt}$). A_tN_t is labor in efficiency units at time t, we use A_t to convert the labor population, N_t, to

[7] The conclusions of the model do not depend on this format. Cobb-Douglas production functions are widely used in economics due to their nice features.

efficiency units. The growth rate in N_t is assumed to be constant and equals to n ($N_t=N_0e^{nt}$). K_t measures the physical capital stock in the economy at time t.

α and (1-α) are the shares of physical capital and labor in efficiency units in output, respectively. Here I am utilizing the assumption of perfect competition in the factor markets. If the market for inputs is perfectly competitive then each factor gets paid, in real terms, its marginal product. For example, the marginal product of capital at time t, MPK_t, is:

$$MPK_t = \alpha K_t^{1-\alpha}(A_tN_t)^{1-\alpha}$$

Which is equal to the rental price of capital, r_t. The share of capital in total output at time t is:

$$(r_t K_t)/ Y_t = (MPKt\ K_t)/Y_t = \alpha$$

Moreover, the marginal product functions meet the Inada conditions:

$$\lim_{k_t\to 0} MP(K_t) = \lim_{A_tN_t\to 0} MP(A_tN_t) = \infty$$
$$\lim_{k_t\to \infty} MP(K_t) = \lim_{A_tN_t\to \infty} MP(A_tN_t) = 0$$

The diminishing marginal productivity is the key to the main results of this model. The physical capital stock accumulates according to:

(2) $$\dot{K}_t = sY_t - \delta K_t$$

This equation shows the physical capital accumulation in this economy at time t.

$\dot{K}_t$ is the change in the stock of physical capital over time at time t, dK_t/dt. The constant saving rate is given by s.

The total saving is sY and this equals to gross investment in equilibrium[8]. δ is the rate of depreciation of the capital stock, if δ = 4% then 4 percent of the total physical capital stock depreciates every year. δK_t is the total amount of depreciation.

The change in the physical capital stock is influenced by two factors:

1) Investment, which is equal to saving in equilibrium. Physical capital stock rises as firms buy new machines.

2) Depreciation. The physical capital stock falls as some of the old capital wears out.

Hence, to have a sensible measure of the increase in the economy's physical capital stock we use net investment that is gross investment, sY, minus depreciation, δK.

31.2 The normalized variables

Here, I will use the lower case letter with *,x^*, to denote our normalized variables. We have to make two normalization, y_t^* will represent output per efficiency unit of labor (Y_t/A_tN_t), k_t^* is physical capital per efficiency unit of labor (K_t/A_tN_t). The production in normalized variables will be:

(3) $$y_t^* = k_t^{*\alpha}$$

Physical capital per efficiency unit of labor accumulates according to the following equation[9]:

[8] $Y_t=C_t+I_t$, where C_t is total consumption at time t and I_t is the gross investment at time t. $C_t=(1-s)\,Y_t$, if we substitute this in the above equation and rearrange we will get s $Y_t= I_t$. In this model investment is proportional to income.

(4) $$\dot{k}_t^* = sy_t^* - (\delta+g+n)k_t^*$$

And the growth rate in the normalized physical capital, γ_{kt}^*, is given by:

(5) $$\gamma_{kt}^* = s\,k_t^{*-(1-\alpha)} - (\delta+g+n)$$

From (4) the break-even investment is $(\delta+g+n)k_t^*$ this is the amount of investment required to keep physical capital per efficiency unit of labor constant. The effective depreciation rate is $(\delta+g+n)$, because it takes into account the physical depreciation that comes as a result of using the physical capital in production and the depreciation as a result of growth in population and technology. The population growth reduces k_t^* by spreading the existing physical capital stock over a larger population of workers. In the same fashion, the growth in A_t will increase the number of efficiency units of labor which reduces physical capital per efficiency unit of labor.

3.1.3 The steady state

The steady state in this model is defined as the point at which all the normalized variables grow at a zero rate. Equation (5) gives the growth rate in the normalized physical capital; this can be shown graphically as follows:

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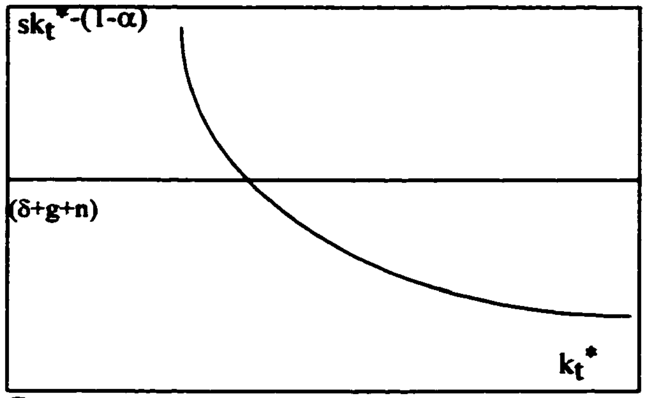
[9] Take the total derivative of physical capital per efficiency unit of labor, $k_t^* = K_t/A_t N_t$, with respect to time and use (2) to get to equation (4).



Graph 1: The Steady state

In the graph the steady state is the point of intersection between $sk_t^{*-(1-\alpha)}$ and $(\delta+g+n)$, at this point the growth rate in physical capital per efficiency unit of labor is zero. From **(5)** the value of k_t^* at the steady state must satisfy:

(6) $$s\,k_t^{*\,-(1-\alpha)} = (\delta+g+n)$$

Which can be solved for the steady state k^*:

(7) $$k^* = \{s/(\delta+g+n)\}^{1-\alpha}$$

Hence, the steady-state output per efficiency unit of labor is given by:

(8) $$y^* = k^{*1-\alpha}$$

From (7) this is equal to:

(9) $$y^* = \{s/(\delta+g+n)\}^{\alpha/(1-\alpha)}$$

The model predicts that the steady-state point is determined by the structural parameters of the model. For a given value the physical capital-income share,α, equation **(9)** shows that output per efficiency unit of labor is positively related with the saving rate, s, and negatively related with the depreciation rate,δ, the growth rate in technology, g, and the population growth rate.

The graph can help us understand the transitional dynamics of y_t^* and k_t^*. We have two immediate results:

1) If k_t^* initially to the left of $\tilde{k}^*$, the rate of growth of k_t^* will be positive and k_t^* rises over time.

2) As k_t^* increases the growth rate of k_t^* decreases and approaches zero as k_t^* approaches $\tilde{k}^*$.

3.1.4 The Growth rates at the Steady State

Our definition of the steady state suggests zero growth rate in both $\tilde{k}^*$ and $\tilde{y}^*$. This can be used to examine the growth rate in physical capital per worker and output per worker at the steady state, $\tilde{k}$ and $\tilde{y}$, respectively. The growth rate in k_t can be calculated as follows:

(10) $$k_t=(K_t/N_t)=k_t^*\,A_t$$

Take the total derivative with respect to time, dk_t/dt:

(11) $$\dot{k}_t=\dot{k}_t^*\,A_t+k_t^*\,\dot{A}_t$$

Divide both sides by k_t to get the growth rate in k_t :

(12) $$\gamma_{kt}=\gamma_{kt}^*+g$$

At the steady-state $\gamma_k^*=0$, then (12) at the steady state is equal to:

(13) $$\gamma_k=g$$

This implies that at the steady state the physical capital stock, $\tilde{K}$, grows at a rate equals to (n+g).

Similarly, output per worker can be written as:

(14) $y_t = y_t^* A_t$

And the growth rate in y_t is:

(15) $\gamma_{yt} = \gamma_{yt}^* + g$

At the steady-state $\gamma_y^* = 0$, then (15) at the steady state is equal to:

(16) $\gamma_y = g$

From this the growth rate in total output at the steady state, ¥, is (g+n).

3.1.5 The dynamics outside the steady state

If the economy is away from its steady state point, it will approach it with the passage of time. The diminishing return to capital is the reason for that. If k_t^* is low relative to its steady state value k^*, $f(k_t^*)/k_t^*$, the average product of capital is relatively high. By the assumption people will save and invest a constant fraction of that. This relatively high amount of saving will exceed the effective depreciation rate (δ+g+n), hence γ_{kt}^* will be high and k_t^* will increase. In the previous graph, when k_t^* is lower than its steady state value, s $k_t^{*\,-(1-\alpha)}$ is higher than (δ+n+g), from **(5)** γ_{kt}^* will be positive and k_t^* will increase.

3.1.6 The speed of convergence

To understand what governs the growth experience of an economy it is very important to calculate its speed of convergence, β_0. This estimate will tell us how close the economy is to its steady state. It tells you how fast the economy will go to its steady state per year[10]. In other words, it measures the percentage of the

[10] The speed of convergence depends on factors that are measured annually, thus it's an annual rate. See equation (20).

initial gap from steady state closed every year. Given our neoclassical production function, equation (5) shows that the growth rate in physical capital per efficiency unit of labor could be written as:

$$(5) \qquad \gamma_{kt}^{*} = s k_t^{*-(1-\alpha)} - (\delta+n+g)$$

To find β_0 we have to write (5) in terms of log k_t^*.

Hence, (5) can be written as[11]:

$$(17) \qquad \dot{\log k_t^*} = s e^{-(1-\alpha)\log k_t^*} - (\delta+n+g)$$

Log-linearize this by using the first-order Taylor expansion of $\log k_t^*$ around $\log k^*$[12]:

$$(18) \qquad \dot{\log k_t^*} \cong -(1-\alpha) s e^{-(1-\alpha)\log k^*} (\log k_t^* - \log k^*)$$

At the steady-state $se^{-(1-\alpha)\log k^*} = (\delta+g+n)$,hence (20) will be:

$$(19) \qquad \dot{\log k_t^*} \cong -(1-\alpha)(\delta+g+n)(\log k_t^* - \log k^*)$$

Which can be expressed as:

$$(20) \qquad \gamma_{kt}^{*} = \dot{\log k_t^*} \cong -\beta_0 \log(k_t^*/k^*)$$

$$\beta_0 = (1-\alpha)(\delta+g+n)^{13}$$

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[11] γ_{kt}^* is the time derivative of $\log k_t^*$, and $k_t^{*(1-\alpha)}$ can be written as $e^{-(1-\alpha)\log k_t^*}$.

[12] $\dot{\log k_t^*} \cong se^{-(1-\alpha)\log k^*} - (\delta+n+g) - (1-\alpha)se^{-(1-\alpha)\log k^*} (\log k_t^* - \log k^*)$. At the steady state $se^{-(1-\alpha)\log k^*} = -(\delta+n+g)$, hence (18).

[13] Equation (20) is a differential equation in $\log k_t^*$ with the solution $\log k_t^* = (1-e^{-\beta_0 t}) \log k^* + e^{-\beta_0 t} \log k_0^*$. Which implies that the gap between $\log k_0^*$ and $\log k^*$ closes at a rate equals to β_0 per year. For given values of $(\delta+g+n)$, β_0 is determined by the capital-output share, α. Researchers use 1/3 as a benchmark value for α. This speed of convergence is what I want to estimate for Jordan and Israel.

This result also applies to the growth rate of y_t^*, from (3) above, we have

(3) $$y_t^* = k_t^{*\alpha}$$

If you divide this by y_t^* and take the log, we get

(21) $$\log(y_t^*/y^*) = \alpha \log(k_t^*/k^*)$$

The growth rate in y_t^* is:

(22) $$\gamma_{yt}^* = \alpha\, \gamma_{kt}^*$$

If we substitute these results in (22), we get

(23) $$\gamma_{yt}^* = -\beta_0 \log(y_t^*/y^*)$$

y_t^* and k_t^* has the same convergence coefficient,β_0.

For empirical purposes (23) can be written as:

(24) $$\dot{\log y_t^*} = -\beta_0 (\log y_t^* - \log y^*)$$

Which is a linear differential equation that has the following solution (Chiang, 1984):

(25) $$\log y_t^* - \log y^* = (\log y_0^* - \log y^*)\, e^{-\beta_0 t}$$

Which says that the initial gap closes at a rate β_0 over time. If you add $\log y^*$ and subtract $\log y_0$ from both sides, we then get

(26) $$\log y_t^* - \log y_0^* = -(1- e^{-\beta_0 t}) (\log y_0^* - \log y^*)$$

The value of y^* is given in (9), substitute this in the above equation to get

(27) $$\log y_t^* - \log y_0^* = (1-e^{-\beta_0 t})[\phi \log s - \phi \log(\delta+g+n)] - (1-e^{-\beta_0 t}) \log y_0^*$$

$$\phi = \alpha/(1-\alpha)$$

Which can be written in terms of the average percentage change in output per worker, y, as follows[14]:

(28) $$(1/T)[\log y_t - \log y_0] = (1/T)[\log A_t - \log A_0] + \Phi \log s - \Phi \log(\delta+g+n) - (1-e^{-\beta_0 t})/T \log y_0 + (1-e^{-\beta_0 t})/T \log A_0 .$$

Where T is the length of the time period under study and $\Phi = \phi(1/T)(1-e^{-\beta_0 t})$.

Notice that the coefficients on the investment in physical capital, s, and the effective depreciation rate, $(\delta+n+g)$, must add up to zero.

[14] This equation will be used in the regression analysis for convergence. See section5.

3.2 THE MODEL WITH HUMAN CAPITAL[15]: The Augmented Solow Model

3.2.1 Production and Physical and Human capital accumulation

The production function is given by:

(29) $$Y_t = K_t^{\alpha} H_t^{\lambda} (A_t N_t)^{1-\alpha-\lambda}$$

$$0 < \alpha, \lambda > 1$$

This is a constant returns to scale Cobb-Douglas production function. Y_t is the total output produced at time t. K_t measures the physical capital stock in the economy at time t. H_t measures the human capital stock in the economy at time t. A_t is a measure of labor efficiency at time t, which is a function of technology, as technology level improves labor efficiency improves. A_t is assumed to grow at a constant rate g ($A_t=A_0e^{gt}$). A_tN_t is labor in efficiency units at time t, we use A_t to convert the labor population, N_t, to efficiency units. The growth rate in N_t is assumed to be constant and equals to n ($N_t=N_0e^{nt}$). α, λ and $(1-\alpha-\lambda)$ are the shares of physical capital, human capital and labor in efficiency units in output, respectively. Here I am utilizing the assumption of perfect competition in the factors market.

Moreover, the marginal product functions meet the Inada conditions:

$$\lim_{K_t \to 0} MP(K_t) = \lim_{H_t \to 0} MP(H_t) = \lim_{A_tN_t \to 0} MP(A_tN_t) = \infty$$

$$\lim_{K_t \to \infty} MP(K_t) = \lim_{H_t \to \infty} MP(H_t) = \lim_{A_tN_t \to \infty} MP(A_tN_t) = 0$$

[15] This part will use the results and techniques from the first part. Thus, I will not discuss it in details to avoid repetition.

As the model without human capital the diminishing marginal productivity is the key to the main results of this model.

Assume that gross investment in physical capital is the fraction s_k of output and that gross investment in human capital is the fraction s_h of output. Moreover, I will assume that both types of capital depreciate at the same rate per year,δ.

Thus, physical and human capital accumulate according to:

(30) $$\dot{K}_t = s_k Y_t - \delta K_t$$

(31) $$\dot{H}_t = s_h Y_t - \delta H_t$$

3.2.2 The normalized variables

We have to make three normalization, y_t^* will represent output per efficiency unit of labor (Y_t/A_tN_t), k_t^* is physical capital per efficiency unit of labor (K_t/A_tN_t) and h_t^* is human capital per efficiency unit of labor (H_t/A_tN_t).

The production function in normalized variables will be:

(32) $$y_t^* = k_t^{*\alpha} h_t^{*\lambda}$$

The equations for physical and human capital per efficiency unit of labor accumulation are[16]:

(33) $$\dot{k}_t^* = s_k y_t^* - (\delta + n + g) k_t^*$$

(34) $$\dot{h}_t^* = s_h y_t^* - (\delta + n + g) h_t^*$$

And their growth rates are given by:

(35) $\gamma_{kt}^{*}=s_k k_t^{*-(1-\alpha)} h_t^{*\lambda} - (\delta+n+g)$

(36) $\gamma_{ht}^{*}=s_h k_t^{*\alpha} h_t^{*-(1-\lambda)} -(\delta+n+g)$

3.2.3 the steady state

At the steady state all normalized variables grow at a zero rate. From equations (35) and (36) the steady state values of k_t^* and h_t^* will be[17]:

(37) $k^*=\{ s_k^{1-\lambda} s_h^{\lambda}/(\delta+n+g)\}^{1/1-\alpha-\lambda}$

(38) $h^*=\{ s_k^{\alpha} s_h^{1-\alpha}/(\delta+n+g)\}^{1/1-\alpha-\lambda}$

Hence, the steady-state output per efficiency unit of labor is equal to:

(39) $y^{*}=\{ s_k^{1-\lambda} s_h^{\lambda}/(\delta+n+g)\}^{\alpha/1-\alpha-\lambda} \{ s_k^{\alpha} s_h^{1-\alpha}/(\delta+n+g)\}^{\lambda/1-\alpha-\lambda}$

Which in log term can be written as:

(40) $$\text{Log } y^*= [\alpha/(1-\alpha-\lambda)] \log s_k+ [\lambda/(1-\alpha-\lambda)] \log s_h - [(\alpha+\lambda)/(1-\alpha-\lambda)] \log (\delta+n+g)$$

Thus the steady-state point in this model is determined by the model's parameters, namely, s_k, s_h, n, α, λ and δ. For given values of physical and human capital income shares in output, α and λ respectively, equation (39) indicates a positive relationship between output per efficiency unit of labor and s_k and s_h and as the model without human capital $(\delta+n+g)$ negatively affects the steady-state output per efficiency unit of labor.

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[16] See footnote 10.

3.2.3 the speed of convergence

To find the speed of convergence in this model, we have to write equations **(33)** and **(34)** in terms of log k_t^* and log h_t^*. Then log-linearize around the steady- state values.

(41) $$\dot{\log k_t^*} = s_k\, e^{-(1-\alpha)\log k_t^*}\, e^{\lambda \log h_t^*} - (\delta+n+g)$$

(42) $$\dot{\log h^*} = s_h^{-(1-\alpha)\log h^*}\, e^{\alpha \log k_t^*} - (\delta+n+g)$$

After taking the first-order Taylor expansion around log $\tilde{k}^*$ and log $\tilde{h}^*$ the above equations become[18]:

(43) $$\gamma_{kt} = \dot{\log k_t^*} \cong (\delta+n+g)[-(1-\alpha)\log(k_t^*/\tilde{k}^*) + \lambda \log(h_t^*/\tilde{h}^*)]$$

(44) $$\gamma_{ht} = \dot{\log h^*} \cong (\delta+n+g)[-(1-\lambda)\log(h_t^*/\tilde{h}^*) + \alpha \log(k_t^*/\tilde{k}^*)]$$

From equation **(32)** above, divide both sides by $\tilde{y}^*$ and take the log to get:

(45) $$\log(y_t^*/\tilde{y}^*) = \alpha \log(k_t^*/\tilde{k}^*) + \lambda \log(h_t^*/\tilde{h}^*)$$

Also from **(33)** the growth rate in output per efficiency unit of labor is:

(46) $$\gamma_{yt}^* = \alpha \gamma_{kt}^* + \lambda \gamma_h^*$$

If we substitute **(43)** and **(44)** into **(46)** and use **(45)**, we can write γ_{yt}^* as:

(47) $$\gamma_{yt}^* = \dot{\log y_t^*} = -\beta_1 \log(y_t^*/\tilde{y}^*)$$

$$\beta_1 = -(1-\alpha-\lambda)(\delta+n+g)$$

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[17] Set (35) and (36) to zero and use the condition that at the steady state $k^*/s_k = h^*/s_h$ then solve for the steady state values.

β_1 is the speed of convergence in this model, that is to say it's the rate at which output per efficiency unit of labor approaches its steady state per year. The inclusion of human capital lowers the speed of convergence in the model; other things remain unchanged[19]. Equation (47) is a linear differential equation with the solution (Chiang, 1984):

(48) $$\log y_t^* - \log y^* = (\log y_0^* - \log y^*)\, e^{-\beta_1 t}$$

Equation (48) shows that the gap between the initial output per efficiency unit of labor and its steady state dissipate at an annual percentage rate equals to β_1. We can use this equation to derive a regression equation for the average growth rate of output per capita. From (48), add $\log y^*$ and subtract $\log y_0$ from both sides to get:

(49) $$\text{Log } y_t^* - \log y_0^* = -(1-e^{\beta 1 t})\,(\log y_0^* - \log y^*)$$

The steady state value of output per efficiency unit of labor is given in (41); substitute this in (50) to write the log difference of output per efficiency unit as a function of the model's parameters[20]:

(50) $$\log y_t^* - \log y_0^* = (1-e^{-\beta_1 t})[\phi_1 \log s_k + \eta \log s_h - \mu \log(\delta+n+g)]$$
$$- (1-e^{-\beta_1 t}) \log y_0^*$$

$$\phi_1 = \alpha/(1-\alpha-\lambda)$$

$$\eta = \lambda/(1-\alpha-\lambda)$$

$$\mu = (\alpha+\lambda)/(1-\alpha-\lambda)$$

---

[18] At steady-state $s_k\, e^{-(1-\alpha)\log k^*}\, e^{\lambda \log h^*} = (\delta+n+g)$ and $s_h\, e^{\alpha \log k^*}\, e^{-(1-\lambda)\log h^*} = (\delta+n+g)$.

[19] Notice that $\beta_1 < \beta_0$ for given values of α and $(\delta+n+g)$.

[20] This will be used later in the regression analysis for convergence. See section5.

As a result of the introduction of human capital the size of the coefficient on $\log s_k$ is lower[21]. Finally, the average growth rate of output per capita is:

$$(51)\qquad (1/T)[\log y_t - \log y_0]=(1/T)[\log A_t - \log A_0]+(1/T)\,(1-e^{-\beta_1 t})\,\phi_1 \log s_k$$
$$+ (1/T)(1-e^{-\beta_1 t})\,\eta \log s_h - (1/T)(1-e^{-\beta_1 t})\,\mu \log(\delta+n+g)$$
$$- (1/T)(1-e^{-\beta_1 t}) \log y_0 + (1/T)(1-e^{-\beta_1 t}) \log A_0$$

This equation suggests that the coefficients on $\log s_k$, $\log s_h$ and $\log(\delta+n+g)$ must add up to zero.

3.3 Criticisms of the Model

The neoclassical model has been attacked as a theory of economic growth. Many writers questioned the validity of this model as a good theory of economic growth. Their attack is based on the following premises:

1- The model predicts that in the steady state all growth is due to technological progress, which is assumed to be exogenous and unexplained (Mankiw, 1995).
2- The model strangely assumes that different countries use the same production function, thus the same technology. Paul M. Romer lunched his attacked against the assumption that technology is a public good and available everywhere in the world. He argues that there is enough evidence in the world against this assumption and we should work with extended theoretical framework that takes the truth behind technology more seriously (Mankiw, 1995).

[21] Notice that $\phi_1<\phi_0$ for a given value of α. I will test this empirically.

The proponents of the neoclassical model refuse to accept these criticisms and argue that they are not compelling. Mankiw (1995) argues that these attacks can be answered as follows:

1. The model's main goal is to answer why growth rates differ among economies. It predicts that different economies will reach different steady states, depending on their rates of saving, depreciation rates and population rate. Moreover, the model predicts that each economy will have a different growth rate, depending on how far it is from its steady state. As a result the use of the assumption of constant, exogenous technological progress does not stand against the model when addressing these goals. The criticism could have been valid, had the model's main goal was to answer why we are richer today than a hundred years ago.
2. The proponents of this model recognize that poor economies have more unskilled labor and less advanced machinery than rich ones. The assumption of one production function used by different economies at given period of time means that if poor economies had the same inputs as rich economies they would produce the same output. In this model if an economy doubles it's capital this does not mean that each worker gets twice as much of the current capital stock, the economy replaces the old capital with new capital. The model assumes poor economies will imitate the technology used by rich economies as they progress, poor countries have a great incentive to do so "...if technical change increases productivity by 2 per cent every year, and if rich countries are five times as productive as poor countries, then poor

countries must be using a production function that is about eighty years out of date." (Mankiw, 1995).

Theoretically, the advocates of the neoclassical model of economic growth avoid the possibility that technology might differ across countries by adding human capital as input in the production function. In this new setting, technology is constant across countries while human capital varies. According to Mankiw's paper with David Romer and David Weil this setting explains 65% of the variation in income per capita in the OECD countries, and this by itself is good enough.

SECTION 4: THE DATA and SAMPLES.

4.1 Data

The data are from the Penn World Table (PWT) constructed by Summers and Heston (1995). PWT includes data on real income, government and private consumption, investment, and population for all the countries in the world other than the centrally planned economies. The data are annual and for most countries cover the period 1960-1992.

I use data on Real GDP Per Capita (RGDPPC) for the period 1960-1992 where it's available. The average share of real investment in real GDP (I/GDP) is used as a measure of the saving rate, s. I use the data on Population to calculate the average growth rate in population, n. I assume that g and δ are constant across countries and g+δ is equal to 0.05.

To measure human capital I use the Barro-Lee data set (1993), which has estimates of educational attainment for the population by age-over 15 and over 25- for 126 countries. The data covers a five years span from 1960-1990[22]. To measure the rate of human capital accumulation I use the seven-year average of the percentage of secondary school complete in population aged 15 years and over (SECC15). For those countries with no data available I use their continental average; which is the average of SECC15 for their corresponding continent.

[22] The data set covers only 1960, 1965, 1970, 1975, 1980, 1985 and 1990.

4.2 Samples

In constructing my samples I use the World Bank's criterion for classifying economies as a way of distinguishing and grouping economies with similar characteristics. The World Bank's income group, according to 1997 GNP per capita, are: Low income, $785 or less (61 countries); Lower middle income, $787-$3,125 (59 countries); Upper middle income, $3,126-$9,655 (37 countries); and high income, $9,655 or more (53 countries)[23].

For this study I consider two samples. The first sample (low/lower-middle income economies) has 56 countries for which the GNP per capita is between $785-$3,125. The second sample (upper-middle/high income economies) has 38 countries for which the GNP per capita is $3,126 or more. As you notice my two samples include selected countries from the World Bank's income groups. The reason for this is the lack of data and the nature of some economies make me believe that the model cannot measure their growth experience, such ones like the rich oil producing countries. The 1997 GNP per capita is $1,520 and $16,180 for Jordan and Israel, respectively[24]. Thus Jordan falls in the low/lower-middle income economies and Israel falls in the upper-middle/high income economies.

4.3 Characteristics

The average growth rate in Real GDP per capita (RGDPPC) for the period 1960-1992 is 1.48% for low/lower-middle income economies and 2.95% for upper-

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[23] The World Bank web page at http://www.worldbank.org/data/databytopic/class.htm.

[24] The World Bank web page at at http://www.worldbank.org/data/databytopic/GNP97.pdf.

middle/high income economies; the growth rate for Jordan 3.10% and for Israel is 3.27%. The average population growth rate for the period 1960-1990 is 2.30% and 1.2% for the low/ lower-middle economies and upper-middle/high income economies respectively. The population growth rate in Jordan is 2.20% and its 2.76% in Israel for the period 1960-1992. For the same period, the average investment-output ratio is 13.51% and 24.27% for the first and the second sample, respectively; the ratio is 13.89% for Jordan and 27.15% for Israel. The rate of human capital accumulation, the average "percentage of secondary school complete" in population aged 15 years and over is 3.32 for the low/lower-middle income economies and 11.34 for the upper-middle/high income economies. For Jordan 6.73% of the population aged 15 years and over has completed secondary school whereas it is 15.91% for Israel. Consider the following table[25].

SAMPLE/COUNTRY	AVERAGE GROWTH RATE IN PREAL GDP PER CAPITA 1960-1992	AVERAGE GROWTH RATE IN POPULATION 1960-1992	AVERAGE INVESTMENT-OUTPUT RATIO 1960-1992	AVERAGE SECC15 FIVE YEARS SPAN 1960-1990
LOW/LOWER-MIDDLE	1.48%	2.30%	13.51%	3.32%
UPPER-MIDDLE/HIGH	2.95%	1.20%	24.27%	11.34%
JORDAN	3.10%	2.20%	13.89%	6.73%
ISRAEL	3.27%	2.76%	27.15%	15.91%

[25] This table is based on my calculations using data from the Penn World Table constructed by Summers and Heston (1995). The time period is not from 1960-1992 for all countries. Jordan is covered from 1960-1990.

Section 3.2.3 discusses the determinants of the steady state point. For fixed values of α, λ and $(\delta+g)$ the steady state point depends on s_k, s_h and n. The higher is s_k, s_h and the lower is n the higher is the steady state point.

From the above table s_k, s_h are higher and n is lower for the Upper-middle/High income economies, thus this group of countries have a higher steady state point than the ones in the low/Lower-middle income sample.

The same table shows that Jordan and Israel have different characteristics, thus the two economies will not converge to the same steady state. The reason for the difference in the two steady states is due to the big difference in the average investment-output ratio and the rate of human. Israel has a higher savings rate and a higher rate of capital accumulation.

The population growth rate needs more explanation because the immigration and migration of people due to wars and government policies mainly affect the number of the population in these two countries.

In Jordan during the sixties the average growth rate in population is 2.73%, between 1970 and 1971 the growth rate is -30%, from 1972 to 1979 it is 3.14% and in the eighties it is 3.37%. In the nineties and after the 1992 Gulf War Jordan received an influx of people, those who left the country during the seventies and found jobs in the Gulf countries. The PWT does not cover beyond 1990, however the data from the Central Bank of Jordan suggests that the average growth rate of population during the nineties (1990-1998) is 3.7% and it is about 5% for the time period 1960-1998.

The population growth rate in Jordan is affected by two factors:

1. Immigration.

a. From the West Bank- after the1948 and 1967 wars with Israel.

b. From the Gulf countries after 1992.

1. Migration -especially those of a Palestinian origins- to the Gulf countries looking for better life opportunities. The population went down from 2.3 million in 1970 to 1.6 million in 1971, a growth rate of -30%.

In Israel during the sixties the average growth rate of population is 3%, 2.4% in the seventies and 1.53% in the eighties. The continually positive growth rate in population is due to the immigration of Jews from all over the world, especially Eastern Europe and the Former Soviet Union, which is encouraged by the government of Israel. Even though the average growth rate has been positive throughout the history of the state of Israel, the numbers suggest a decline in the growth rate.

This analysis suggests that if you take the average growth rate for each decade and compare the two countries you will find that Jordan has a higher growth rate in population than Israel. This combined with the fact that Israel has a higher saving and human capital accumulation rate Israel and Jordan have two different steady states and the steady state for Israel is higher.

SECTION 5: CONVERGENCE AND REGRESSIONS

5.1 Types of Convergence

The Solow model predicts that economies will go to the same equilibrium point in the long run. At that point the growth rate and the level of output will be the same, in other words the neo-classical model predicts that economies with different initial levels of output will eventually grow to equal standards of living. This prediction is questionable.

Barro describes this as:

"In neo-classical growth models with diminishing returns, such as Solow (1956), Cass (1965) and Koopmans (1965), a country's per capita growth rate tends to be inversely related to its starting level of income per person. Therefore, in the absence of shocks, poor and rich countries would tend to converge in terms of levels of per capita income. However, this convergence hypothesis seems to be inconsistent with the cross-country evidence, which indicates that per capita growth rates are not correlated with the starting level of per capita product." (Barro, 1991a)

The convergence hypothesis by itself explains the transitional dynamics to the steady state. There are two kinds of convergence, absolute and conditional convergence, the difference between them stems from testing the model's prediction against data.

5.1.1Absolute Convergence

Absolute Convergence is the hypothesis that poor economies tend to grow faster per capita than rich ones- without conditioning on any other characteristics of economies. Absolute convergence holds only for economies with equal savings rates, rate of human capital accumulation, growth rates of population, depreciation rates of capital and with access to the same technology. For a sample of homogeneous economies the absolute convergence hypothesis implies that the correlation coefficient between y_0, the initial value of output per capita, and the average growth rate in output per capita must be negative.

5.1.2 Conditional Convergence

It is clear enough that economies differ. This hypothesis takes into account the heterogeneity among economies. Conditional convergence is predicted for economies with different savings rate, rate of human capital accumulation, population growth, depreciation rates and access to technology, i.e., economies have different parameters and thus different steady states. In other words, an economy grows faster per capita the further it is from its own steady state.

5.2 Tests For Convergence

In this section I will use OLS regressions to test for convergence, both absolute and conditional, and estimate the speed of convergence,β_0 and β_1..

5.2.1 Test for Absolute Convergence

Table I reports regressions of the growth rate in GDPPC over the period 1960-92 on the log of GDPPC in 1960. Running the following regression will allow us to test this hypothesis:

$$(1/T)\ (\log Y_t - \log Y_0) = \pi - (1-e^{\beta t}) \log y_0 + u_t$$

$$\pi = (1/T)(\log A_t - \log A_0) + (1-e^{-\beta t})/T \log A_0 + \phi \log s + \phi \log(\delta+n+g)$$

This equation is from equation **(28)** with the assumption that economies are homogeneous.

The coefficient on the initial level of GDPPC is negative in all regressions; however, it is statistically insignificant for the first regression, which indicates the rejection of the absolute convergence hypotheses by this sample (Low/Lower-middle income).

Table I Test For Absolute Convergence Dependent Variable: average growth rate in Real GDP Per Capita (RGDPPC) over 1960-1992		
Sample	Low/Lower-middle income 1st Regression	Upper-lower/High income 2nd Regression
Observations	56	38
Constant	0.052 (0.025)	0.161 (0.024)
Initial level of Real GDP per capita (Log GDPPC1960)	-0.005 (0.004)	-0.016 (0.003)
Adjusted R^2	0.021	0.44
Implied β_0	0.0059	0.0224

In the second regression the coefficient on the initial level of GDPPC is statistically significant. In other words, the results from these regressions imply that there is no tendency for poor economies to grow faster per capita than rich economies in the Low/lower-middle income economies whereas it's possible in the Upper-middle/high income economies.

The implied speed of convergence reported in the table for the Upper-middle/High income economies tells us that the economy of Israel takes 62 years to move ¾ of the way to the steady state. The insignificance of the 1st regression makes the speed of convergence for the Low/Lower-middle income economies unreliable.

5.2.2 Test for conditional Convergence

In this section Table II and Table III report the result on conditional converge. The regressions from Table II and Table III are based on equation (28) and (51) respectively.

5.2.2.1 Conditioning on saving rate and population growth rate.

I added the saving rate and the population growth rate as distingushing parameters among economies. Only the saving rate enters significantly[26].

Table II

Test For Conditional Convergence: Conditioning on savings rate and population growth rate.

Dependent Variable: average growth rate in Real GDP per Capita (RGDPPC) 1960-1992

Based on Equation (28)

Sample	Low/Lower-middle income 1st Regression	Upper-middle/High income 2nd Regression
Observations	56	38
Constant	0.080 (0.0331)	0.159 (0.0445)
Initial level of income (Log GDPPC1960)	-0.007 (0.0035)	-0.018 (0.0027)
Log (I/GDP)	0.011 (0.0031)	0.023 (0.0075)
Log(n+g+δ)	-0.002 (0.0059)	-0.017 (0.0156)
Adjusted R^2	0.18	0.58
Implied β_0	0.0076	0.0261

The coefficient on the initial level of GDPPC is significant in both samples which indicates the presences of coditional convergence . The fittness of the regressions is much higher especially for the Low/Lower-middle income sample regression. From the speed of convergence it will take Jordan 182 years to close ¾ of the initial gap to its steady state, where as Israel will close ¾ of its initial gap to the steady state in 53 years.

As equation (28) shows that the coefficients on log (I/GDP) and Log (n+g+δ) must add up to zero. The regressions in Table II show that the two coefficients have the correct sign but do not sum up to zero. This is not to be taken as evidence against the model; the fact that they do not sum up to zero could be due to sampling errors, which affect the coefficients in the regressions (Griffiths, Hill and Judge, 1993). To handle such situations we must run a restricted regression. The results of the restricted regression are shown in Table III below.

Table III
Restricted Regressions
Test For Conditional Convergence: Conditioning on savings rate and population growth rate.
Dependent Variable: average growth rate in Real GDP per Capita (RGDPPC) 1960-1992
Based on Equation (28)

Sample	Low/Lower-middle income 1st Regression	Upper-middle/High income 2nd Regression
Observations	56	38
Constant	0.048 (0.0234)	0.149 (0.0208)
Initial level of income (Log GDPPC1960)	-0.006 (0.0035)	-0.018 (0.0025)
Log (I/GDP- Log (n+g+δ)	0.009 (0.0027)	0.022 (0.0056)
Adjusted R^2	0.17	0.59
Implied β_0	0.0065	0.0268
Implied α	0.60	0.54

As the above Table III shows the restrection is not rejected by the data. The reported speed of convergence indicates that the three quarter life of convergence is 213 and 38 years for Jordan and Israel. The speed of convergence is very low for the Jordanian economy. The implied capital share is 60% for Jordan and 54% for Israel. I do not expect a narowly defined capital to has such a high share in output.

[26] The significance level is10% and 5% for the first and second sample respectively.

5.2.2.2 Conditioning on Savings rate, population growthrate and rate of human capital accunulation

Economists always disscuse the importance of human capiatal in the growth process. In this section I have a dded log(SECC15)defined earlier as the average percentage of seconadary school complete in the population aged 15 years and over as a proxy of human capital.

Table IV

Test For Conditional Convergence: Conditioning on savings rate, population growth rate and rate of human capital accumulation.

Dependent Variable: average growth rate in Real GDP per Capita (RGDPPC) 1960-1992

Based on Equation (51)

Sample	Low/Lower-middle income 1st Regression	Upper-middle/High income 2nd Regression
Observation	56	38
Constant	0.140 (0.0370)	0.191 (0.0389)
Initial level of income (Log GDPPC1960)	-0.012 (0.0037)	-0.022 (0.0026)
Log (I/GDP)	0.008 (0.0031)	0.0158 (0.0067)
Log $(n+g+\delta)$	-0.001 (0.0055)	-0.022 (0.0133)
Log (SECC15)	0.006 (0.0019)	0.009 (0.0026)
Adjusted R^2	0.29	0.70
Implied β_1	0.0153	0.0368

From Table IV, human capital is highly significant in both regressions. The introduction of the human capital rate of accumulation lowered the size of coefficient on physical capital investment and improved the fitness of the regressions. It also increased the speed of convergence in both samples, this is opposite to the prediction of the model but not uncommon in empirical work on convergence (Mankiw et al, 1992). However, only in the second regression the coefficient on the population growth rate is statistically significant. The reported speed of convergence sugestes that Jordan needs 91 years to move 3/4 of the way to its steady state while Israel only needs 37 years[27]. The result for the speed of convergence for Jordan is more acceptable.

The coefficients on Log(I/GDP), Log(n+g+δ) and Log(SECC15) do not add up to zero as equation **(51)** indicates. Once more I imposed the restriction on these coefficient and tested it against data.

Table V

Restricted Regression

Test For Conditional Convergence: Conditioning on savings rate, population growth rate and rate of human capital accumulation.

Dependent Variable: average growth rate in Real GDP per Capita (RGDPPC) 1960-1992

Based on Equation (51)

Sample	Low/Lower-middle income 1st Regression	Upper-middle/High income 2nd Regression
Observation	56	38
Constant	0.081 (0.0266)	0.185 (0.0202)
Initial level of income (Log GDPPC1960)	-0.009 (00036)	-0.022 (0.0024)
Log (I/GDP) – log ((n+g+δ)	0.006 (0.0030)	0.015 (0.0051)
Log (SECC15) - log (n+g+δ)	0.005 (0.0019)	0.009 (0.0025)
Adjusted R^2	0.24	0.71
Implied β_1	0.0109	0.0374
Implied α	0.29	0.32
Implied λ	0.24	0.21

The restriction on the coefficient can not by rejected by the data in either sample and has a negligible impact on the coefficients. However, the speed of convergence in the Low/Lower-middle income sample is lower and implies that

[27] This means that at the end of our sample Jordan would have only closed 26% of the initial gap while I srael would have closed 65%.

Jordan will move ¾ of the way to its steady state in 72 years; Israel still needs 37 years to move ¾ of the way to its steady state. The restriction does not change the three-quarter life of convergence for Israel.

The results on the physical and human capital shares are notable. The estimate for α is 29% and 32% for the Low/Lower-middle and Upper-middle/High income sample respectively. These figures are very close to the benchmark value of one-third. The human capital share is 24% and 21% for the Low/Lower-middle and Upper-middle/High income sample respectively; these findings are very close to the findings of other researchers (Mankiw et al, 1992)[28].

[28] Makiw, Romer and Weil (1992) estimate of the human capital share is 23% in all three samples.

Conclusion

Even though Jordan and Israel are two economies that are located very close to each other and share a great deal of common history, this paper shows why the two countries are on different growth paths. The peace between the two countries might eliminate the destruction of war and its negative impacts on growth and development, but it will never guarantee the same long-run equilibrium. Ruling out the possibility of different production functions and access to technology, the paper found that the difference in saving and education between the two countries was enough to send each economy to a different steady state. Israel due to its high saving rate and human capital accumulation rate enjoys a higher steady state than Jordan.

The estimated speed of convergence for Jordan is between 0.01 and 0.02 per year. Thus Jordan's three-quarter life of convergence is between 70 and 139 years. For Israel the estimated speed of convergence is between 0.02 and 0.04 per year, thus we expect Israel to close three-quarter of the initial gap to its steady state within a time period not more than 70 years but not less than 35 years.

The government of Jordan must adopt economic policies aiming at increasing saving rate and accumulation of human capital. On the saving side, policies such as increasing the rate of return to saving will attract households to save more[29]. Also, the government can directly engage in increasing the saving rate by running a budget surplus that can be used to pay off previous debt and stimulate investment (Mankiw, 1997). On the human capital side, investment in teachers, schools, colleges, libraries and research centers are important to promote economic growth. During the process of capital accumulation new ways of production may be developed theses externalities are observed in many economies all over the world.

[29] Economists disagree on the extent at which private saving might respond to these incentives.

Appendix.

Table 1: Population, Real GDP per Capita, and their Growth Rates in Upper-middle/ High-income economies[1]						
Country	Population (In 000's)		Average Growth Rate in Population	Real GDP Per Capita (Laspeyres Index) (1985 intl. Prices)		Average Growth Rate in Real GDP Per Capita
	1960	1992	1960-1992	1960	1992	1960-1992
Argentina [b]	20618	32322	1.50%	4481	4708	0.02%
Australia	10274	17483	1.66%	7754	14484	1.95%
Austria	7048	7883	0.35%	5137	12949	2.89%
Belgium	9119	10040	0.30%	5469	13474	2.82%
Brazil	72594	154000	2.35%	1780	3886	2.44%
Canada	17910	27445	1.33%	7240	16371	2.55%
Chile	7695	13599	1.78%	289	4886	1.63%
Cyprus	573	718	0.71%	2075	9212	4.66%
Denmark	4581	5170	0.38%	6730	14114	2.31%
Finland	4430	5047	0.41%	5283	12064	2.58%
France	45685	57372	0.71%	5820	13925	2.73%
Germany, West	55435	65120	0.50%	6569	14703	2.52%
Greece [c]	8327	10330	0.74%	2086	6779	3.8%
Hong Kong	3051	5812	2.01%	2231	16461	6.25%
Ireland	2832	3547	0.70%	3299	9647	3.35%
Israel	2114	5118	2.76%	3447	9801	3.27%
Italy	50200	57809	0.44%	4580	1 2724	3.19%
Japan	94104	124000	0.86%	2943	15095	5.11%
Korea, Rep. [c]	24756	43268	1.80%	898	7235	6.73%
Luxembourg	315	392	0.68%	7977	16774	2.32%
Malaysia	8197	18606	2.56%	1409	5729	4.38%
Netherlands	11487	15178	0.87%	6087	13284	2.44%
New Zealand	2380	3433	1.14%	7953	11372	1.12%
Norway	3581	4286	0.56%	5592	15546	3.20%
Portugal [b]	8943	9868	0.33%	1857	7487	4.65%
Puerto Rico [a]	2397	3501	1.18%	3103	8722	3.56%
Reunion [a]	337	585	1.90%	1100	2988	3.45%
Singapore	1647	2818	1.68%	1626	12633	6.41%
Spain	30455	39085	0.78%	3128	9802	3.57%
Sweden	7480	8678	0.46%	7573	14009	1.92%
Switzerland	5362	6905	0.79%	9399	15914	1.65%
Trinidad & Tobago [c]	776	1253	1.55%	5623	8249	1.24%
Turkey	27508	58544	2.36%	1615	3818	2.69%
U.K.	52557	57848	0.30%	6808	12740	1.96%
Uruguay	2538	3130	0.66%	3955	5183	0.85%
U.S.A.	180673	255000	1.08%	9908	17986	1.86%
Venezuela	7303	20249	3.19%	6313	7068	0.40%
Yugoslavia [b]	18401	23809	0.85%	1947	4570	2.84%

1. Penn World data by Summers and Heston (1995).
a. Data for 1960-1990
b. Data for 1960-1990
c. Data for 1960-1991.

Table 2:Real Investment share of GDP (%) in Upper-middle/High-income economies[1]			
Country	Real Investment Share of GDP (%) (1985 intl. Prices) 1960	1992	Average Real investment Share of GDP 1960-1992
Argentina [b]	17.4	11.5	16.50
Australia	22.7	25.9	24.02
Austria	20.7	19.4	21.30
Belgium	21.7	19.3	19.82
Brazil	18.9	14.3	19.02
Canada	32.1	27.2	26.18
Chile	20.4	27.0	20.02
Cyprus	25.7	22.7	26.93
Denmark	26.7	17.9	25.37
Finland	26.0	37.4	34.43
France	11.0	36.2	31.18
Germany, West	24.3	26.4	25.77
Greece [c]	21.2	19.5	24.54
Hong Kong	23.1	24.2	23.81
Ireland	38.4	22.9	34.14
Israel	25.1	25.1	27.15
Italy	31.9	25.3	27.77
Japan	17.2	17.3	24.38
Korea, Rep. [c]	7.0	39.1	23.7
Luxembourg	40.6	32.7	29.95
Malaysia	15.0	32.6	23.51
Netherlands	33.8	24.1	27.77
New Zealand	26.7	20.9	24.44
Norway	30.4	18.7	30.33
Portugal [b]	22.2	16.3	22.70
Puerto Rico [a]	23.6	16.7	22.15
Reunion [a]	24.2	18.3	22.92
Singapore	19.3	27.8	25.50
Spain	25.5	20.2	23.35
Sweden	28.7	29.9	29.51
Switzerland	17.3	16.9	18.05
Trinidad & Tobago [c]	15.7	10.0	12.32
Turkey	16.8	16.4	20.83
U.K.	30.7	22.2	28.20
Uruguay	11.6	11.7	12.74
U.S.A.	23.7	23.7	24.49
Venezuela	16.1	16.7	17.60
Yugoslavia [b]	28.2	16.8	29.82

1. Penn World data by Summers and Heston (1995).
a. Data for 1960-1990.
b. Data for 1960-1990.
c. Data for 1960-1991.

Table 3: A Proxy For Human Capital Accumulation in Upper-middle/High income economies[1]

Country	Average Percentage of secondary school complete in population aged 15 years and over SECC15
Argentina	7.07
Australia	21.76
Austria	12.41
Belgium	9.99
Brazil	4.70
Canada	18.10
Chile	10.56
Cyprus	11.44
Denmark	17.69
Finland	11.41
France	4.93
Germany, West	6.46
Greece	10.79
Hong Kong	20.10
Ireland	12.21
Israel	15.91
Italy	9.24
Japan	14.54
Korea, Rep.	19.31
Luxembourg [a]	10.30
Malaysia	6.74
Netherlands	6.20
New Zealand	16.54
Norway	8.31
Portugal	3.21
Puerto Rico [b]	16.17
Reunion [c]	2.60
Singapore	9.40
Spain	5.59
Sweden	28.37
Switzerland	21.67
Trinidad & Tobago	5.09
Turkey	3.04
U.K.	7.26
Uruguay	5.96
U.S.A.	25.33
Venezuela	5.00
Yugoslavia	5.53

1. Barro-Lee Data set (1993).

a. The data is not available. As a proxy I used the continental (Europe) average, only countries in this sample are used to compute the continental average.

b. The data is not available. As a proxy I used the continental (Central & North America) average, only countries in this sample are used to compute the continental average.

c. Data for 1960, 1965, 1970, 1975, 1980.

Table 4: Population, Real GDP Per Capita, and their Growth Rates in Low/Lower-middle-income economies[1]						
Country	Population (In 000's)		Average Growth Rate in Population	Real GDP Per Capita (Laspeyres Index) (1985 intl. Prices)		Average Growth Rate in Real GDP Per Capita
	1960	1992	1960-1992	1960	1992	1960-1992
Algeria	10800	26254	2.28%	1710	2723	1.50%
Bolivia	3428	7524	2.46%	1133	1719	1.30%
Botswana [d]	481	1235	3.25%	525	2172	4.90%
Cameroon	5332	12242	2.60%	634	1031	1.52%
Cape Verde Is.	197	389	2.13%	471	1084	2.60%
China	667073	1162000	1.73%	564	1494	3.04%
Colombia	15754	33399	2.35%	1686	3380	2.20%
Costa Rica	1254	3193	2.92%	2090	3569	1.70%
Dominican Rep.	3325	7321	2.47%	1188	2827	2.00%
Ecuador	4563	11023	2.76%	1457	2827	2.10%
Egypt	25831	54679	2.34%	804	1869	2.64%
El Salvador	2578	5380	2.30%	1433	1873	0.80%
Fiji	394	750	2.01%	2108	4002	2.0%
Gambia [e]	372	875	2.85%	614	798	0.87%
Ghana	6825	15788	2.79%	886	956	0.24%
Guatemala	3887	9742	2.87%	1661	2244	0.90%
Guinea	3850	6097	1.53%	554	740	0.90%
Guinea-Bissau	540	1022	2.13%	500	628	0.71%
India	434825	884000	2.22%	769	1284	1.60%
Indonesia	93506	184000	2.12%	641	2104	3.70%
Iran	20301	59607	3.37%	2987	3641	0.62%
Iraq [b]	6847	6372	3.23%	3416	3205	-0.24%
Jamaica [f]	1622	2376	1.23%	1761	2440	1.10%
Jordan [e]	1695	3278	2.20%	1158	2922	3.10%
Kenya	8049	25669	3.87%	646	915	1.10%
Liberia [a]	1050	2268	2.75%	721	788	0.32%
Mauritania	975	2079	2.52%	785	839	0.21%
Mexico	38227	84967	2.5%	2825	6250	2.48%
Morocco	11891	26193	2.47%	825	2176	3.00%
Mozambique	7551	16511	2.61%	1145	711	-1.50%
Nicaragua [e]	1578	3676	2.82%	1623	1295	-0.75%
Niger [d]	3234	7436	2.87%	537	505	-0.21%
Nigeria	51595	102000	2.27%	560	978	1.74%
Pakistan	45970	119000	2.97%	644	1432	2.50%
Panama	1145	2515	2.46%	1568	3318	2.30%
Papua N. Guinea	1935	4055	2.31%	1208	1607	0.90%
Paraguay	1825	4519	2.83%	1172	2176	1.90%
Peru	9936	22370	2.54%	2031	2092	0.10%
Philippines	27909	64259	2.61%	1133	1690	1.20%
Romania	18403	22748	0.66%	427	1464	3.85%
Rwanda	2753	7320	3.26%	535	763	1.10%
Senegal [f]	3498	7625	2.51%	1062	1120	0.17%
Sierra Leone	2346	4354	2.06%	883	737	-0.56%
Somalia [d]	2544	7566	3.76%	1100	775	-1.20%
Sri Lanka	9889	17405	1.77%	1253	2215	1.78%
Sudan [h]	14302	25836	2.82%	901	714	-1.10%
Suriname [d]	290	437	1.14%	2095	2491	0.60%
Swaziland [d]	306	766	3.16%	1240	2550	2.50%

Table 4: Population, Real GDP per Capita, and their Growth Rates in Low/Lower-middle-income economies[1]						
Country	Population (In 000's)		Average Growth Rate in Population	Real GDP Per Capita (Laspeyres Index)		Average Growth Rate in Real GDP Per Capita
	1960	1992	1960-1992	1960	1992	1960-1992
Syria [f]	4561	12529	3.26%	1577	4001	3.00%
Tanzania [c]	10027	23020	2.97%	315	534	1.90%
Thailand	26405	57992	2.46%	940	3924	4.50%
Togo	1514	3900	2.96%	371	531	1.12%
Tunisia	4221	8418	2.16%	1095	3073	3.20%
Yemen [g]	5098	10896	3.80%	749	1979	4.86%
Zambia [f]	3141	8319	3.14%	946	696	-0.10%
Zimbabwe	3606	10364	3.52%	998	1163	0.48%

1. Penn World data by Summers and Heston (1995).

a. Data for 1960-1986.
b. Data for 1960-1987.
c. Data for 1960-1988.
d. Data for 1960-1989.
e. Data for 1960-1990.
f. Data for 1960-1991.
g. Data for 1969-1989.
h. Data for 1970-1991.

Table 5:Real Investment share of GDP (%) in Low/Lower-middle-income ies[1]			
Country	Real Investment Share of GDP (%) (1985 intl. Prices)		Average Real investment Share of GDP
	1960	1992	1960-1992
Algeria	19.9	14.8	20.99
Bolivia	17.7	6.7	15.89
Botswana [d]	4.9	24	19.10
Cameroon	3.7	5.1	8.32
Cape Verde Is.	29.5	21.7	23.20
China	22.8	24	20.47
Colombia	17.8	14.2	15.64
Costa Rica	12.6	18.9	16.23
Dominican Rep.	7.9	20.6	15.50
Ecuador	23.0	18.0	21.75
Egypt	3.5	3.9	4.57
El Salvador	9.2	9.4	8.33
Fiji	19.7	9.2	17.18
Gambia [e]	2.0	8.8	4.97
Ghana	11.0	4.8	6.12
Guatemala	8.1	10.3	9.10
Guinea	5.2	5.5	6.01
Guinea-Bissau	24.5	27.3	17.78
India	13.0	12.9	13.74
Indonesia	6.2	25.3	17.09
Iran	11.1	21.4	15.44
Iraq [b]	6.0	15.9	1.96
Jamaica [f]	31.1	15.3	21.59
Jordan [e]	9.0	9.6	13.89
Kenya	23.2	7.7	15.09
Liberia [a]	19.2	3.6	12.76
Mauritania	12.4	8.6	14.73
Mexico	14.5	15.6	16.44
Morocco	6.8	8.8	9.01
Mozambique	1.8	2.1	1.88
Nicaragua [e]	8.6	8.5	11.44
Niger [d]	7.4	5.8	8.65
Nigeria	7.6	8.5	12.23
Pakistan	13.1	10.0	10.57
Panama	15.9	20.9	20.17
Papua N. Guinea	9.9	13.0	15.42
Paraguay	7.1	17.2	13.62
Peru	18.7	18.2	17.69
Philippines	10.9	16.0	15.30
Romania	15.8	19.3	28.33
Rwanda	1.4	4.3	3.88
Senegal [f]	7.2	4.2	5.10
Sierra Leone	1.2	1.8	1.46
Somalia [d]	6.5	9.1	8.61
Sri Lanka	4.7	12.1	9.26
Sudan [h]	11.7	11.9	13.41
Suriname [d]	20.1	5.8	17.81
Swaziland [d]	8.5	16.4	12.95
Syria [f]	12.7	6.7	14.47
Tanzania [c]	6.8	12.1	10.72
Thailand	11.3	29.8	18.14
Togo	8.5	9.7	15.52

Table 5: Real Investment share of GDP (%) in Low/ Lower –middle income economies [1]			
Country	Real In vestment Share of GDP (%) (1985 intl. Prices) 1960	1992	Average Real Investment Share of GDP 1960-1992
Tunisia	8.0	11.6	14.45
Yemen [g]	0.1	6.5	13.55
Zambia [f]	36.0	18.6	21.77
Zimbabwe	30.4	13.2	16.99

1. Penn World data by Summers and Heston (1991).

a. Data for 1960-1986.

b. Data for 1960-1987.

c. Data for 1960-1988.

d. Data for 1960-1989.

e. Data for 1960-1990.

f. Data for 1960-1991.

g. Data for 1969-1989.

h. Data for 1970-1991.

Table 6:A Proxy For Human Capital Accumulation in Low/Lower-middle income economies[1]	
Country	Average Percentage of secondary school complete in population aged 15 years and over SECC15
Algeria	2.9
Bolivia	9.4
Botswana	2.61
Cameroon	2.13
Cape Verde Is. [a]	1.47
China	6.27
Colombia	5.27
Costa Rica	4.21
Dominican Rep.	2.8
Ecuador	5.8
Egypt	2.61
El Salvador	1.83
Fiji	7.13
Gambia	1.14
Ghana	2.49
Guatemala	1.5
Guinea [a]	1.47
Guinea-Bissau	0.17
India	2.67
Indonesia	3.11
Iran	4.84
Iraq	2.36
Jamaica	3.33
Jordan	6.73
Kenya	0.53
Liberia	2.11
Mauritania [a]	1.47
Mexico	5.39
Morocco [a]	1.47
Mozambique	0.43
Nicaragua [a]	1.36
Niger	0.21
Nigeria	1.47
Pakistan	4.1
Panama	10.7
Papua N. Guinea	1.3
Paraguay	5.04
Peru	7.91
Philippines	7.2
Romania	14.5
Rwanda	0.91
Senegal [f]	1.07
Sierra Leone	0.89
Somalia [a]	1.47
Sri Lanka	10.41
Sudan	1.06
Suriname [b]	5.38
Swaziland	2.07
Syria	2.73
Tanzania	0.1

Table 6: A proxy For Human Capital Accumulation in Low/Lower-middle income economies [1]	
Country	Average Percentage of secondary school complete in population aged 15 years and over SECC15
Thailand	2.39
Togo	0.73
Tunisia	4.17
Yemen	0.78
Zambia	2.3
Zimbabwe	0.17

1. Barro-Lee Data set (1993).

a. The data is not available. As a proxy I used the continental (Africa) average, only countries in this sample are used to compute the continental average.

b. The data is not available. As a proxy I used the continental (South America) average, only countries in this sample are used to compute the continental average.

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