Human Capital, Educational Levels and Growth

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Abstract

This paper analyzes the transition of countries between educational levels in the period 1970-2010 in order to assess the contribution of human capital to the increase of GDP per-worker. Using a sample of 41 countries that includes both developing and developed economies, we show that the transition from primary or no schooling, to significant levels of higher education, is a crucial factor in explaining growth. By using a panel cointegration framework, we show that escalating the educational ladder can make the difference between remaining a developing economy and becoming a developed one. We also find that an excess of higher education implies diminishing returns: escalating from 25 to 40 percent of employees at higher education, to more than 40 percent, reduces the marginal return of a one percent increase in higher education from 2.1 to 1.76 percent.

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1. Introduction

Human capital is a crucial factor for explaining differences in GDP per-capita between countries. In the last thirty years many countries have performed reforms in their educational policy, under a mix of both public and private education systems. The general trend included an enhancement of higher education, while countries with a relatively premature stage of development, started this process by educating people with low school attainments with the goal of advancing their skills toward higher levels of education.

In this paper we concentrate on the transition of countries along diverse educational paths, from no-schooling to primary, secondary and higher education. Our dataset includes countries that began and ended with a high level of higher education such as the U.S. or Sweden; those that began with a low level of higher education and ended with high level such as Korea or Singapore; and those that began with a low level of higher education and continued with low level such as Brazil.

Thus we can hope to shed some light on the role of higher education in economic growth.

Our measure of the level of education is somewhat different from that of former studies. It is not the average years of schooling that is used, but rather the proportion of employees with higher education out of the total persons employed. This specification allows for scale economies in the effect of higher education. It is plausible that higher education requires a critical mass to be effective for the advancement of the economy[2]. Our findings indeed support this conjecture: the return on higher education is increasing at the initial stages. But what happens at later stages? Can there be 'too much' education?

In other words, should countries pursue a policy of non-limited enhancement of higher education? Are there limits to this policy? Our findings show that the return on higher education indeed diminishes after a certain level, raising important issues about the desired educational policy.

The paper is organized as follows: section 2 provides a literature review on the importance of education for explaining differences of GDP per-employee between different countries; section 3 presents a model that shows the impact of the transition between educational levels on steady-state GDP per-capita; section 4 presents our empirical findings, that are based on a sample of 41 countries that includes both developing and developed countries. To test our hypothesis about the crucial role played by climbing along educational ladder, we implement a novel technique: using a Panel Cointegration framework, we test whether excluding the variables that represent education defeats the cointegrative relationship between GDP per-employee and the group of explaining variables. By looking only at the regressions that pass this test, we calculate the return on the different levels of education, which are then used to simulate the resulting increase of the GDP per-employee of the different countries. Section 5 summarizes and concludes.

[2] See: Becker, Murphy and Tamura (1990, 1994).

2. A literature Review

As pointed out by Sala-i-Martin (2001), the introduction of human capital as an explanatory variable to growth literature started with Romer (1986), who added what he called 'knowledge' as an endogenous production factor. This contribution gave rise to the well-known 'endogenous growth model', in which knowledge has an increasing marginal productivity. Later on, Mankiw, Romer and Weil (1992) added human capital to Solow's (1956) classical exogenous growth model. Their model added human capital to the basic production function, assuming that it multiplies the labor input. According to these authors only the augmented Solow model, that includes accumulation of human capital, provides an empirical explanation to the international variation in GDP per-capita[3]. Mankiw, Romer and Weil (1992) used secondary school enrolment as a proxy for human capital. However, the use of this proxy, as well as the linkage between years of schooling and human capital, may not be obvious. Here is where the micro-literature, represented mainly by the Mincerian approach [based on Mincer's (1974) work that established the connection between years of schooling and wage], can help. In his work Mincer explores the rate of return of an extra year of schooling, to a person's wage[4], and finds a linear connection. Hungerford and Solon (1987), as well as Belman and Heywood (1991), explore the existence of non-linear return to one year of schooling. They assume nonlinearity for 8, 12 or 16 years of schooling (end of primary, secondary and higher education respectively) and find evidence of nonlinearity for 16 years of schooling.

In a macro-growth model, Bils and Klenow (1996) as well as Hall and Jones (1999) argue that the appropriate way to incorporate years of schooling into an aggregate production function, is to assume that human capital (H) is represented by $\mathrm{H_i} = \mathrm{e}^{\emptyset(\mathrm{E_i})} \cdot \mathrm{L_i}$. When $\emptyset(\mathrm{E})$ represents the efficiency of one unit of labor with E years of schooling, L stands for the physical quantity of labor, and $\emptyset'(\mathrm{E})$ is the percentage return to an additional year of schooling estimated in a Mincerian wage regression.

The effect that years of schooling have on GDP per-worker was also studied by Barro and Lee (1993, 1996, 2001 and 2010) and Cohen and Soto (2007) in a newly extended dataset - school enrollment collected by OECD, Eurostat and UNESCO. All writers use practically the same raw data in order to generate long term series of years of schooling. Although based on different frameworks, Barro and Lee, as well as Cohen and Soto, find similar results: years of schooling, as human capital proxy, are an important factor for GDP per-worker. Both pairs of writers estimate a 5% to 12% rate-of-return, per an additional year of schooling; these estimates are close to typical Mincerian return, as found by Psacharapoulos and Patrinos (2010). Barro and Lee (2010) report another interesting finding regarding the rate-of-return: they find that the estimated rate-of-return to an additional year of schooling is higher at secondary and tertiary levels than in primary level. It should be noted that we find the same

[3] They also discuss the endogenity of human capital, physical capital and GDP per-capita, an issue that is tackled in our paper by using a cointegration cross country panel econometric technique, as described in section 4.

[4] Mincer's work includes other factors that influence wage, like years of experience, but those are less relevant to the macroeconomic discussion.

phenomenon in our study, but also some satiation, i.e., the existence of diminishing returns, when the proportion of labor force with high education is large (above 40% of labor force).

Our study is also based on the the Barro Lee (2010) data set, but we use a different measure as a proxy for human capital, closer to the one used by Mankiw, Romer and Weil (1992). It has one important distinction though: in addition to the proportion of labor force with secondary education, it includes the proportion of labor force with primary education and those with higher education. This enables us to examine the effect of different proportions of worker's education level on GDP per-capita. Using this variable, as well as the use of a novel econometric technique, is the main contribution of this paper.

Macro-economic growth literature presents many explanatory variables other than human or physical capital. Hall and Jones (1996) study the idea that a country's social infrastructure affects output per-worker. Because social infrastructure is hard to define and measure, they use different proxies, such as distance from the Equator. Sachs and Warner (1995) provide evidence that international integration and trade liberalization have a positive effect on growth. Sachs (2001) argues that geography is a barrier to technology transfer, especially in agriculture or health, as viewed by the distinctive development challenges faced by economies situated in tropical climates. La Porta et al. (1999) assess government performance and find that low corruption has a positive effect, whereas ethno-linguistically heterogeneity might have a negative one. These variables are not the main focus of this paper, but we include them in order to control for their effects.

3. Modeling Educational Levels

3.1 The microeconomic structure

The optimization problem from the point of view of an individual consists of maximizing utility (U), which is assumed to be logarithmic:

$$\begin{aligned} &\underset{l}{MAX}\;\; U = \left[\ln(1-l) + \beta_i \ln[D + w_i l(1-\tau)]\right] \\ &\mathrm{c_i} = \mathrm{D} + w_i(1-\tau)l_i \end{aligned} \tag{1}$$

Where i = P,R (poor and rich), l represents labor, β represents the strength of individual's tastes toward consumption (relatively to leisure), D is a government demogrant intended for income redistribution, w represents the wage, τ is the linear income tax rate and c is consumption.

Applying the F.O.C. for labor we obtain the following labor supply:

$$\begin{aligned} &\frac{\partial U}{\partial l} = \frac{\beta_i(1-\tau)w_i}{(1-\tau)w_i l + D} - \frac{1}{1-l} = 0 \\ &l = \frac{\beta_i}{1+\beta_i}\left(1 - \frac{D}{\beta_i(1-\tau)w_i}\right),\;\; w_i > \frac{D}{\beta_i(1-\tau)} \end{aligned} \tag{2}$$

Plugging the labor supply obtained in (2) in the budget constraint we obtain:

(2)' $$c_i = D + \frac{\beta_i}{1+\beta_i} w_i(1-\tau) - \frac{1}{1+\beta_i} D = \frac{\beta_i}{1+\beta_i}[D + w_i(1-\tau)]$$

For simplicity we assume that the income tax schedule includes a threshold under which incomes are not taxed. Thus, the single group paying income tax is the rich one. Note that it is plausible to have:

$$w_R > w_P, \beta_R < \beta_P$$

While there are many combinations of β and w that are consistent with the solution of this model, the following table shows a particular one which results an equal labor supply for the rich and the poor[5].

Table 1 - A possible combination of parameters

β_P	β_R	w_P	w_R	D	τ
2.4	0.8	20	80	18	0.47

From this table we get that $l = l^* = 0.21$. The poor's marginal propensity to consume is 0.7, and the rich's marginal propensity to consume is 0.44.

We assume now that the economy is composed of skilled and unskilled workers. The rich individuals have the needed resources to invest in education and become skilled ($w_R = n_S$). As opposed to that, the poor do not have enough resources for investing in education and becoming skilled[6]. Consequently, at the initial steady state $w_P = n_U$ where n_U is the unskilled wage ($n_U < n_S$). In the future the poor can achieve the skilled wage, but in order do so he/she depends on government's investment in education.

In the next sub-section we introduce this structure into a macroeconomic model, in which the government chooses the tax rate. The government maximizes the income tax revenue from high-skilled work:

(3) $$\underset{t}{MAX} \; T(t)$$

$$T(t) = \tau w_S l = \tau w_S \frac{\beta_R}{1+\beta_R}\left(1 - \frac{D}{\beta_R(1-\tau)w_S}\right)$$

And the F.O.C. is:

(4) $$w_s \frac{\beta_R}{1+\beta_R} = \frac{D(1-\tau)+D\tau}{(1-\tau)^2}$$

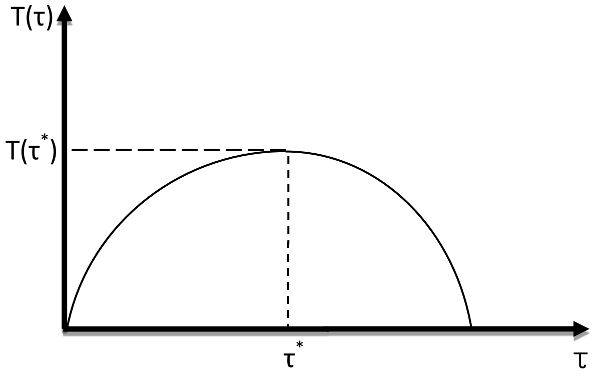
$$\tau^* = 1 - \left(\frac{D(1+\beta_R)}{w_S \beta_R}\right)^{0.5}$$

[5] These numbers are shown for a demonstration purpose only. An equal labor supply is not needed for applying the model shown in this paper.

[6] While the poor can in principle finance education through loans, Galor and Zeira (1993) analyze the difficulties associated with this channel. Strawczynski (2014) presents a model in which education finance is performed by parents or grand-parents.

The optimal tax is the Laffer tax rate that maximizes the revenue from skilled labor taxation. Note that the optimal tax rate represents a maximum on the Laffer curve (Figure 1).

Figure 1 - The optimal Tax



3.2 The Macroeconomic Structure

As in Galor and Zeira (1993), The GDP produced by the N_U unskilled individuals equals to:

(5) $$Y_U = N_U n_U l_U$$

The GDP of the skilled worker is a function of physical capital, K, and productivity, A. The contribution of skilled labor to production takes place according to a Cobb-Douglas production function with a coefficient (1-α), which takes into account labor supply and the number of skilled workers, N_S:

(6) $$Y_S = A(l_S N_S)^{1-\alpha} K^{\alpha}$$

Y_S and K represent skilled GDP and capital, respectively. The wage of the skilled workers is the marginal productivity of skilled GDP, which is higher than the unskilled wage. The basic assumption is that the contribution of skilled workers interacts with productivity, represented by an exogenously given technology. One possibility is to think of the interaction between research and development and skilled work, as stressed by Grossman and Helpman (1991)[7]. Another possibility is to think that as the number of skilled workers goes up, society becomes more apt for incubating productivity changes, which demand high skill.

Assume for simplicity that at the initial steady state there are three workers. In developed economies all three workers are skilled, while in developing economies there is only one skilled worker and two unskilled[8].

Given available tax revenues, the government decides on the total amount spent on education, E, which in turn determines the number of skilled workers:

(7) $$N_S = N_S(E)$$

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[7] We adopt, though, Solow's assumption of exogenous productivity.

[8] We can easily change the setup so as to allow unskilled workers in the developed economy.

This is so since as shown above, we assume a minimum required investment in education, as in Galor and Zeira (1993); i.e., the poor depend on the government to become skilled:

$$(8) \qquad X_P = \theta_P(a_i)E$$

Where X_p represents the investment in education that is needed for becoming skilled; i.e., only when E is sufficiently high, will the poor be able to become skilled. The effectiveness of the investment on education for the poor (i=1,2) depends on ability, a_i . Since as explained above in developing economies there are two unskilled workers, we assume that there are two levels of ability: $a_1 > a_2$. Thus, the first individual makes better use of public education than the second one. Note that for different countries these levels may differ; countries may also differ in their labor preference, represented by β.

Consistently with the empirical model shown below, we assume that E represents higher education.

The government budget constraint is:

$$(9) \qquad \mathrm{E} + \mathrm{mD} = \tau \mathrm{Y}$$

Where τ is the tax rate shown in equation (4), and m is the number of individuals.

At the beginning, when resources are scarce, the invested amount on education by the government does not help the poor to get the skilled wage. Only when resources are high enough, the investment in education could help poor people to get out of the poverty trap. At the initial steady state the number of skilled workers is:

$N_S^0 = N_S(E_0)$, which represents the total number of rich people, R.

GDP at the initial steady state is:

$$(10) \qquad Y_0 = N_U n_U l_U + A_0(l_S N_S^0)^{1-\alpha} K^\alpha$$

Note that in a developed economy, at the initial steady state, $N_S = 3$ while in an undeveloped economy, $N_S = 1$. In the empirical part we will differentiate between two kinds of developing economies: countries with a high growth prospects, denominated "Asian Tigers" (AT), which in terms of our model are characterized by a higher β (and hence a higher tax rate) and a higher a; and countries that are less successful in terms of GDP-enhancing educational reform, that are denominated "Falling Behind" countries (FB), and are characterized by a lower β (and hence a lower tax rate) and a lower a. The initial GDP for developed and developing countries, respectively, is:

$$(11) \qquad Y_0^D = A_0(3l_S)^{1-\alpha} K^\alpha$$

$$(11)' \qquad Y_0^{AT} = Y_0^{FB} = 2n_U l_U + A_0(l_S)^{1-\alpha} K^\alpha$$

An exogenous increase in A allows the government to increase the investment in education. Since the skilled wage can be achieved only when the investment in education is high enough (as in Galor and Zeira, 1993), only a sufficiently high E will allow poor workers to achieve the required skills, which will allow them to obtain the market skilled wage. Assume that this level of E for countries of the type AT is obtained at the GDP Y_1 (below it, E increases with Y, but the unskilled workers do not yet achieve the needed threshold for the investment in education):

(12) $E_1 = \tau Y_1 - mD$

Equation 12 means that the economy will jump once this level of GDP is achieved, allowing for an increase in the number of skilled workers. This increase is parallel to a reduction of the number of unskilled workers, while the total number of workers remains unchanged. In terms of the empirical model shown below, this result means that there is a jump at the aggregate level to a higher category of education.

Assume now an exogenous improvement in technology, from A_0 to A_1. The initial conditions concerning β and $\theta(a)$ help the AT countries achieve a better steady state, characterized by a transition of unskilled workers to a higher skill level; opposite to that, the composition of skilled and unskilled at the new FB country steady state does not change:

(13) $Y_1^{FB} = 2n_U l_U + A_1(l_S)^{1-\alpha}K^\alpha$

(13)' $Y_1^{AT} = n_U l_U + A_1(2l_S)^{1-\alpha}K^\alpha$

The results in (13) imply a substantial increase in GDP per-employee at the AT countries as compared to a mild increase in FB countries (caused only by the increase in A). The materialization of the increase in exogenous productivity in AT countries is related to the existence of a high number of educated individuals[9]; i.e., the more educated individuals in the country, the higher is the positive effect on growth – due to the specification of production, which is characterized by a multiplication between productivity and the number of skilled workers. The new element compared to the classical model is that the technological change causes a substantial jump in GDP at AT countries (as opposed to FB countries) because they have enough skilled workers that make this change valuable. One possible explanation is that the existence of these workers, that have the right skills and know how to "profit from the opportunity" of technological change, makes the difference between becoming developed and falling behind.

Assume now a second exogenous improvement in technology, from A_1 to A_2. The following is the new steady state:

(14) $Y_2^{FB} = n_U l_U + A_2(2l_S)^{1-\alpha}K^\alpha$

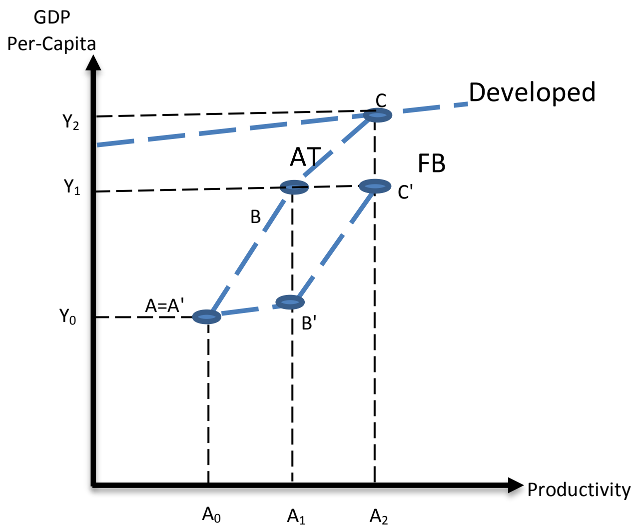
(14)' $Y_2^{AT} = A_2(3l_S)^{1-\alpha}K^\alpha$

In Figure 2 we show the new steady states: at AT countries once the higher level of GDP is achieved, the government is able to invest more resources in education and thus it achieves a higher level of education (point B). This change will drive the economy to a new steady state with a higher level of GDP per-employee. As opposed to that, at points A' and B' the level of education for the FB country remains the same, and the increase in output is related only to the increase in productivity. In point C the AT country jumps to a new and higher level of investment in education, that is subject to diminishing returns. Now the AT country has fully converged to the GDP per capita of the developed country. At this point the FB

[9] A feature of this type was stressed by Becker, Murphy and Tamura (1990, 1994).

country also climbs along the educational ladder (to point C'), allowing for a substantial increase in the GDP per-employee.

Figure 2 - Productivity, Education and Growth



4. Empirical Analysis

Using data for the period 1970-2010, and a panel cointegration framework, enables us to examine the effect of the transition among different levels of education, on GDP per-worker development patterns of different countries.

4.1 Data

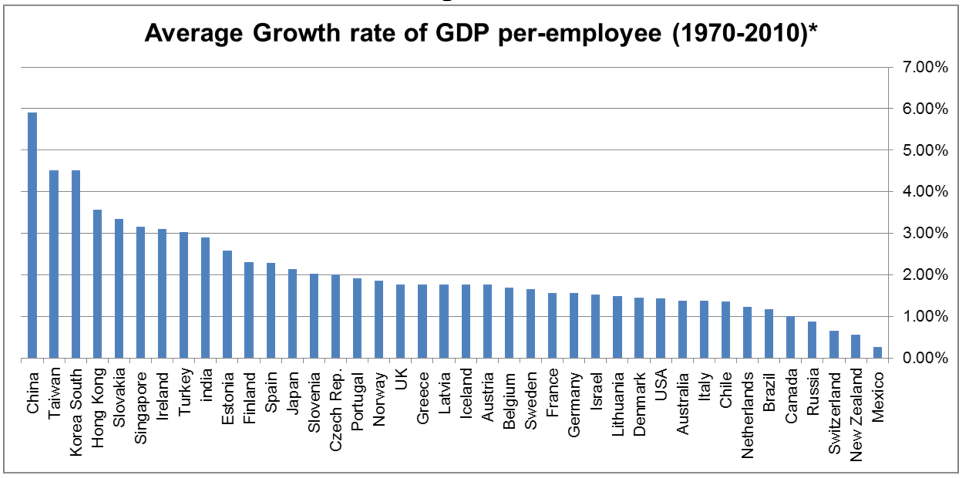
In order to decide which countries should be included in our the sample, we chose as a criterion, a threshold of 40% relative to the USA GDP per-capita, in 2008[10]. Lack of sufficient data forced us to omit Equatorial Guinea, Trinidad & Tobago, UAE, Mauritius, Kuwait and Belarus. "BRIC" countries (Brazil, Russia, India, and China), as well as Mexico and Turkey, had a GDP per-capita lower than the threshold; however, these countries are subject to a major scholarly attention concerning growth, and thus they were added to our sample. A list of the 41 countries used in this paper is specified in annex A.

The Dependent variable is GDP per-employee for the years 1970-2010. Data was taken from the Conference Board Total Economy Database, January 2013. We use 1990 US$ (PPP). During this period there were substantial changes in the GDP per-employee in the different countries, as shown in Figure 1. The six countries with the highest average growth rate

[10] We applied this threshold for the years 1995, 2000, 2005 and 2010. In general, results did not differ. For part of the years, Latvia, Chile, Czech Republic, Slovakia and Lithuania are left out. We also checked sensitivity by applying a 50% threshold; results did not differ by much.

(China, Taiwan, South Korea, Hong-Kong, Slovakia and Singapore) were subject to a substantial transition between educational levels (shown in annex B).

Figure 3



* Due to lack of data, a first year later than 1970 was used for the following countries: Estonia, Latvia, Slovenia, Czech Republic, Slovakia, Lithuania and Russia.

Our main explanatory variables are the education levels at different countries. Data is based on Benaabdelaali, Hanchane and Kamal (2012) dataset, who use estimates of average years of schooling from Barro and Lee (2010). This dataset specifies percentage of total population employed[11], according to different age groups (15 years and older), with 7 types of educational levels: (a) no formal education (b) some primary education (c) full primary education (d) some secondary education (e) full secondary education (f) some high education and (g) full high education. We choose the 25-29 age group, as in most countries labor force acquires its peak effective education level by this age[12]. In our analysis we use four of the seven educational levels: no formal education, some primary education (PRIM_EDUC_29), some secondary education (SEC_EDUC_29) and some higher education (HI_EDUC_29). Partial participation is accounted for, so as to allow categories summing up to 100 percent of the population[13]. Choosing this variable is one of the novelties of this study, as many papers take average years of schooling as an explanatory variable representing human capital. However, the two variables are well connected because if one multiplies the percentage of employees at each education level group, by the number of school years it takes to achieve this level of education, one will get average years of schooling. Using this variable enables us to highlight some aspects that years of schooling cannot. Mainly we can explore if for example 10 years of schooling, composed of 50% of the

[11] Though we use total population employed, data is available for male and female employed separately. One can consider using this data for future research regarding the effect that education levels of different gender have on GDP per-employee.

[12] The assumption here is that the education acquired at later stages of life, has lesser effect on a person's productivity at work. Naturally, one can dispute this assumption.

[13] Though it is interesting to explore the different effects partial and total education attainments have on GDP per-employee, note that data for additional three categories (full primary, full secondary and full high education) are extrapolated based on dropouts estimated ratios. Thus, more elaborated data is needed for assessing this issue in an accurate manner.

labor force with 8 years of education and 50% of the labor force with 12 years of education, are better or worse compared to 50% of labor force with 6 years of education and 50% of the labor force with 14 years of education.

One interesting additional explanatory variable used in this paper, based on Benaabdelaali, Hanchane and Kamal (2012), is the Gini coefficient for education levels of the 25-29 age group (EDUC_GINI_29). This variable measures educational inequality within a country. Note, however, that if a country's whole population has only high education, then there will be complete equality and the education Gini will be 0. The education Gini will also be 0 if a country's population has no education at all. Based on the above model, since no country fits either of the two extreme examples, this variable may potentially contribute to the explanation of GDP per-employee. Note, however, that the changes in this variable are included in the educational levels introduced above, and consequently we shall analyze its additional contribution (further elaboration is given in section 4.4.1).

A very important and basic explanatory variable is capital per-employee (CAPITAL_PEN/LABOR). Capital stock at constant 2005 national prices data is taken from Penn World Table - International Comparisons of Production, Income and Prices (version 8.0). Labor force data is taken from the OECD Annual labor force statistics database[14]. As in Barro and Lee (2010) and many other papers, we predict a strong positive coefficient for capital per-employee[15].

When dealing with GDP growth patterns, we must control for a country's quality of macroeconomic management. We construct a macro index (MACRO_IDX) using Sirimaneetham and Temple (2009) technique. This macro index is based on principal component analysis that provides a linear[16] combination of 5 variables: (a) Government deficit \ surplus (b) Inflation (CPI based) (c) Black Market Premium[17] (d) Overvalue of FX[18] (e) Real exchange rate variation. While a country's stable macro atmosphere is a necessary condition for growth, it is not a sufficient one. Hence, coefficient strength is predicted not to be large, and positive.

We use two additional macroeconomic variables. The first is government investment (GOV_INVEST), measured in 2000 constant prices. Data is taken from the GFS. The second is corporate statutory tax (CORP_TAX), measured as the top marginal tax rate for corporations. Data for the years 1981 and onwards is taken from OECD tax database. Previous data is taken from Michigan University tax database. We predict a negative sign for corporate statutory tax, and a positive one for government investments.

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[14] Israel Labor force data is based in BOI annual report statistic annex.

[15] While capital per-employee is clearly endogenous, note that under a cointegration framework its role is limited to contributing in explaining the long-run trend of the GDP per-employee.

[16] Macro index = 0.334*surplus-0.447*infla-0.585*bmp-0.347*overvalu-0.475*erate.

[17] This variable measures the difference between announced (if managed) and actual exchange rate. For years in which a country's exchange rate is not managed, this variable is 0.

[18] Overvalue = $\{[(E_t-E_{t-1})/E_{t-1}] - P_t+P_t^*\}$; E_t = Local Currency Unit per US$ (period average); P* = local Consumer Price Index (CPI); P* = U.S.A. CPI.

As in many studies dealing with growth[19], a set of seven explanatory variables tries to assess country's quality of Institutions and geography:

1. Open – A binary variable (1 for open). This variable assess the openness of a country to trade, based on the fraction of years during the period 1965-1990 in which the country is rated as an open economy according to the criteria in Sachs and Warner (1995). An economy is deemed to be open to trade if it satisfies four tests: (1) average tariff rates below 40 percent; (2) average quota and licensing coverage of imports of less than 40 percent; (3) a black market exchange rate premium that averaged less than 20 percent during the decade of the 1970s and 1980s; and (4) no extreme controls (taxes, quotas, state monopolies) on exports.
2. Coast – Measures the percentage of land area within 100 km of ice-free coast / river, calculated using 100 km from ice-free coast or navigable river buffer. Data was taken from the Center for International Development (Harvard university), based on Gallup et al. (2010).
3. Tropic – Measures the percentage land area in geographical tropics, calculated in equal area projection. Data was taken from the Center for International Development (Harvard university), based on Gallup et al. (2010).
4. Corruption index (CORRUPT_INDX) - Scale from 0 to 10. Low ratings indicate that high government officials are likely to demand special payments and similar acts. Score is based on the average status between 1982 and 1995. Data was taken from La Porta et al. (1999).
5. Ethnic – Measures the ethnic fractionalization in a country by specifying a country's largest ethnic group (percentage of total population); see Cederman et al. (2009).
6. Latitude – Latitude of a country's capital. Dividing by 90 normalizes this variable to a scale of 0 to 1 relative to the equator. Data was taken from La Porta et al. (1999).
7. Infrastructure index (INFRAS_INDX) – Assesses the ease of communication between headquarters and the operation, as well as the quality of the transportation in a country. Scale from 0 to 10, with higher scores for superior quality. Based on average data for the years 1972 to 1995[20]. Data was taken from La Porta et al. (1999).

We predict a positive sign for Coast, Open, Latitude, Infrastructure index and a negative one for Ethnic, Tropic and Corruption index.

4.2 Stylized Facts about Educational Levels across countries

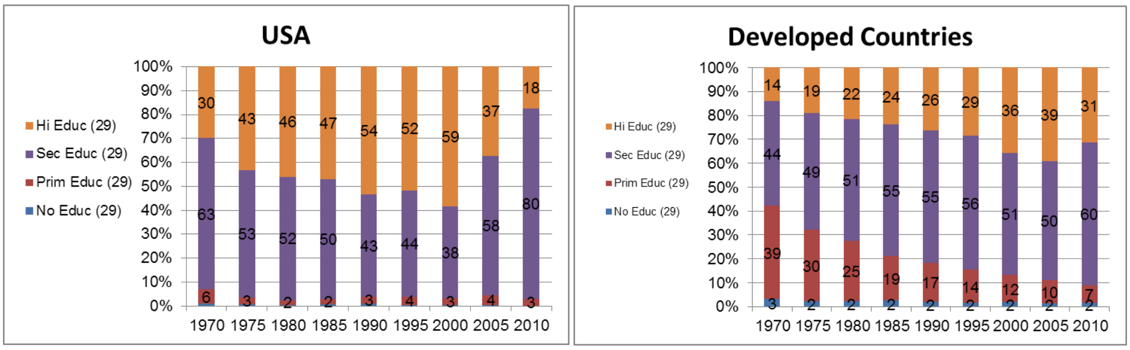
As explained above, we distinguish between four different educational levels: no formal education, primary, secondary and high education. Figures 4 to 7 show the transition of selected countries among these levels (the complete sample is shown at the annex B). Four different types of education levels patterns can be observed:

[19] For a recent contribution that also uses a cointegration framework, see Batisti, Vaio and Zeira (2014).

[20] See BERI's Operation Risk Index.

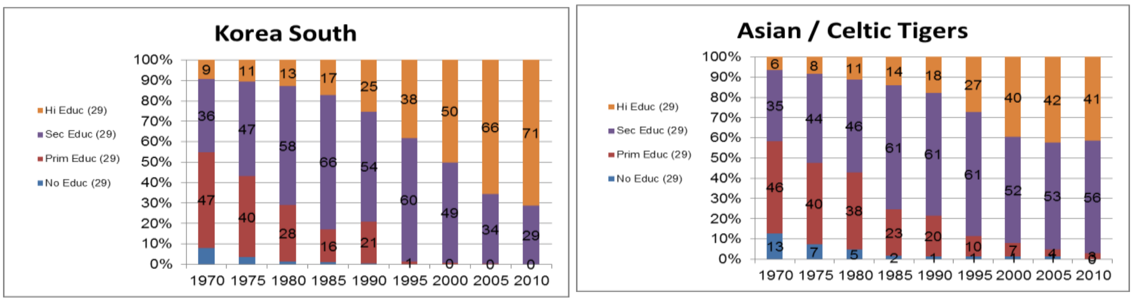
(1) Developed countries type[21] – Developed countries have been characterized by a high proportion of high education ever since the beginning of the sample. In addition, developed countries have practically no part of the population without any formal education. Consequently, as will be demonstrated later in this paper, countries of this type benefit considerably from the contribution that education has to GDP per-employee. Please refer to figure 4[22].

Figure 4 - Educational levels: Developed Economies



(2) Asian / Celtic Tigers type[23] – The four countries known as the Asian Tigers (Hong Kong, Singapore, Taiwan and South Korea) plus Ireland, experienced a similar education pattern. In the beginning of the sample 60% of the population had only primary education, or less. In all countries (mainly South Korea), major shifting occurred since, and consequently in 2010 education levels are similar, or higher, compared to developed countries, with almost no people without any formal education or with only primary education. Please refer to figure 5.

Figure 5 - Educational levels: Asian Tigers

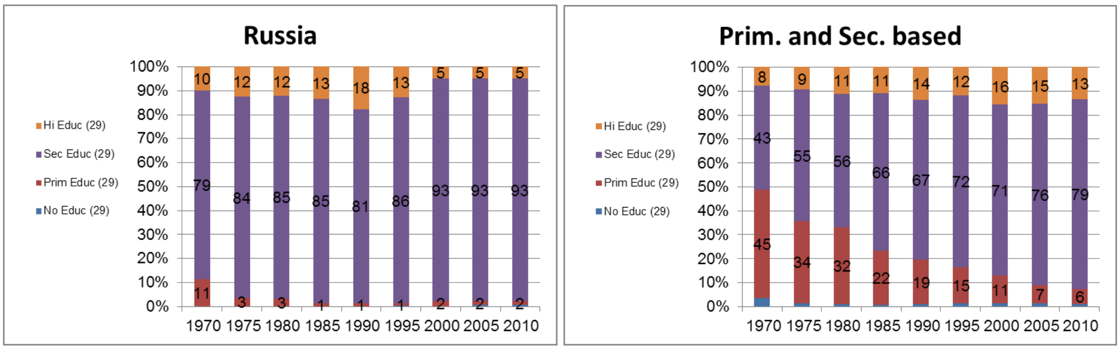


(3) Primary and Secondary education based type – Countries of this type, such as Russia and other ex-Soviet countries, are characterized by a vast majority of the population having primary and secondary education, and a small proportion of the population having high

[21] Corresponding to the 'D' countries group, mentioned in the model presented in section 3.2.
[22] Some countries in the sample experience a major change in 2010 relative to 2005 (previous observation reported by Barro and Lee). Though no data is left out, we believe this is an anomaly, as such a change in only 5 years, does not make sense.
[23] Corresponding to the AT countries group, mentioned in the model presented in section 3.2.

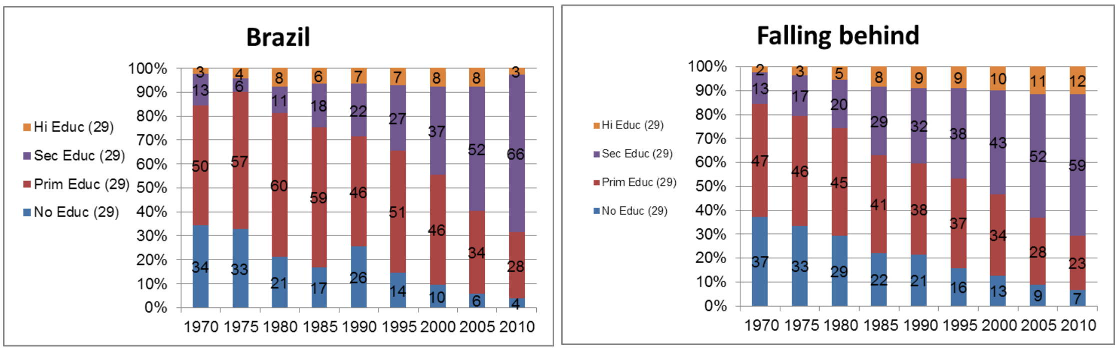
education. In these countries practically no part of the population has no formal education. Please refer to figure 6.

Figure 6 - Educational levels: Primary and Secondary based Countries



(4) Falling behind type[24] – Countries of this type have a very bad starting point with regard to education level, as a very high portion of the population had no formal education, or only primary education, at the beginning of the sample. In addition, unlike the Asian / Celtic Tigers group, education progress focused only with getting people up to the secondary level, leaving substantial proportion of the population with only primary education. High education proportion is very limited even towards the end of the period. Please refer to figure 7.

Figure 7 - Educational levels : Falling Behind Countries



Figures 4 to 7 combined with Figure 3, tells us a story that will be corroborated by the econometric cointegration framework presented in the next section. Some countries drive a significant part of its population to achieve a high education level, while others keep significant parts of it with only primary education or less. Though fast growing countries such as China, can have not more than a medium education level while experiencing a rapid growth pace, a clear correlation between GDP per-employee growth and education level, can be observed. Even more, countries that made the biggest leap are countries whose population went from no formal education level to secondary or high education level. These patterns are analyzed in the next sub-section.

[24] Corresponding to the FB countries group, mentioned in the model presented in section 3.2.

4.3 A Cointegration Framework

The issue dealt here raises serious endogenous problems as it is a well-known phenomenon that the richer a country gets, the higher its education expenses are, and hence, its education level[25]. For this reason we choose a cointegration econometric framework to analyze the effect different education levels have on GDP per-employee. We estimate 10 basic different specifications using well known GDP per-employee contributing factors, such as capital stock per-employee and various macroeconomic variables[26,27]. All specifications include levels of education, as well as education Gini index, as explanatory variables. For every specification residuals, we run a unit root test (ADF - Fisher Chi-square) in order to check the existence of a cointegrative relationship. Both the statistic and the probability for this test are reported at the top of Table 2. Then, we proceed by calculating the ADF of the regression when excluding each of the explaining variables that were included in the original regression, one by one. By doing so we are able to check whether a particular variable is crucial for the cointegrative relationship. A variable is denominated "crucial" if its exclusion implies that the residual is not stationary anymore (as assessed by using the ADF Statistic).

In all of our regressions, except AMY 4 and 5, the ADF statistic is significant at 5%, implying that almost all cointegration specifications are solid. It should be noted that a different unit root test, other than ADF - Fisher Chi-square, can be chosen for this purpose. We choose to use this test as it assumes the existence of individual unit root process, so that the lagged observation coefficient may vary across cross-section units; meaning: different countries are allowed to have different coefficients. This technique, as well as the different applicable tests, is discussed in Maddala and Wu (1999).

In order to examine how different levels of high education affect the GDP per-employee, we construct four dummy variables for four different ranges of high education within a country. These levels are: (1) below 12 percent of total population has some high education (D_HIEDUC_U12); (2) between 12 and 25 percent of total population has some high education (D_HIEDUC_12_25); (3) between 25 and 40 percent of total population has some high education (D_HIEDUC_25_40); and, (4) above 40 percent of total population has some high education (D_HIEDUC_O25). Multiplying the variable with the corresponding dummy enables us to assess how different levels of high education affect GDP per-employee[28]. As reported, specifications do not contain the no-education proportion as it is assumed that its return is zero[29].

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[25] See: Bils and Klenow (1996).

[26] Beside variables that have a relatively low time-series variation, the variables were found to be I(1) according to ADF criteria.

[27] We run the same 10 basic regressions adding net natural resources export as an explanatory variable. Results did not differ by much and evidence of cointegration relationship was not found, hence it is left out.

[28] We also apply all specified tests to a continuance model, using (hi_educ) and (hi_educ)^2 instead of the 4 dummy variables representing the 4 groups. In general, we find similar results, including diminishing return of high education as shown in section 4.4.1. However, the turning point is found to be at about 70% (and not 40%, as we show in the next section).

[29] See: Hall and Jones (1999).

4.4 Empirical Results

4.4.1 Long term GDP per-employee

In table 2 regressions results are reported. The dependent variable is the logarithmic transformation of the GDP per-employee. For all specifications the time span, as well as the total number of observations, are reported.

Educational return, estimated in all specifications, ascends as a country climbs the educational levels ladder. For example, by taking AMY 10 we learn that: when high education level within a country is below 12%, total return is 2.15%; when it is between 12% and 25%, it becomes 2.53%; when it is between 25% and 40%, it is 2.45%; and when it exceeds 40% it diminishes to 2.04%. Note that all mentioned returns are higher than the return on secondary education (1.54%), and primary education (1.04%). The theoretical model presented in section 3 addresses this issue, as it demonstrates what happens every time a country is rich enough so as to invest more in education. In other words, being richer enables a country to climb to the next education stage, with the same tax rate.

A very important feature that can be observed in all specifications, is that escalating from 25 to 40 percent of employees at higher education, to more than 40 percent, reduces the return of a one percent increase in higher education from 2.1 to 1.76 percent (numbers here are average, taken from table 4, but the diminishing returns pattern is the same in all specifications). This result should be addressed very seriously, as it implies high education's contribution to growth is not without boundaries.

In order to make sure that high education is important for the cointegration relationship, we need to examine the ADF statistic that is obtained by removing the educational transition, and compare it to the basic one. By looking at AMY1 we learn that the ADF goes down from 103.1 to 62.0, which implies that the cointegration relationship changes from a 2 percent significant relationship to no significance (we show in parentheses the significance level, which for AMY1 is 0.4). This result is interesting: it means that the escalation of the educational ladder is a crucial variable for explaining the differences of GDP-per employee between countries. The other crucial variable is the capital stock per-employee, whose ADF declines to 65.99 (i.e., cointegration becomes insignificant).

Note that the education Gini is positive, but with a rather low contribution to the ADF. It seems that the explanation for this result is related to the fact that the increase in education equality is already captured by the climb along educational levels, which enhances growth.

Thus, its additional contribution to the explanation of GDP per-employee is related to effects that were not captured by the educational levels. In particular, it captures the level of no schooling, which was left out; thus, not surprising it has a positive contribution to GDP per-employee. Having said that, all 10 basic specifications are also regressed without the educational level variables, leaving education Gini as a proxy to Human capital. We find evidence of weak cointegration, implying that education inequality cannot serve as a substitute for education level. We also find a negative coefficient, meaning the more equal an education level of a country is, the higher it's GDP per-employee will be.

Table 2 - Explaining GDP per Employee

Dependent variable: LOG(GDP_PER_EMP)										
Name	**AMY_01**	**AMY_02**	**AMY_03**	**AMY_04**	**AMY_05**	**AMY_06**	**AMY_07**	**AMY_08**	**AMY_09**	**AMY_10**
Period	1970-2010	1970-2010	1970-2010	1970-2010	1970-2010	1970-2010	1970-2010	1970-2010	1970-2010	1970-2010
Observ #	1064	991	1064	947	1023	1064	991	1064	1212	1216
Basic ADF	103.11	84.25	106.10	86.18	69.92	90.08	84.73	104.20	109.85	110.22
ADF Prob.	0.0210**	0.0432**	0.0039***	0.0829*	0.1035	0.0167**	0.0132**	0.0016***	0.0213**	0.0210**
LOG(CAPITAL_PEN/LABOR)	0.5625	0.5621	0.5156	0.4104	0.4972	0.5601	0.5102	0.5632	0.5621	0.5600
	0.0118	0.0125	0.0124	0.0131	0.0131	0.0113	0.0129	0.0118	0.0115	0.0116
	66.0 *(0.2)*	72.3*(0.1)*	75.9*(0.0)*	44.1*(0.8)*	73.0*(0.0)*	78.5*(0.0)*	77.4*(0.0)*	66.2*(0.2)*	68.9*(0.7)*	69.5*(0.6)*
(HI_EDUC_29)*D_HIEDUC_U12	0.0179	0.0231	0.0169	0.0199	0.0152	0.0166	0.0235	0.0179	0.0221	0.0215
	0.0037	0.0039	0.0036	0.0033	0.0035	0.0035	0.0037	0.0037	0.0039	0.0039
	62.0(0.4)	*55.8(0.6)*	*60.7(0.5)*	*67(0.0)*	*62.4(0.3)*	*63.4(0.4)*	*63.6(0.4)*	*55.5(0.6)*	*96(0.0)*	*96(0.0)*
(HI_EDUC_29)*D_HIEDUC_12_25	0.0182	0.0214	0.0180	0.0226	0.0169	0.0170	0.0227	0.0185	0.0256	0.0253
	0.0024	0.0024	0.0023	0.0021	0.0022	0.0022	0.0023	0.0024	0.0025	0.0025
	62.0(0.4)	*55.8(0.6)*	*60.7(0.5)*	*67(0.0)*	*62.4(0.3)*	*63.4(0.4)*	*63.6(0.4)*	*55.5(0.6)*	*96(0.0)*	*96(0.0)*
(HI_EDUC_29)*D_HIEDUC_25_40	0.0189	0.0217	0.0192	0.0243	0.0178	0.0185	0.0235	0.0191	0.0248	0.0246
	0.0021	0.0022	0.0020	0.0019	0.0020	0.0020	0.0021	0.0021	0.0023	0.0023
	62.0(0.4)	*55.8(0.6)*	*60.7(0.5)*	*67(0.0)*	*62.4(0.3)*	*63.4(0.4)*	*63.6(0.4)*	*55.5(0.6)*	*96(0.0)*	*96(0.0)*
(HI_EDUC_29)*D_HIEDUC_O40	0.0151	0.0181	0.0163	0.0240	0.0139	0.0155	0.0212	0.0154	0.0206	0.0204
	0.0021	0.0022	0.0020	0.0019	0.0020	0.0020	0.0021	0.0021	0.0022	0.0022
	62.0(0.4)	*55.8(0.6)*	*60.7(0.5)*	*67(0.0)*	*62.4(0.3)*	*63.4(0.4)*	*63.6(0.4)*	*55.5(0.6)*	*96(0.0)*	*96(0.0)*
SEC_EDUC_29	0.0110	0.0138	0.0129	0.0219	0.0110	0.0109	0.0178	0.0114	0.0154	0.0154
	0.0020	0.0021	0.0019	0.0018	0.0019	0.0019	0.0020	0.0020	0.0022	0.0022
	93.2*(0.0)*	75.2*(0.0)*	79.4*(0.0)*	57.5*(0.2)*	65.0*(0.2)*	71.7*(0.1)*	73.2*(0.1)*	93.2*(0.0)*	105.1*(0.0)*	101.7*(0.0)*
PRIM_EDUC_29	0.0063	0.0076	0.0077	0.0141	0.0079	0.0066	0.0103	0.0068	0.0106	0.0104
	0.0016	0.0016	0.0015	0.0015	0.0015	0.0015	0.0016	0.0016	0.0017	0.0017
	93.7*(0.0)*	78.4*(0.0)*	89.1*(0.0)*	57.5*(0.2)*	66.1*(0.2)*	77.6*(0.0)*	80.2*(0.0)*	93.7*(0.0)*	104.5*(0.0)*	104.1*(0.0)*
EDUC_GINI_29	0.0067	0.0098	0.0089	0.0095	0.0073	0.0067	0.0139	0.0065	0.0103	0.0101
	0.0019	0.0020	0.0018	0.0017	0.0018	0.0018	0.0019	0.0019	0.0020	0.0020
	93.7*(0.0)*	72.5*(0.1)*	85.7*(0.0)*	66.1*(0.0)*	62.4*(0.3)*	78.5*(0.0)*	79.7*(0.0)*	91.9*(0.0)*	103.4*(0.0)*	102.8*(0.0)*
MACRO_IDX	-0.0011	-0.0014	-0.0014	-0.0004	-0.0020	-0.0007	-0.0018	-0.0011	-0.0007	-0.0006
	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	81.3*(0.0)*	80.8*(0.0)*	81.8*(0.0)*	61.1*(0.2)*	80.8*(0.0)*	70.7*(0.1)*	78.8*(0.0)*	87.0*(0.0)*	117.6*(0.0)*	118.7*(0.0)*
OPEN	0.2096	0.1865	0.2343	0.0654	0.3153	0.1558	0.2141	0.2152		
	0.0263	0.0276	0.0254	0.0278	0.0294	0.0256	0.0264	0.0268		
	103.1*(0.0)*	98.0*(0.0)*	112.4*(0.0)*	60.8*(0.2)*	103.6*(0.0)*	101.2*(0.0)*	96.3*(0.0)*	102.1*(0.0)*		
TROPIC	-0.3560	-0.3489	-0.2497	-0.6021	-0.3045	-0.0943	-0.2185	-0.3576	-0.3044	-0.2778
	0.0386	0.0405	0.0388	0.0501	0.0372	0.0446	0.0403	0.0387	0.0408	0.0437
	89.4*(0.0)*	89.5*(0.0)*	95.2*(0.0)*	70.6*(0.0)*	72.6*(0.0)*	85.7*(0.0)*	88.3*(0.0)*	89.3*(0.0)*	99.3*(0.0)*	102.1*(0.0)*
COAST	0.0056	0.0070	0.0350	-0.0764	-0.0130	0.0586	0.0398	0.0100		0.0348
	0.0187	0.0190	0.0182	0.0163	0.0178	0.0185	0.0185	0.0191		0.0203
	97.4*(0.0)*	79.9*(0.0)*	96.3*(0.0)*	61.0*(0.1)*	71.5*(0.1)*	85.4*(0.0)*	86.8*(0.0)*	97.5*(0.0)*		103.0*(0.0)*
LOG(CORP_TAX)		-0.1415					-0.2004			
		0.0249					0.0242			
		97.4*(0.0)*					93.2*(0.0)*			
LOG(CORRUPT_INDX)			0.3055				0.3495			
			0.0327				0.0335			
			97.4*(0.0)*				79.2*(0.0)*			
LOG(GOV_INVEST)				-0.0183						
				0.0021						
				61.0*(0.0)*						
LOG(INFRAS_INDX)					0.3893					
					0.0390					
					97.4*(0.0)*					
LATITUDE						0.0047				
						0.0005				
						97.4*(0.0)*				
LOG(ETHNIC)							-0.0212	-0.0291		
							0.0250	0.0253		
							85.4*(0.0)*	97.4*(0.0)*		
C	6.2691	6.4952	5.6377	6.4338	5.7578	6.0440	5.8875	6.3538	5.8990	5.8961
	0.1988	0.2023	0.2025	0.1723	0.1912	0.1904	0.2180	0.2120	0.2138	0.2136

Comments for table 2:

(1) (***) is for 1% significance; (**) is for 5% significance, (*) is for 10% significance.
(2) S.D. as well as ADF coefficient is reported below each variable's coefficient. ADF coefficient's significance level is reported in parentheses.
(3) ADF test is preformed to all high education proportion as a whole. Therefor ADF statistics reported are the same.

Though important and interesting, the rest of the variables are reported but not discussed in detail due to our will to stay focused with educational levels results. Still, in general we see that for all specifications other than AMY5[30], the vast majority of variables bear the expected

[30] It is not unexpected, as it is the only one that is not even 10% significant.

sign. With regard to the ADF statistics, most variables are found to contribute to the cointegration relationship, but less than high education and capital per-employee, as the reported ADF decline is modest.

Elaboration regarding the meaning of the coefficients and comparison to previous literature is called for. As specified in table 4, we find that adding one percent of labor force to the group with only some primary education adds 0.8253% to the GDP per-employee[31]. Taking the same one percent and adding it to the secondary educated group, adds 0.5283% to the GDP per-employee (the difference between 1.3536% and 0.8253%). Taking the same one percent and adding it to the high educated group, if proportion of labor force with high education is below 12%, adds 0.6409% to the GDP per-employee (the difference between 1.9945% and 1.3536%). Please be noted that the diminishing return of the leap from the 25%-40% group to the above 40% group, means that taking an additional one percent, while the existing proportion of labor force with high education is exactly 40%, causes return to be negative (decline from 2.106% to 1.767%)[32].

Since primary education is assumed to be 6-8 years long, the 0.8253% return mentioned above equals a return of 10.31%-13.75%[33] to one extra year of schooling. Return for secondary education is 13.2%-17.61%. Return for high education (if proportion of labor force with high education is below 12%) is 16.02%-21.36%. In general, rates of return reported here are higher than those found in most of the labor literature[34], as well as those reported by Barro and Lee (2010).

4.4.2 Short term GDP per-employee

In table 3 we report the results for the short term regressions. By regressing the difference of the logarithmic transformation of GDP per-employee on the difference of the logarithmic transformation of the explanatories variables, and adding the lagged residuals [presented as R(-1)] derived from the long term regressions in table 2, we check whether short term convergence exists.

[31] Be advised that as mentioned in section 4.3, specifications do not contain the no-education, as we assume that its return is zero. Meaning this is the origin for the marginal one percent of labor force.

[32] In order to make sure results are solid for all groups, we count the number of countries and the number of observations composing each of the four categories. We find that the smallest group (countries with high education above 40%) includes 161 observations (about 10% of the sample) and 15 different countries (out of 41).

[33] Adding one percent of labor force to the primary education group, rises average years of schooling for total labor force by 0.06 to 0.08 years, and donate 0.8253% to GDP per-employee. Hence a full year of schooling donates 13.75% to 10.31% to GDP per-employee, respectively.

[34] Bear in mind that the dependent variable in the labor force literature is wage, as here it is GDP per-employee. Also, labor force literature does not tackle externalities between individuals, surly exist when discussing macro-economic growth.

Table 3 - Short-run Regressions

Dependent variable: DLOG(GDP_PER_EMP)										
Name	**D_AMY 01**	**D_AMY 02**	**D_AMY 03**	**D_AMY 04**	**D_AMY 05**	**D_AMY 06**	**D_AMY 07**	**D_AMY 08**	**D_AMY 09**	**D_AMY 10**
Period	1971-2010	1971-2010	1971-2010	1971-2010	1971-2010	1971-2010	1971-2010	1971-2010	1971-2010	1971-2010
Observ #	1034	946	1034	920	994	1034	946	1034	1178	1178
Durbin-Watson stat	1.624	1.643	1.628	1.778	1.632	1.625	1.645	1.626	1.463	1.468
R-squared	0.43	0.43	0.44	0.39	0.43	0.43	0.44	0.43	0.39	0.39
DLOG(CAPITAL_PEN/LABOR)	0.4847***	0.4738***	0.4628***	0.3480***	0.4164***	0.4833***	0.4572***	0.4796***	0.4885***	0.4877***
	18.786	17.621	16.886	12.510	14.821	18.457	16.173	18.563	17.890	17.891
D(HI_EDUC_29)*(D_HIEDUC _U12)	0.0092***	0.0082***	0.0081***	0.0070***	0.0069***	0.0089***	0.0074***	0.0086***	0.0085***	0.0084***
	3.913	3.441	3.405	3.071	2.870	3.805	3.066	3.642	3.588	3.525
D(HI_EDUC_29)*(D_HIEDUC _12_25)	0.0057**	0.0049**	0.0047**	0.0036	0.0034	0.0055**	0.0041*	0.0052**	0.0083***	0.0082***
	2.492	2.112	2.030	1.596	1.437	2.412	1.747	2.276	3.581	3.520
D(HI_EDUC_29)*(D_HIEDUC _25_40)	0.0069***	0.0057**	0.0060**	0.0052**	0.0048**	0.0067***	0.0050**	0.0064***	0.0086***	0.0085***
	2.928	2.386	2.512	2.257	1.970	2.864	2.056	2.725	3.597	3.546
D(HI_EDUC_29)*(D_HIEDUC _O40)	0.0053**	0.0047*	0.0041	0.0042*	0.0034	0.0049*	0.0038	0.0048*	0.0065**	0.0066**
	2.058	1.813	1.607	1.673	1.279	1.938	1.478	1.867	2.492	2.519
D(SEC_EDUC_29)	0.0061**	0.0052**	0.0050**	0.0047**	0.0036	0.0059**	0.0044*	0.0055**	0.0087***	0.0085***
	2.604	2.217	2.132	2.041	1.513	2.514	1.846	2.344	3.639	3.557
D(PRIM_EDUC_29)	0.0062**	0.0054***	0.0054***	0.0049**	0.0046**	0.0059***	0.0048**	0.0055***	0.0074***	0.0071***
	3.173	2.735	2.767	2.542	2.347	3.076	2.429	2.826	3.673	3.519
D(EDUC_GINI_29)	0.0015	0.0006	0.0012	0.0004	0.0002	0.0014	0.0003	0.0015	0.0063***	0.0062***
	0.663	0.240	0.519	0.176	0.069	0.586	0.144	0.647	2.948	2.934
D(MACRO_IDX)	0.0004*	0.0004**	0.0004*	0.0006**	0.0004*	0.0004*	0.0004**	0.0003	0.0002	0.0002
	1.865	2.020	1.849	2.093	1.882	1.849	2.022	1.629	1.015	1.052
OPEN	0.0068**	0.0044	0.0054*	0.0094***	0.0064**	0.0045	0.0063*	0.0059*		
	2.290	1.463	1.840	2.602	1.874	1.539	1.901	1.868		
TROPIC	0.0003	0.0006	-0.0056	0.0143**	-0.0099**	-0.0015	-0.0059	-0.0012	-0.0029	-0.0069
	0.078	0.128	-1.117	2.306	-2.065	-0.267	-1.071	-0.259	-0.658	-1.428
COAST	-0.0028	-0.0026	-0.0033	0.0042*	-0.0029	-0.0028	-0.0031	-0.0020		-0.0052**
	-1.289	-1.151	-1.488	1.872	-1.322	-1.216	-1.332	-0.892		-2.171
DLOG(CORP_TAX)		-0.0062					-0.0071			
		-0.705					-0.804			
LOG(CORRUPT_INDX)			-0.0091**				-0.0081**			
			-2.337				-2.050			
DLOG(GOV_INVEST)				0.0142***						
				3.272						
LOG(INFRAS_INDX)					-0.017***					
					-4.183					
LATITUDE						-0.0000				
						-0.567				
LOG(ETHNIC)							-0.0015	-0.0035		
							-0.553	-1.359		
R(-1)	-0.015***	-0.011***	-0.018***	-0.009*	-0.016***	-0.018***	-0.012***	-0.017***	-0.018***	-0.018***
	-3.861	-2.641	-4.540	-1.835	-3.819	-4.518	-2.772	-4.335	-4.912	-4.893
C	0.0030	0.0048	0.0247	-0.0023	0.0397	0.0066	0.0280	0.0186	0.0097	0.0132

Comments for table 3:

(1) (***) is for 1% significance; (**) is for 5% significance; (*) is for 10% significance.
(2) t-Statistic is reported below each variable's coefficient.
(3) Open, Tropic, Coast, Infrastructure index, Ethnic and Latitude, are not differenced as (here) they don't change over time.

As shown, for all regressions, R(-1) sign is negatively significant (for D_AMY 04 it is only 10% significant, for the rest it is 1%) and with an absolute value that ranges between 0 and minus 1. This means that once it runs out of its long term pattern, the GDP per-employee converges towards the long-run level. The table also reports R-squared values for all regressions (ranging from 39% to 43%), and the Durbin-Watson statistic (ranging from 1.46 to 1.77).

4.5 A simulation of GDP per-capita level changes attributed to education

Using a simulation based on the estimated returns derived from the above long run econometric estimation, we show the importance that education has on growth.

Out of the 10 regressions reported in table 2, we chose only the seven regressions complying a 5% ADF statistic significance (AMY 1, 2, 3, 6, 7, 8, 9 & 10) and calculate the average effect that each level of education has on growth. Results are reported in Table 4.

Table 4 - The return to Educational Levels

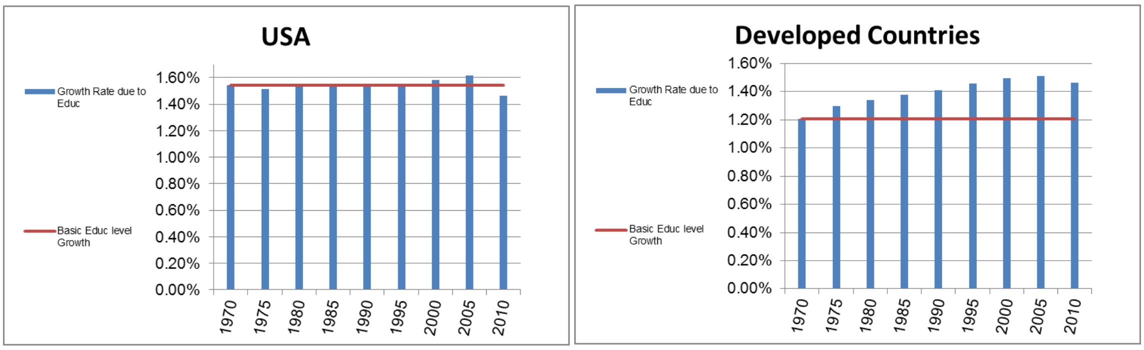
	AMY01	AMY02	AMY03	AMY04	AMY05	AMY06	AMY07	AMY08	AMY09	AMY10	Educational Return: 5% significance based Average
PRIM_EDUC_29	0.632%	0.760%	0.768%	1.407%	0.791%	0.659%	1.028%	0.653%	1.061%	1.041%	**0.8253%**
SEC_EDUC_29	1.103%	1.380%	1.292%	2.188%	1.099%	1.093%	1.777%	1.098%	1.544%	1.542%	**1.3536%**
(HI_EDUC_29)*(D_HIEDUC_U12)	1.789%	2.314%	1.691%	1.991%	1.523%	1.659%	2.346%	1.794%	2.210%	2.153%	**1.9945%**
(HI_EDUC_29)*(D_HIEDUC_12_25)	1.824%	2.138%	1.800%	2.257%	1.687%	1.701%	2.274%	1.614%	2.560%	2.535%	**2.0557%**
(HI_EDUC_29)*(D_HIEDUC_25_40)	1.885%	2.168%	1.916%	2.433%	1.783%	1.845%	2.354%	1.742%	2.479%	2.458%	**2.1060%**
(HI_EDUC_29)*(D_HIEDUC_O40)	1.512%	1.813%	1.629%	2.399%	1.389%	1.546%	2.120%	1.422%	2.060%	2.041%	**1.7679%**

Based on the above results we try to assess each country's change in GDP per-employee level that can be attributed to education. Results are reported in the following figures (blue columns). For the reader's convenience, figures 8 to 11 also draw the basic change of GDP per-employee level that can be attributed to education in 1970 (the base year) (red line).

Following the same four types discussed in section 4.2, we draw the following conclusions:

(1) Developed countries type – Since these countries are characterized by a relatively high education level ever since the beginning of the sample, the change of GDP per-employee level that can be attributed to education is high since the beginning, with almost no change. As shown in Figure 8, education attributed change rises slightly from 1.2% to 1.4% for the average of all developed countries, and remains stable at a high level of 1.5% -1.6% for USA.

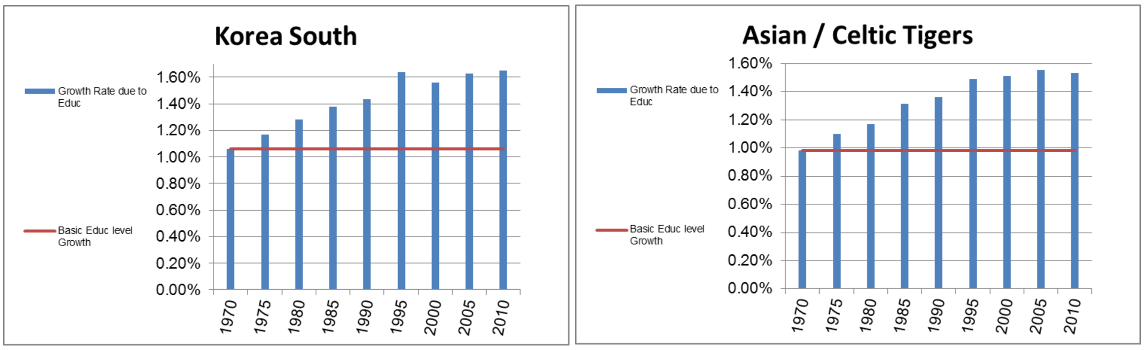
Figure 8 - Rise in GDP per-employee atributed to education: Developed Countries



(2) Asian / Celtic Tigers type - Due to major changes in education level, change in GDP per-capita level that can be attributed to education climbs sharply since the beginning of the sample. As shown in Figure 9, this value reaches 1.5% in 2010 (close to the developed countries values) from a basic value of less than 1%. The empirical results in this paper

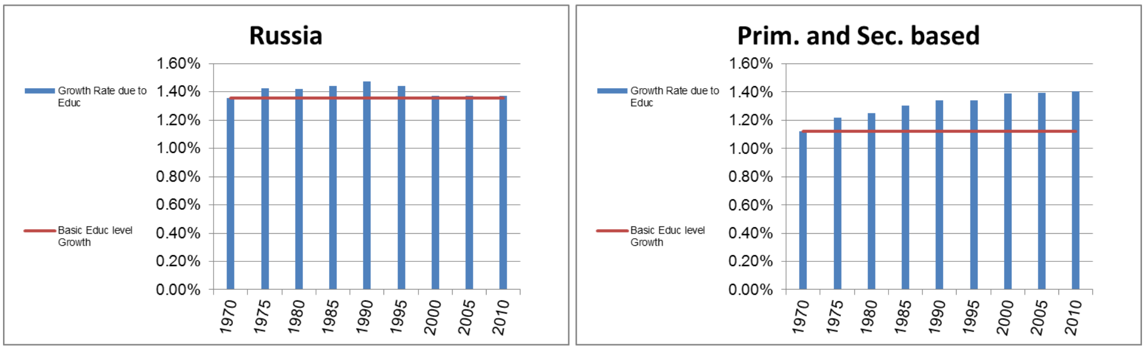
predict that the rapid development in these countries will continue, because of the dramatic changes in investment in education.

Figure 9 - Rise in GDP per-employee atributed to education: Asian Tigers



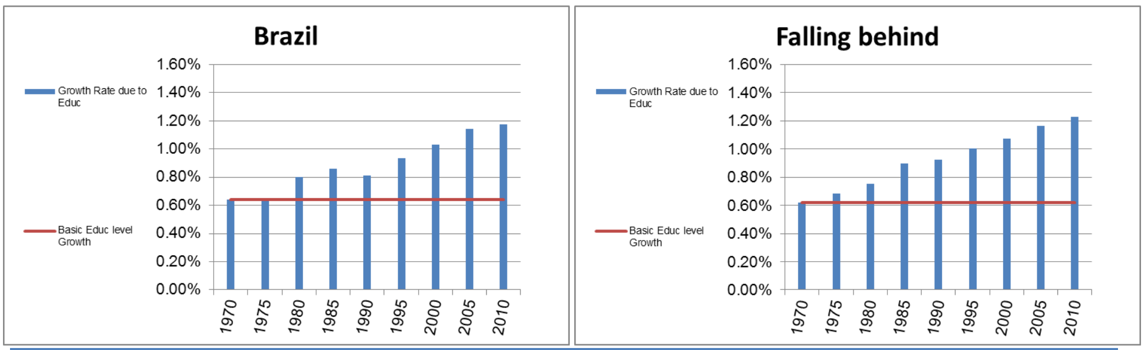
(3) Primary and Secondary education based type – as shown above, education level in countries of this type, did not change much since the beginning of our sample. Secondary education steadily constitutes very high proportion. Since this structure of education is stable, as demonstrated in figure 10, change in GDP per-capita level that can be attributed to education rises only from about 1.1% to about 1.4%. For Russia it is steady, as the attributed change in 1970 and 2010 is t about 1.3% - 1.4%.

Figure 10 - Rise in GDP per-employee atributed to education: Primary and Secondary based Countries



(4) Falling behind type – countries of this type have a very low, though substantially improving, GDP per-capita that can be attributed to education level. As demonstrated in figure 11, base year value is about 0.6% and 2010 value rises substantially to a 1.2%, comparable to the low end that all other groups of countries experienced 30 years ago, in 1980.

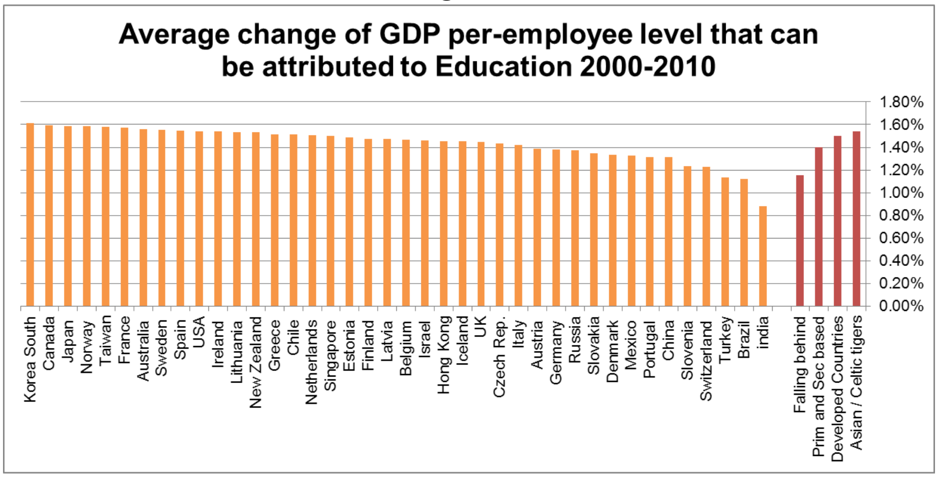
Figure 11 - Rise in GDP per-employee atributed to education: Falling Behind Countries



It is plausible that human capital and physical capital are jointly endogenous[35]. Under this hypothesis, we shall estimate the indirect effect of education that is caused by its positive effect on the capital stock. We do so by regressing exactly the same specifications above, substituting the dependent variable to capital per-employee[36]. Among the different specifications, only the equivalent to AMY 4 has a significant ADF. In this specification, adding one percent of labor force to a high education group adds between 5.7% and 7.2% to the capital stock. Since the capital stock's coefficient in the corresponding original regression (as reported in table 2) is about 41%, the indirect effect ranges between 2.33% and 2.95%.

Figure 12 summarizes average change of GDP per-capita level that can be attributed to education, as calculated by the direct effect of the simulation presented here, for all countries, between 2000 and 2010[37]. The relative position of each country might suggest future changes of GDP per-capita patterns. In a very successful process, the Asian / Celtic tigers invested a lot of their growth fruits and enhanced the level of education for their population. In turn, this level of education is expected to sustain future, as well as some of what we see in the last years, changes of GDP per-capita level.

Figure 12



[35] See: Grier (2002, 2005).
[36] Full results are not reported here and are available on request.
[37] Findings were also checked for the period 2005-2010. No major changes were observed.

5. Summary and Conclusions

In the seventies many developing economies had a high proportion of their population with virtually no schooling or with a high proportion of individuals that only finished primary school. This fact generated a huge incentive to perform an educational reform, which allows individuals to climb along the educational ladder. In some countries this reform resulted in a path-breaking growth that transformed them into developed economies, while in other countries the reform generated only accelerated growth that did not change their status.

This pattern calls for an empirical examination of the transition between educational levels and its quantitative importance for increasing the GDP per-employee. Using a sample of developing and developed economies in the period 1970-2010, we check the transitions among primary, secondary and high education. For this purpose we build a simple theoretical model that allows us to understand this transition. We assume that the government is restrained from providing free higher education to everyone since it cannot impose a burden that is higher than the Laffer's tax rate. Given this constraint, we show that some countries will be able to escalate the educational ladder quicker than others, allowing a transition from developing to developed economies.

In order to assess the importance of the educational reform we use a cointegration framework, and check whether the escalation through educational levels is crucial for explaining the increase in the GDP per-employee between 1970 and 2010. We find that for some countries in our sample, the escalation to higher educational levels contributes substantially to the transition process from a developing economy to a developed one.

We also find that an excess of higher education implies diminishing returns: increasing the proportion of individuals that participate in higher education from the range of 25-40 percent of labor force, to more than 40 percent, results in a reduction of the marginal return to education from 2.1 to 1.76 percent.

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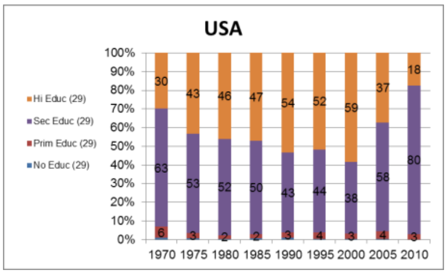
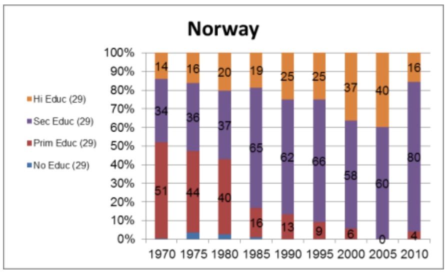
Annex A –Full list of countries:

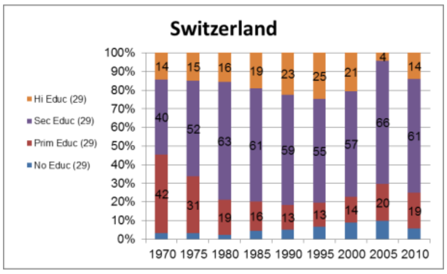
#	Country name	2008 GDP per-capita (US $)
(1)	USA	31,251.27
(2)	Hong Kong	29,810.26
(3)	Norway	28,430.29
(4)	Singapore	26,638.20
(5)	Switzerland	25,293.19
(6)	Canada	25,262.07
(7)	Australia	25,218.24
(8)	Sweden	25,181.21
(9)	Netherlands	25,112.31
(10)	Denmark	24,788.59
(11)	Finland	24,694.07
(12)	UK	23,926.69
(13)	Austria	24,565.47
(14)	Ireland	26,074.69
(15)	Belgium	23,701.33
(16)	Japan	22,175.13
(17)	France	22,057.35
(18)	Taiwan	21,554.07
(19)	Estonia	21,325.35
(20)	Germany	20,801.44
(21)	Korea South	20,453.78
(22)	Italy	19,473.23
(23)	New Zealand	18,875.34
(24)	Israel	18,833.95
(25)	Slovenia	18,745.07
(26)	Spain	17,756.98
(27)	Greece	15,845.60
(28)	Iceland	26,878.90
(29)	Turkey	8,126.94
(30)	Portugal	14,583.52
(31)	Latvia	14,332.80
(32)	Chile	13,479.09
(33)	Czech Rep.	13,476.41
(34)	Slovakia	13,037.09
(35)	Lithuania	11,768.21
(36)	Puerto Rico	15,074.16
(37)	Russia	9,038.49
(38)	Mexico	7,977.51
(39)	China	6,197.34
(40)	Brazil	6,541.13
(41)	India	2,952.69

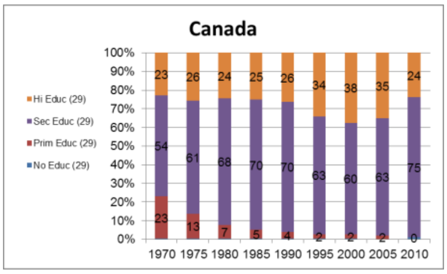
Annex B – Education patterns for all 41 countries in the sample:

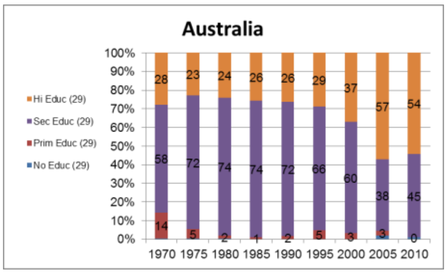
(1) Developed countries type:

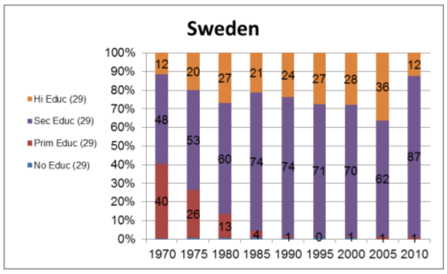


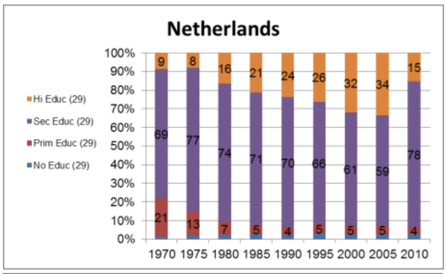


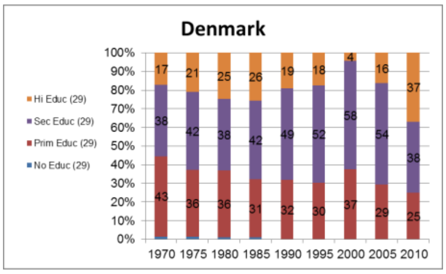


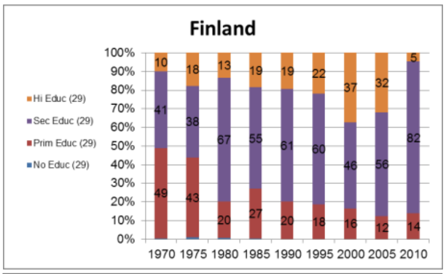


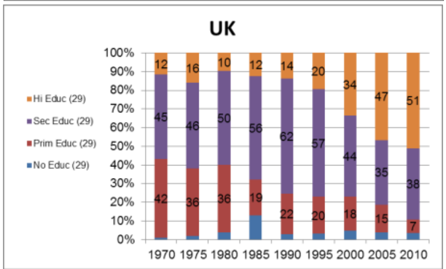


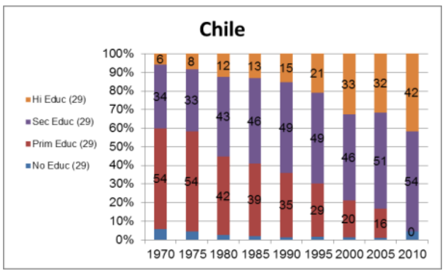


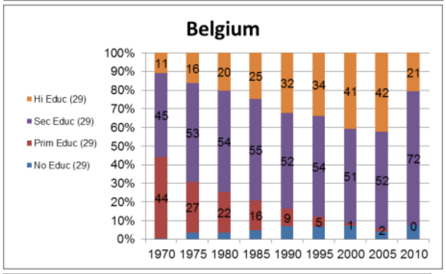


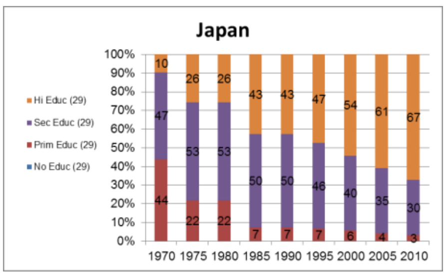


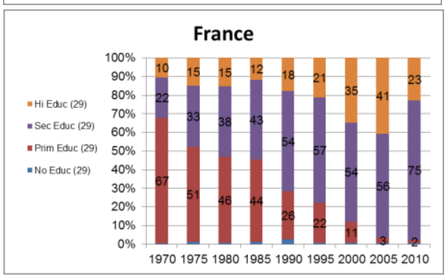


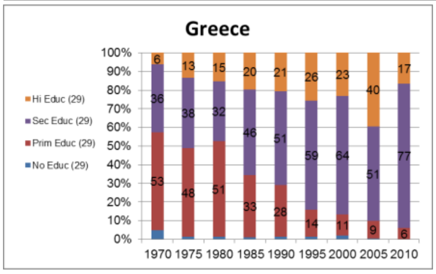


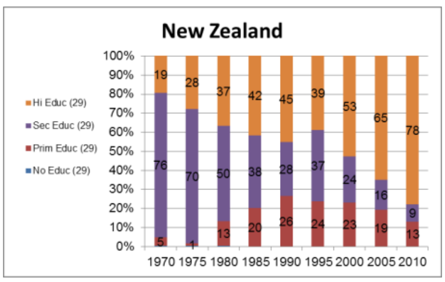


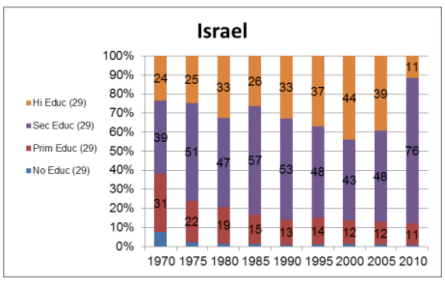


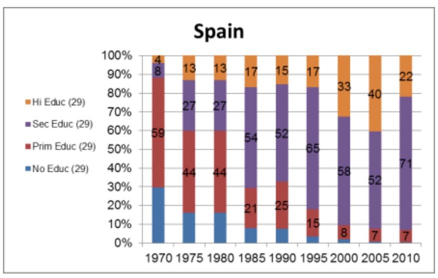


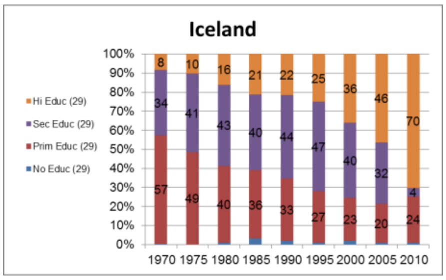




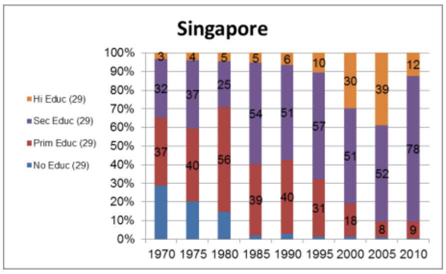


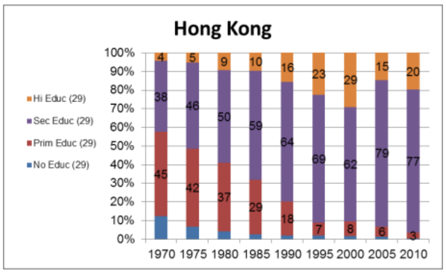


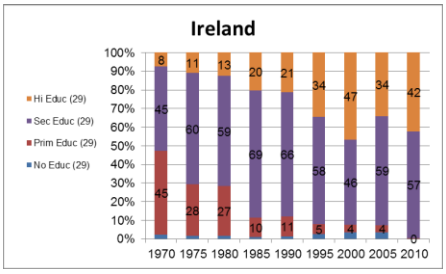


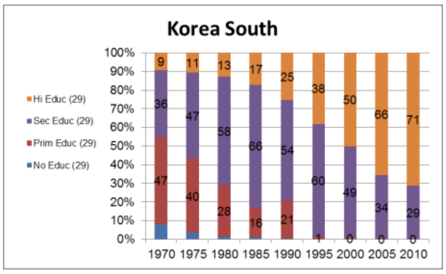


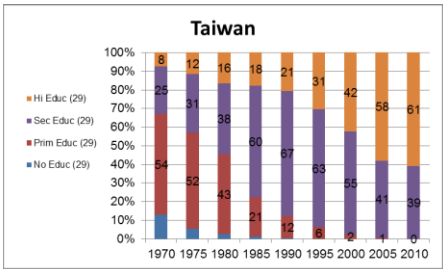
(2) Asian / Celtic tigers type:



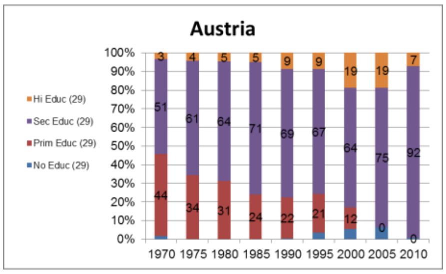


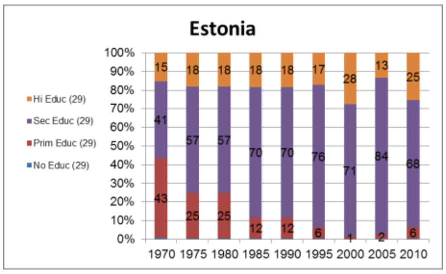


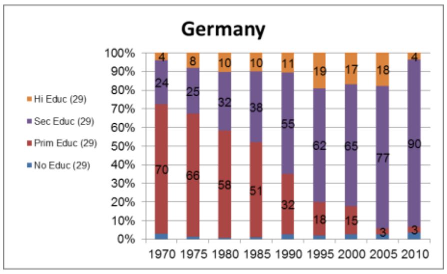


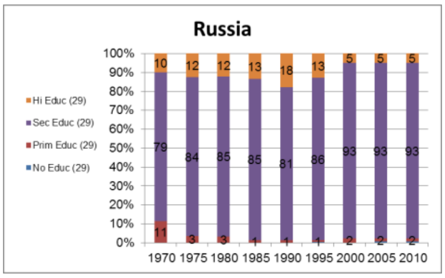


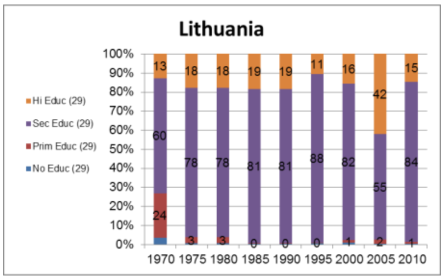
(3) Primary and Secondary based type:

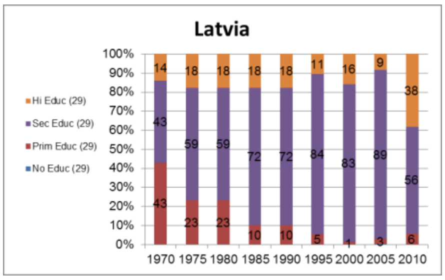


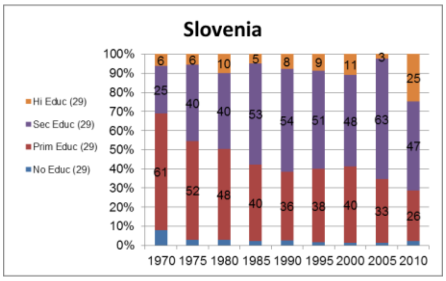


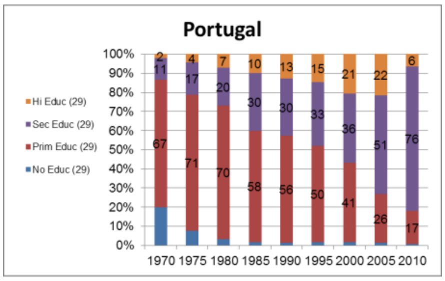


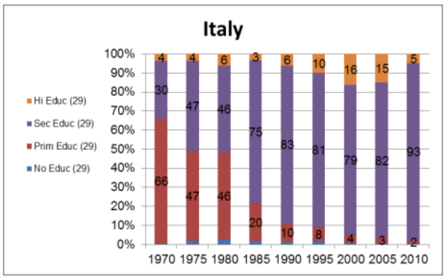


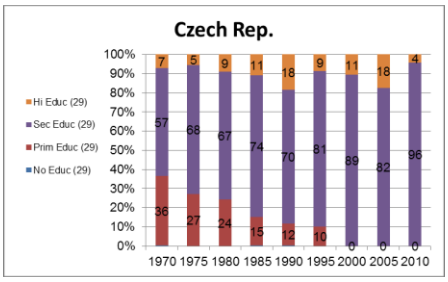


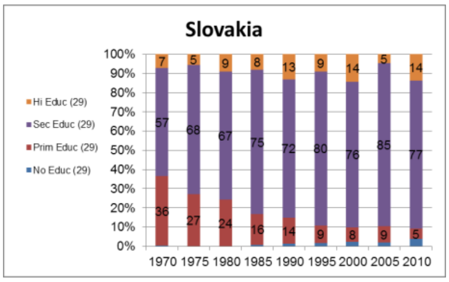












(4) <u>Falling behind type:</u>