Basically the statistical values for GDP per capita (GDPpC) and education index (EI) for the year 2000 and 2010 have been discussed above, but keep in mind the different amount of available data given here in Table 14 and Table 15. The states Gabon, Oman and Venezuela do not profit of their above-average GDP per capita to perform also an above-average value in education index.

Table 14: *Descriptive Statistics GDPpC and EI 2000*

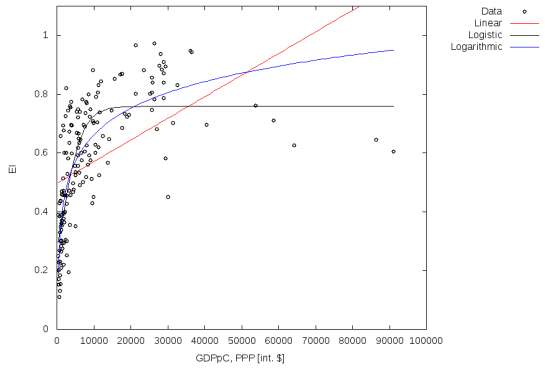
| 2000 | N | Spread | Min | Max | Mean | Std |
|---|---|---|---|---|---|---|
| **GDPpC** | 169 | 90741 | 271 | 91012 | 10840 | 14385 |
| **EI** | 169 | 0.863 | 0.111 | 0.974 | 0.577 | 0.214 |

Table 15: *Descriptive Statistics GDPpC and EI 2010*

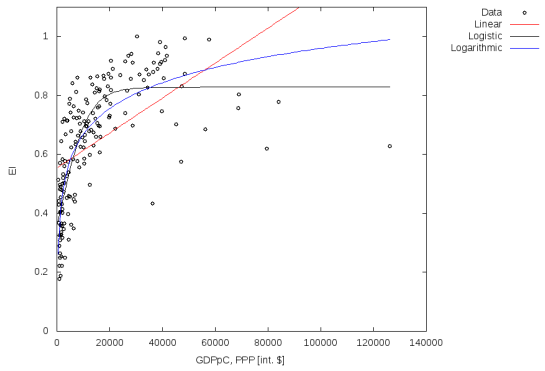
| | 2000 | | 2010 | |
|---|---|---|---|---|
| | **LSE** | $R^2$ | **LSE** | $R^2$ |
| **Linear** | 5.782 | 0.246 | 5.033 | 0.291 |
| **Logistic** | 2.874 | 0.625 | 2.461 | 0.653 |
| **Logarithmic** | 2.977 | 0.612 | 2.705 | 0.619 |

*Table 16:* LSE and $R^2$ for Regression EI = f(GDPpC)

| 2010 | N | Spread | Min | Max | Mean | Std |
|---|---|---|---|---|---|---|
| **GDPpC** | 176 | 125630 | 408 | 126038 | 16067 | 18288 |
| **EI** | 176 | 0.822 | 0.177 | 0.99 | 0.648 | 0.200 |




(a) 2000




(b) 2010

Figure 5: Education Index (EI) as function of GDP per capita (GDPpC), Year 2000 (a) and 2010 (b)

Table 16 gives the values of least square error (LSE) and coefficient of determination ($R^2$) for year 2000 and 2010. The linear regression function fits the data for the relation between GDP per capita and education index not well in 2000, but for the year 2010 better than for year 2000. The logistic model explains this relation best out of the considered functions, as it is for adult literacy and GDP per capita. But compared to adult literacy rate the mean value of the education index is far away from a saturation value, which is theoretically at 1.

Figure 5 shows the relation between both variables. Interesting is in 2010 compared to the year 2000, that there are more countries with above-average income level and simultaneously with below-average education index. These 'underperforming' countries are Equatorial Guinea, Kuwait, Oman, Qatar and Turkey. They performed well in economic development since 2000, but they could not reflect this to their educational development. But in fairness one should say, that the results of educational development occurs with a time lag.

## 7. Multivariate Linear Regression to explain Internet Penetration

So far we use only univariate linear and non-linear regression analysis to explain the mutual relation between education level, average income level and Internet penetration rate of countries in the year 2000 and 2010. Now, this study will use multivariate regression analysis to explain the Internet penetration rate by the combination of average GDP per capita and education index as well as by the combination of average GDP per capita and adult literacy rate. Multivariate linear regression is a generalization of the basic linear regression model by considering more than one independent variable. Since non-linear regression functions are also used to model the relation between the education level and Internet in this study, it is necessary to rearrange the multivariate non-linear regression model for multivariate linear regression.

### 7.1 Internet Penetration, GDP per capita and Adult Literacy Rate

Looking to the Internet penetration rate (IPR) as the dependent variable and GDP per capita (GDPpC) and adult literacy rate (ALR) as the independent variables, we want to know, to which extent the average income level drives the Internet penetration rate relatively measured to the extent, that adult literacy drives the Internet penetration rate in a country, see equation 1. A is the factor for average income, B the weight for adult literacy and C a constant variable. According to the previous

findings, f (equation 5) and g (equation 6) are the functions which _t best to the given data.

$$IPR = A \cdot f(GDPpC) + B \cdot g(ALR) + C = A \cdot GDPpC^* + B \cdot ALR^* \quad (1)$$

$$GDPpC^* = f(GDPpC) = \frac{a \cdot GDPpC_t^b}{c \cdot exp^{d \cdot GDPpC_{t-1}}} \quad (2)$$

$$ALR^* = g(ALR) = a + b \cdot exp^{(c \cdot ALR - d)} \quad (3)$$

$$\Rightarrow \quad A = 0.880,\ B = 0.459,\ C = -2.343$$

First, the factors A and B are positive, which means, that average income level and adult literacy rate impacts the Internet penetration rate positive. However, the result for the year 2000 shows, that GDP per capita has a weight of 65.7% and the adult literacy a weight of 34.3% regarding the contribution to Internet penetration. This means in plain, that GDP per capita impacts the Internet penetration twice more as the adult literacy rate impacts the Internet penetration.

Continuing in the same concept for the relation between Internet penetration rate, GDP per capita and adult literacy rate for the year 2010, the result for A, B and C is as follows.

$$A = 0.806,\ B = 0.425,\ C = -5.274$$

Again the weight for A and B is positive in the year 2010. The GDP per capita contributes to Internet penetration rate with 65.4% and the adult literacy with 34.6%. It should be noted, that the relatively contribution of GDP per capita and adult literacy rate to Internet penetration remains with the same weight in 2010 compared to the year 2000. One can say that GDP per capita is still that factor in 2010, which is more important than the ability to read and write. Average income determines the ability to afford Internet connection. On the other hand, without the ability to read and write an Internet connection is nearly pointless. This is valid for year 2000 and for 2010.

## 7.2 Internet Penetration, GDP per capita and Education Index

The same multivariate regression analysis is done for the relation between Internet penetration rate, GDP per capita and education index for year 2000 and 2010. It is expected that the EI has to contribute anyway more to the Internet penetration rate as the adult literacy rate does. For year 2000 following coefficients are calculated.

$$IPR = A \cdot f(GDPpC) + B \cdot g(EI) + C = A \cdot GDPpC^* + B \cdot EI^* \quad (4)$$

$$GDPpC^* = f(GDPpC) = \frac{a \cdot GDPpC_t^b}{c \cdot exp^{d \cdot GDPpC_{t-1}}} \quad (5)$$

$$EI^* = g(EI) = a + b \cdot exp^{(c \cdot EI - d)} \quad (6)$$

$$A = 0.617,\ B = 0.536,\ C = -1.040$$

The factors A and B are positive, which means, that average income level and education index impacts the Internet penetration rate positive. The result shows, that GDP per capita impacts the Internet penetration rate with 53.5% and the education index with 46.5% in year 2000. Indeed, both independent variables have approximately the same weight of contribution to the Internet penetration rate. This result is not much surprising, due to the fact, that we expect a higher contribution of the education index to Internet penetration in comparison to the adult literacy rate. But a surprising fact is that the income level and education level are almost equivalently important for Internet penetration in 2000.

The multivariate regression analysis for the relation between the Internet penetration rate, average income level and education index in the year 2010 results following coefficients.

$$A = 0.669,\ B = 0.440,\ C = -4.497$$

The factors A and B are positive in the year 2010 again as it is for the year 2000. The result shows, that GDP per capita impacts the Internet penetration rate with 60.3% and the education index with 39.7%. Now, compared to the year 2000, the education index has not approximately the same weight of contribution to the Internet penetration rate as the GDP per capita. One can argue, that GDP per capita still remains important, to be financially affordable to have Internet connection. But the education index measured as a weighted average of expected years of schooling and means years of schooling in a country, is not so important after a decade anymore as in the year 2000. This result is not much surprising, due to the fact, that technological development can eliminate somewhat the education level necessary for Internet usage.

## 7.3 Multivariate Regression for Internet Penetration, GDP per capita, Adult Literacy and Education Index

Looking to all variables together, i.e. the Internet penetration rate (IPR) as the dependent variable and the three variables GDP per capita (GDPpC), adult literacy rate (ALR) and education index (EI) as the independent variables, we want to know, to which extent the average income level, education index and adult literacy rate are driving the Internet penetration rate, see equation 7. It is expected that the education index does contribute anyway more to the Internet penetration rate as the adult literacy rate does. A is the factor for average income, B the weight for

education index, C the weight for adult literacy and D a constant variable.

$$IPR = A \cdot f(GDPpC) + B \cdot g_1(EI) + C \cdot g_2(ALR) + D \quad (7)$$

The analysis results in following coefficients for the year 2000.

$$A = 0.671,\ B = 0.584,\ C = -0.239,\ D = -0.222$$

It can be said, that average income and education index influence the Internet penetration positive, and somehow, the adult literacy a bit negative, but near at zero. If the same analysis is done for the relation between Internet penetration rate, GDP per capita, education index and adult literacy for the year 2010, following coefficients are the result.

$$A = 0.658,\ B = 0.467,\ C = -0.016,\ D = -4.608$$

The analysis for year 2010 shows, that average income level and education index still impact the Internet penetration most. The impact of the education index to Internet penetration is to a lesser extent in 2010 than in 2000. Indeed, in the year 2010, the weight for adult literacy rate is very close to zero now.

### 7.4 Findings for Multivariate Regressions

The multivariate analysis shows that Internet penetration rate is better explained by the combination of average GDP per capita and education index, than by either average GDP per capita or education index alone. The influence of both factors to Internet penetration is similar with some more power of the average GDP. The situation from 2000 and 2010 shows that average GDP even gains in importance. When comparing the impact of average GDP and adult literacy rate to Internet penetration rate, the influence of GDP per capita is almost double as the influence of adult literacy rate and the influence for average GDP remains essentially the same over time. This supports our expectations, that the education index tells more about having access to the Internet than does adult literacy rate. It is interesting, that the role of average GDP per capita even increases from 2000 to 2010 regarding the relation between Internet penetration, GDP per capita and education index, while remains the same for the relation between Internet penetration, GDP per capita and adult literacy. It might be that the growing Internet rates as well as the increase in adult literacy worldwide are reasons for that. Finally, the financial situation in terms of average income still defines strongly the limit of being able to join the Internet.

## 8. Conclusion

This study shows relations between education level expressed via adult literacy rate and education index and the Internet penetration rate with regression analysis of data from 2000 and 2010. First, it should be noted, that this analysis is of great intent, since the worldwide Internet penetration rate is about one-third, i.e. two-third of the world population has no access to the Internet. The analysis would reveal no relation between the education level of a country and the Internet penetration rate for a country.

The relation between education level and Internet penetration is modeled via linear and exponential regression functions. In general the exponential model fits the data well, while the linear model is less compatible, except for the relation between Internet penetration and education index in year 2010. There is a positive relation between education level in terms of adult literacy rate as well as education index and Internet penetration rate. The education index has a higher relation with the Internet penetration rate than the adult literacy rate. One reason for this is the higher relation of education index by means of school education years to monetary investments of states than the relation of adult literacy rate to money available and average income measured by GDP per capita. This has a consequence, that the relation between GDP per capita and education index is higher than the relation between GDP per capita and adult literacy rate, independent of whether these relations are modeled via linear, logarithmic and logistic functions, whereby the logistic model suits well compared to the other functions. So this study argues that policymakers need to promote comprehensive literacy education.

In general, Internet usage and penetration is a motivational and monetary issue. So far higher educated people are an indication for higher developed countries and for higher income countries, but the same is even more true for high average GDP per capita, which comes along with a higher Internet penetration rate as well as higher education levels.

The results of multivariate regression analysis show, that GDP per capita drives primarily the Internet penetration rate and even gains in importance regarding the multivariate regression between Internet penetration rate, GDP per capita and education index from 2000 through 2010. One can say in other words, that the education index became less important in relative terms. But the role of GDP per capita remains at the same level regarding the multivariate regression for Internet penetration, GDP per capita and adult literacy. Adult literacy rate essentially vanishes as an explaining factor, i.e. GDP per person and the education index carry principally all information concerning Internet

penetration, that literacy rate could supply. The multivariate regression analysis argues similarly as the univariate regression that policymakers need to promote comprehensive literacy education.

Finally, this study concludes that the digital divide in terms of education level and economic development still is in place, but is declining, because more people worldwide use the Internet since 2000.The growth in Internet penetration occurs in developed and developing countries, although developing countries reached almost saturation. The results show a high digital inequality resulting from different education levels and income situations. Policymakers should rather encourage investments into (digital) literacy than into higher education if the aim is to increase the internet penetration rate.

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