Economic and educational correlates
of TIMSS results

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Abstract

The good knowledge of the correlates of educational achievement highlights the ways to the efficient use of economic and human capital in raising the efficiency of education. The present paper investigates the correlates and compares the values of the correlates for the Republic of Lithuania with the average international values. The data for the analysis were taken from the TIMSS 2003 mathematics report. The correlation analysis revealed a strong relationship between TIMSS results and the economic development of countries, teacher and parent education, the students' safety in schools, etc. Mathematics instructional time had no correlation with the TIMSS results in international comparison. Students' self-confidence in mathematics was lower in the countries with a higher TIMSS score but in-country comparison revealed a positive relationship between these variables. The Lithuanian students scored 0.46 standard deviations higher the international average TIMSS result. The educational correlates of TIMSS results had higher values in Lithuania than the international average. The economic correlates had lower values in Lithuania, however the Republic of Lithuania has succeeded in using the available economic and human resources very efficiently in education.

Key words: TIMSS, educational achievement, economics and education, the Republic of Lithuania.

Introduction

TIMSS (Trends in International Mathematics and Science Studies) is a measurement of educational achievement in the different countries of the world. In 2003, forty-six countries participated on the eighth grade level and twenty-four countries on the fourth grade level. The TIMSS studies include not only testing the subject knowledge of students in mathematics and science but also questionnaires to teachers, students, and school headmasters to fix the different conditions of teaching and learning.

The Republic of Lithuania participated in TIMSS studies in 2003 for the third time. The average scale score of Lithuanian students was 472 in 1995, 482 in 1999 and 502 in 2003 (Mullis et al., 2004, p. 43). Now Lithuania belongs to the twenty most successful countries in the world in teaching mathematics. Which might be the correlates of these high results? If we know the correlates, we have more possibilities to raise the efficiency of education.

The characteristics of schooling have a big influence on the students' achievement as a rule. H. Jürges and K. Schneider (2004) have made a systematic analysis of TIMSS 1999 results and found that teacher education, the frequency of assigning homework, and school autonomy improve the students' performance. Disruptive students had a statistically significant negative relationship to the students' test results. J. Dandy and T. Nettelbeck (2002) found the students' homework

important as well. Good classroom climate fosters learning (O'Dwyer, 2005, p. 171). Textbooks determine the results of learning as much as teachers' qualification (Gopinathan, 1989).

Students' IQ has a positive correlation coefficient about 0.5 with educational attainment (Jensen, 1998, 277). Wainwright et al. (2005) have found that the coefficient of heritability was 0.72 in one test of academic achievement – the Queensland Core Skills Test. The capacity of the short-term memory of students is a predictor of school achievement (te Nijenhuis, van der Flier, 2004). However, the tracking of students into ability groups has very little or no effect on the country students' average achievement (O'Dwyer, 2005, p. 174).

The students' attitude toward learning is one of the most consistent predictors of achievement (Dandy, Nettelbeck, 2002; O'Dwyer, 2005, p. 175). J. D. House (2004) has found that high science achievement test scores were related to positive attitudes toward science learning and these students attributed success in learning to hard work at home and memorising the textbook. He considers the finding important in designing science lessons and materials.

The socio-economic status (SES) of families has a positive relationship on the students' achievement. At the individual level, the correlation between SES and student academic achievement is around 0.3. When the school is the unit of analysis, then the correlation coefficient is around 0.7 (Yang, 2003, p. 23).

We know that it is better to teach in the smaller groups of students, however research has revealed no relationship between the class size and the students' performance (Jürges & Schneider, 2004, pp. 368 - 367). Bigger classes are in bigger schools and the students of the bigger schools have a higher achievement indicator. Jürges and Schneider (2004, p. 371) conclude that "it is hard to find any systematic effect of interesting variables such as resources, decentralized decision-making or central exit examinations on average student performance." O'Dwyer (2005, p. 172) has also found "that the availability of school resources for mathematics was not a strong predictor of the differences in achievement between schools."

L. M. O'Dwyer (2005) found that the home background index was an important predictor of academic achievement. The index included the educational level of mother and father and the books at home. Parents' education and the number of books at home were significant factors of TIMSS 2003 mathematics results in Lithuania (Elijio A., Dudaitė J., 2005). Jürges and Schneider have revealed the same factors and PC at home as the facilitators of school performance. The students who always spoke the test language at home scored 15 points higher than the students who never spoke the test language at home (Jürges and Schneider, 2004, p. 364).

The present paper investigates the correlates of TIMSS mathematics 2003 results and compares the values of the correlates in Lithuania with the international average value. The correlates are looked for in teacher qualification, students' backgrounds and attitude, the economic development of countries, etc. The data for the Republic of Lithuania are compared with the average data for the 46 countries having participated in the TIMSS 2003 study.

The hypothesis is that the characteristics related to educational attainment in previous studies will have a statistically significant relationship to TIMSS 2003 results as well. As far as the students of the Republic of Lithuania achieved higher international average results in TIMSS test, the correlates should also have the values higher than the international average.

Method

The average TIMSS mathematics Grade 8 result (Mullis et al., 2004, p. 34) was used in this research. The average result included the results in the following content domains: number (39% of items), algebra (15%), measurement (20%), geometry (15%), and data (10%). The coefficients of correlation between the average TIMSS result and the results in different content domains were 0.96 – 0.99. Due to the high correlation coefficients, considering the content domains separately will add very little to the results of the research and therefore the average results were used in this research. The items in the tests were in four cognitive domains: knowing facts and procedures (24%), using concepts (23%), solving routine problems (37%) and reasoning (16% of items) (Mullis et al., 2004, p. 343).

The values of characteristics under study were also taken from the TIMSS report tables (Mullis et al., 2004) and for one characteristic (GDP) from the World Factbook (2005) (WF). The raw data were used without the standard errors. Sometimes new characteristics were calculated. For example, the values of the characteristic "Language of the test at home always or almost always" were calculated by adding the percentage of students who always spoke it at home and who spoke it almost always.

The correlates of TIMSS results will be identified by the correlation coefficients between the characteristics and the average TIMSS score. In some cases, the average scores of students with high, medium, and the low value of the characteristic will be used to validate the findings. The values of TIMSS correlates for Lithuania will be compared with the international average values of the characteristics in δ units to achieve the comparability of differences for various characteristics.

Results

Table 1 includes the characteristics under study. The international average of the characteristics was calculated as the average of the 46 countries participating in the TIMSS 2003 study. Standard deviations are based on the differences of countries' averages from the international average. The value of characteristics in δ units was calculated as follows: the international average was subtracted from the value for the Republic of Lithuania and the difference divided by standard deviation. The coefficients of correlation were usually calculated on the data of 46 countries but some data were absent for some countries and then the number of countries is smaller. The coefficients of correlation 0.3 and higher in the absolute value are statistically significant at 0.05 level. The lower coefficients are considered as the indices of the missing relationship.

The units of the measurement of the characteristics are usual ones, however, in many cases percentages are given. For example, the number 1 after the characteristic "Parent finished no more than primary schooling" means that there is one percent of students with such parents in the Republic of Lithuania.

TIMSS tables include many similar characteristics, for example, school climate high, medium, and low. All the similar characteristics were included in the analysis but Table 1 usually includes this characteristic which had the highest coefficient of correlation with the TIMSS results.

The correlates of TIMSS 2003 mathematics results
and the values of the correlates in Lithuania
in comparison with the international average

The characteristics of countries	The source of the data (Mullis et al., 2004)	Lithu- ania	Inter- nat. avera- ge	St. dev. of intern. data	Lithu- ania (in δ units)	Corre lation with TIM SS
TIMSS 2003 mathematics scale score in 8. Grade	Exh. 1. 1	502	467	76	0,46	1.00
Human development index (HDI)	Exh. 1. 1	0,824	0.82	0.10	0.04	0,74
Gross national income per capita (GNI)	Exh. 3	3670	10359	10874	-0,62	0,56
Pupil-teacher ratio (primary grades)	Exh. 3	16	19	7	-0,52	-0,49
Life expectancy	Exh. 3	73	72	8	0,09	0,67
>50% economically disadvantaged homes (EDH)	Exh. 8. 1	8	31	23	-1,02	-0,73
Gross domestic product (GDP) in USD	WF	12500	15510	11142	-0,27	0,62
Computer at the home	Exh. 4. 5	48	60	30	-0,39	0,67
Study desk at the home	Exh. 4. 5	97	83	13	1,08	0,76
Parent finished university or equivalent or higher	Exh. 4. 1	36	28	14	0,61	0.35
Parent finished post secondary education	Exh. 4. 1	31	17	13	1,08	0,19
Parent finished upper secondary schooling	Exh. 4. 1	30	28	12	0,13	0,36
Parent finished lower secondary schooling	Exh. 4. 1	2	15	10	-1,24	-0,27
Parent finished no more than primary schooling	Exh. 4. 1	1	12	15	-0,76	-0,59
Students intend to finish university and either parent went to university or equivalent	Exh. 4. 2	33	21	11	1,09	0,33
Language of the test at home always or almost always	Exh. 4. 3	98	79	26	0,71	0,53
More than 25 books at home	Exh. 4. 4	61	56	20	0,28	0,68
School climate low	Exh. 8. 4	4	18	16	-0,83	-0,43
Students' safety high (students' perception)	Exh. 8. 8	60	48	16	0,73	0.64
Mathematics instructional hours in a year	Exh. 7. 3	122	123	23	-0,03	-0,20
Percentage of instructional time for mathematics	Exh. 7. 3	11	12	2	-0,69	-0,20
Students' self-confidence in learning math. low	Exh. 4. 9	26	22	8	0,52	0,64
Students valuing mathematics medium or low	Exh. 4.10	47	45	19	0,09	0,74
Teachers with an university degree or beyond	Exh. 6. 4	96	76	33	0,61	0,36
Teachers use the textbook as a primary basis for lessons	Exh. 7. 9	100	65	21	1,67	0,49

Some specifications of the characteristics are given together with the discussion of the research results in the next part of the paper.

Discussion

The characteristics of the economic development of countries have an intense relationship with the TIMSS results – the coefficients of correlation are 0.6 – 0.75 in Table 1. The strongest relationship was between the TIMSS results and the availability of a study desk at home: r = 0.76. The other indicator of the socio-economic status (SES) of families, the school principal's report on the percentage of

students coming from economically disadvantaged homes had also a very strong relationship with the students' success in TIMSS test: r = - 0.73. These coefficients of correlation affirm the well-known fact that SES is a good predictor of school achievement (Yang 2003). The two indicators of the economic development of countries as the whole – the gross domestic product (GDP) and the gross national income (GNI) are related to students' achievement although the correlation cofficients (0.62 and 0.56) are not as high as the correlations between TIMSS and SES.

There is only one indicator which characterises the resources given to schools – the pupil-teacher ratio. The higher the ratio, the fewer there are teachers in schools and this leads to lower TIMSS results: r = - 0.49. More resources to schools facilitated students' advancement. The statistically significant correlation is not in accordance with the findings of O'Dwyer (2005, p. 172), however he has used another aspect of using the resources given to schools – the resources for teaching mathematics.

What is the reason for the very intense relationship between the educational attainment and the economic development of families, schools, and countries? The economic wellbeing of families is a powerful predictor of educational achievement but the influence of good education on students' and countries' success is also important. In developing countries, the entrepreneurs have difficulties in finding employees with the needed level of education and this hinders the economic development of the countries. Education and economics have reciprocal causation.

Educational achievement and economic development can be caused by some third factor to some degree as well. For example, R. Lynn and T. Vanhanen (2002, p. 196) conclude that "... differences in intelligence are a major cause of national economic disparities …". On the other hand, it is well known that differences in IQ cause differences in educational achievement. The two causal relationships may cause similarity in changing TIMSS results and the economic development, which we observe as the correlation between these two characteristics of countries.

Education as a reason for societies' well being is seen in the coefficients of correlation between TIMSS results and life expectancy (r = 0.67) and the human development index (HDI) (r = 0.74). The three characteristics vary together because they reflect the cultural development of countries. Some countries value education, healthiness, and diligence higher.

The Republic of Lithuania achieved about a half of standard deviation better results in TIMSS test than was the international average (Table 1). Which of the discussed correlates might cause the Lithuanian success? The country's economic indicators (GNI and GDP) are below the international average up to 0.62 δ, which predicts that the Lithuanian TIMSS result should be lower than the international average. Really the Lithuanian TIMSS result is higher than the international average. In spite of difficult economic conditions, the pupil teacher ratio in Lithuanian schools is better than in the studied countries on average. Especially favourable for learning is the low percentage of schools, in which more than 50% of students are from economically disadvantaged schools. The last two characteristics counterbalance the possible negative effect of the low economic indicators of the country on the TIMSS results. The Republic of Lithuania has succeeded in engaging more teachers in schools and in creating an egalitarian school system.

Parents' education is a correlate of TIMSS results. The higher the percentage of students, whose parents have university education, the higher the educational achievement is (r = 0.35). However, the percentage of students, whose parents have primary education is a more powerful predictor of TIMSS results (r = -0.59). It leads

to the hypothesis that working with students from unfavourable conditions is very important for raising the average educational level of a country.

The relationship between parents' education and TIMSS test results can be observed in in-country comparisons as well. The children of parents with primary schooling had only TIMSS score 410 on the average of the 46 countries. The children of parents with university education or higher had the average score 503 (Mullis et al., 2004, pp. 128 – 129). The difference of these scores 93 exceeds the standard deviation of TIMSS results in inter-country comparison 76. Not very high correlation coefficients may indicate the significant influence of the correlate on TIMSS scores.

The percentage of students, whose parents finished university, is higher in the Republic of Lithuania than in the TIMSS countries on average (0.61δ) (Table 1). Especially low is the percentage of students whose parents have only primary education (1% or -1.09δ). The high educational level of parents is an important factor of high TIMSS test results in Lithuania.

Students' aspiration to finish university is a correlate of TIMSS results (r = 0.33) (Table 1). Good educational achievement evokes the aspiration and the aspiration constitutes a part of students' achievement motivation, which leads to higher achievement (Mikk, 2005). Many Lithuanian students have the aspiration and this is one more reason for high TIMSS results in Lithuania.

It is important that the students' home language is the same as the test language. The percentage of students who always spoke the test language at home or almost always had correlation 0.53 with the TIMSS results (Table 1). The students had average TIMMS score 473 while the students who spoke the test language only sometimes at home had the TIMSS test score 441 (Mullis et al., 2004, p. 132). Jürges & Schneider (2004, p. 364) have also found the highly significant influence of the home language on TIMSS results. In Lithuania, 98 per cent of students always spoke the test language at home or almost always. This value is 0.71δ higher than the international average. Good accordance between the home language and TIMSS test language is one more reason for the high TIMSS results of Lithuanian students.

The cultural background of homes is further characterised by the number of books in students' homes. The more children have over 25 books at home, the higher the countries TIMSS results (r = 0.68). In Lithuania, more children have 25 books at home than the students in the TIMSS sample have on average. The investigation by Elijio A., Dudaitė J. (2005) revealed that the more books have Lithuanian students' at home the higher the TIMSS 2003 results.

Many investigations have revealed that the school climate influences educational achievement (Schmitt et al., 1999). The conclusion can be drawn from the data in Table 1 as well. The more there are students in schools with low school climate, the lower the TIMSS results (r = -0.43). The index of the school climate included such characteristics of schools as "teachers' job satisfaction"; "teachers' degree of success in implementing the school's curriculum"; "teachers' expectations for student achievement"; "parental support for student achievement" (Mullis et al., 2004, p. 318). These characteristics of school ethos can be developed more or less independently from the economics of the country. The Republic of Lithuania has succeeded in developing the school climate (0.83δ better than international average) and this is one more important reason for the success of Lithuanian students.

In the TIMSS study, the students were asked about the safety in school (have you been hurt by other students, have you been left out of activities, etc). The school safety was considered high if the students answered "no" to five such questions. Students' high safety is an important correlate of TIMSS results (r = 0.64). The

students who felt themselves safe in schools had the average TIMSS score 478 while the students who assessed being safe in school low had the average TIMSS score 447 (Mullis et al., 2004, p. 330). The Lithuanian students assessed the safety in schools higher than the international average (0.73δ) and this is still another reason for high TIMSS results in Lithuania.

Surprisingly, the mathematics instructional time had no relationship to the average TIMSS score. The correlation between the yearly mathematics instructional hours and TIMSS results was not significant and even negative (r = -0.20) although the time varied considerably – 193 hours per year in Philippines and 75 hours in a year in Cyprus (Mullis et al., 2004, p. 270). Possible reasons for the lack of the relationship should be studied: the teaching methods, the study aids, the volume of curricula, etc.

Students' self-confidence in learning mathematics was assessed by their responses to four statements, for example "I usually do well in mathematics", "I learn things quickly in mathematics" etc. (Mullis et al., 2004, p. 154). The percentage of students who assessed their self-confidence in learning mathematics low had a strong positive correlation with the TIMSS results of the country (r = 0.64). The more students in a country assess their self-confidence low, the higher the TIMSS score in international comparison.

To understand the unexpected finding, let us look at the data of in-country comparison. The students with the high self-confidence in learning mathematics achieved the average score 504 in TIMSS test; the students with medium self-confidence 453 and the students with the low self-confidence achieved the average score 433 (Mullis et al., 2004, p. 154). The in-country comparison reveals the validity of students' self-confidence assessments. Why does the inter-country comparison lead to the opposite sign of the correlation? An explanation is the different cultural and curricula demands in different countries. For example, the highest percentage of students with low self-confidence was in Japan and Chinese Taipei but these countries achieved very high TIMSS test results. In some countries the curricula demands can be very high and the students' self-confidence is therefore low but TIMSS test results are good.

Similar results can be observed regarding the students' valuing mathematics. The characteristic was composed from the students' answers to seven questions: "I need mathematics…" (five questions) and "I enjoy learning mathematics" (two questions) (Mullis et al., 2004, p. 158). The percentage of students who value mathematics medium or low, had a strong positive correlation with TIMSS results (r = 0.74). This is the inter-country comparison. The in-country comparison revealed the opposite relationship. The students, who valued mathematics high, had a higher TIMSS score (479) than the students, who valued mathematics medium or low (458) (Mullis et al., 2004, p. 158). If students cognise the need of mathematics and enjoy learning it, then they have a higher TIMSS result. However, the students of many countries with high TIMSS results do not cognise the value of mathematics, for example the students in the Netherlands, Japan, Korea, etc. The connection of this cognition with curricula demands is of interest.

The last two correlates in Table 1 are easily understandable. The more there are teachers with the university degree or beyond, the better the TIMSS test results (r = 0.36). The more teachers use the textbook as primary bases for their lessons, the higher the students' achievement (r = 0.49). In both these characteristics Lithuania is far ahead of the international average (0.61δ and 1,67δ). The high level of teachers'

education and the intense use of textbooks are the additional possible reasons for the very good TIMSS results of Lithuanian students.

Conclusion

The aim of the research was to find the economic and the educational correlates of TIMSS 2003 mathematics results and to compare the level of the correlates in Lithuania with the international average. The coefficients of the correlation between many characteristics of countries and the TIMSS results were high and very high. The characteristics of the economic development of countries such as the gross domestic product, the gross national income per capita, the percentage of economically disadvantaged homes, etc. had correlation coefficients about 0.6 or higher. Books at home, parents' education, and the home language had also correlation coefficients over 0.5. The educational characteristics revealed, however, mixed results. Students' safety in schools, teachers' education, and the intense use of textbooks facilitated the educational achievement of students. The time for mathematics studies was not the positive correlate of TIMSS results. Students' self-confidence and valuing mathematics were the negative correlates of TIMSS results in the inter-country comparison. This leads to the problem of cultural and curricula difference between countries as the factors of TIMSS results.

The Republic of Lithuania scored 0.46 standard deviations higher than the international average. The most important factors of the success of Lithuanian students can be students' safety in schools, parents' education, and the intense use of textbooks as bases for lessons, etc. The economic development, especially the gross national income per capita is far below the international average in Lithuania, however, the available resources are very efficiently used: pupil-teacher ratio is considerably lower than the international average, almost every student has a study desk at home, etc. Lithuanian people value education highly.

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