SCHOOL SIZE AS A DETERMINANT OF EDUCATIONAL PERFORMANCE IN TRANSITION COUNTRIES

by

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Abstract

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Education nowadays is considered as one of the basic determinants of economic growth. Given that, reforms in education can have a direct influence on a country's prosperity and well-being in the long run. This paper examines influence of the school size on educational performance of students of 4th and 8th grade by building educational production functions for 12 transition countries. This enables us to contribute to the policy discussion on the size of the school. We find that there exists an optimal (number of students in the school, which maximizes student performance) school size for Czech and Slovak Republic with 660 and 840 students respectively. Additionally, for Armenia and Georgia there exists a non-optimal (number of students in the school, which minimizes student performance) size of the school with 1060 and 940 students respectively. The results for Ukraine show that there is no clear relation between the school size and student performance.

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GLOSSARY

TIMSS – Trends in International Mathematics and Science Study

ARM – Armenia

CZE – Czech Republic

GEO – Georgia

HUN – Hungary

KAZ – Kazakhstan

LVA – Latvia

LTU – Lithuania

MNG – Mongolia

RUS – Russian Federation

SVK – Slovak Republic

SVN – Slovenia

UKR – Ukraine

Chapter 1

INTRODUCTION

During transition years, when most of the institutions change their form, the quality of education plays a significant role. It comes from the fact that social structure changes a lot, from one, where career success depended on the position of an individual in the party, to another, where educational background is a major driving force of social mobility (Heyneman, 1997). Thus, the rate and effectiveness of transition depends on reforms in education, which prepare people for the new roles in a new society (Heyneman, 1997). Furthermore, capitalist society and its economy request other abilities and skills in addition to those, demanded by communist ones, e.g. managing, marketing skills (Berryman, 2000) etc. The major role of education is confirmed by the fact that returns to education are found to increase during transition times (Newell et al., 1999). Given that, the role of education for transition countries is truly substantial.

The quality of schooling can depend on many factors such as student characteristics and family background as well as on the institutional setting, available resources and their usage. The goal of this research is to estimate the impact of different characteristics on educational performance of students, with a focus on the effect of school size. To do this, educational production functions for several transition countries, including Ukraine will be estimated.

Educational production functions relate educational achievements to different inputs, such as different student and family characteristics, resources and teacher characteristics and also the institutional setting. Student and family characteristics include age, gender, immigration status, parents' education, number of books at home etc. The resource characteristics include class size, school size, teacher's education, teacher's gender etc. Institutional setting might include degree of schools autonomy, teacher's influence on the curriculum, hours of homework per week etc.

Recently international organizations, concerned with a demographic decline in Ukraine suggested that schools should be merged into larger ones, thus increasing the effectiveness of existing infrastructure (Berryman, 2000). It is argued that such a step would contribute to lower per-student costs. Such a consolidation would require closing large number of small schools and the expansion of others. Given the fact that this is a substantial reform, in this research I will be examining the influence of the school size on educational performance. The question is whether large schools are more efficient in producing positive schooling outcomes than the small ones. Moreover, it should be determined if benefits that stem from larger school size are actually related to the size and not to the other factors as the type of community etc.

Standardized scores from the fourth Trends in International Mathematics and Science Study will be used as a measure of educational achievement. The main advantage of this database is that it is fully comparable across countries.

A similar study in terms of database and methodology was conducted by Ammermüller, Heijke & Wößmann in 2003. They show that countries could be divided into two parts, depending on the level of reforms, the progress in transition and the impact of background characteristics of students. However, the data they use are only for 7 countries in 2003 and now the 2007 data is available for 13 countries, including Ukraine. Moreover, they do not take into account possible impact of the school size on educational performance. Thus, this would be the first study, exploiting such a huge database and for such a mix of countries. Moreover, it would be interesting to compare the results and to observe if they change with further years of transition, economic development and the addition of school size as one of the determinants of educational achievement. Further, including 6 more countries, which are Armenia, Georgia, Kazakhstan, Mongolia, Russian Federation and Ukraine makes it possible to study the 3rd group of countries, which had the closest relation to the Soviet Union. This fact could bring further insights into understanding the role of determinants of educational performance in the least reformed transition countries.

Chapter 2

LITERATURE

In the literature review that follows I first examine studies that stress the importance of education, first at the micro level, than at the macro level. Then I focus on the quality of education, rather than quantity, and its determinants, reviewing studies estimating educational production functions. Finally, I arrive at the variable of interest, namely, the school size for which previous estimates of its significance in the educational performance are presented. At the end, other factors that contribute to educational performance are discussed.

Both micro and macro studies on the determinants of economic growth emphasize the role of education. In the microeconomic studies the value of schooling is mostly captured by the returns to educational attainment. Studies consistently agree that the more schooling an individual gets the more he or she will be rewarded in the future through higher wages. Mincer (1974) showed that in the US each year of schooling raises the individual's future wage by approximately 10%. Since then many of the researchers estimated this relation worldwide and on average the coefficient in front of years of schooling years varies between 5% and 15% (Psacharopoulos, 1994). The theories behind this reward for education include Spence (1973), who describes education as a signal for ability, and Becker (1964), who assumes that education increases productive skills.

For the economy as a whole, education is able to increase human capital, which increases labor productivity and thus leads to a higher equilibrium level of output (Mankiw, Romer and Weil, 1992). Moreover, it can also increase the innovative capacity of the economy, which promotes growth (Lucas, 1988);

Romer, 1990; Aghion and Howitt, 1998). Furthermore, it can assist the diffusion and transmission of knowledge, which is essential in understanding and processing information and applying new technologies invented by others, again promoting growth (Nelson and Phelps, 1966). Additionally, education can create positive externalities, such as crime eradication or more informed political decisions (Krueger and Lindahl, 2001).

Similar to the microeconomic approach, the majority of the macroeconomic literature uses the years of education aggregated over the labour force, as a quantitative measure of education. A standard way of estimating education influence on growth is to run a cross-country regression, in which annual average growth rates of GDP per capita are regressed on measures of schooling along with other controls important for growth. Hanushek and Wößmann (2007), using data for 1960-2000 show that each year of schooling increases a long-run growth by 0.58 percentage points.

It's worth mentioning that education affects national income not only in such a way that can be measured in monetary terms. It is shown, for instance by Glewwe (2000), that especially in developing countries education has a negative effect on women's fertility and a positive effect on infants' health.

Generally, the empirical macro studies that focused on education as one of the determinants of economic growth, find that the initial stock of human capital matters, not just the change in capital and also that secondary and post-secondary education have higher impact on growth than primary education (Krueger and Lindahl, 2001).

Although the literature on education and growth gives us further insights into the process of economic growth itself, it has significant limitations, namely the fact that it sticks to the years of schooling as the only measure of education, not taking into account qualitative differences in the latter. Clearly, a typical year of education in Sweden and Norway is somehow different from the same year of schooling, for instance, in Guinea or Somalia. Nevertheless, the years of education approach to measuring education performance ignores this. Furthermore, it assumes that all the skills a person gets in the process of education come from a formal schooling. Yet many studies, the number of which started to grow significantly in the last 30 years, show that cognitive skills and factors outside the school, such as family, institutional characteristics also matter much.

Since 1960s, many international institutions started to perform international tests of students' performance in terms of cognitive skills. Over the last 15 years research has shown that taking into account the qualitative side of education can alter the assessment of education's impact on economic growth and development. For example, Hanushek and Kimko (2000) find that for the period of 1960-90 the quality of education, measured by cognitive skills, mattered much more for growth than just the quantitative measure. They find that for 31 countries a one-standard deviation increase on a country-level in test scores would foster economic growth by 1% a year additionally to the basic factors affecting growth. Furthermore, adding the quality of education as one of the explanatory variables for the growth model significantly lowers the impact of the quantitative measure, while the opposite is not true (Barro, 2001, Wößmann, 2002, 2003b. That is why examining the determinants of educational performance is so crucial.

The majority of the literature concerning determinants of educational achievements focuses on the concept of the educational production function, where some outcome of the educational process is regressed on the set of inputs, which typically are grouped into background characteristics, school resources and institutional setting.

Concerning the school size, first of all, it has to be mentioned that a size of the school per se doesn't have a direct effect on a quality of a school. It, rather, indirectly affects the academic outcomes through its relationships to a variety of other variables (Jones and Slate, 2005). Moreover, the relationship between school size and other variables, such as a teacher's quality, dropout rates, attendance, discipline, morale might be entangled.

The first argument which considers the impact of the school size on educational performance is the concept of economies of scale, which states that larger organizations can operate more efficiently than smaller ones due to lower per unit costs engaged. Advocates of school consolidation, based on this argument, define an effective school the one which has 1000-2000 students (Fox, 1981). On contrary, Gooding and Wagner (1985) find that in labor-intensive service organizations, such as county governments, where productivity depends mainly on human effort there exists negative association between the increasing size and economic efficiency. Opponents of school consolidation argue that Gooding and Wagner (1985) findings can be generalized to education as well. McKenzie (1983) and Haller (1992) show that additional administrative costs that increase with size can undermine the effect of economies of scale. The second argument for school consolidation is that reduced per-student cost translates into higher academic achievement because schools can be improved with the money saved. While McGuffey and Brown (1978) actually find that lower costs are associated with higher achievement, later studies which include Monk (1987) and Burrup, Brimley and Garfield (1988) couldn't confirm this. Ramirez (1992) conducted a literature review on the school size and found that there is very little difference in terms of educational achievement between large and small schools.

Cotton (1996) examined 31 studies regarding school effect in educational performance and found them divided evenly between studies that support the hypothesis of effectiveness of school consolidation and those, who found no association between the increasing school size and educational achievement. Greenwald, et al. (1996) conducted a meta-analysis of about 60 studies on the topic of the school size and found that in most cases increase in the school size was negatively associated with educational performance. In contrast to that, Friedkin & Necochea (1988) and Huang and Howley (1993) found the opposite, namely that educational achievement in small schools was lower. More recent studies, which include Howley (2002), Hicks and Rusalkina (2004), McMillen (2004) and Stevenson (2006) support the idea that student's performance in small and middle schools is generally better than that in large schools.

Generally, different studies produce different results, which can be attributed to the complex influence of the school size on other determinants of educational performance and it is not clear how merging of schools could affect academic achievement in transition countries, including Ukraine. This is partly due to the fact that most of the literature on the topic concerns developed countries, paying limited attention to emerging ones.

Next, we take a closer look at the studies that focused their scope on specific determinants of educational production. First the student and family background inputs come. Given the fact that child learning outside the school is a very important factor, family background characteristics have long been treated as one of the most important factors contributing to educational achievement. Moreover, estimating the effect of the background helps to reveal and understand and compare the equality of opportunity of students with various kinds of background characteristics, such as social status, gender etc.

Schuetz et al. (2008) examine the correspondence between family background proxied by the number of books at home and TIMSS test scores, controlling for other factors such as parents' education, gender, age, immigration status etc. The choice of the proxy is not a random one – the studies of Woessmann (2003a, 2008) show that the number of books at home is the only significant predictor of family and background characteristics in most of the countries. Nevertheless, it is essential not to misuse the interpretation of that factor. The consensus among studies does not mean that the number of books at home is casually related to educational performance and that providing more books would raise the latter. The explanation here is that the number of books at home proxies and incorporates systematic differences in the way of bringing up children, availability of home resources and the quality of home education all of which seem to be casually related to the educational performance. Other studies use different measures of background characteristics. Bedard and Dhuey (2006), for instance, find a significant positive effect of the relative school starting age.

Next we are engaged in discussing school determinants of educational achievement usually measured by the inputs available at schools. Looking across countries, it is possible to examine the relationship between average spending on a student and test scores. Generally, what the studies find is the fact that the spending per student is not a significant measure of educational performance as in Woessmann (2002), even when controlling for student background and other characteristics as in Hanushek and Kimko (2000). Moreover, there are studies by Afonso and St. Aubyn (2006), in which the expenditure efficiency is measured and which indicate substantial inefficiencies in most countries.

Other possible variables that represent school resources are teacher salaries, length of a school year and student-teacher ratios. Actually the study of Barro and Lee (2001), where they examine the case of 58 countries, finds a significant impact of school resources represented by the variables discussed above. In addition to this, Jürges and Schneider (2004) confirm the fact that school resources matter with observations in 23 countries, based on the TIMSS score. Summing up, most of the studies show that quantitative measures of school resources such as class-size and expenditures do not matter for student performance. Nevertheless, some studies reveal the significance of other resource characteristics, such as teacher salaries and student-teacher ratio.

Taking into account the fact that school and resource characteristics have poor explanatory power, researchers focused their attention on non-resource institutional factors, such as accountability, school autonomy, competition from private schools etc. These factors are considered mostly in cross-country studies, where the degree of variation is very high, compared to limited variability in within country studies as in Woessmann (2007). Curriculum-based external exit exams (CBEEE) seem to have a significant impact on students' productivity, as noted in Bishop, 2006, 1997. This is due to the fact that external exams increase student's reward for learning and parents' motivation to monitoring their children educational process. This, in turn, stems from the fact that employers are often more interested in the results of an external examination while looking for new employees.

Another institutional feature that is claimed to have an effect on educational performance is the degree of school autonomy, measured by decisions in purchases of supplies, budget allocation, hiring new teachers, choosing textbooks and instructional methods. International evidence supports the significant influence of all the factors, discussed above. The general trend is that students who study in schools that have more autonomy, perform better (Fuchs and Woessmann, 2007; Woessmann et al. 2009). Another institutional factor that may drive educational productivity is competition between private and public schools. Studies that found higher performance in private schools include Woessmann, Luedemann, Schuetz and West (2009), Fuchs and Woessmann (2007).

Summing all up, both micro and macroeconomic studies agree on the significant impact of education on either private income or economic growth if considering nationwide. While the contribution of education to growth was first measured by returns to years studied, it further evolved into the more sophisticated measure of the quality of education. The latter has been estimated by using educational production functions that relate academic achievement to different inputs. These are generally divided into three parts: individual characteristics, resource set and institutional setting. Most of the studies show, that the first set of determinants, namely individual and family characteristics of students are the most significant predictors of educational achievement.

In this paper the particular variable of interest is the size of the school and its influence on academic achievement. Generally different studies on the school size produce different results, which can be attributed to the complex influence of the school size on other determinants of educational performance. I will examine the influence of the school size, using the latest data for transition countries, namely the 2007 TIMSS math and science scores. This will be done by estimating educational production functions with WLS, where the school size will be used as one of the explanatory variables. Furthermore, results for Ukraine will be obtained which will enable us to contribute to the policy discussion on school size in Ukraine.

C h a p t e r 3

METHODOLOGY & DATA DESCRIPTION

The basic estimation technique, which will be used in order to estimate the educational production functions, is the following equation:

$$T_{ics} = \beta_0 + B_{ics}\beta_1 + R_{cs}\beta_2 + I_{cs}\beta_3 + \varepsilon_{ics} + v_s \quad (1)$$

where T is the TIMSS score of student $\boldsymbol{i}$ in school $\boldsymbol{s}$ and in class $\boldsymbol{c}$,

B – a set of background factors;

R – a set of resource characteristics;

I – institutional setting characteristics;

$\boldsymbol{\varepsilon}$ and $\boldsymbol{v}$ – student and school level error terms respectively.

TIMSS was created by the International Association for the Evaluation of Educational Achievement (IEA) to measure trends in students' achievement in sciences and mathematics. TIMSS 2007 was already the fourth assessment of this kind with 67 countries participants, including Ukraine. This makes TIMSS the largest and most complex achievements study ever conducted. This paper focuses on the 13 transition countries included in TIMSS 2007 and uses data for more than 100,000 students from over 1,500 schools. The target population of TIMSS are students of the 4^{th} and 8^{th} grade. Every student, as well as his teacher and principal, are given questionnaires asking for the background information on institutional setting, school, teacher and students characteristics.

Considering the fact that questionnaires consisted of many questions, the problem of missing observations might arise. To deal with this problem without lowering the sample size or introducing bias by ignoring missing observations, data were imputed by IEA creating so-called plausible values. They represent random draws from an empirically derived distribution of proficiency values that are conditional on the observed values of the assessment items and the background variables (American Institutes for Research, 2008).

Although all students were expected to be included into the target populations, sometimes it was not possible to do that due to the fact that some schools are situated in geographically remote regions, with a small number of students and organized for students with special needs or with unique curriculum. However, the exclusion rate was less than 5%, which means it is unlikely to introduce any bias.

Table 1 presents variables to be used as explanatory for educational production function. Since the school size is not the only factor influencing educational performance, other controls were used. The factors controlled for are student characteristic and family background, which was done by including student's gender, age, dummies for whether the student, the father, the mother was born in the country of a test, dummies for the number of books at home and a dummy for whether the test language was spoken at home. Also, the way students spend their free time was controlled for. For this, dummies for hours spent on a certain activity, like playing with friends, going for sports, playing computer games or reading books for enjoyment were included.

At the teacher level factors controlled for are the teacher's experience and its squared (since this factor most probably enters into the educational production functions in a non-linear form), dummy for teacher's education (if it's higher than ISCED 5) and dummies for per cent of students in the class coming from disadvantaged background is 25%-50% and higher 50% respectively, dummies for high number of disruptive and uninterested students in the class. At the school level control factors included the dummy for significant shortage of either budget for supplies, instructional materials, school buildings or teachers. Furthermore, the dummies for the size of community where the school was located were included.

Under the assumptions that there are no uncontrolled factors left besides those to be used in the model, least-squares estimation will provide unbiased estimates of the model (1). The model specification is aimed at capturing factor effects in levels rather than value added, which is reasonable for background characteristics since they change rarely over time. Also, as noted in Woesmann (2003), student's background could be viewed as exogenous to student performance, thus not introducing any endogeneity. Moreover, most of the institutional and resource characteristics affect student performance over several years, since students spend at least 9 years at school.

The basic way in which it is possible to estimate the effect of the school size is to include the number of students in school as a continuous variable. However, it is not clear, why there should be a linear relationship between the number of students and their educational attainment. Due to the fact that increasing the school size from 200 to 300 is somehow different from the same increase from 2000 to 2100 it is rather plausible that the relationship between the school size and educational achievement is a non-linear one, taking an inverse U-shape form. Thus, at first, student achievement is regressed on the school size and its square to capture the general pattern of the data. Next, other variables are added to control for different effects that influence performance to exclude an omitted variable bias.

Table 1. Proposed variables to include into production function

Variable	Definition	Type
Background		
SDAGE	student's age in years	numeric
SGEND	student's gender (=1 if a boy)	dummy
GPLCG (.)	time spent playing computer games (4 = 2-4 hrs.; 5 = over 4)	dummies
GPLFD (.)	time spent on playing and talking with friends (4 = 2-4 hrs.; 5 = over 4 hrs.)	dummies
GREBO (.)	hours spent on reading books for enjoyment (4 = 2-4 hrs.; 5 = over 4 hrs.)	dummies
GMBRN	if mother was born in the country of test (=1 if no)	dummy
GFBRN	if father was born in the country of test (=1 if no)	dummy
GBORN	if student was born in a country of testing (=1 if no)	dummy
GBOOK (.)	number of books at home 1 = none or very few (0-10 books) 2 = one shelf (11-25 books) 3 = one bookcase (26-100 books) 4 = two bookcases (101-200 books) 5 = three or more bookcases (over 200 books)	dummies
GWATV (.)	time spent watching TV (4stands for 2-4hrs; 5=more than 4)	dummy
GPLSP (.)	time spent playing sports (4stands for 2-4hrs; 5=more than 4)	dummy
GDOHW (.)	time doing homework (4stands for 2-4hrs; 5=more than 4)	dummy
GLEFT	if student was left out of activities (=0 if yes)	dummy
GOLAN (.)	if language of the test is spoken at home 3 = sometimes 4 = never	dummies
Resource		
GTENR	total number of students	numeric
GTENRSQ	total number of students squared	numeric
MSTUD	number of students in class	numeric
GST03	high shortage of school buildings	dummy
GSTo4	high shortage of heating and lighting	dummy
GSPME	if a degree of school shortage of materials is a serious problem	dummy
GTAUT	teacher's experience in years	numeric
GTAUTSQ	teacher's experience in years squared	numeric
TGEND	teacher's gender (=1 if male)	dummy
GFEDC	highest level of teacher's education is ISCED 5 or higher	dummy
Institutional		
MVMDS (.)	number of disruptive students in class (4 = some; 5 = a lot)	dummies
MVMUS (.)	number of uninterested students in class (4 = some; 5 = a lot)	dummies
GSBED	percentage of students coming from disadvantaged background 3 = 26 to 50; 4 = more than 50	dummies
GCOMU (.)	type of community 2 = large (100,000 to 500,000 people) 5 = small (3001 to 15000 people) 6 = very small (less than 3000 people)	dummies

Nevertheless, the design of TIMSS is constructed in such a way that we will need to exploit special regression techniques in order to estimate educational production functions. Since varying sampling probabilities are a part of sampling design of TIMSS it will be essential to use WLS for all the regressions. Furthermore, the sample design is such that first schools were selected in each country and then classes within schools were chosen. This issue can be dealt with so-called clustering-robust linear regression (CRLR). Thus, for estimating educational production functions in a single country, model (1) with CRLR will be estimated by means of WLS.

Finally, it should be noted that the results should be interpreted with a little caution. This stems from the fact that it could be possible that the school size is not exogenous in the sense that better students could prefer small schools over the large ones or vice versa. However, for small communities it is reasonable to assume that such kind of selection was unavailable.

Table 2 provides descriptive statistics for the size of schools in the sample used. The largest average schools are situated in Mongolia with the mean of 1441 students, which is 2 times larger than the sample average. However, some schools in Latvia are the largest in the sample with 5873 students, which is 8 times larger than the average school for the whole sample. Czech Republic, Hungary and Slovak Republic have the smallest average schools with number of students around 480. Ukraine is in between with 726 students on average at school. In most of the countries, except Czech Republic and Russia, the distribution of the school size is somewhat positively skewed.

Table 2 Descriptive statistics for the school size

Country	Size	st.dev	min	max	50%	75%	95%	Skewness	Kurtosis
Armenia	633.0	351.3	30	1995	567	821	1310	1.49	6.17
Czech	480.5	193.4	24	975	501	623	749	-0.16	2.73
Georgia	845.5	491.7	41	2322	774	1181	1735	0.61	3.12
Hungary	474.4	200.6	73	1027	435	570	858	0.70	3.85
Kazakhstan	915.5	586.0	58	2866	828	1299	2866	0.96	3.71
Latvia	691.8	569.5	27	5873	591	920	1203	5.40	47.96
Lithuania	710.3	391.6	16	1840	702	994	1370	0.28	2.38
Mongolia	1441.2	848.9	132	4341	1312	1980	2774	0.88	3.61
Russia	736.2	316.7	10	1434	771	960	1241	-0.23	2.55
Slovak	490.9	236.1	20	1175	485	642	883	0.17	2.74
Slovenia	522.3	191.1	88	953	498	659	867	0.23	2.90
Ukraine	726.6	331.9	56	1553	740	939	1320	0.23	2.48

Source: TIMSS 2007 database

Next, qualitative aspects of schooling systems are discussed by considering mean values of key explanatory variables, which are presented in Table 3. Considering background characteristics, the number of books at home (GBOOK), which reflects the students' home setting, is the highest in Latvia and Hungary and the lowest in Mongolia and Kazakhstan. The time students do homework (GDOHW) is the highest in Georgia and the lowest in Czech Republic. The number of hours student play computer games (GPLCG) is the highest in Czech Republic and Hungary and the lowest in Mongolia, Ukraine and Georgia while the number of hours talking and playing with friends (GPLFD) is the highest in Latvia and Slovak Rep. and the lowest in Georgia and Armenia.

Talking about resources, Latvia together with Lithuania have the greatest shortage of materials (GSPME), while the least shortage is observed in Czech Republic. The teachers with the lowest average experience (GTAUT) are in Czech Republic, Slovak Republic, Slovenia and Kazakhstan. The greatest number of disruptive students (MVMDS) is observed in Latvia, followed by Kazakhstan and Slovenia, while the highest percentage of students coming from bad social background (GSBED) is in Mongolia, followed by Georgia and Armenia.

Table 3 Descriptive statistics for important control variables

Country	GBOOK	st.dev	GREBO	st.dev	GSBED	st.dev	GTAUT	st.dev	GDOHW	st.dev
ARM	2.9	1.4	2.6	1.2	2.6	1.0	22.2	10.8	2.9	1.2
CZE	3.0	1.1	2.4	1.1	2.3	0.9	18.5	10.3	2.4	0.8
GEO	3.0	1.3	2.5	1.2	2.8	1.1	24.5	11.5	3.2	1.3
HUN	3.1	1.2	2.3	1.1	2.7	0.9	23.1	8.7	2.8	0.9
KAZ	2.5	1.1	2.6	0.8	1.7	0.9	18.0	9.3	2.9	0.9
LVA	3.1	1.1	2.2	1.0	1.7	0.9	22.6	10.0	2.7	0.8
LTU	2.6	1.0	2.4	1.0	1.8	0.8	21.0	8.4	2.7	0.9
MNG	1.9	1.0	2.7	1.2	3.0	1.0	17.4	9.7	2.9	1.3
RUS	3.1	1.1	2.5	1.0	2.1	1.0	21.7	9.4	2.8	0.9
SVK	2.8	1.1	2.3	1.1	1.8	0.9	20.4	10.1	2.6	1.0
SVN	2.9	1.1	2.4	1.0	2.3	0.9	19.7	9.5	2.5	0.8
UKR	2.9	1.1	2.6	1.1	1.4	0.8	22.4	8.9	2.7	0.9

Table 3 (continued). Descriptive statistics for important control variables

Country	GPLCG	st.dev	GST03	st.dev	MVMDS	st.dev	GPLFD	st.dev	GSPME	st.dev
ARM	2.2	1.2	2.2	1.2	3.0	1.2	2.5	1.1	2.0	0.8
CZE	2.7	1.3	1.3	0.7	3.2	1.1	3.5	1.3	1.7	0.7
GEO	2.0	1.2	1.8	1.1	3.0	1.0	2.5	1.2	2.3	0.7
HUN	2.7	1.2	1.8	0.9	2.8	0.9	3.4	1.2	1.8	0.7
KAZ	1.9	0.9	1.7	1.0	3.4	0.8	3.4	1.2	1.8	0.7
LVA	2.4	1.2	1.9	1.1	3.7	1.1	3.8	1.2	2.4	0.7
LTU	2.5	1.2	1.8	0.9	2.8	1.2	3.6	1.3	2.4	0.6
MNG	1.8	1.1	2.3	1.1	3.2	1.1	2.3	1.0	2.2	0.8
RUS	2.2	1.2	1.6	0.9	2.3	1.3	3.3	1.3	2.1	0.7
SVK	2.6	1.2	1.8	1.0	3.0	1.6	3.7	1.2	2.2	0.7
SVN	2.4	1.1	1.7	0.9	3.4	1.1	3.1	1.2	2.1	0.7
UKR	2.0	1.2	1.9	1.1	2.9	1.4	3.4	1.3	2.3	0.7

Source: TIMSS 2007 database

We end this chapter with the analysis of correlation between the size of school and students' performance, which is presented in Table 4. Generally, such a correlation is positive in all the countries from the sample except Armenia and Kazakhstan. Also, countries could be divided into those that exhibit relatively strong correlation (~20%) and to those with a small one. First group consists of Ukraine, Russia and Mongolia, while Latvia, Georgia, Hungary, Slovenia and Czech Republic form the second group with the correlations in a range from 0% to 10%. One interesting observation is that Lithuania shows very small correlation for 4th year students, namely around 5% but much higher (25%) one for 8th year students.

Table 4. Correlation between the school size and students' performance.

Country	4 year		8 year	
	math	science	math	science
Armenia	-0.042	-0.077	0.022	-0.002
Czech	0.101	0.092	0.103	0.075
Georgia	0.061	0.086	0.107	0.077
Hungary	0.087	0.076	0.104	0.078
Kazakhstan	-0.015	-0.036	-	-
Latvia	0.018	0.012	-	-
Lithuania	0.061	0.055	0.250	-
Mongolia	0.184	0.184	0.126	0.100
Russia	0.181	0.159	0.211	0.193
Slovak	0.122	0.138	-	-
Slovenia	0.082	0.092	0.029	0.033
Ukraine	0.214	0.193	0.154	0.122

In the next chapter we expand previous analysis with 2 steps. One is adding control variables to be able to capture the marginal effect of other determinants of educational performance and the second is in allowing for the non-linear effect in the size-performance relationship.

Chapter 4

EMPIRICAL RESULTS

As it was mentioned earlier, student test scores are regressed first on the school size and its squared in order to capture general pattern in the data. The results of such estimation are given in Appendix A, in Tables A.1, A.2, A.3, and A.4. Appendix C with Tables C.1, C.2, C.3 and C.4 provides the results for the regressions of the student performance on a school size and a set of control variables. Next, all the results are discussed separately.

4.1 Fourth Grade Math Students

For the 4^{th} year math students in 4 countries there seem to exist a non-linear dependence between the school size and students' performance, however these dependencies differ. In Armenia and Georgia on one hand, there exists a non-optimal size of schools, meaning that having number of students in the school around 1100 in Armenia and 837 in Georgia seems to have the worst effect on performance. On the other hand, in Slovenia and Ukraine, having around 800 and 1400 students respectively optimizes performance. Finally, in Latvia there exists a positive linear dependence between size and performance. Having added a set of control variables which will allow to account for the possible bias, the results change somehow. The U-shaped dependencies in Armenia and Georgia seem to remain but the non-optimal number of students decreased to 1060 in Armenia and increased to 940 for Georgia. For Ukraine the dependence does not change although the optimal number of students fell from

1400 to around 950. Results for Slovenia seem to reveal no dependence between performance and size.

4.2 Fourth Grade Science Students

The results for 4^{th} grade science students are very similar to those of math ones, discussed previously. In 2 countries, namely Armenia and Georgia there exists U-shaped non-linear dependence between size and performance with the non-optimal number of students 1160 for Armenia and 760 for Georgia. In Slovenia the results are also close to those that math students had previously revealed, namely an inverted U-shaped dependence with 775 students at optimum. Also, in Russia and Ukraine there exists positive linear dependence. After including the set of control variables the results change a little, namely the dependence for Slovenia seems not to hold any more but on the other hand, there exists an inverted U-shaped relationship for Slovak Republic with an optimal number of students of 840. Also, linear relationship between size and performance seem not to hold in Russia and Ukraine any more.

4.3 Eighth Grade Math & Science Students

Examining students of 8^{th} grade the only one non-linear significant result is observed in Czech Republic with around 700 students at optimum, which lowers to 660 (690 for science students) with addition of set of control variables. Also, data suggests that for 8^{th} year Ukrainian science students there exists a non-optimal number of students which is 860 (this result is discussed a bit later). For the rest of the countries, there seems to be no relation between the school size and performance. Appendix B presents the results of comparison of the estimation between 4^{th}, 8^{th} grade math and science students.

The results obtained from the first and second estimation seem to be robust (in the sense that coefficients stay significant within grades and the relationship between size and performance doesn't change its direction). For Ukraine, however, results for 4^{th} grade math students seem to contradict with 8^{th} grade science students, since for the first group there exists an optimal number of students of 945 and for the second group there exists a non-optimal number of 860 students, which is very unlikely to hold. Appendix E provides all the robust results for estimations performed.

Next, other factors, which affect performance, are discussed[1]. Starting with the student background the "books at home" dummies are significant positive predictors of student performance. In all of the countries, except Kazakhstan and Mongolia where student's gender came out to be a significant predictor of performance, boys did better in both math and sciences. In all of the countries, including Ukraine, where the immigrant status of a child was a significant predictor of his performance, children, who were immigrants performed worse. Very similar are the results for parent immigrant status and whether the language of a test is spoken at home. As for the student's free time, playing computer games more than 4 hours a day is negatively associated with educational performance in more than half of the countries examined, including Ukraine, while playing with friends positively affects student performance. Interesting results come from the data on reading books for enjoyment: in 4 countries. In Ukraine, Armenia, Czech Republic and Russia students who read about 2 to 4 hours a day for enjoyment perform much better. Also, in half of the countries disassociating from doing homework lowers students' performance.

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[1] Results of estimations for complete set of variables are available upon request.

As for the school resources, in most of the cases the shortage of any resources described above seems not to have any influence on students' performance. However, having the school situated in a small community negatively affects performance in half of the countries, including Ukraine. Speaking about teacher and class characteristics, high number of disruptive, uninterested students and those who come from disadvantaged background seem to have negative influence on educational performance. This result holds also in Ukraine. Finally, the results for teacher's experience and education are mixed, being significant for a few countries and being insignificant for Ukraine.

Chapter 5

CONCLUSIONS

In this thesis the determinants of educational performance in transition countries are analyzed with the focus on the schools size. For that, the results of the fourth Trends in International Mathematics and Science Study (2007) are used. The data is available for 4^{th} and 8^{th} grade students in math and sciences. Factors that affect student performance include background, resource and institutional characteristics. The effect of these factors is captured by the means of WLS and clustering-robust linear regression.

The estimation is done in 2 steps. First, student achievement is regressed on the school size and its squared to catch the general pattern of the data and account for possible non-linearity. Next the set of control variables is added to eliminate bias, which could stem from not including into regression analysis other determinants affecting student performance.

The results for 4^{th} year students reveal an existence of a non-optimal school size in both Armenia and Georgia. The relationship between the school size and student performance for these countries could be described with a U-shape. The number of students in the school corresponding to the lowest test scores is 1060 for Armenia and 940 for Georgia. For such countries like Czech and Slovak Republic, data shows the existence of an inverse U-shaped dependence between size and performance. The numbers of students in the school that maximizes the performance is 660 for Czech and 840 for Slovak Republic. For the other countries there is no clear evidence of a relationship between the school size and student performance. For Ukraine, however, the results are somewhat mixed, since 4^{th} year math students data indicates an optimal size of the school of 945 while the 8th year science data suggests a non-optimal number of students of 860. This seems unlikely to hold and might stem from a selection bias, which can't be addressed in this research.

Thus, the results of this research can be used by policymakers in order to increase the effectiveness of an educational system which can further lead to an increase in a long-term economic growth.

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APPENDIX A

Table A.1. Regression of student performance on the school size and its squared for 4th year math students

Country	# observations	linear	std. error	quadratic	std. error	shape	optimal size
Armenia*	4079	-.11467**	.045036	.000050**	.0000219	U	1140
Czech	4153	-.02439	.057839	.000063	.0000667	N.A.	-
Georgia*	4038	-.06935***	.025993	.00004**	.0000131	U	837
Kazakhstan	3990	-.02419	.042231	.00001	.0000178	N.A.	-
Latvia	3796	.02783*	.014476	-5.216e-06	7.567e-06	positive linear	-
Lithuania	3864	.02608	.023511	-3.629e-06	.000015	N.A.	-
Mongolia	3648	.01291	.0291975	8.931e-07	9.262e-06	N.A	-
Russia	4380	.11206	.050063	-.000052	.0000387	N.A	-
Slovak Republic	4888	.03045	.050532	1.978e-06	.0000486	N.A.	-
Slovenia	4044	.09778*	.037089	-.0000607**	.0000327	inverted U	806
Ukraine	4292	.11342**	.030257	-.0000395*	.0000209	inverted U	1430

Table A.2. Regression of student performance on the school size and its squared for 8th year math students

Country	# observations	linear	std. error	quadratic	std. error	shape	optimal size
Armenia	4577	.04765597	.035893	-.0000272	.0000268	N.A.	-
Czech	4804	.144206***	.053649	-.0001039*	.0000601	inverted U	694
Georgia	4161	-.00332791	.056337	5.656e-06	.0000356	N.A.	-
Kazakhstan	-	-	-	-	-	-	-
Latvia	-	-	-	-	-	-	-
Lithuania	3965	.04531394*	.023047	8.094e-06	.0000140	positive linear	-
Mongolia	4170	.02110613	.016365	-2.506e-06	4.280e-06	N.A	-
Russia	-	.05751763	.025951	-6.758e-06	.0000184	N.A.	-
Slovak Republic	-	-	-	-	-	-	-
Slovenia	3797	.06037114	.060634	-.00004622	.0000558	N.A.	-
Ukraine	4424	.06054031	.034725	-.00001437	.0000223	N.A	-

Table A.3. Regression of student performance on the school size and its squared for 8th year science students

Country	# observations	linear	std. error	quadratic	std. error	shape	optimal size
Armenia	17614	.01235648	.037109	-.00001203	.0000250	N.A.	-
Czech	19216	.1058981**	.041788	-.0000755*	.0000428	inverted U	700
Georgia	16385	-.00987853	.040279	5.346e-06	.0000247	N.A.	-
Kazakhstan	-	-	-	-	-	-	-
Latvia	-	-	-	-	-	-	-
Lithuania	-	-	-	-	-	-	-
Mongolia	4170	.02182824	.013584	-3.527e-06	3.538e-06	N.A	-
Russia	17871	.04277028*	.023026	-5.499e-07	.0000160	positive linear	-
Slovak Republic	-	-	-	-	-	-	-
Slovenia	11382	.07098132	.071029	-.00005563	.0000642	N.A.	-
Ukraine	17696	.04106317	.0321294	-8.583e-06	.0000214	N.A.	-

Table A.4. Regression of student performance on the school size and its squared for 4th year science students

Country	# observations	linear	std. error	quadratic	std. error	shape	optimal size
Armenia*	4079	-.204579***	.0582327	.0000883***	.0000304	U-shaped	1160
Czech	4153	-.02104185	.0650269	.000054	.0000771	N.A.	-
Georgia*	4038	-.0550682**	.025067	.000036***	.0000121	U-shaped	760
Kazakhstan	3990	-.01214912	.0322942	4.279e-06	.0000146	N.A.	-
Latvia	3796	.02197547	.0151099	-4.325e-06	7.970e-06	N.A.	-
Lithuania	3864	.01967996	.0190091	-2.659e-06	.0000119	N.A.	-
Mongolia	3648	.02667983	.0181551	-2.678e-06	5.419e-06	N.A.	-
Russia	4380	.11285496**	.0517880	-.000059	.0000407	positive linear	-
Slovak Republic	4888	.06600552	.0548911	-.000024	.0000497	N.A.	-
Slovenia	4044	.1251060***	.0461536	-.000081*	.0000407	inverted U	775
Ukraine	4292	.0838993***	.0282094	-.000024	.000019	positive linear	-

APPENDIX B

Table B.1. Robust results for the regressions of student performance on the school size and its squared.

Country	# observations	smallest	largest	% of stud at schools with larger size	optimal size
Armenia*	4079	30	1995	<10%	1140
Georgia*	4038	41	2322	~40%	837
Slovenia	4044	88	953	10%	806
Ukraine	4292	56	1553	<5%	1430
Czech	4804	24	975	~10%	700

* a non-optimal size

APPENDIX C

Table C.1. Regression of student performance on the school size and a set of control variables for 4th year math students

Country	# observations	linear	std. error	quadratic	std. error	shape	optimal size
Armenia*	1390	-.143517***	.05067348	.0000673*	.00002721	U-shaped	1060
Czech	2822	.04322802	.04536923	-.00003311	.0000438	N.A.	-
Georgia*	1827	-.07244425*	.04177063	.00003853*	.00002038	U-shaped	940
Kazakhstan	3893	-.0440207	.03839361	.00001806	.00001731	N.A.	-
Latvia	2592	-.00029942	.00780559	-3.250e-07	1.734e-06	N.A.	-
Lithuania	2942	-.00734022	.02178592	4.880e-06	.00001481	N.A.	-
Mongolia	1399	-.00244934	.01498979	2.099e-06	3.415e-06	N.A.	-
Russia	3379	.03559337	.06531826	-6.102e-06	.00004011	N.A.	-
Slovak Republic	3612	.05810984	.03493106	-.00002974	.00002696	N.A.	-
Slovenia	2784	.01438396	.04208934	2.724e-06	.00003493	N.A.	-
Ukraine	3383	.0847744**	.03383299	-.0000449*	.000023	inverted U	945

Table C.2. Regression of student performance on the school size and a set of control variables for 4th year science students

Country	# observations	linear	std. error	quadratic	std. error	shape	optimal size
Armenia*	1390	-.2460112***	.0875633	.0001161*	.0000555	U-shaped	1060
Czech	2822	.05210044	.0574531	-.0000439	.0000587	N.A.	-
Georgia*	1827	-.06770461*	.0362083	.0000362*	.0000156	U-shaped	936
Kazakhstan	3893	-.05213268*	.0293874	.0000191	.0000123	inverted linear	-
Latvia	2592	-.00495884	.0097766	2.652e-07	3.257e-06	N.A.	-
Lithuania	2942	-.00385699	.0191251	3.834e-06	.0000126	N.A.	-
Mongolia	1399	.00320875	.0142818	-7.970e-07	3.378e-06	N.A.	-
Russia	3379	.02903309	.0593566	-4.782e-06	.0000362	N.A.	-
Slovak Republic	3612	.08276467*	.0371485	-.0000492*	.0000271	inverted U	840
Slovenia	2784	.07876562	.0485857	-.0000441	.0000415	N.A.	-
Ukraine	3383	.04659891	.0330483	-.0000232	.0000211	N.A	-

Table C.3. Regression of student performance on the school size and a set of control variables for 8th year science students

Country	# observations	linear	std. error	quadratic	std. error	shape	optimal size
Armenia	11141	.0069921	.0483187	-.0000111	.00003	N.A.	-
Czech	15383	.1078012**	.0418926	-.0000772**	.00003182	Inverted U	700
Georgia	9122	-.0244335	.0418926	6.117e-06	.00002383	N.A.	-
Kazakhstan	-	-	-	-	-	-	-
Latvia	-	-	-	-	-	-	-
Lithuania	12530	.0124713	.0238889	6.942e-06	.00001223	N.A.	-
Mongolia	2339	-.0077201	2.737e-06	7.785e-07	.01237799	N.A.	-
Russia	14001	-.0311461	.0569144	.00002834	.00002685	N.A.	-
Slovak Republic	-	-	-	-	-	-	-
Slovenia	9503	-.0576207	.0575594	.00006033	.0000524	N.A.	-
Ukraine	14715	-.068073**	.0305110	.00003942**	.00001878	U-shaped	860

Table C.4. Regression of student performance on the school size and a set of control variables for 8th year math students

Country	# observations	linear	std. error	quadratic	std. error	shape	optimal size
Armenia	2861	.0330857	.03154834	-.00002545	.00002123	N.A.	-
Czech	3936	.144956***	.04757293	-.000109**	.00004202	inverted U	660
Georgia	2381	-.0367332	.04941717	9.600e-06	.00002812	N.A.	-
Kazakhstan	-	-	-	-	-	-	-
Latvia	-	-	-	-	-	-	-
Lithuania	3228	.0107881	.02591529	.000012	.00001425	N.A.	-
Mongolia	2496	-.005227	.0139559	1.327e-06	3.296e-06	N.A.	-
Russia	3608	-.0621015	.04709017	.000042	.00002176	N.A.	-
Slovak Republic	-	-	-	-	-	-	-
Slovenia	3179	-.0446672	.04618154	.000048	.00004145	N.A.	-
Ukraine	3677	-.06424863	.04114966	.000039	.00002449	N.A.	-

APPENDIX D

Table D.1. Comparison of previous results for 4th year math students

	Without controls		With controls			
Country	**linear**	**quadratic**	**linear**	**quadratic**	**shape**	**optimal size**
Armenia	-.11467352**	.00005021**	-.1435166***	.0000673*	U-shaped	1060
Czech	-.02438985	.00006289	.04322802	-.00003311	-	-
Georgia	-.06934643***	.0000414**	-.07244425*	.00003853*	U-shaped	940
Kazakhstan	-.02419034	.00001005	-.0440207	.00001806	-	-
Latvia	.02782733*	-5.216e-06	-.00029942	-3.250e-07	-	-
Lithuania	.02607842	-3.629e-06	-.00734022	4.880e-06	-	-
Mongolia	.0129121	8.931e-07	-.00244934	2.099e-06	-	-
Russia	.1120593	-.0000524	.03559337	-6.102e-06	-	-
Slovak Republic	.03045386	1.978e-06	.05810984	-.00002974	-	-
Slovenia	.09778426*	-.00006065**	.01438396	2.724e-06	-	-
Ukraine	.11342626**	-.00003948*	.0847744**	-.00004487*	inverted U	945

Table D.2. Comparison of previous results for 4th year science students

	Without controls		With controls			
Country	**linear**	**quadratic**	**linear**	**quadratic**	**shape**	**optimal size**
Armenia	-.20457957***	.00008828***	-.24601118***	.00011609*	U-shaped	1060
Czech	-.02104185	.00005485	.05210044	-.00004398	-	-
Georgia	-.05506817**	.00003602***	-.06770461*	.00003616*	U-shaped	936
Kazakhstan	-.01214912	4.279e-06	-.05213268*	.0000191	-	-
Latvia	.02197547	-4.325e-06	-.00495884	2.652e-07	-	-
Lithuania	.01967996	-2.659e-06	-.00385699	3.834e-06	-	-
Mongolia	.02667983	-2.678e-06	.00320875	-7.970e-07	-	-
Russia	.11285496**	-.00005882	.02903309	-4.782e-06	-	-
Slovak Republic	.06600552	-.00002417	.08276467*	-.00004925*	inverted U	840
Slovenia	.12510603***	-.00008066*	.07876562	-.00004407	inverted U/-	-
Ukraine	.08389933***	-.0000243	.04659891	-.00002317	-	-

Table D.3. Comparison of previous results for 8th year math students

	Without controls		With controls			
Country	**linear**	**quadratic**	**linear**	**quadratic**	**shape**	**optimal size**
Armenia	.04765597	-.0000272	.03308573	-.00002545	-	-
Czech	.1442064***	-.00010388*	.14495587***	-.00010919**	inverted U	660
Georgia	-.00332791	5.656e-06	-.03673316	9.600e-06	-	-
Kazakhstan	-	-	-	-	-	-
Latvia	-	-	-	-	-	-
Lithuania	.04531394*	8.094e-06	.01078808	.00001236	-	-
Mongolia	.02110613	-2.506e-06	-.00522689	1.327e-06	-	-
Russia	.05751763	-6.758e-06	-.06210151	.00004227	-	-
Slovak Republic	-	-	-	-	-	-
Slovenia	.06037114	-.00004622	-.0446672	.00004824	-	-
Ukraine	.06054031	-.00001437	-.06424863	.00003951	-	-

Table D.4. Comparison of previous results for 8th year science students

Country	**linear**	**quadratic**	**linear**	**quadratic**	**shape**	**optimal size**
Armenia	.01235648	-.00001203	.00699205	-.0000111	N.A.	-
Czech	.10589815**	-.00007555*	.10780118**	-.00007724**	Inverted U	695
Georgia	-.00987853	5.346e-06	-.02443349	6.117e-06	N.A.	-
Kazakhstan	-	-	-	-	-	-
Latvia	-	-	-	-	-	-
Lithuania	-	-	.01247131	6.942e-06	N.A.	-
Mongolia	.02182824	-3.527e-06	-.0077201	7.785e-07	N.A.	-
Russia	.04277028*	-5.499e-07	-.03114612	.00002834	N.A.	-
Slovak Republic	-	-	-	-	-	-
Slovenia	.07098132	-.00005563	-.05762069	.00006033	N.A.	-
Ukraine	.04106317	-8.583e-06	-.06807255**	.00003942**	U-shaped	860

APPENDIX E

Table E.1. Robust results.

Country	Without controls		With controls		shape	optimal size
	linear	quadratic	linear	quadratic		
Armenia	-.11467352**	.00005021**	-.1435166***	.0000673*	U-shaped	1060
Czech	.1442064***	-.00010388*	.14495587***	-.00010919**	inverted U	660
Georgia	-.06934643***	.0000414**	-.07244425*	.00003853*	U-shaped	940
Slovak Republic	.06600552	-.00002417	.08276467*	-.00004925*	inverted U	840