Causal Inference in International Comparisons of Student Achievement

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Causal questions

- Many policy issues in education involve questions about causes and effects, such as:
  - Does amount of instructional time have an effect on students' academic achievement?
  - Does homework have an effect on achievement?
- Such questions ask us to imagine alternative states of the world, and we need to determine the potential outcomes associated with different alternative states.

What is a causal effect?

- The causal effect of a treatment is the difference in outcome for a particular individual when the individual is given the treatment and when the individual is not given the treatment.
- We can typically not observe a certain individual under two treatment conditions. However, we can create two groups of persons with identical characteristics, and compare the outcomes of the treatments for those two groups. The mean difference between the experimental group and the control group can be taken as an estimate of the causal effect.

Limitations of the experimental approach

- Regrettably, there are many problems associated with the experimental approach:
  - Impossible to apply to many central educational policy issues
  - Blind or double-blind designs are typically impossible
  - Cost is often prohibitive
- There is, thus, a great need for methods which allow causal inference from non-manipulative, observational data such as those collected in the IEA studies.

Threats to causal inference from observational data

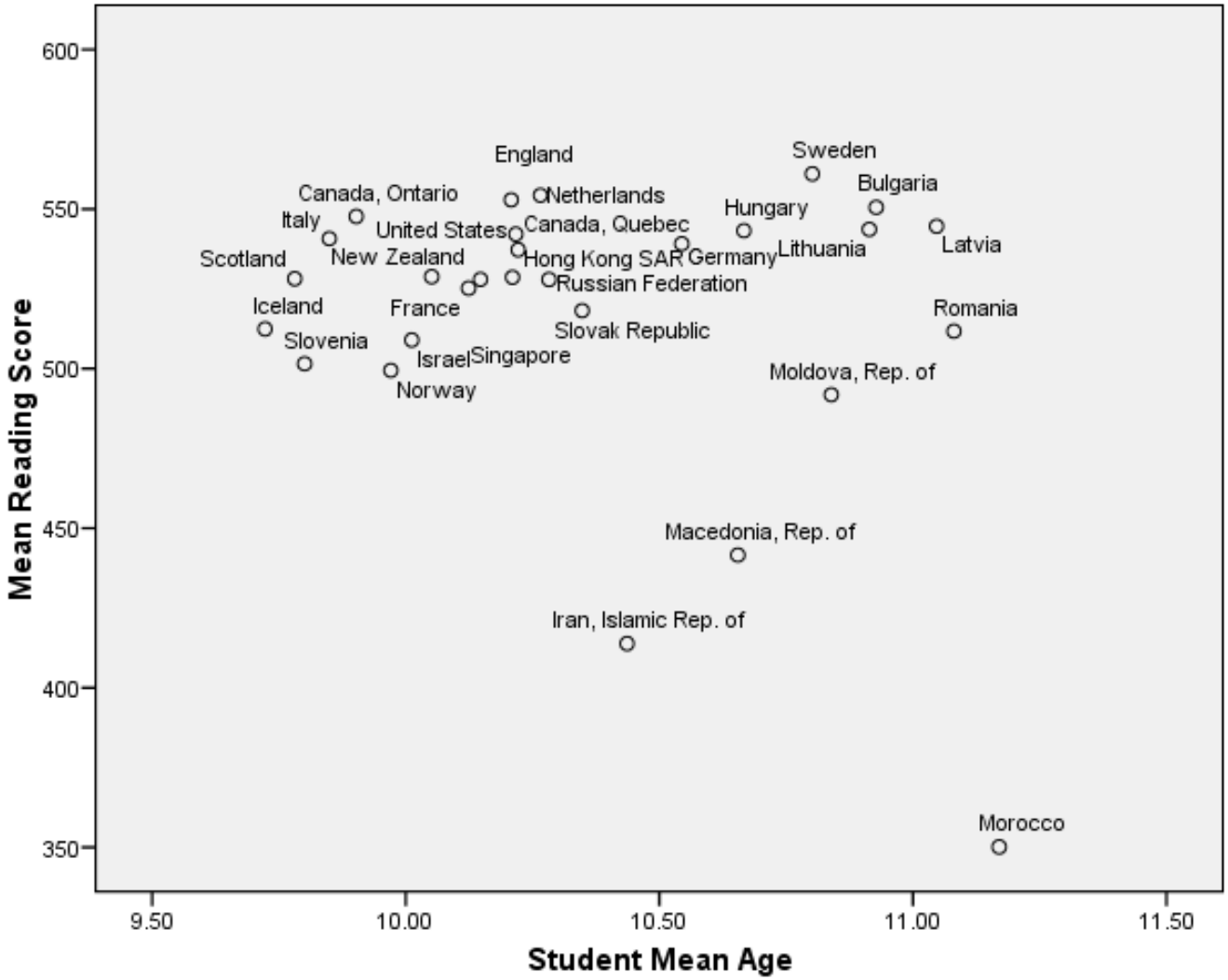
- With cross-sectional data we can compute correlations between assumed determinants and outcomes, but ”correlation is not causation”:
  - *Reverse causation*. For example, if poorly achieving students are allocated more resources to compensate for the poor achievement, we will typically observe a negative association between resources and achievement, even when there is a positive effect of resources on achievement.
  - *Omitted variables*. For example, parents with high education may successfully lobby for more resources to their children’s school. A relation between resources and achievement may therefore be observed because parental education is related both to resources and achievement.

Methods supporting causal inference from observational data

- Lately, new methods have been developed for causal inference from longitudinal data.
- Some of these are quite complicated, but some may be illustrated with simple techniques.
- Country-level longitudinal analysis is one such method.

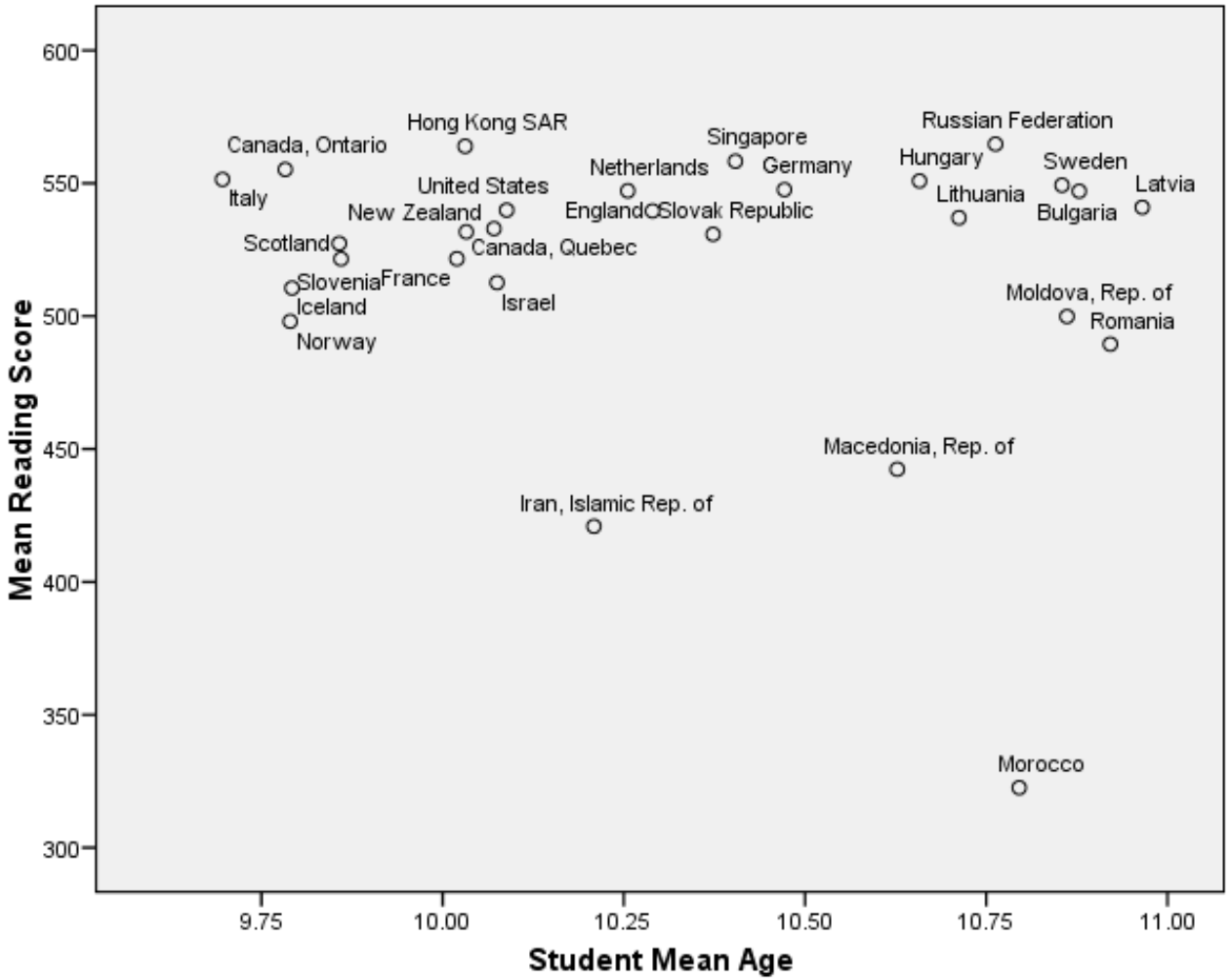
Mean age and mean reading achievement in PIRLS 2001

The correlation between mean student age and reading achievement is -.23.



Mean age and mean reading achievement in PIRLS 2006

The correlation between mean student age and reading achievement is -.15.

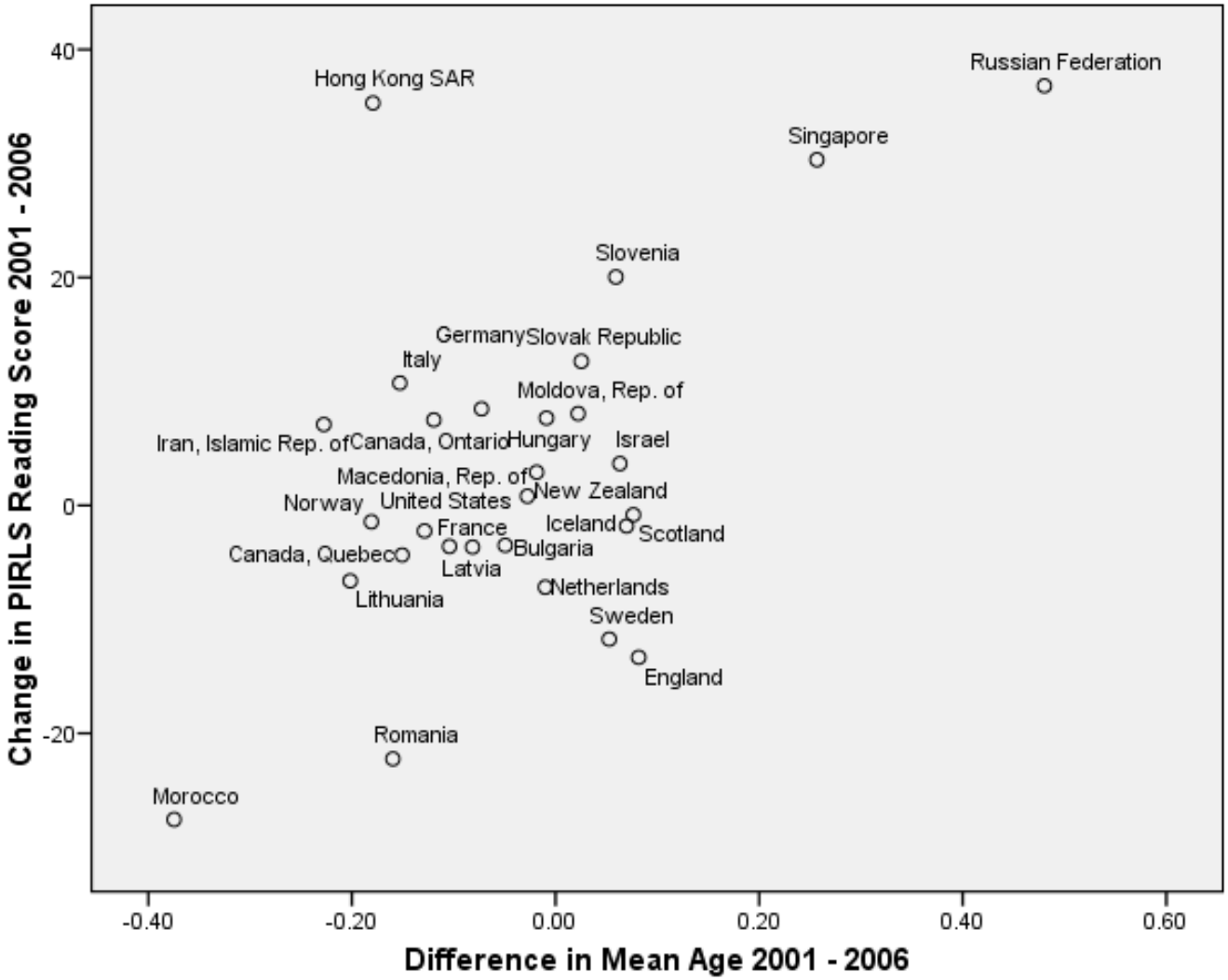


Martin, M.O., Mullis, I., & Foy, P. (2011). Age distribution and reading achievement configurations among fourth-grade students in PIRLS 2006. *IERI Monograph Series*, *4*, 9-33.

Difference in age and difference in reading achievement PIRLS 2001 and 2006

Strong correlation between difference in mean age and difference in reading score (r =.53).

b = 45



Does More Time Mean More Learning?

- Many studies have verified what most people regard as obvious, namely that more time spent of learning leads to more learning.
- However, Loveless (2007) observed that studies based on international test data typically fail to show a correlation between time spent on education and academic achievement.

Cross-sectional country-level analyses of data from TIMSS 1995 and TIMSS 2008 (from Loveless, 2007)

Pearson correlation coefficients for cross-sectional test scores and time variables
(eighth-grade TIMSS scores)

Table 3-1

	1995 Coefficient	2003 Coefficient
Instruction (I)	0.05	-0.20
Homework (H)	-0.22	-0.28
I+H	-0.18	-0.28

Source: 1995 and 2003 TIMSS reports and userguides.
See endnotes for a complete list of sources.

Loveless, T. (2007). Does more time mean more learning? In The Brown Center Report on American Education, Vol II, 2, 20-28. Washington, DC: Brookings

Longitudinal country-level analyses of data from TIMSS 1995 and TIMSS 2008

Pearson correlation coefficients for changes in test scores and time variables.

Table 3-2

	Correlation coefficient
Instruction (I)	0.42*
Homework (H)	-0.06
I+H	0.27

*p<.10

NOTE: Time variables analyzed in units of minutes per year

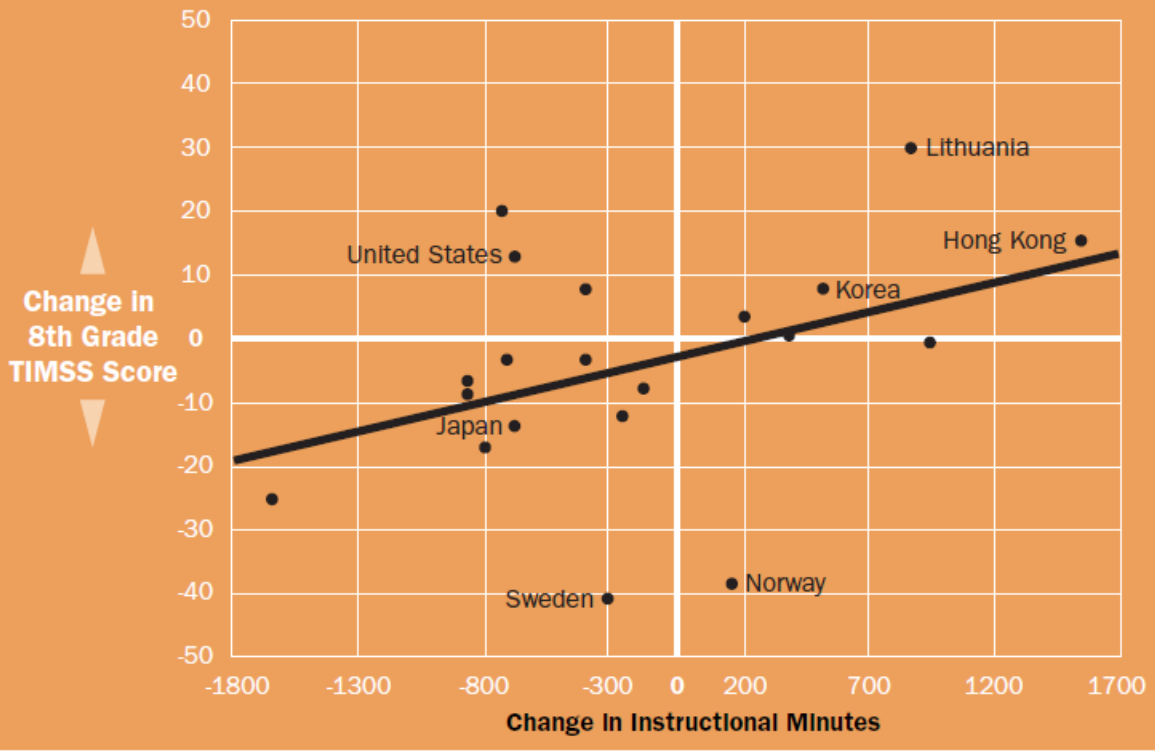
Source: 1995 and 2003 TIMSS reports and userguides.
See endnotes for a complete list of sources.

A scatterplot of the data shows a positive relationship between changes in yearly instruction and achievement (1995–2003).

Fig 3-1

Most countries that added instructional time increased their math scores.

Source: 1995 and 2003 TIMSS reports and userguides.
See endnotes for a complete list of sources.



Conclusions

- The longitudinal analysis is correlational too, but
  - the positive relationship for change in instructional time with change in achievement is more in line with the findings from other types of research on the impact of time on learning.
  - it is difficult to identify other explanations than causal effects for the pattern of findings.
- Loveless (2007) demonstrated on the basis of these results that adding 10 minutes per day to math instruction is associated with a 19 point gain in TIMSS score for U.S. 8th graders.

Does homework have an effect on achievement?

- A review by Cooper et al. (2006) showed a positive correlation between amount of homework and achievement in studies of secondary school students, but there was no relation for primary school students.
- Trautwein (2007) showed in analyses of German PISA and TIMSS data a strong negative relation between homework time and achievement at student level, and a positive relation between homework frequency and achievement at school/classroom levels.
- The negative relationship at student level is likely to be due to reverse causality between homework completion and achievement.
- The positive relation at the classroom level may at least partially be a true causal effect,

Homework in TIMSS Advanced 2008

- Analyses of relations between homework time and achievement for eight countries in TIMSS Advanced (Armenia, Iran, Italy, Lebanon, Norway, Phillipines, Russia, Slovenia).
- Analyses at student- and class-levels, controlling for socio-economic status.

- The mean correlation between homework time and achievement was 0.12 (t = 4,21).
- The mean correlation within classes was 0.05 (t = 1.92), and between classes the correlation was 0.32 (t = 3.28).

Relations between homework time and achievement

	Within classes	Between classes
Armenia	0.24	0.40
Iran	0.14	0.66
Italy	0.09	0.56
Lebanon	0.07	0.08
Norway	-0.14	0.37
Phillipines	0.03	0.12
Russia	-0.05	0.16
Slovenia	0.04	0.19

Class-level correlations with SES

	Homwork time	Achievement
Armenia	0.50	0.33
Iran	0.36	0.46
Italy	0.48	0.58
Lebanon	-0.21	0.69
Norway	-0.19	0.58
Phillipines	-0.23	0.67
Russia	-0.07	0.53
Slovenia	-0.36	0.43

Relations between homework time and achievement, controlling for SES

	Within classes	Between classes
Armenia	0.23	0.24
Iran	0.14	0.50
Italy	0.09	0.28
Lebanon	0.06	0.25
Norway	-0.15	0.48
Phillipines	0.03	0.27
Russia	-0.05	0.19
Slovenia	0.04	0.35

Conclusions

- The within-class relations between homework time and achievement vary widely, probably reflecting different demands on and strategies for homework completion.
- Taking SES into account, the between-class relations between homework time and achievement are positive and quite consistent over countries. This may reflect a causal effect of class-level assignment of homework.