A Slice of PISA: The OECD Program for International Student Assessment

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Credentials – or “why me”?

- Member: Technical Advisory Group 2005 - 2009
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What is the OECD?

- Began as the Organization for European Economic Co-operation (OEEC) in 1948 to help the Marshall Plan for the reconstruction of Europe after World War II. The headquarters on the grounds and neighborhood of Chateau de la Muette in Paris, France. After the end of the implementation of the Marshall Plan, the OEEC focused on economic questions.

- Following the 1957 Rome Treaties to launch Europe's Common Market, the Convention on the Organisation for Economic Co-operation and Development was drawn up to reform the OEEC. The Convention was signed in December 1960 and the OECD officially superseded the OEEC in September 1961. It consisted of the European founder countries of the OEEC plus the United States and Canada, with Japan joining three years later.

- There are now 30 OECD countries, with many partner countries involved in projects such as PISA.

What is PISA?

- PISA is part of the tradition of international student assessments originally launched by the IEA, such as the First, Second, and Third International Math and Science Studies, PIRLS.
- PISA sprang out of the OECDs International Indicators of Education Systems (INES) Project but now stands alone as the OECDs main educational assessment program.
- The INES Project began in 1988 in response to national policy makers' desire for information that would allow them to compare the performance of their education systems with those of other countries and thus better assess and monitor the effectiveness and evolution of their education systems.

- INES is composed of three networks:

1. Network A, chaired by the United States, develops indicators on learning outcomes;
2. Network B, chaired by Sweden, develops indicators of the social and economic outcomes of education;
3. Network C, chaired by the Netherlands, develops indicators on structures and processes of schools;

- At some point, there was a need for a focussed assessment of the knowledge and skills of students coming to the end of compulsory schooling. That is the role of PISA. Formerly under Network A, but now a stand-alone project.

- OECD member countries appoint individuals to the PISA Governing Board (PGB).
- The PGB is the final authority on all decisions regarding the goals and structure of PISA.
- The OECD Secretariat for Education manages PISA and reports to the PGB. They issue the “Call for Tender” (i.e. the RFP), to conduct PISA.
- PISA is run through an international consortium currently headed by the Australian Council for Education Research (ACER), located in Melbourne.
- Current members of the PISA consortium for the 2012 cycle are: cApStAn (Belgium), DIPF (Germany), ETS (US), ILS (Norway), IPN (Germany), NIER (Japan), CRP (Luxembourg), aSPe (Belgium), Westat (US).

- The international consortium, with approval from the PGB, forms expert groups and appoints members.
- Two expert groups are permanent across all cycles of PISA: The technical working group (TAG) and the questionnaire expert group (QEG).
- The TAG oversees and advises the consortium on the technical quality of PISA (sampling design, assessment design, assessment items, translation quality, etc.). They also arbitrate issues among the other expert groups.
- Representatives of other expert groups as well as the OECD Secretariat attend TAG meetings and seek advice from the TAG to take to the PGB.

- The QEG advises the consortium on the design and psychometric quality of the background questionnaire.
- The QEG advises on the overall conceptual framework for the specific PISA cycle, in consultation with the substance area expert group.
- The QEG advises on the design of policy relevant questions, as well as attitude and affective items.
- QEG members (i.e. your’s truly) also advise on the scaling of background questions to be used in policy relevant advanced statistical modeling.
- Other expert groups include: REG, MEG, SEG, PEG.
- Meetings are often twice a year during the design phase and once a year during implementation phase.

- The implementation of PISA in each country is the responsibility of that country’s National Project Manager (NPM).
- Typically (but not always), the NPM is an employee of that country’s educational ministry; perhaps a member of the data collection arm of that ministry.
- In the US, PISA is implemented by NCES.
- The international consortium works very closely with NPMs to ensure implementation fidelity within and across countries and resolves any issues that might arise.

What is PISA about?

- “...PISA is a collaborative effort among OECD member countries (and many partner countries) to measure how well 15 year old students approaching the end of compulsory schooling are prepared to meet the challenges of today’s knowledge societies” (2006 Technical Report)
- PISA is an age-based rather than grade based survey. Fifteen year olds are approaching the end of compulsory schooling in most OECD countries.
- PISA takes place every three years. These are the “cycles” of PISA:
  - 2000: Reading
  - 2003: Math
  - 2006: Science
  - 2009: Reading (first full cycle)
  - 2012: Math (in preparation)

- The PISA assessments take a literacy perspective that focuses on the extent to which students can use the knowledge and skills they have learned and practised at school when confronted with situations and challenges for which that knowledge may be relevant.
  - Can students use their reading skills to understand and interpret various kinds of written material that they are likely to meet as they negotiate their daily lives?
  - Can students use their mathematical knowledge and skills to solve various kinds of mathematics-related challenges and problems?
  - Can students use their scientific knowledge and skills to understand, interpret and resolve various kinds of scientific situations and challenges?

- The PISA survey collects information from students on various aspects of their home, family and school background; and information from schools about various aspects of organisation and educational provision in schools.

- This information is collected to facilitate a detailed study of factors within and between countries that are associated with varying levels of reading, mathematical and scientific literacy among the 15-year-old students of each country.

- Countries can implement international options or national options.
  - The parent questionnaire is an international option, following international guidelines and summarized by the international consortium.
  - A national option might be a teacher survey (e.g. the PISA-TALIS link). The international consortium does not provide analyses of these surveys, but the implementation of the national option cannot compromise the overall PISA design.

Core Features of PISA

- Sample Size
  - Approximately 400,000 students representative of 20 million 15 year olds enrolled in the schools of 66 participating countries and economies. (2009 cycle numbers).

- Methods
  - The 2006 assessment consisted of a 2 hour paper and pencil test. Computerized assessment is being studies. Very difficult.
  - Both multiple choice and constructed responses were used and analyzed with IRT methods.
  - A booklet spiraling approach was used (described later)
  - A 30 minute background questionnaire was administered
  - School principals answered questions about their schools.

- Outcomes
  - A profile of the knowledge and skills of 15-year olds
  - Contextual indicators relating results to student and school characteristics
  - A knowledge base for policy analysis and research
  - Trend indicators at the country level showing how results change over time

- Sampling Design
  - The PISA target population are 15-year old students attending educational institutions in the country, in grades 7 and higher.
  - Full-time, part-time, and vocational school attendance are included. Home schooled 15-year olds, or 15-year olds working are excluded.
  - A two-stage stratified sampling design is used.
    - First stage: Schools with 15-year olds are sampled with probability proportional to size.
    - Second stage: Students sampled within schools. A target cluster size of 35 was set, but could be adjusted for some countries if needed.
    - One country required a three-sage sampling design.

- Sampling Design (cont’d)
  - Exclusions were necessary but based on international agreement.
  - School level exclusions due to geographic inaccessibility.
  - Student level exclusions
    - Intellectually disabled students.
    - Functionally disabled students.
    - Students with insufficient assessment language experience: non-native speakers of assessment language; limited proficiency in language; less than one year of instruction in assessment language.

- Test Design
  - Each cycle consists of a major domain (e.g. reading), and minor domains (e.g. math, science).
  - Items are arranged in a unit around a common stimulus.
  - For 2006 there were 37 science units comprising 108 items.
  - Item formats are multiple choice, short closed constructed responses, and open constructed responses.
  - Attitudinal items for the science assessment were embedded in the test (**very controversial**), and required students to indicate their interest in the topic or support for evidenced based inquiry on the topic.

- Test Design (cont’d)
  - No student can sit for all of the items.
  - The goal is to give students a sample of items, but to obtain balance across all samples, and to create balance in terms of positioning of items.
  - This is accomplished through a balanced incomplete block design
  - Thirteen booklets were formed containing thirteen item clusters, yielding 30 minutes of test time for each booklet.
  - Each cluster appears in each of the four posible positions within a booklet once.
  - The scaling of the cognitive items is based on a mixed coefficients multinomial logit model.

Scaling and Validation of Context Questionnaires

- Two types of indices were created
  - Simple indices based on transformations of variables
    - Examples: highest occupational status of parents, educational level of parents, school size, etc.
  - Scale indices based on CFA models for dichotomous or Likert-scale items for dimensionality followed by IRT models for scaling.
    - Examples: Interest in science, self-efficacy in science, parent support for science learning.
  - Research is being conducted to look at multilevel IRT and multilevel latent class scaling models for PISA data.

Example: Multilevel SEM with PISA data

- From
  - Kaplan, D., Kim J-S., & Kim, S-Y. (2009). Multilevel latent variable modeling: Current research and recent developments. In R. E. Millsap and A. Maydeu-Olivares (eds.), *The SAGE Handbook of Quantitative Methods in Psychology*. Newbury Park: SAGE Publications.

Multilevel SEM

- In recent years attempts have been made to integrate multilevel modeling with structural equation modeling in order to provide a general methodology that can account for issues of measurement error and simultaneity as well as multi-stage sampling.

- This can now be handled in a relatively straightforward fashion.

- Consider a model that decomposes a p-dimensional response vector $\mathbf{y}_{ig}$ for student i in school g into the sum of a grand mean $\boldsymbol{\mu}$, a between groups part $\boldsymbol{\nu}_g$ and a within groups part $\mathbf{u}_{ig}$. That is,

$$\mathbf{y}_{ig} = \boldsymbol{\mu} + \boldsymbol{\nu}_g + \mathbf{u}_{ig}, \tag{1}$$

The total sample covariance matrix for the response vector can be written as $\mathbf{y}_{ig}$

$$\boldsymbol{\Sigma}_T = \boldsymbol{\Sigma}_b + \boldsymbol{\Sigma}_w, \tag{2}$$

where $\boldsymbol{\Sigma}_T$ is the population total sample covariance matrix, $\boldsymbol{\Sigma}_b$ is the population between groups covariance matrix, and $\boldsymbol{\Sigma}_w$ is the population within groups covariance matrix.

- Sample quantities can be defined as

$$\bar{\mathbf{y}}_{.g} = \frac{1}{n_g} \sum_{i=1}^{n_g} \bar{\mathbf{y}}_{ig} \tag{3}$$

$$\bar{\mathbf{y}} = \frac{1}{N} \sum_{g=1}^{G} \sum_{i=1}^{n_g} \bar{\mathbf{y}}_{ig} \tag{4}$$

$$\mathbf{S}_w = \frac{1}{N-G} \sum_{g=1}^{G} \sum_{i=1}^{n_g} (\mathbf{y}_{ig} - \bar{\mathbf{y}}_{.g})(\mathbf{y}_{ig} - \bar{\mathbf{y}}_{.g})' \tag{5}$$

$$\mathbf{S}_b = \frac{1}{G-1} \sum_{g=1}^{G} n_g (\bar{\mathbf{y}}_{.g} - \bar{\mathbf{y}})(\bar{\mathbf{y}}_{.g} - \bar{\mathbf{y}})', \tag{6}$$

where $\bar{\mathbf{y}}_{.g}$ is the sample mean for group g, $\bar{\mathbf{y}}$ is the grand mean, $\mathbf{S}_w$ is the sample pooled within group covariance matrix, and $\mathbf{S}_b$ is the between groups covariance matrix.

- Let's assume that the vector of student responses can be expressed in terms of the multilevel linear factor model as

$$\mathbf{y}_{ig} = \boldsymbol{\nu} + \boldsymbol{\Lambda}_w \boldsymbol{\eta}_{w_{ig}} + \boldsymbol{\Lambda}_b \boldsymbol{\eta}_{b_g} + \boldsymbol{\epsilon}_{w_{ig}} + \boldsymbol{\epsilon}_{b_g}, \tag{7}$$

where $\mathbf{y}_{ig}$ was defined earlier, $\boldsymbol{\nu}$ is the grand mean, $\boldsymbol{\Lambda}_w$ is factor loading matrix for the within group variables, $\boldsymbol{\eta}_{w_{ig}}$ is a factor that varies randomly across units within groups, $\boldsymbol{\Lambda}_b$ is the between groups factor loading matrix, $\boldsymbol{\eta}_{b_g}$ is a factor that varies randomly across groups, $\boldsymbol{\epsilon}_{w_{ig}}$ and $\boldsymbol{\epsilon}_{b_g}$ are within and between group uniquenesses.

- Under the assumptions of linear factor analysis, here extended to the multilevel case, the total sample covariance matrix defined in Equation (2) can be expressed in terms of factor model parameters as

$$\mathbf{\Sigma}_T = \mathbf{\Lambda}_w \mathbf{\Phi}_w \mathbf{\Lambda}_w' + \mathbf{\Theta}_w + \mathbf{\Lambda}_b \mathbf{\Phi}_b \mathbf{\Lambda}_b' + \mathbf{\Theta}_b, \quad (8)$$

where $\mathbf{\Phi}_w$ and $\mathbf{\Phi}_b$ are the factor covariance matrices for the within group and between group parts and $\mathbf{\Theta}_w$ and $\mathbf{\Theta}_b$ are diagonal matrices of unique variances for the within group and between groups part.

- It is usually straightforward to specify a factor structure for the within school variables.
- It is also straightforward to allow for within school variables to vary between schools.
- Conceptual difficulties sometimes arise in warranting a factor structure to explain variation between groups.
- The fact that it is sometimes difficult to conceptualize a factor structure for the between groups covariance matrix does not diminish the importance of taking the between group variability into account when conducting a factor analysis on multilevel structured data.

An Example of Multilevel Factor Analysis

- In this example, I use the South Korea sample of the PISA 2003 cycle.
- I estimate a single level and multilevel confirmatory factor analysis with and without the addition of gender as a covariate.
- On the basis of initial exploratory factor analyses, I specify two within school factors and one between school factor.
- The first within school factor can be factor labeled *CALCULATING MATHEMATICS IN LIFE* and the second within school factor can be labeled *SOLVING EQUATIONS*.
- The single between school factor can be interpreted as representing perhaps an overall school level emphasis on mathematics instruction, and can be labeled *GENERAL MATHEMATICS EMPHASIS*.
- Sometimes this between school factor takes on the look of an "average profile" for schools within a country.

- As an additional analysis, I added gender as a predictor of the latent variables with males coded 0 and females coded 1.

- Adding a predictor to a CFA model yields the specification of a multiple indicator multiple cause (MIMIC) structural equation model.
- Model evaluation is assessed by looking at the likelihood ratio chi-square test as well as model selection measures AIC and BIC.

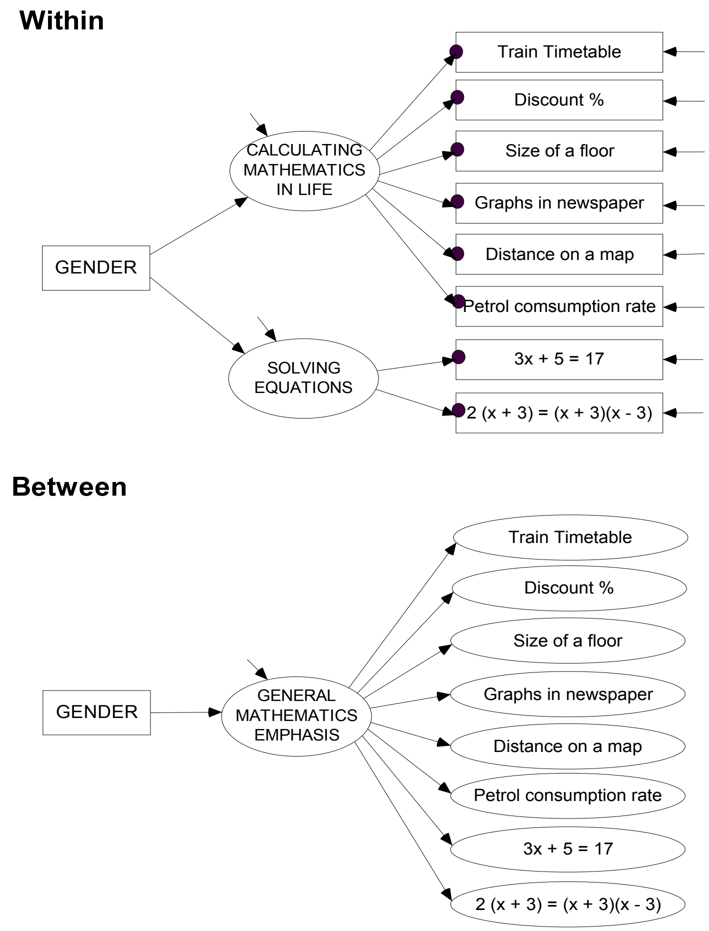

Figure 24.1. Multilevel factor analysis with a covariate.

Table 1: Results of Confirmatory Factor Analysis of PISA 2003 Mathematics Assessment

	Single-Level CFA				Multilevel CFA			
	WO Predictors		*With Predictors*		*WO Predictors*		*With Predictors*	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
					Within School Model			
Calculating Mathematics								
Train timetable	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000
Discount %	1.187*	0.022	1.190*	0.022	1.136*	0.026	1.135*	0.025
Size (m^2) of a floor	1.140*	0.023	1.140*	0.023	1.125*	0.027	1.124*	0.027
Graphs in newspaper	0.909*	0.021	0.908*	0.021	0.876*	0.026	0.875*	0.026
Distance on a map	1.184*	0.028	1.185*	0.028	1.113*	0.031	1.109*	0.033
Petrol consumption rate	0.881*	0.022	0.883*	0.022	0.905*	0.027	0.904*	0.027
Solving equations								
$3x + 5 = 17$	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000
$2(x + 3)=(x + 3)(x - 3)$	1.060*	0.015	1.059*	0.015	1.039*	0.020	1.036*	0.021
Calculating Mathematics on MALE			-0.133*	0.016			-0.113*	0.024
Solving Equations on MALE			-0.039	0.023			0.001	0.038
Factor Covariances								
Calculating Mathematics with *Solving Equations*	0.286*	0.009	0.284*	0.009	0.197*	0.008	0.197*	0.008
					Between School Model			
General Mathematics Emphasis								
Train timetable					1.000	0.000	1.000	0.000
Discount %					1.373*	0.067	1.379*	0.068
Size (m^2) of a floor					1.192*	0.062	1.195*	0.060
Graphs in newspaper					1.047*	0.063	1.053*	0.064
Distance on a map					1.460*	0.102	1.474*	0.105
Petrol consumption rate					0.752*	0.072	0.764*	0.074
$3x + 5 = 17$					1.808*	0.132	1.814*	0.143
$2(x + 3)=(x + 3)(x - 3)$					1.987*	0.136	1.994*	0.145
General Mathematics Emphasis on MALE							-0.057	0.051
Model Fit Indices								
χ^2	456.250 (19 *df*)		526.500 (25 *df*)		641.253 (39 *df*)		670.784 (52 *df*)	
AIC	86593.8		95130.6		85173.1		89797.8	
BIC	86758.6		95308.9		85443.3		90088.2	

Note. Unstandardized estimates are displayed. SE: standard error. AIC: the Akaike information criterion. BIC: the Bayesian information criterion.

- Comparison of the single level and multilevel results without predictors suggests that accounting for clustering slightly worsened model fit as evidenced by the larger likelihood ratio chi-square.
- The estimates are also negligibly different with the exception that the standard errors for the multilevel solution are uniformly larger.
- It should be noted that taking into account clustering is known to improve fit in simulation studies.
- In the context of real data however, accounting for clustering is still appropriate, but can also reveal other problems that can lead to poorer fit.
- In this analysis, we find that the multilevel factor model is preferred based on model selection measures - AIC and BIC.

- An important feature of the multilevel model with the predictor added is that predictors could be added at both levels.
- Interpretation would have be undertaken cautiously.
- For PISA, an important aspect of this model is that policy relevant predictors (perhaps supporting counterfactuals) could be added along with background predictors to study policy implications on latent variables (the error free measures).
- This is something that should be explored.

Multilevel Path Analysis

- Conventional multilevel regression models may not be suited for capturing the structural complexity within and between organizational levels.
- For example, it may be of interest to determine if school level variation in student science achievement can be accounted for by school level variables.
- Moreover, one might hypothesize and wish to test direct and indirect effects of school level exogenous variables on that portion of student level achievement that varies over schools.
- These questions are important for a fuller understanding of educational systems and such questions can be addressed via multilevel structural equation modeling.

- The model that we will consider allows for varying intercepts and varying structural regression coefficients.

- Earlier work on multilevel path analysis by Kaplan & Elliott (1997a) building on the work of Muthen & Satorra (1989) specified a structural model for varying intercepts only.

- This "intercepts as outcomes" model was applied to a specific educational problem in Kaplan & Elliott (1997b) and Kaplan & Kreisman (2000).

- Recent developments now allow for modeling structural slopes.

Specification of Multilevel Path Analysis

- In what follows, we write the within-school (level–1) full structural equation model as

$$\mathbf{y}_{ig} = \boldsymbol{\alpha}_g + \mathbf{B}_g \mathbf{y}_{ig} + \boldsymbol{\Gamma}_g \mathbf{x}_{ig} + \boldsymbol{r}_{ig}, g = 1, 2, \ldots, G \quad (9)$$

  where $\mathbf{y}_{ig}$ is a *p*–dimensional vector of endogenous variables for student i in school g, $\mathbf{x}_{ig}$ is a q–dimensional vector of within school exogenous variables.

- $\boldsymbol{\alpha}_g$, $\mathbf{B}_g$, and $\boldsymbol{\Gamma}_g$ are structural coefficients that are allowed to vary across schools.

- $\mathbf{r}_{ig}$ is the within school disturbance term assumed to be normally distributed with mean zero and constant within school variance σ_r^2.

- We can model the structural intercepts and slopes as a function of between school endogenous variables $\mathbf{z}_g$ and between school exogenous variables $\mathbf{w}_g$.

- Specifically, we write the level–2 model as

$$\boldsymbol{\alpha}_g = \boldsymbol{\alpha}_{00} + \boldsymbol{\alpha}_{01}\mathbf{z}_g + \boldsymbol{\alpha}_{02}\mathbf{w}_g + \boldsymbol{\epsilon}_g, \quad (10)$$

$$\mathbf{B}_g = \mathbf{B}_{00} + \mathbf{B}_{01}\mathbf{z}_g + \mathbf{B}_{02}\mathbf{w}_g + \boldsymbol{\zeta}_g, \quad (11)$$

$$\boldsymbol{\Gamma}_g = \boldsymbol{\Gamma}_{00} + \boldsymbol{\Gamma}_{01}\mathbf{z}_g + \boldsymbol{\Gamma}_{02}\mathbf{w}_g + \boldsymbol{\theta}_g. \quad (12)$$

- Equations 10–12 allow for randomly varying intercepts and two types of randomly varying slopes – namely $\mathbf{B}_g$ are randomly varying slopes relating endogenous variables to each other and $\boldsymbol{\Gamma}_g$ are randomly varying slopes relating endogenous variables to exogenous variables.

- These randomly varying structural coefficients are modeled as functions of a set of between school predictors $\mathbf{z}_g$ and $\mathbf{w}_g$.

- Of particular importance for substantive research is the fact that the full multilevel path model allows for a set of structural relationships among between school endogenous and exogenous variables, which we can write as

$$\mathbf{z}_g = \boldsymbol{\tau} + \boldsymbol{\Delta}\mathbf{z}_g + \boldsymbol{\Omega}\mathbf{w}_g + \boldsymbol{\delta}_g, \tag{13}$$

where $\boldsymbol{\tau}$, $\boldsymbol{\Delta}$, and $\boldsymbol{\Omega}$ are the fixed structural effects. Finally, $\boldsymbol{\epsilon}$, $\boldsymbol{\zeta}$, $\boldsymbol{\theta}$, and $\boldsymbol{\delta}$ are disturbances term that are assumed to be normally distributed with mean zero and covariance matrix $\mathbf{T}$ with elements

$$\mathbf{T} = \begin{pmatrix} \sigma^2_\epsilon & & & \\ \sigma_{\zeta\epsilon} & \sigma^2_\zeta & & \\ \sigma_{\theta\epsilon} & \sigma_{\theta\zeta} & \sigma^2_\theta & \\ \sigma_{\delta\epsilon} & \sigma_{\delta\zeta} & \sigma_{\delta\theta} & \sigma^2_\delta \end{pmatrix} \tag{14}$$

- We can obtain the so-called *reduced form* of the level–1 model and level–2 model and express $\mathbf{y}_{ig}$ as a function of a grand mean, the main effect of within-school variables, the main effect of between–school variables and the cross level moderator effects of between and within school variables.

- These reduced form effects contain the structural relations as specified in Equations (9) through (13).

- The importance of this model for PISA analyses is that if $\mathbf{w}$ consists of variables that could, in principle, be manipulated in the context of a hypothetical experiment, then this model could be used to test cross level causal hypotheses taking into account the structural relationships between and within levels.

- This point is related to a specific counterfactual model of causality based on manipulability theory (Woodward, 2003; see also Heckman) and is, arguably, crucial for policy analysis with PISA.

An Example of Multilevel Path Analysis

- A multilevel path analysis was employed to study within and between school predictors of mathematics achievement again using data from the PISA 2003 survey.
- The final outcome variable at the student level was a measure of mathematics achievement (MATHSCOR).
- Mediating predictors of mathematics achievement consisted of whether students enjoyed mathematics (ENJOY) and whether students felt mathematics was important in life (IMPORTNT).
- Student exogenous background variables included student's perception of teacher qualities (PERTEACH), as well as both parent's educational levels (MOMEDUC & DADEDUC).

- At the school level, a model was specified to predict the extent to which students are encouraged to achieve their full potential (ENCOURAG).
- A measure of teachers' enthusiasm for their work (ENTHUSIA) was viewed as an important mediator variable between background variables and encouragement to make students achieve full potential.
- The variables used to predict encouragement via teachers' enthusiasm consisted of math teachers' use of new methodology (NEWMETHO), consensus among math teachers with regard to school expectations and teaching goals as they pertain directly to mathematics instruction (CNSENSUS), and the teaching conditions of the school (CNDITION).
- The teaching condition variable was computed from the shortage of school's equipment, so higher values on this variable reflect a worse condition.

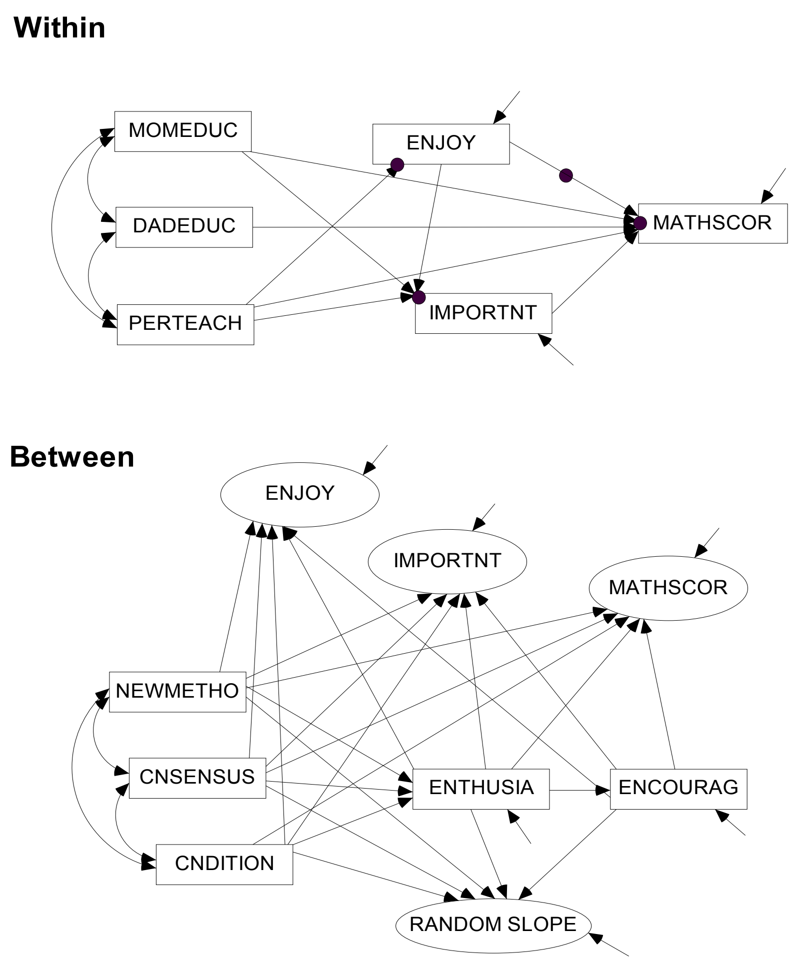

Figure 24.2. Multilevel path model of mathematics achievement with structural model at the between school level.

- First we estimated the intra-class correlations to determine the amount of variation in the student level variables that can be accounted for by differences between schools.
- We found intra-class correlations (not shown) ranging from a low of 0.02 for the importance of math in one’s life to a high 0.259 for mathematics achievement.
- Under the heading “Within School” we find that MOMEDUC, DADEDUC, ENJOY, and IMPORTNT are significant and positive predictors of MATHSCOR.
- We also observe that ENJOY is significantly and positively predicted by PERTEACH. Finally, MOMEDUC, PERTEACH, and ENJOY is a positive and significant predictor of IMPORTNT.

Table 2: Results of Multilevel Path Analysis

Within School Model			**Between School Model**		
	Estimate.	SE		Estimate	SE
MATHSCOR on			RANDOM SLOPE on		
MOMEDUC	4.011*	1.042	NEWMETHO	-4.632	2.652
DADEDUC	4.813*	0.929	ENTHUSIA	10.101*	3.838
PERTEACH	6.273*	2.765	CNSENSUS	-3.629	3.224
IMPORTNT	15.873*	2.334	CNDITION	-8.181*	2.532
			ENCOURAG	-1.668	2.863
ENJOY on					
PERTEACH	0.457*	0.026	MATHSCOR on		
			NEWMETHO	6.806	6.550
IMPORTNT on			ENTHUSIA	-14.081	8.881
MOMEDUC	0.026*	0.006	CNSENSUS	2.407	7.898
PERTEACH	0.245*	0.021	CNDITION	3.366	6.683
ENJOY	0.534*	0.015	ENCOURAG	14.594	7.299
			ENJOY on		
			NEWMETHO	0.008	0.025
			ENTHUSIA	0.016	0.038
			CNSENSUS	0.109*	0.036
			CNDITION	0.019	0.025
			ENCOURAG	-0.035	0.024
			IMPORTNT on		
			NEWMETHO	-0.027	0.019
			ENTHUSIA	0.028	0.031
			CNSENSUS	0.057	0.030
			CNDITION	0.044*	0.020
			ENCOURAG	0.002	0.020
			ENCOURAG on		
			ENTHUSIA	0.579*	0.086
			ENTHUSIA on		
			NEWMETHO	0.164*	0.044
			CNSENSUS	0.323*	0.067
			CNDITION	-0.042	0.040

Note. Unstandardized estimates are displayed. SE: standard error.

- What is of importance to this talk are the results under the heading “Between School”.
- We find that the resource conditions of the school (CNDITION) and the extent to which the school encourages students to use their full potential (ENCOURAG) are both significant predictors of math achievement.
- Enjoyment of mathematics is significantly related to whether there is consensus among mathematics teachers in with regard to expectations and teaching goals. Importance of mathematics is related to the resource conditions of the school.
- Teacher enthusiasm for their work is significantly predicts the extent to which they encourage students to use their full potential.
- Enthusiasm is predicted by use of new methods for teaching math and the extent of consensus around school expectations and teaching goals pertaining to mathematics instruction.

- The results for the random slope relating ENJOY to MATHSCOR reveals that teacher enthusiasm moderates the relationship between enjoyment of mathematics and math achievement.

- Higher levels of teacher reported enthusiasm associated with a stronger positive relationship between enjoyment of math and math achievement.

- Finally, the condition of the school also demonstrates a significant moderating effect on the relationship between enjoyment of math and math achievement, where poorer conditions of the school lowers the relationship between enjoyment of mathematics and math achievement.

Some Important Websites

- OECD website: www.oecd.org

- PISA website: www.pisa.oecd.org

  - On the PISA website are links for downloading data and syntax files in SPSS and SAS format.