Teacher Quality and Cross Country Differences in Student Achievements

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Objectives

- Develop a model to discuss the determinants of teacher quality (TQ).
- Build an approximation of the average TQ for a set of countries.
- Discuss if cross-country differences in TQ are related with differences in student outcomes.
- Understand why TQ is different across-countries.
Motivation

Teacher quality matters


- Teacher quality is the educational input with highest impact on student outcomes (Hanushek, 2003).
Motivation

But little is known about TQ

- Teacher quality is not strongly related with observable characteristics of teachers.
- There aren’t measures of teacher quality in the literature.
- There is scarce evidence regarding the determinants of teacher quality.
- Little is known regarding the importance of Teacher quality to explain cross-country differences in student achievements.
Contributions of this paper

- Provides a theoretical framework to think about the determinants of teaching quality.

- Provides time series measures of average teacher quality for a sample of 22 countries.
  - The only previous measure of TQ at a country level (Hanushek et. al., 2014) includes only one year (2012).

- Studies if TQ trends explain the time dynamic of student outcomes.
  - No previous studies include this analysis because there aren’t time series of country TQ.

- Discuss determinants of cross-country differences in TQ.
Road Map

1. Present a theoretical model of teacher selection.
2. Build a measure of country teacher quality.
   ▶ Solve and calibrate the model for a panel of countries.
3. Analyse the importance of TQ as educational input.
4. Discuss the determinants of cross-country differences in TQ.
Part 1

A Model of teacher selection
The theoretical approach

I propose a theoretical model with two stages of selection:

- **A self selection stage:** every potential teacher chooses between working in the teaching sector or the non-teaching sector (market sector in ahead).

- **A school selection stage:** schools select some of the individuals who integrate the teacher supply to fill in their vacancies.
  
  - This stage represents an extension to previous models which focus on the self selection stage (Nagler et al. (2015), Rothstein (2014) and Tincani (2011)).
The model

General Assumptions

- A measure $1$ of potential teachers characterized by the pair $(\hat{\theta}, \hat{t})$ where $\hat{\theta}$ is the general skill and $\hat{t}$ is the teaching skill.

- General skill $(\hat{\theta})$ is assumed observable but teaching skill $(\hat{t})$ is not.

- $\ln(\hat{\theta}, \hat{t}) \sim N \left( \begin{bmatrix} \mu_\theta \\ \mu_t \end{bmatrix}, \begin{bmatrix} \sigma^2_\theta & \sigma_{\theta t} \\ \sigma_{\theta t} & \sigma^2_t \end{bmatrix} \right)$ skills are distributed log-normal.

- $\rho_{\theta t} \geq 0$, where $\rho_{\theta t}$ indicates the correlation between both skills.
The Model (II)

General Assumptions

- School board needs only a fraction $\gamma$ of teachers.
- $y = y(F; \hat{t}; R)$ is the educational production function
  - students outcomes ($y$) depend on family inputs ($F$); teacher skills ($\hat{t}$); and other school resources ($R$).
- $\hat{w}_0$ is the teacher wage.
  - Teacher wage is the same for all teachers
- $\hat{w}_\theta$ is the market wage, where $\hat{w}_\theta = \hat{\theta}^\alpha$
  - Market wage depends on the general skill ($\hat{\theta}$)
  - $\alpha$ is the wage elasticity to the general skill ($\hat{\theta}$) in the market sector.
  - I assume that $\alpha > 0$
Self-selection stage

Individuals have the following utility function:

\[ u_i = \begin{cases} 
\ln(\hat{w}_0) + \ln(\hat{t}^\tau) & \text{if teach} \\
\ln(\hat{w}_\theta) & \text{otherwise} 
\end{cases} \]

- \( \ln(\hat{w}_0) \) and \( \ln(\hat{w}_\theta) \) indicates the pecuniary utility in each sector.
- \( \ln(\hat{t}^\tau) \) captures a non-pecuniary utility of teach.
  - \( \tau \) measures the elasticity of the non-pecuniary utility respect to the individual teacher skill
  - I assume that \( \tau \geq 0 \)

\[ \Rightarrow \text{Individuals will choose to be a teacher } (I = 1) \text{ if:} \]

\[ \ln(\hat{w}_0) + \tau \ln(\hat{t}) > \alpha \ln(\hat{\theta}) \]
School selection stage

School problem

- Schools select $\gamma$ individuals from the teacher supply to maximize student achievements taking teacher salary as given.
- Schools screen teachers based on observables ($\rho_{\theta t} \geq 0$).

School strategy

- Sort the teacher supply based on $\theta$.
- Hire the fraction $\gamma$ of individuals with the higher level of $\theta$. 
Equilibrium in the teacher market

- After the two stages we known who are the teachers and we can compute their expected average ability.
- Equilibrium quantity is assumed exogenous ($\gamma$).
- I focus on the relationship between teacher wage and teacher quality.
- Solving the model for different levels of teacher salary, I build a "Teaching Wage-Teaching Quality" (TW-TQ) equilibrium curve.
Part 2.

Model Calibration
Parameters to calibrate

The model has nine parameters to calibrate

- Five parameters are associated to the distribution of skills among the population ($\mu_t$, $\mu_\theta$, $\sigma_t$, $\sigma_\theta$ and $\rho_{\theta t}$).

- One parameter is associated to the individual utility function ($\tau$).

- Three parameters are related to the labour market conditions:
  - $\widehat{w}_0$ measures the teacher salary relative to the median wage in the market sector.
  - $\alpha$ states the elasticity of wages respect to the general skill.
  - $\gamma$ states the share of the teacher in the labour force.
Parameters to calibrate (II)


- Observable parameters were approximated directly by country data. Sources (Education at a Glance, IMF, PIAAC).

- Unobservable parameters ($\mu_t$, $\sigma_t$, $\rho_{\theta t}$ and $\tau$) were approximated indirectly
  - The strategy was based on minimizing distance between a theoretical TW-TQ curve for the average country with an empirical estimation of the TW-TQ curve.
Main results of calibration

- Distribution of teacher skills present big differences across countries (in mean and variance).
  - but in line with the cross-country differences in the core skills measured in PIAAC.
- Correlation between the teacher and general skills is significantly positive (0.57)
  - but clearly weaker than the correlation among core skills.
- Utility of teaching is weakly related with the individual teacher skill ($\tau = 0.24$).
Model Results

Average Teacher quality (2000-2015) by countries - Math

G. Zunino (UAM)
Model Results

Average Teacher quality (2000-2015) by countries - Read

G. Zunino (UAM)
Evaluation of Model results

Empirical approach

TQ dispersion within-country and between subjects was used to identify its effect on student outcomes.

\[ y_{is} = \beta_0 TQ_{cst} + \beta_1 S_i + \beta_2 F_i + \beta_3 SCH_i + \beta_4 M_{ct} + T_t + C_c + u_{is} \]

- \( y_{is} \) is the student score for individual \( i \) in subject \( s \).
- \( TQ_{cst} \) is the simulated TQ for country \( c \), subject \( s \) and period \( t \).
- \( S_i \) represents a set of individual characteristics.
- \( F_i \) states the family background for individual \( i \).
- \( SCH_i \) states the school characteristics for individual \( i \).
- \( M_{ct} \) represents macro variables for country \( c \), in period \( t \).
- \( T_t \) are time dummies and \( C_c \) is a country fixed effect.
- \( u_{is} \) is the error term.
Table 4 - Effect of TQ on student achievements

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TQ</td>
<td>8.3562***</td>
<td>9.1052***</td>
<td>10.0148***</td>
</tr>
<tr>
<td>Student</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>characteristics</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Family</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>background</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>School</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>characteristics</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Macro controls</td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Country</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>fixed effects</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Time dummies</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.0344</td>
<td>0.2073</td>
<td>0.2209</td>
</tr>
</tbody>
</table>

Note: Student characteristics includes gender, age, migration status, and dummies regarding repetition and difference between the language of the test and language at home. School characteristics includes index of autonomy, school size and the student teacher ratio. Family background is captured by the ESCS index of PISA.
Part 3.

Does teacher quality explain cross-country differences in student outcomes?
Importance of TQ

Counter-factual Exercise

- Remove all other country differences (i.e.) except in TQ. (to isolate its effect)

Results

- Cross-county variance on PISA results is approximately a 22% of the observed variance in our panel.
**Table 4 - Effect of Educational Inputs on cross-country variance in student achievements**

<table>
<thead>
<tr>
<th>Component</th>
<th>% of the observed variance explained by each component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Quality</td>
<td>22%</td>
</tr>
<tr>
<td>School organization</td>
<td>5%</td>
</tr>
<tr>
<td>Student Teacher ratio</td>
<td>1%</td>
</tr>
<tr>
<td>Educational spent (% of GDP)</td>
<td>8%</td>
</tr>
<tr>
<td>Family Background</td>
<td>20%</td>
</tr>
</tbody>
</table>

TQ is the single school input with highest impact on student achievements. Its effect is quite similar to the family background effect.
Part 4.

What are the main drivers of TQ at the country level?
Determinants of country TQ

Our model allows us to study the importance of different sources of TQ dispersion:

- Differences in teacher salaries
- Differences in labour market conditions
- Differences in population distributions of skills

TQ determinants
I evaluate the importance of each determinant using the theoretical model to simulate new vectors of TQ under different assumptions.
Determinants of cross-country variance in TQ - Summarize

Table 5 - Sources of TQ differences across countries

<table>
<thead>
<tr>
<th>Modified parameters</th>
<th>Imputed value</th>
<th>Variance in TQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex. 1 $\hat{w}_0$</td>
<td>panel mean</td>
<td>-6.6%</td>
</tr>
<tr>
<td>Ex. 2 $\alpha$</td>
<td>panel mean</td>
<td>-0.2%</td>
</tr>
<tr>
<td>Ex. 3 $\gamma$</td>
<td>panel mean</td>
<td>-3.5%</td>
</tr>
<tr>
<td>Ex. 4 $\mu_t, \mu_\theta, \sigma_t, \sigma_\theta$</td>
<td>panel mean</td>
<td>-91%</td>
</tr>
</tbody>
</table>

The importance of the starting point

Differences in population distributions explain most of the cross-country differences in TQ
Conclusions
Conclusions

- Empirical estimations suggest that our measure of TQ is a significantly determinant of student outcomes.
- TQ differences play a key role to explain cross-country differences in student achievements.
- Most of current cross country differences in TQ follows from differences in the population distribution of skills.
Thank you!

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