THE INFLUENCE OF PERFORMANCE BASED INCENTIVES ON THE QUALITY OF THE CHILEAN EDUCATION SYSTEM

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ABSTRACT

Improving the quality of education systems is one of the most important challenges faced by Latin American governments**.** In order to achieve this goal, Chile has introduced several reforms such as the National System for Assessing School Performance (SNED). The System provides monetary incentives to teachers mainly based on students' performance on national standardized tests. This study shows that ***reading, mathematical and scientific literacy*** measured by PISA-2006 assessments are positively related with attendance at schools awarded by SNED-2006, after controlling for individual socio-economical factors as well as school-quality factors. Schools awarded by SNED-2006 not only offered higher education quality compared to their peers in terms of national curriculum coverage, but they also contributed to develop higher competences relevant to future personal, social and economic well being among their students.

The research and writing of this thesis
is dedicated to my father Ivan, my mother Ximena, my brother Alberto, my sister Ximena Belen, my aunt Maria del Carmen, my uncle Fidel, and my cousins Paula and Diana whose love and help were the most important factors for success during these two years.

Many thanks,
Maria Daniela Araujo

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1. Introduction

Countries' improvements in education are significantly correlated with productivity growth and economic development. The theory of human capital accumulation supports the idea that education gives people cognitive skills and competences that make them more productive and enable them to receive higher wages in the market (Perkins, Radelet, and Lindauer, 2006). Theodore Shults (1961), one of the first economists who studied this theory, concluded that investment in human capital accounted for most of the impressive rise in real earnings per worker in the industrialized countries. Moreover, some studies attribute positive externalities to schooling that impact societies beyond the individuals' benefits from education. These include civic engagement (Dee, 2003), societies' support for democracy (Glaeser, Ponzetto, and Shleifer, 2006), and better health outcomes (de Walque, 2005).

On the other hand, researchers have also highlighted the fact that spending money on schooling does not guarantee better education outcomes (Glewwe, Ilias and Kremer, 2003; Hanushek and Woessmann, 2007). They point out that in any educational system, the character of the system's incentives is fundamentally important. If people do not learn at school, the investment is not effective because the higher labor productivity expected is not achieved.

It is widely recognized that measuring students' learning achievement is very complex and also that teachers play a key role in how much students learn (Vegas and

Umansky, 2005). Currently, researchers have opted to evaluate the quality of educational systems and teachers' effectiveness by analyzing students' performance on standardized tests. The Programme for International Student Assessment (PISA) is an internationally standardized evaluation administered to 15-year-olds in OECD[1] and partner countries, that determines whether students have acquired some of the knowledge and skills that are essential for full participation in society (OECD, 2008). The Programme provides comparative indicators of students' performance in reading, mathematical and scientific literacy. The PISA-2006 results showed that students in most of the middle income nations, including those in Latin America, performed far lower than students in OECD countries, especially on mathematical skills. Chile's performance in science and reading was the highest of the six Latin American countries that participated in PISA-2006[2] and the second highest in mathematics. Although this performance is still low with respect to all participating countries, Chile registered the largest increase in reading scores of all participants compared with results of PISA-2000 (Manzi, et. al, 2008).

Governments have tried to improve student performance by introducing school reforms that attempt to change the educational systems' incentives. These reforms, including for example, merit-based systems, school-based awards, and school-based management, appear to be successful depending on whether they induce teachers to achieve higher student learning, generate incentives for the highest proportion of

[1] The Organisation for Economic Cooperation and Development.
[2] Latin-American participating countries: Argentina, Colombia, Mexico, Brazil, Chile, and Uruguay.

teachers, offer a large enough reward for additional school efforts, and avoid potential negative behavioral responses, such as cheating, disfavoring weaker students, and limiting curricula to material in the test (Vegas, E. and Umansky, 2005).

Since 1980, Chile's education system has been the subject of several reforms which have been especially focused on improving the quality of the system since the return to democracy. During the first years of the 1980's, the military government decentralized the schools' management to the municipal level and started distributing per-student voucher payments to municipal schools based on their enrollment, as well as to private schools if they did not charge tuition (McEwan, 2002). In 1988 the System for Measuring the Quality of Education (Sistema de Medición de la Calidad de la Educación, SIMCE) was introduced. SIMCE is a standardized national evaluation of student performance in language, mathematics, and environmental, cultural and social comprehension, administrated to 4^{th}, 8^{th} and 10^{th} graders[3]. Since 1995, SIMCE results have been published in the media in order to provide parents with information about schools' performance. In 1996, SIMCE was complemented with the introduction of the National System for Assessing School Performance (Sistema Nacional de Evaluación del Desempeño Docente, SNED). The main purposes of the SNED, described in more detail below, are to improve students' academic performance through the introduction of a monetary incentive for teachers, and to increase households' information regarding school effectiveness.

[3] 10^{th} graders correspond to 2^{nd} middle school graders in the Chilean system.

The National System for Assessing School Performance (SNED): Background and description.

SNED in Chile is one of the most important examples of school and teacher performance incentives in Latin America. It awards municipal and private-subsidized schools that perform excellently based on an index that considers the following components:

• Students' performance in SIMCE standardized tests	37%
• Students' improvement in SIMCE scores	28%
• Schools' equality of opportunities[4]	22%
• Schools' initiative[5]	6%
• Schools' improved working conditions[6]	2%
• Integration of teachers and parents[7]	5%
• TOTAL	100%

SNED competition takes place every two years. The system compares schools within homogenous groups in order to distribute monetary awards[8]. The groups are constructed in two stages. First, they are divided according to three characteristics: administrative regions, whether the school works in a rural or urban area, and whether the type of schooling offered is primary only, primary and secondary or special needs. In a

[4] Repetition and dropout rates; absence of discriminatory practices, and absence of improper punishment.
[5] School-level survey about their educational activities and initiatives.
[6] School classification in the inspection system of the Ministry of Education; and school assessment regarding information delivery to the Ministry.
[7] School level surveys on their activities to encourage integration and information; and parents' SIMCE survey about their perception of school quality.
[8] Formally named Performance Subsidy of Excellence (*Subvención por Desempeño de Excelencia*).

second step, each group is subdivided according to students' socio-economic status, which is calculated with data on parental schooling, household income, and an index of children's vulnerability[9] (Mizala and Urquiola, 2007). For SNED-2006, 111 homogeneous groups were formed (Chilean Ministry of Education, 2007).

Ninety percent of the SNED award goes directly to schools' teachers as bonuses, in proportion to their hours of work. Schools decide how to distribute the remaining ten percent among teachers who have made outstanding contributions to the school performance (Chilean Ministry of Education, 2007). On average, in 2006, teachers in selected schools were paid an annual bonus of about 1,000 U.S. dollars (Mizala and Urquiola, 2007).

Seven SNED competitions have taken place between 1996 and 2009. Schools representing up to 25 percent of each administrative region's enrolment received SNED grants in the first five rounds. The system was reformed in 2004 and since SNED-2006, schools representing up to 35 percent of region's enrolment have been given the award. However, schools representing the top 25 percent of enrolment received 100 percent of the maximum award whereas the remaining schools received 60 percent of it. According to the Chilean Ministry of Education, after 6 rounds of SNED (1996 - 2006), 53 percent of the participant schools have been awarded at least once. The results of SNED competitions are available on-line on the Chilean Ministry of Education's web page.

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[9] Based on SIMCE questionnaires; and theJUNAEB Index (*Indice de la Junta Nacional de Auxilio Escolar y Becas).*

The Chilean system has some characteristics that most of the Latin American programs of collective incentives do not have. It gives a high weight to students' performance, considers improvements over time, and compares schools within socio-economical homogenous groups (Mizala, 2005). In addition, it provides information to the community on school quality in order to improve households' choice and develop competitiveness among similar schools.

The aim of this thesis is to analyze whether the incentives provided by the SNED impact students' skills development measured by PISA-2006 tests of reading, mathematics and science literacy.

2. Literature Review

The impact of SNED on school performance has been previously analyzed. Contreras, Flores, and Lobato (2003) found that the introduction of SNED increased the scores on the standardized SIMCE exams by 5 to 18 points. Their study also suggested that schools with more educated parents and classified as less vulnerable were more affected by the SNED awards and, therefore, obtained better results. Similarly, Vegas and Umansky (2005) found that the analysis of data from three comparable SNED applications showed that SNED incentives have had a positive impact on student performance among schools with good chances of winning the awards.

Several studies have shown that Chile's student performance is importantly

explained by socioeconomic factors such as family income and parents' education. Manzi et al. (2008) found that 60 percent of the between-school variation in SIMCE test results is explained by a combination of individual and school socio-economic factors. These results reaffirm the extent of socio-economic segregation in the Chilean educational system, and substantially explain the student performance gap between private and public schools. The study also highlighted that Chilean results on the PISA-2006 evaluation showed a strong effect of socio-economic status. Introducing PISA-2006's individual socioeconomic index reduced differences in science scores between public and private schools by about half, while introducing school socio-economic status practically made these differences disappear. In a study about public subsidies for private schooling, McEwan (2002) also suggested that the differences in Chilean students' outcomes are due to differences in socio-economic background.

In addition, Manzi et al (2008) found large differences between Chilean male and female student performance on PISA-2006. Chile was the Latin American country with the largest differences in favor of men in math and science, and the smallest difference in favor of women in reading.

It is also important to consider whether SNED incentives have changed teachers' behavior. McMeekin (2000) pointed out that opportunistic behavior could appear as SNED becomes better known. Teachers and school directors could devote increasing efforts to improving schools' scores in a way that do not truly benefit students. Whether SNED has encouraged opportunistic behavior has not been studied. However, it appears

that this kind of behavior is discouraged by the index factor of equality of opportunities (22 percent), which penalizes schools' discriminatory practices, grade repetition and dropout rates. In addition, SNED awards are moderate, which apparently tends to avoid problems of opportunistic behavior.

The available information suggests also that SNED has been more successful than other performance incentive programs in Latin America because it emphasizes educational achievement, considers school-level evaluations, provides collective incentives, and compares schools within homogeneous socio-economic groups. In contrast, the Mexican individual performance program "Carrera Magisterial" which gives teachers the opportunity to achieve higher career levels and receive higher payments based on factors including academic education, professional development, years of experiences, a peer review, and students' performance has had no apparent effect on improving students' achievement as measured by standardized exams (Vegas and Umansky, 2005). On one hand, Mexico's program provides strong incentives for teachers to focus on their own improvement, but apparently the weight assigned to students' performance in the evaluation system is too low to reward teachers who have students with higher achievement (22 percent of teacher's evaluation). On the other hand, it seems that individual incentives have motivated teachers to leave rural schools in order to have more access to advanced training available in urban areas which lets them advance in their careers more quickly and receive higher salaries (Romaguera and

Mizala's, 2004). In addition, the experience of the PLAN[10] school award system in El Salvador, which offers a monetary incentive for each teacher working at schools that meet the objectives established by the Ministry of Education, shows that not dividing schools into homogeneous groups biases results in favor of wealthier schools (Romaguera and Mizala's, 2004).

The question of the impact of SNED awards on students' knowledge development is still unresolved, as well as whether teachers have changed their behavior in response to this program of incentives. The distribution of SNED grants is fundamentally based on students' performance and improvement on national standardized tests designed to cover the Chilean curriculum. In contrast, the aim of PISA is to examine how well students have acquired knowledge, competences and skills that will help them in the future, rather than how well they master a curriculum (OECD, 2003). To some extent PISA examines the effectiveness of education systems in terms of students' human capital development. The schools awarded by SNED are expected to offer higher educational quality compared to their peer institutions since their educational outputs are higher in terms of achievement in standardized tests. However, whether their students have also developed higher competences relevant to future personal, social and economic well being is not known. This study will contribute to answering this question.

[10] Plan de Estímulos a la Labor Educativa Institucional [*Stimulus Plan for Education*]

3. Hypothesis

Reading, mathematical and scientific literacy achievement on PISA-2006 standardized assessment is positively related with attendance at schools awarded by the National System for Assessing School Performance (SNED-2006), after controlling for individual socio-economical factors and school-quality factors.

4. Data

The databases used to develop this research were the PISA-2006 education surveys for students and schools. The target population of PISA is students aged between 15 years 3 months and 16 years 2 months at the time of the assessment and who have completed at least 6 years of formal schooling. In Chile 5,235 students were randomly selected to participate in PISA-2006, representing a population of 233,526 students (99 percent of the national enrolled population).

Dependent variables

The aim of this study is to determine whether students who attended schools awarded by SNED have developed higher skills and competences to face future economic and social challenges. Consequently, the three dependent variables of this study are ***literacy in science, mathematics and reading.***

PISA definition of ***scientific literacy*** is "*Scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific*

phenomena, and to draw evidence-based conclusions about science-related issues". In order to measure students' scientific literacy PISA conducts a test using a scale of scientific performance that associates each question with a point score according to its difficulty. The question difficulty is estimated by considering the proportion of test takers that got each question correct. PISA also defines and generates student proficiency levels in order to describe what competencies are demonstrated by the students' scores. Student scores in science are grouped into six proficiency levels with Level 1 representing the lowest scores (above 334.9 score points) and Level 6 representing the highest scores (above 707.9 score points). Students with below 334.9 score points are classified as below Level 1. PISA has established Level 2 (above 409.5 score points) as the baseline level at which students "*begin to demonstrate the science competence that will enable them to participate actively in life situations related to science and technology"* (OECD, 2007).

Mathematical literacy is defined by PISA as *"an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen"*. There are six levels of proficiency in mathematics with Level 1 representing the lowest performance (above 354.8 score points) and Level 6 representing the highest performance (above 669.3 score points). Students who perform below Level 1 would be expected to have *"serious difficulties in using mathematics as an effective tool to benefit from further education and*

learning opportunities throughout life" (OECD, 2007).

Reading literacy is defined by PISA as *"understanding, using and reflecting on written texts, in order to achieve one's goals, to develop one's knowledge and potential and to participate in society"*. Reading scores are reported according to five levels of proficiency with Level 1 representing the lowest scores (above 334.8 score points) and Level 6 representing the highest performance (above 625.6 score points). Students performing below Level 1 would have "*serious difficulties in using reading literacy as an effective tool to advance and extend their knowledge and skills in other areas*" (OECD, 2007).

International surveys such as PISA-2006 report student performance through plausible values (PVs). PISA estimates a probability distribution for students' ability instead of reporting a point score. PVs are random draws from the estimated distribution. These values are a representation of the range of abilities that a student might reasonably have. ***Scientific, mathematical and reading literacy*** are reported in a set of five PVs for each student in PISA-2006. The reported statistics in this study for ***scientific, mathematical and reading literacy*** correspond to the average of the statistics of the five PVs.

Independent variables

The explanatory variable central to this analysis is ***SNED.*** It is a dummy variable that takes the value of one if the school attended by the student assessed in PISA-2006 was awarded by SNED-2006. This variable was created with information provided by the

Chilean Ministry of Education and introduced in the PISA-2006 data base.

The SIMCE standardized tests used to build SNED's index in 2006 corresponded to previous years. The index's component of students' performance was based on:

- SIMCE 4th graders, year 2002
- SIMCE 8th graders, year 2004
- SIMEC 10th graders, year 2003

The index's component of students' improvement was based on:

- SIMCE 4th graders, differences between 2002-1999
- SIMCE 8th graders, differences between 2004-2000

The information used by the Chilean Ministry of Education to build the rest of the components was based on records and surveys dated between 2003 and 2006.

PISA-2006 collected information about students' personal and family background as well as schools' characteristics. Therefore, it was possible to introduce several individual-level and school-level control variables to determine an unbiased relationship between ***SNED*** and ***scientific, mathematical, and reading literacy***.

PISA constructed two indexes with the students' socio-economic information that were used in this thesis: the highest international socioeconomic index of occupational status ***(HISEI)*** of the father or mother, and the index of home possessions ***(HOMEPOS).*** The latter of the two was obtained by asking students whether they had at their home a desk to study at, a room of their own, a quiet place to study, a computer they could use for school, educational software, a link to the Internet, their own calculator, classic

literature, books of poetry, works of art, books to help with their school work, and a dictionary; whether their home possessed a dishwasher, a DVD player or VCR; and the number of cellular phones, televisions, computers, cars, and three other country-specific items in their house (OECD, 2007). The student scores on ***HOMEPOS*** are factor scores which are standardized to have an OECD mean of zero and a standard deviation of one. A positive score on the ***HOMEPOS*** index indicates that the respondent answered more favorably than respondents did, on average, in OECD countries (OECD, 2007). In other words, a high positive score means that the respondent's wealth is greater than the OECD's mean.

Other two variables included in this analysis which corresponded to students' personal and family background were the highest parental education in years (***PARED)*** and the students' gender (***female)***.

The school-level variables from PISA-2006 introduced in the analysis in order to control for school-quality factors were: proportion of teachers with university degree (***PROPQUAL***), student-teacher ratio (***STRATIO***), and school size (***SCHSIZE***) which corresponds to the total enrollment at school. Two dummy variables were built based on the information provided by PISA-2006: ***public*** and ***city.*** The variable ***public*** takes the value of 1 if the school is public and 0 if it is private-subsidized or just private. The variable ***city*** corresponds to 1 if the school is placed according to PISA-2006 in a city or large city, ant it corresponds to 0 if the school is located in a village, small town or town. Exhibit 1 summarizes the information about the dependent and independent variables.

Exhibit 1: Dependent and Independent Variables Summary

Variable	Name	Definition	Predicted relationship	Previous Studies
Dependent variable	scientific literacy	Student PVs in PISA-2006 science test		
	mathematical literacy	Student PVs in PISA-2006 math test		
	reading literacy	Student PVs in PISA-2006 reading test		
Variable	**Name**	**Definition**	**Predicted relationship**	**Previous Studies**
Independent variables	SNED	SNED Dummy variable 1= School was award by SNED-2006 0= School was not award by SNED-2006	Positive	- Vegas and Umansky (2005) - Contreras, Flores & Lobato (2003)
	Students' characteristics			
	PARED	Highest parental education in years	Positive	- Manzi et al. (2008) - Contreras, Flores & Lobato (2003) - McEwan (2002)
	HOMEPOS	Index of home possessions, PISA-2006	Positive	
	HISEI	Index of highest parental occupational status, PISA-2006	Positive	
	Female	Gender Dummy variable 1= Female 0= Male	Negative for science & math Positive for reading	- Manzi et al. (2008)
	Schools' characteristics			
	PROPQUAL	Proportion of teachers with university degree	Positive	- Kingdon (1996) - Hanushek (1995)
	STRATIO	Student-teacher ratio	Negative	- Rivkin, Hanushek & Kain (2005) - Case & Deaton (1999) - Angrist & Lavy (1999)
	SCHSIZE	School size (enrollment)	Positive	-Huang & Howley (1993) - Forbes, Fortune & Packard (1993)
	public	Public Dummy variable 1= public school 0= private-subsidized school	Negative	- Manzi et al. (2008) - Contreras, Flores & Lobato (2003) - McEwan (2002)
	city	City Dummy variable 1= city school 0= non-city school	Positive	- Manzi et al. (2008)

5. Specification of the Model

Differences in the performance of students attending schools awarded and not awarded by SNED might reflect different factors. On one hand, students that come from households with higher income and more educated parents perform better in Chile. On the other hand, schools' quality characteristics such as the number of qualified teacher should also have an impact on students' achievement. In order to accurately determine whether attendance at schools awarded by SNED impacts students' human capital and skills development measured by PISA-2006 assessment, three Ordinary Least Squares (**OLS)** regressions were conducted controlling for students' social-economical characteristics as well as school-quality factors:

- $\textbf{\textit{scientific\_literacy}} = Bo + B_1 \textbf{\textit{SNED}} + B_2 PARED + B_3 HOMEPOS + B_4 HISEI + B_5 female + B_6 PROPQUAL + B_7 STRATIO + B_8 public + B_9 city + B_{10} SCHSIZE + e$
- $\textbf{\textit{mathematical\_literacy}} = Bo + B_1 \textbf{\textit{SNED}} + B_2 PARED + B_3 HOMEPOS + B_4 HISEI + B_5 female + B_6 PROPQUAL + B_7 STRATIO + B_8 public + B_9 city + B_{10} SCHSIZE + e$
- $\textbf{\textit{reading\_literacy}} = Bo + B_1 \textbf{\textit{SNED}} + B_2 PARED + B_3 HOMEPOS + B_4 HISEI + B_5 female + B_6 PROPQUAL + B_7 STRATIO + B_8 public + B_9 city + B_{10} SCHSIZE + e$

In the three models students' achievement in PISA-2006 was explained by whether students attended schools awarded by the SNED-2006, their gender, and their economic, cultural and social status measured by parents' education (***PARED***), family

possessions (***HOMPOS***) and parents' occupational status (***HISEI***). Also, each of the three models included variables that capture the impact of schools' quality such as teachers' education (***PROPQUAL***), the student-teacher ratio (***STRATIO***), whether the school was public (***public***) or private-subsidized, whether the school was located in a city (***city***), and the school size (***SCHSIZE***). The independent variable of interest in each of the three regressions is ***SNED.***

6. Findings

Relevant SNED Statistics

As expected, the average achievement of schools that participated in PISA-2006 and were awarded by SNED was higher in ***science, mathematics, and reading literacy***. A student who attended a SNED school would on average achieve 67 score points more in science, 66 in mathematics, and 70 in reading (Table 1).

Table 1: Mean Achievement by SNED Awarded and Non-Awarded Schools

Achievement	SNED YES	SNED NO	Difference
scientific literacy	475.51	408.61	66.90
mathematical literacy	449.83	384.21	65.62
reading literacy	482.12	412.09	70.03

Note: Appendix 1 presents the results for each plausible value in scientific, mathematical and reading literacy

Previous studies have pointed out that differences in school performance in Chile are highly correlated with students' socio-economic background which impacts the distribution of students between public and private-subsidized schools. It is interesting to observe that the differences between private-subsidized and public schools awarded by SNED were small in terms of PISA-2006 achievement, while the differences between public and private-subsidized schools not awarded were substantially bigger (Table 2).

Table 2: Public and Private-Subsidized School Mean Achievement by SNED Awarded and Non-Awarded Schools

SNED YES			
Achievement	**Public**	**Private-Subsidized**	**Difference**
scientific literacy	473.76	476.93	3.17
mathematical literacy	455.46	446.64	-8.82
reading literacy	479.07	483.59	4.52
SNED NO			
Achievement	**Public**	**Private-Subsidized**	**Difference**
scientific literacy	391.39	429.17	37.78
mathematical literacy	367.44	402.60	35.16
reading literacy	394.78	432.82	38.04

Note: Appendix 2 presents the results for each plausible value in scientific, mathematical and reading literacy.

A student who attended a private SNED school would have on average 3 score points more in science and almost 5 more in reading compared to a student from a public SNED school; however, he would have 9 score points less in math. On the other hand, a

student from a public school that was not awarded by SNED would on average perform far lower than a comparable student in a private school in science, reading and mathematics. This would suggest that the learning gap between public and private-subsidized schools awarded by SNED is smaller than in non-awarded schools.

There were also important differences in male and female performance among both SNED schools and non-SNED schools (Table 3).

Table 3: Female and Male Achievement by SNED Awarded and Non-Awarded Schools

SNED YES			
Achievement	**Females**	**Males**	**Difference**
scientific literacy	458.05	489.86	31.81
mathematical literacy	429.04	466.92	37.88
reading literacy	483.92	480.65	-3.27
SNED NO			
Achievement	**Females**	**Males**	**Difference**
scientific literacy	400.85	415.84	14.99
mathematical literacy	371.95	395.64	23.69
reading literacy	425.83	399.30	-26.53

Note: Appendix 3 presents the results for each plausible value in scientific, mathematical and reading literacy.

Males outperformed females in science and mathematics; however, the differences in non-SNED schools were smaller. Females did better in reading; though the difference in the average achievement of males and females in SNED schools was rather small (3 score points) compared to the difference in the schools not awarded (27 score

points). This would suggest a persistent performance gap in math and science for females among SNED awarded and non-awarded schools.

Regression findings

Table 4 presents results of the model for ***scientific literacy***.

Table 4: OLS Regression for *Scientific Literacy*

scientific literacy	**coefficient**	**SE**	**t-statistic**	**p-value**
Intercept	370.326 **	10.412	35.570	<.0001
SNED	49.556 **	3.004	16.496	<.0001
PARED	1.752 **	0.479	3.658	0.0003
HOMEPOS	9.795 **	1.678	5.840	<.0001
HISEI	0.724 **	0.112	6.462	<.0001
Female	-16.508 **	2.777	-5.940	<.0001
PROPQUAL	18.306 **	5.998	3.052	0.0023
STRATIO	-0.662 **	0.270	-2.456	0.0141
Public	-18.384 **	3.222	-5.710	<.0001
City	7.885 **	3.395	2.322	0.0203
SCHSIZE	0.017 **	0.003	5.310	<.0001
F statistics			**112.416**	**<.0001**
R^2				**0.286**
Sample				**2812**

Notes: Appendix 4 presents the regressions for each plausible value in scientific literacy.
* indicates significant at .05 and ** indicates significant at .01

The regression explained 28.6 percent of the variation in ***scientific literacy*** (R^2=0.286). The independent variables were highly jointly significant (F= 112.42). The variable of interest (***SNED***) was statistically significant (t=16.50) and positively related to ***scientific literacy*** achievement. Students who attended SNED schools would achieve 49.6 score points more in the PISA-2006 scientific assessment than students who did not

attend SNED schools, after controlling for individual socio-economic factors as well as school-quality factors. This relationship was very robust. As expected, parents' education and occupational status, as well as households' possessions were positively and significantly related to performance in science. Also, as found in previous studies, the relationship between the variables ***female*** and ***science literacy*** was strongly negative in magnitude (-16.51) and statistically significant (t=-5.94). With respect to schools' characteristics, as expected students who attended public schools had lower and statistically significant achievement in science (t=-5.71). The variable student-teacher ratio also had a negative and statistically significant impact on students' achievement (t=-2.46). That is, small class size matters for science skills development. Schools' characteristics that had a positive and significant impact were proportion of teachers with a university degree (t=3.05), whether the school was located in the city (t=2.32), and the school size (t=5.31).

The dependent variable in the second model was ***mathematical literacy*** achievement in PISA-2006. Results from this regression are presented in Table 5. The model explained 33.1 percent of the variation in ***mathematical literacy*** achievement (R^2=0.331). Also, the regression was highly jointly significant (F=138.60). The variable of interest (***SNED***) was statistically significant and positively related to students' ***mathematical literacy*** (t=17.57). This relationship was also robust. The signs and relations between students' socio-economical characteristics and achievement in math were the same as those observed in the first model. Also, ***female*** was negatively and

statistically significantly related to ***mathematical literacy*** (t=-8.90) and the magnitude of the coefficient was even greater than in the first model. Regarding control variables for school quality, the student-teacher ratio variable (***STRATIO)*** was negative but not statistically significant. The other school quality variables were significant and had the same signs as those presented in the previous regression. For instance, a student who attended a public school had 8 score points less in math achievement, after controlling for other factors.

Table 5: OLS Regression for *Mathematical Literacy*

mathematical literacy	**coefficient**	**SE**	**t-statistic**	**p-value**
Intercept	335.942 **	9.614	34.948	<.0001
SNED	48.732 **	2.774	17.568	<.0001
PARED	1.418 **	0.442	3.208	0.0014
HOMEPOS	9.937 **	1.549	6.416	<.0001
HISEI	0.890 **	0.103	8.604	<.0001
female	-22.834 **	2.564	-8.904	<.0001
PROPQUAL	11.427 *	5.538	2.062	0.039
STRATIO	-0.310	0.249	-1.244	0.214
public	-8.217 **	2.975	-2.760	0.006
city	15.595 **	3.134	4.972	<.0001
SCHSIZE	0.013 **	0.003	4.546	<.0001
F statistics			**138.602**	**<.0001**
R^2				**0.331**
Sample				**2812**

Notes: Appendix 5 presents the regressions for each plausible value in mathematical literacy.
* indicates significant at .05 and ** indicates significant at .01

The third regression presented the association between ***reading literacy*** in PISA-2006 assessment, students' attendance at SNED schools, and the other individual and school-level variables of control. The results of this model are shown in Table 6.

Table 6: OLS Regression for *Reading Literacy*

reading literacy	**coefficient**	**SE**	**t-statistic**	**p-value**
Intercept	349.420**	12.173	28.708	<.0001
SNED	50.400**	3.513	14.354	<.0001
PARED	1.788**	0.560	3.190	0.0014
HOMEPOS	10.271**	1.962	5.238	<.0001
HISEI	0.846**	0.131	6.454	<.0001
female	22.912**	3.247	7.054	<.0001
PROPQUAL	19.352**	7.012	2.764	0.0057
STRATIO	-0.502	0.315	-1.592	0.1115
public	-14.894**	3.767	-3.956	0.0001
city	14.297**	3.969	3.604	0.0003
SCHSIZE	0.013**	0.004	3.398	0.0007
F statistics			**87.104**	**<.0001**
R^2				**0.237**
Sample				**2812**

Notes: Appendix 6 presents the regressions for each plausible value in reading literacy.
* indicates significant at .05 and ** indicates significant at .01

The regression explained 23.7 percent of the variation in ***reading literacy*** achievement (R^2=0.237). In addition, the independent variables were highly jointly significant (F=87.104). ***SNED*** is significantly and positively related to ***reading literacy*** and this relationship is robust (t=14.35). Students who attended SNED awarded schools achieved 50.42 score points more in ***reading literacy***, after controlling for other factors.

As expected household education and income was positively and significantly related to reading performance, as well as schools' characteristics such as proportion of teachers with high education, whether the school was located in the city, and school size. In this model the relation between ***female*** and ***reading literacy*** was positive and statistically significant (t=7.05); moreover, its magnitude was also high, with girls scoring 22.91 score points higher than boys on average. In terms of the difference between public and private-subsidized schools, ***public*** was negatively and significantly related to performance (t=-3.96). The impact of student-teacher ratio was again not statistically significant (t=-1.59). This is in keeping with other studies, which have found significant as well as non-significant impacts of student-teacher ratio on performance.

The three regressions did not present problems of multicollinearity or heteroscedasticity. These diagnostics are presented in Appendices 7 and 8, respectively. An analysis of model specification is presented in Appendix 9. It showed that there might be omitted variables in the model, which is not surprising since achievement in science, math and reading tests is also correlated with unobservable variables such as students' initial ability. However, this would be a problem only if an omitted variable is correlated with the variable of interest ***SNED***, because this would bias the estimator. Also, since the variable ***SNED*** was very robust in the three models, the possible problems associated with misspecification would hardly affect its significance.

Discussion and limitations

This study used student-level variables as well as school-level variables from PISA-2006 databases. Consequently, when school quality factors such as school size (***SCHSIZE***), student-teacher ratio (***STRATIO***) and proportion of teachers with university degree (***PROQUAL***) were included in the model, students from schools that did not report these variables were automatically excluded from the analysis. This could represent a problem if the missing values from those schools are not random. For instance, one could argue that disadvantaged schools are less likely to report their quality characteristics, and therefore, they would have been systematically excluded from the analysis.

The problem of missing data from schools appeared particularly when the variable ***PROPQUAL*** was included in the models[11]. Results from the three regressions without ***PROPQUAL*** are presented in Appendix 10. The variable of interest ***SNED*** was also statistically significant and robust in these regressions. In fact, the only variable that was significantly affected in the models was student-teacher ratio (***STRATIO***) which is correlated with ***PROPQUAL.*** Also, in order to determine if the school and student characteristics from the samples used in the regression with and without ***PROPQUAL*** differed importantly, the samples' means were analyzed (Appendix 11). The samples' means do not differ importantly, with the exception of the variables ***public*** and ***city*** since

[11] The sample size decreased from 3462 to 2812 students when ***PROPQUAL*** was introduced.

the sample that includes ***PROPQUAL*** has fewer public schools (6 percent) and more schools located in the city (5 percent). Also, the evidence suggests that, contrary to what would have been expected, when ***PROPQUAL*** is introduced in the regressions, on average the sample of missing schools had slightly advantaged students in terms of parents' educations and home possession.

Another important consideration is the fact that this study has just used cross sectional information for a single year (2006). The introduction in the models of information about previous SNED results could add valuable information to the study and minimize the probability of a problem of omitted variable bias.

7. Conclusion and Policy Relevance

Improving Chilean students' achievement by introducing a performance-based incentive system has been a fundamental objective of SNED since its implementation in 1996. Some studies suggest that SNED incentives have improved the quality of education in Chile by increasing student scores in SIMCE national standardized tests; however, whether SNED has given teachers the incentives to investment in their students' learning and skill development has been an opened question.

This study shows that ***reading, mathematical and scientific literacy*** achievement on PISA-2006 standardized assessments are positively related with attendance at schools awarded by the National System for Assessing School Performance SNED-2006, after

controlling for individual socio-economical factors as well as school-quality factors. A student who attended a SNED-2006 awarded schools would achieve 45.56 score points more in science, 48.73 score points more in mathematics and 50.40 score points more in reading. Indeed, schools awarded by SNED-2006 not would only offer higher educational quality compared to their peers in terms of national curriculum coverage, but they would have also contributed to develop higher competences relevant to future personal, social and economic well being among their students.

The results also suggest that Chilean students' socio-economical background plays an important role in skills development. Students that came from more educated and wealthier parents achieved higher ***reading, mathematical and scientific literacy*** scores. Also, school-quality factors such as teacher quality, school size, and whether the school is public or located in a city were significantly related to students' achievement. In addition, differences between male and female students seemed to be particularly important. The expected achievement of a Chilean female student would be 22.91 score points more in reading, but 16.51 score points less in science, and 22.83 less in math.

Evaluating whether SNED has promoted the development of competences that enable students to face future challenges has important policy implications for Chile and other middle income countries. The results of this study suggest that SNED has given teachers and schools the right incentives to invest in student learning. To some degree, the study shows that teachers' behavioral responses such as "teaching for the test" have been avoided since students that attended SNED-2006 awarded schools outperformed

non-awarded schools not just in SIMCE tests but also in PISA-2006 assessments.

The fact that SNED has been recognized as one of the most successful programs in Latin America and seems to promote students' human capital development also has significant implications for the region. Most Latin American governments are still trying to improve the quality of their educational systems in order to promote human and economic development. In general, the systems in the region are controlled by unions and teachers' incomes are not related to performance measured through students' achievement. This study suggests that the introduction of monetary incentives based on performance can encourage improvements in the quality of an educational system not just by increasing students' achievement in standardized tests but also by improving students' skills to face future challenges in life.

Appendix 1

Pisa-2006 PVs Mean Achievement by SNED Awarded and Non-Awarded Schools

SNED	YES	NO
Observations	1725	2890
PV1SCIE	474.21	408.58
PV2SCIE	475.31	408.52
PV3SCIE	475.70	408.60
PV4SCIE	475.68	408.80
PV5SCIE	476.65	408.54
AVERAGE	**475.51**	**408.61**

SNED	YES	NO
Observations	1725	2890
PV1MATH	449.41	385.04
PV2MATH	449.72	384.72
PV3MATH	450.33	383.47
PV4MATH	449.69	384.50
PV5MATH	450.02	383.32
AVERAGE	**449.83**	**384.21**

SNED	YES	NO
Observations	1690	2877
PV1READ	483.8	412.6
PV2READ	485.0	413.2
PV3READ	483.8	412.3
PV4READ	483.2	412.4
PV5READ	484.9	412.5
AVERAGE	**484.1**	**412.6**

Appendix 2

Pisa-2006 PVs Public and Private-Subsidized School Mean Achievement by SNED Awarded and Non-Awarded Schools

	SNED YES		SNED NO	
	Public	**Private-Subsidized**	**Public**	**Private-Subsidized**
Observations	662	1023	1502	1314
PV1SCIE	473.12	475.09	392.26	428.21
PV2SCIE	473.61	476.50	391.19	429.15
PV3SCIE	473.90	477.40	390.32	430.58
PV4SCIE	473.77	477.36	391.79	428.92
PV5SCIE	474.42	478.29	391.39	429.00
AVERAGE	**473.76**	**476.93**	**391.39**	**429.17**

	SNED YES		SNED NO	
	Public	**Private-Subsidized**	**Public**	**Private-Subsidized**
Observations	662	1023	1502	1314
PV1MATH	454.07	446.53	367.76	404.02
PV2MATH	455.49	446.71	368.58	402.12
PV3MATH	455.54	447.26	365.63	403.12
PV4MATH	456.35	446.19	368.57	402.21
PV5MATH	455.86	446.50	366.65	401.50
AVERAGE	**455.46**	**446.64**	**367.44**	**402.60**

	SNED YES		SNED NO	
	Public	**Private-Subsidized**	**Public**	**Private-Subsidized**
Observations	662	1023	1502	1314
PV1READ	478.60	482.79	395.31	432.75
PV2READ	478.18	485.15	396.02	432.71
PV3READ	478.49	483.40	393.36	433.73
PV4READ	479.59	482.31	394.22	432.71
PV5READ	480.49	484.31	394.97	432.19
AVERAGE	**479.07**	**483.59**	**394.78**	**432.82**

Appendix 3

Pisa-2006 PVs Female and Male Achievement by SNED Awarded and Non-Awarded Schools

	SNED YES		SNED NO	
	Females	**Males**	**Females**	**Males**
Observations	778	947	1394	1496
PV1SCIE	456.2	489.0	400.7	415.9
PV2SCIE	458.6	489.1	401.6	414.9
PV3SCIE	458.2	490.1	400.5	416.2
PV4SCIE	458.5	489.8	401.7	415.4
PV5SCIE	458.8	491.3	399.7	416.7
AVERAGE	**458.1**	**489.9**	**400.8**	**415.8**

	SNED YES		SNED NO	
	Females	**Males**	**Females**	**Males**
Observations	778	947	1394	1496
PV1MATH	427.9	467.1	372.5	396.7
PV2MATH	428.8	466.9	373.3	395.3
PV3MATH	430.2	466.8	371.2	394.9
PV4MATH	428.6	467.1	372.5	395.7
PV5MATH	429.8	466.6	370.1	395.6
AVERAGE	**429.0**	**466.9**	**371.9**	**395.6**

	SNED YES		SNED NO	
	Females	**Males**	**Females**	**Males**
Observations	778	947	1394	1496
PV1READ	482.9	480.8	426.6	398.7
PV2READ	485.3	480.8	427.3	399.1
PV3READ	484.2	479.8	423.7	400.6
PV4READ	483.2	480.1	427.0	397.7
PV5READ	484.0	481.8	424.5	400.4
AVERAGE	**483.9**	**480.6**	**425.8**	**399.3**

Appendix 4

OLS PVs Regressions for *Scientific Literacy*

IV	PV1SCIE			PV2SCIE			PV3SCIE			PV4SCIE			PV5SCIE		
	β	t	p	β	t	p	β	t	p	β	t	p	β	t	p
Intercept	362.345	34.54	<.0001	371.693	36.34	<.0001	376.633	36.17	<.0001	365.643	35.13	<.0001	375.316	35.67	<.0001
SNED	48.639	16.07	<.0001	49.109	16.64	<.0001	49.370	16.43	<.0001	49.610	16.52	<.0001	51.050	16.82	<.0001
PARED	2.122	4.4	<.0001	1.664	3.54	0.0004	1.423	2.97	0.003	1.959	4.09	<.0001	1.591	3.29	0.001
HOMEPOS	8.844	5.23	<.0001	9.909	6.01	<.0001	10.517	6.27	<.0001	9.853	5.88	<.0001	9.854	5.81	<.0001
HISEI	0.725	6.42	<.0001	0.707	6.43	<.0001	0.749	6.69	<.0001	0.724	6.47	<.0001	0.714	6.3	<.0001
female	-16.926	-6.05	<.0001	-14.706	-5.39	<.0001	-17.164	-6.18	<.0001	-15.015	-5.41	<.0001	-18.729	-6.67	<.0001
PROPQUAL	19.137	3.17	0.0016	17.718	3.01	0.0027	15.966	2.66	0.0078	19.134	3.19	0.0014	19.577	3.23	0.0013
STRATIO	-0.572	-2.1	0.0354	-0.717	-2.71	0.0069	-0.668	-2.48	0.0133	-0.576	-2.13	0.0329	-0.779	-2.86	0.0043
public	-17.167	-5.29	<.0001	-19.656	-6.21	<.0001	-20.570	-6.39	<.0001	-17.559	-5.45	<.0001	-16.969	-5.21	<.0001
city	7.757	2.27	0.0234	7.419	2.22	0.0262	6.684	1.97	0.049	7.353	2.17	0.0303	10.211	2.98	0.0029
SCHSIZE	0.016	4.98	<.0001	0.0192	6.12	<.0001	0.018	5.73	<.0001	0.0160	4.98	<.0001	0.015	4.74	<.0001
F statistics		109.24	<.0001		115.28	<.0001		113.95	<.0001		112.7	<.0001		110.91	<.0001
R^2			0.2806			0.2916			0.2892			0.2869			0.2836
Sample			2812			2812			2812			2812			2812

Appendix 5

OLS PVs Regressions for *Mathematical Literacy*

IV	PV1MATH			PV2MATH			PV3MATH			PV4MATH			PV5MATH		
	β	t	p	β	t	p	β	t	p	β	t	p	β	t	p
Intercept	333.655	34.52	<.0001	335.595	35.42	<.0001	342.117	35.65	<.0001	331.255	34.43	<.0001	337.087	34.72	<.0001
SNED	47.587	17.06	<.0001	47.497	17.37	<.0001	50.226	18.14	<.0001	48.241	17.38	<.0001	50.107	17.89	<.0001
PARED	1.529	3.44	0.0006	1.442	3.31	0.0009	1.271	2.88	0.004	1.543	3.49	0.0005	1.304	2.92	0.0035
HOMEPOS	9.208	5.91	<.0001	10.100	6.62	<.0001	9.956	6.44	<.0001	10.546	6.8	<.0001	9.874	6.31	<.0001
HISEI	0.929	8.93	<.0001	0.868	8.52	<.0001	0.908	8.79	<.0001	0.861	8.32	<.0001	0.884	8.46	<.0001
female	-23.475	-9.11	<.0001	-21.225	-8.4	<.0001	-23.169	-9.05	<.0001	-21.982	-8.57	<.0001	-24.320	-9.39	<.0001
PROPQUAL	11.884	2.13	0.0329	10.804	1.98	0.0478	10.284	1.86	0.0629	13.073	2.36	0.0184	11.089	1.98	0.0475
STRATIO	-0.194	-0.78	0.4374	-0.252	-1.03	0.305	-0.560	-2.25	0.0242	-0.193	-0.77	0.4389	-0.351	-1.39	0.1634
public	-9.455	-3.16	0.0016	-7.664	-2.61	0.009	-10.873	-3.66	0.0003	-4.711	-1.58	0.1136	-8.381	-2.79	0.0053
city	12.871	4.08	<.0001	14.391	4.66	<.0001	16.336	5.22	<.0001	16.482	5.25	<.0001	17.897	5.65	<.0001
SCHSIZE	0.013	4.33	<.0001	0.014	4.72	<.0001	0.015	5.24	<.0001	0.012	4.1	<.0001	0.013	4.34	<.0001
F statistics		134.65	<.0001		136.64	<.0001		145.01	<.0001		136.67	<.0001		140.04	<.0001
R^2			0.3246			0.3279			0.3411			0.3279			0.3333
Sample			2812			2812			2812			2812			2812

Appendix 6

OLS PVs Regressions for *Reading Literacy*

IV	PV1READ			PV2READ			PV3READ			PV4READ			PV5READ		
	β	t	p	β	t	p	β	t	p	β	t	p	β	t	p
Intercept	345.539	27.94	<.0001	347.323	28.82	<.0001	360.501	29.53	<.0001	337.876	27.72	<.0001	355.860	29.53	<.0001
SNED	49.034	13.74	<.0001	52.587	15.12	<.0001	49.352	14.01	<.0001	48.627	13.83	<.0001	52.399	15.07	<.0001
PARED	2.106	3.70	0.0002	1.470	2.65	0.008	1.390	2.48	0.0133	2.087	3.72	0.0002	1.887	3.40	0.0007
HOMEPOS	9.971	5.00	<.0001	10.400	5.36	<.0001	10.384	5.28	<.0001	10.285	5.24	<.0001	10.312	5.31	<.0001
HISEI	0.842	6.32	<.0001	0.890	6.86	<.0001	0.838	6.38	<.0001	0.895	6.82	<.0001	0.763	5.89	<.0001
female	24.024	7.28	<.0001	23.498	7.31	<.0001	18.899	5.80	<.0001	26.045	8.01	<.0001	22.096	6.87	<.0001
PROPQUAL	21.696	3.05	0.0023	21.277	3.07	0.0022	14.733	2.10	0.0362	17.423	2.48	0.0131	21.630	3.12	0.0019
STRATIO	-0.443	-1.38	0.1664	-0.513	-1.64	0.1002	-0.493	-1.56	0.1191	-0.282	-0.89	0.3721	-0.777	-2.49	0.0128
public	-15.185	-3.97	<.0001	-15.404	-4.13	<.0001	-17.782	-4.71	<.0001	-10.996	-2.92	0.0036	-15.101	-4.05	<.0001
city	11.927	2.96	0.0031	16.240	4.13	<.0001	12.671	3.18	0.0015	16.499	4.15	<.0001	14.150	3.60	0.0003
SCHSIZE	0.011	2.96	0.0031	0.014	3.66	0.0003	0.014	3.83	0.0001	0.011	2.89	0.0038	0.013	3.65	0.0003
F statistics		82.89	<.0001		93.81	<.0001		81.94	<.0001		88.68	<.0001		88.20	<.0001
R^2			0.2284			0.2509			0.2263			0.2405			0.2395
Sample			2812			2812			2812			2812			2812

Appendix 7

Multicollinearity Diagnostics

	SNED	PARED	HOMPOS	HISEI	female	PROPQUAL	STRATIO	public	city	SCHSIZE
SNED	1.000	0.198	0.240	0.207	-0.030	0.008	0.066	-0.136	0.055	0.067
PARED	0.198	1.000	**0.555**	**0.605**	-0.064	0.087	-0.068	-0.253	0.252	0.099
HOMEPOS	0.240	**0.555**	1.000	**0.552**	-0.038	0.111	-0.073	-0.332	0.267	0.100
HISEI	0.207	**0.605**	**0.552**	1.000	-0.039	0.099	-0.095	-0.270	0.236	0.081
female	-0.030	-0.064	-0.038	-0.039	1.000	0.001	0.000	-0.011	-0.082	-0.001
PROPQUAL	0.008	0.087	0.111	0.099	0.001	1.000	0.198	-0.108	0.024	0.173
STRATIO	0.066	-0.068	-0.073	-0.095	0.000	0.198	1.000	-0.025	0.053	**0.528**
public	-0.136	-0.253	-0.332	-0.270	-0.011	-0.108	-0.025	1.000	-0.192	0.119
city	0.055	0.252	0.267	0.236	-0.082	0.024	0.053	-0.192	1.000	0.320
SCHSIZE	0.067	0.099	0.100	0.081	-0.001	0.173	**0.528**	0.119	0.320	1.000

Note: The table shows the partial correlations of independent variables

Several indicators lead to the conclusion that there is no multicollinearity in the OLS regressions presented. The t statistics for most the coefficients were highly significant, as well as the F statistics. The R-square was moderated and the signs of the coefficients in the regressions were the ones predicted from previous studies.

In order to verify if there were not multicollinearity problems, partial correlations among the explanatory variables were calculated. There were no partial correlations in excess of 0.8 among the independent variables. However, the variables *PARE*, *HOMEPOS*, and *HISEI* were moderately correlated. This was an obvious result since they were created to represent households' welfare in terms of parents' education, occupational status and possessions. This collinearity did not affect the model.

The variables *SCHSIZE* and *STRATIO* were also moderately correlated. This shows that bigger schools tended to have higher student-teacher ratios. These variables were expected to be somehow correlated; however, this did not affect the models.

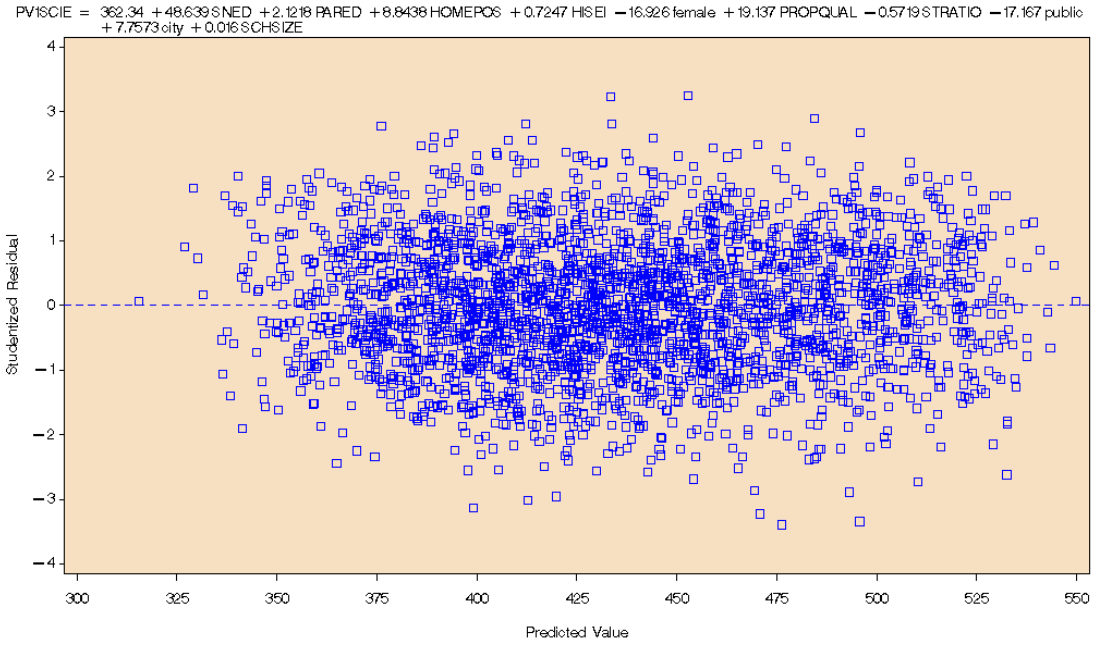
Appendix 8

Heteroscedasticity Diagnostics

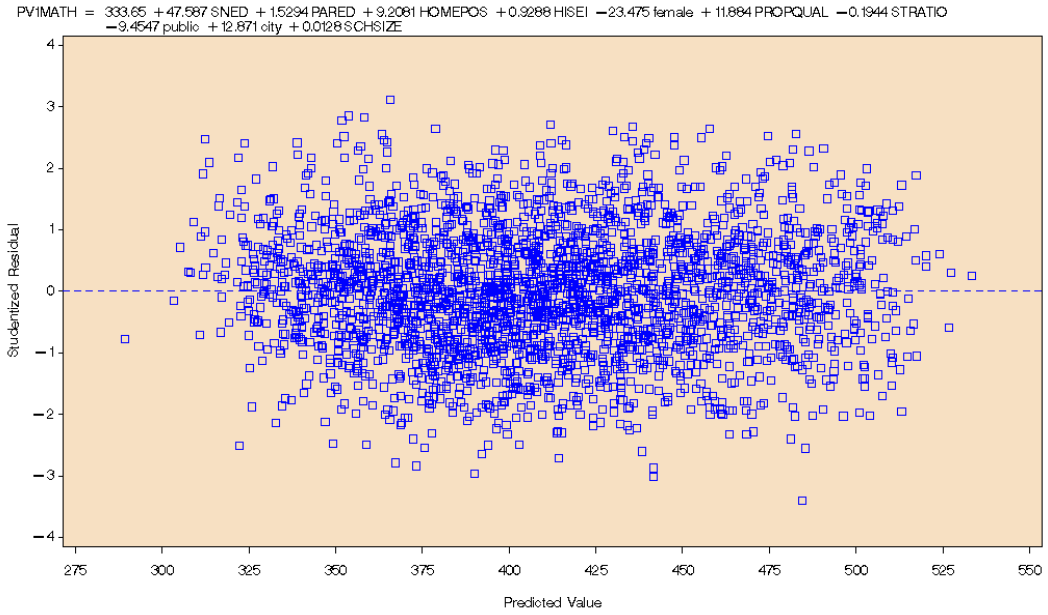
In order to determine if there was a problem of heteroscedasticity, two test were conducted. The first one was an informal test of plotting the standardized residuals of each regression against the predicted values of the dependent variables (***scientific***, ***mathematical***, and ***reading literacy***)

The plots show random distributions for the three models which implies that heteroscedasticity apparently was not a problem.

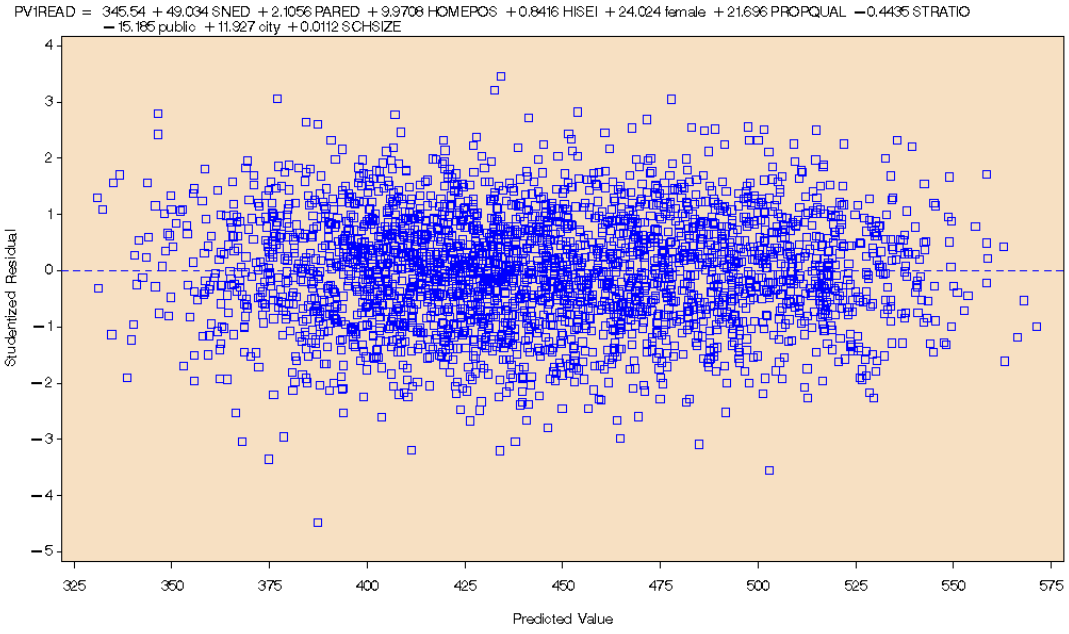
- ***scientific literacy***



- ***mathematical literacy***



- ***reading literacy***



White Tests for heteroscedasticity were conducted in order to confirm that the models did not have this problem. The null hypothesis for the White Test maintains that the errors are homoscedastic. When the model is correctly specified and the errors are independent of the regressors, the rejection of the null hypothesis is evidence of heteroscedasticity. In the model concerning ***scientific literacy*** the $\chi 2$ value obtained in the test was 55.76 which implied that the null hypothesis was failed to reject and therefore, the homoscedasticity assumption holds.

White Test of Heteroscedasticity: *scientific literacy*

	$\chi 2$	**Pr > $\chi 2$**	**Result**
PV1SCIE	52.36	0.7768	Fail to reject Ho
PV2SCIE	55.87	0.6619	Fail to reject Ho
PV3SCIE	62.60	0.4193	Fail to reject Ho
PV4SCIE	58.99	0.5491	Fail to reject Ho
PV5SCIE	49.00	0.8656	Fail to reject Ho
AVERAGE	**55.76**		**Fail to reject Ho**

In the model of ***mathematical literacy*** the $\chi 2$ value obtained was 71.81. Consequently, the null hypothesis was failed to reject and therefore, the homoscedasticity assumption holds.

White Test of Heteroscedasticity: *mathematical literacy*

	$\chi 2$	**Pr > $\chi 2$**	**Result**
PV1MATH	70.26	0.1951	Fail to reject Ho
PV2MATH	73.45	0.1319	Fail to reject Ho
PV3MATH	86.39	0.0179	Reject Ho
PV4MATH	67.61	0.2618	Fail to reject Ho
PV5MATH	61.34	0.4638	Fail to reject Ho
AVERAGE	**71.81**		**Fail to reject Ho**

Finally, in the model of ***reading literacy,*** the $\chi 2$ value obtained was 70.41. Therefore, the null hypothesis of homoscedasticity was failed to reject. The model does not have a problem of heteroscedasticity.

White Test of Heteroscedasticity: *reading literacy*

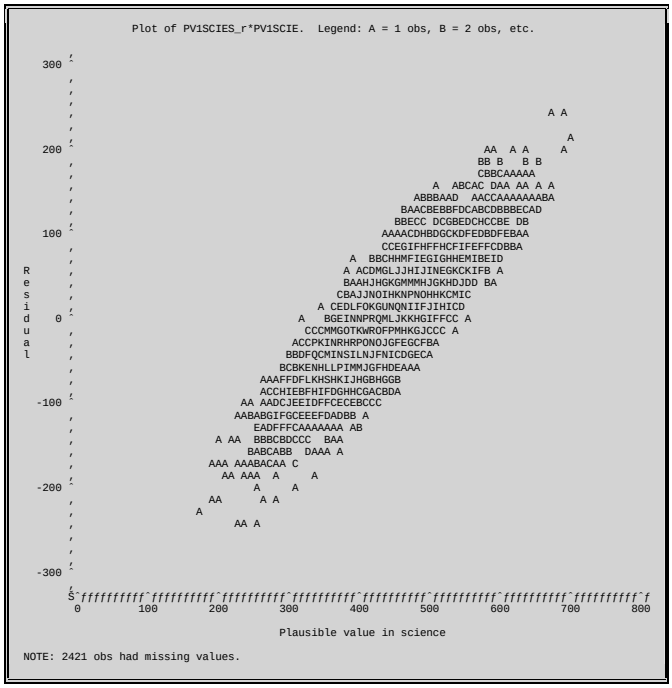
	$\chi 2$	**Pr > $\chi 2$**	**Result**
PV1READ	76.36	0.0889	Fail to reject Ho
PV2READ	64.70	0.3487	Fail to reject Ho
PV3READ	77.55	0.0749	Fail to reject Ho
PV4READ	75.35	0.1022	Fail to reject Ho
PV5READ	58.11	0.5813	Fail to reject Ho
AVERAGE	**70.41**		**Fail to reject Ho**

Appendix 9

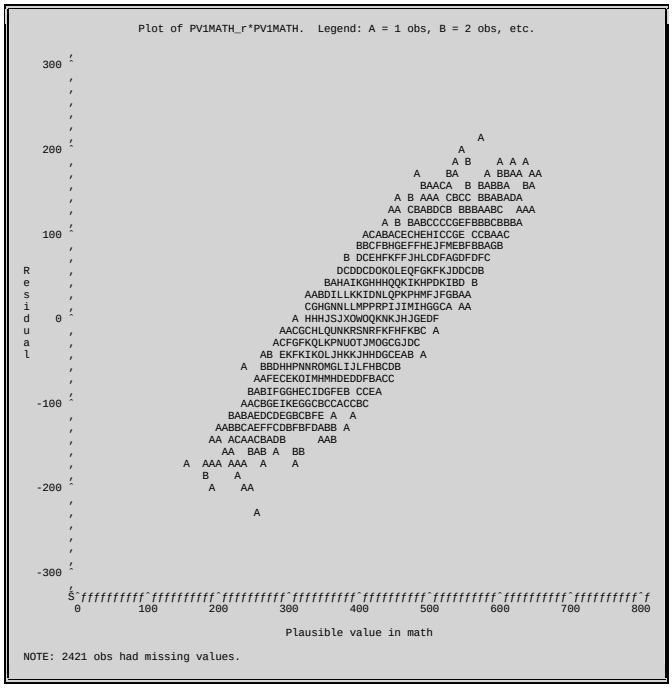
Model Specification Diagnostics

In order to determine if the models were well specified informal and formal tests were conducted. The informal test consisted of plotting the residuals for each model against the observed dependent variables of ***scientific***, ***mathematical***, and ***reading literacy***. Random points would indicate that there were no problems of misspecification.

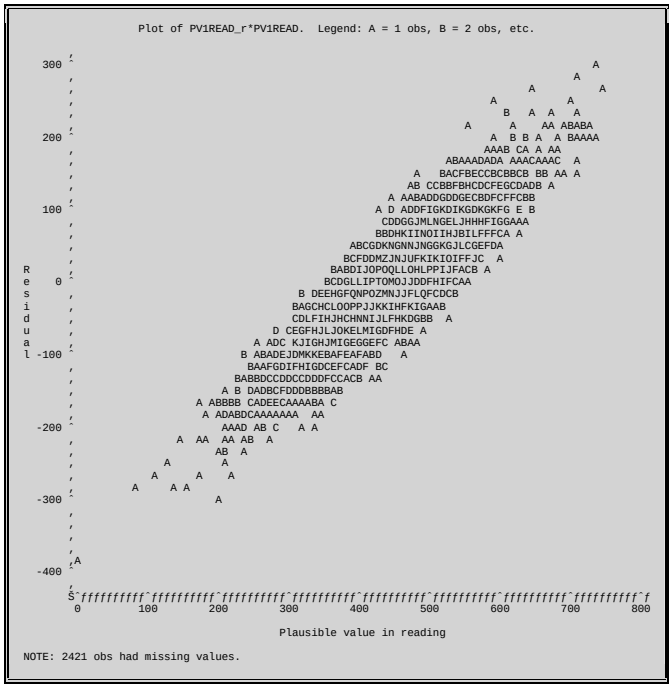
- ***scientific literacy***



- ***mathematical literacy***



- ***reading literacy***



The plots of the three models showed non-random patrons. There might be relevant variables omitted in the model. This is not surprising since achievement in science, math and reading tests is also correlated with students' initial ability which is difficult to measure, and was not provided by the PISA-2006 data base. On the other hand, this would be a problem only if an omitted variable was correlated with the variable of interest ***SNED***, because this would bias positively or negatively the estimator

The Ramsey's Reset test was also conducted in order to formally determine if there was a problem of specification in the model. Ramsey's test can be viewed as a linearity test that checks whether any nonlinear transformation of the specified independent variables has been omitted. The null hypothesis in the Ramsey Test is that the model is well specified; therefore, the rejection of the null hypothesis is evidence of misspecification. The Ramsey Test was conducted in the three models. In the models of ***scientific literacy*** and ***mathematical literacy*** the null hypotheses were failed to reject which suggested that the models were well specified. On the other had, the null hypothesis was rejected for the ***reading literacy*** model which suggested that the model had a problem of misspecification.

The variable SNED for three models was very robust which implies that the possible problems associated with misspecification would hardly affect its significance.

Ramsey Test: ***science literacy***

	F			Pr >F			Result
	2	3	4	2	3	4	
PV1SCIE	13.76	9.26	6.55	0.0002	<.0001	0.0002	Fail to reject Ho
PV2SCIE	9.35	6.95	5.38	0.0022	0.0010	0.0011	Fail to reject Ho
PV3SCIE	8.94	5.94	4.80	0.0028	0.0027	0.0024	Fail to reject Ho
PV4SCIE	10.00	7.83	5.22	0.0016	0.0004	0.0014	Fail to reject Ho
PV5SCIE	11.60	6.86	4.70	0.0007	0.0011	0.0028	Fail to reject Ho
AVERAGE	**10.73**	**7.37**	**5.33**				**Fail to reject Ho**

Ramsey Test: ***mathematical literacy***

	F			**Pr >F**			**Result**
	2	3	4	2	3	4	
PV1MATH	19.05	13.65	9.15	<.0001	<.0001	<.0001	Fail to reject Ho
PV2MATH	23.13	16.48	11.07	<.0001	<.0001	<.0001	Fail to reject Ho
PV3MATH	16.71	14.13	9.42	<.0001	<.0001	<.0001	Fail to reject Ho
PV4MATH	23.36	18.88	12.58	<.0001	<.0001	<.0001	Fail to reject Ho
PV5MATH	17.86	12.75	8.73	<.0001	<.0001	<.0001	Fail to reject Ho
AVERAGE	**20.02**	**15.18**	**10.19**				**Fail to reject Ho**

Ramsey Test: ***reading literacy***

	F			**Pr >F**			**Result**
	2	**3**	**4**	**2**	**3**	**4**	
PV1READ	1.88	3.08	2.50	0.1703	0.0463	0.0581	Reject Ho
PV2READ	5.04	3.70	4.74	0.0249	0.0250	0.0027	Fail to reject Ho
PV3READ	4.45	2.33	1.73	0.0351	0.0973	0.1591	Reject Ho
PV4READ	0.15	1.31	1.93	0.6994	0.2703	0.1227	Reject Ho
PV5READ	1.24	1.92	2.41	0.2648	0.1467	0.0657	Reject Ho
AVERAGE	**2.55**	**2.47**	**2.66**				**Reject Ho**

Appendix 10

OLS Regressions without PROPQUAL

scientific literacy	coefficient	SE	t-statistic	p-value
Intercept	372.924	8.715	42.800	<.0001
SNED	41.960	2.769	15.154	<.0001
PARED	2.026	0.428	4.730	<.0001
HOMEPOS	10.258	1.542	6.658	<.0001
HISEI	0.866	0.103	8.404	<.0001
female	-17.287	2.536	-6.814	<.0001
STRATIO	-0.171	0.245	-0.696	0.4865
public	-16.715	2.879	-5.808	<.0001
City	9.654	3.045	3.168	0.0016
SCHSIZE	0.011	0.003	3.744	0.0002
F statistics			**139.196**	**<.0001**
R^2				**0.274**
Sample				**3462**

a. * indicates significant at .05 and ** indicates significant at .01

mathematical literacy	coefficient	SE	t-statistic	p-value
Intercept	334.228	8.096	41.290	<.0001
SNED	43.297	2.573	16.830	<.0001
PARED	1.790	0.398	4.502	0.0000
HOMEPOS	9.886	1.432	6.904	<.0001
HISEI	1.003	0.096	10.474	<.0001
female	-23.755	2.356	-10.080	<.0001
STRATIO	0.119	0.228	0.522	0.602
public	-8.768	2.674	-3.278	0.001
city	13.224	2.828	4.674	<.0001
SCHSIZE	0.009	0.003	3.538	<.0001
F statistics			**177.480**	**<.0001**
R^2				**0.3163**
Sample				**3462**

a. * indicates significant at .05 and ** indicates significant at .01

reading literacy	**coefficient**	**SE**	**t-statistic**	**p-value**
Intercept	348.588	10.122	34.446	<.0001
SNED	46.418	3.216	14.434	<.0001
PARED	2.006	0.497	4.032	0.0001
HOMEPOS	8.822	1.791	4.930	<.0001
HISEI	1.008	0.120	8.416	<.0001
female	22.381	2.945	7.600	<.0001
STRATIO	-0.061	0.285	-0.218	0.8274
public	-15.973	3.343	-4.778	<.0001
city	15.800	3.536	4.470	<.0001
SCHSIZE	0.008	0.003	2.376	0.0176
F statistics			**118.048**	**<.0001**
R^2				**0.235**
Sample				**3462**

Notes: * indicates significant at .05 and ** indicates significant at .01

Appendix 11

Means' Analysis for Regression Samples with and without PROPQUAL

Means	Sample PROPQUAL			Sample NO-PROPQUAL			Diff PROP/ NO PROP (2-4)
	Missing (1)	Sample (2)	Diff (1-2)	Missing (3)	Sample (4)	Diff (3-4)	
		2812			3462		650
SNED	38.16%	36.88%	1.28%	44.32%	35.07%	9.25%	1.81%
PARED	12.362	12.059	0.303	12.91	11.859	1.0509	0.2000
HOMEPOS	-0.758	-0.904	0.146	-0.58	-0.963	0.3832	0.0590
HISEI	42.202	40.534	1.668	44.991	39.603	5.3881	0.9310
female	45.31%	46.44%	-1.13%	43.87%	46.97%	-3.10%	-0.53%
STRATIO	22.989	26.081	-3.092	19.856	26.125	-6.269	-0.0440
public	43.35%	41.39%	1.96%	31.56%	47.40%	-15.80%	-6.01%
city	59.87%	64.08%	-4.21%	69.77%	58.75%	11.02%	5.33%
SCHSIZE	1069.3	1075.3	-6.000	1028	1089.5	-61.45	-14.2000

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