Effects on Class-size Reduction on Students’ Performance

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Abstract

A major factor affecting students’ academic performance is the classroom environment, where class size is one of the important factors. This study focused on the impact of lowering class sizes and evaluating student performance, and examined a number of other factors affecting students’ performance. The results were established using a simple model based on Lazear (2001). The results reveal the benefits of class-size reduction, and notably, how elementary

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students benefited from the smaller class size. This study will help school managers, teachers, and society to understand the importance of creating an optimal learning environment based on students’ needs.

JEL classification:

Keywords: class-size reduction, learning environment, eagerness toward studying, optimal class size
1 Introduction

Education is one of the major factors promoting economic development and can lead people to overcome poverty. Only through education can people develop adequate skills, knowledge, and the mindset to perform effectively and contribute to developing themselves and society. Many factors associated with education may enhance or weaken students’ learning and academic performance, and among them, a key factor responsible for the falling standard of education is the large class size. Numerous studies have been conducted to determine the effect of class size on students’ academic performance. Teachers and parents believe that in a small class, students receive more attention than in big classes, and some students also feel more comfortable to clarify their queries and participate in class discussion in small classes. For school authorities, class size reduction is considered to be an increase in their operating expenditures and not a cost-effective means to increase student performance. This area of research has always been controversial due to differences in the opinions of academicians and school authorities.

This study examines the impact of class-size reduction (CSR) in elementary school, by examining the learning environment, the impact of class size reduction in a poor learning environment, the level of comprehension in a small class, and how it affects students’ academic achievements. Through this research, it is established that small class size favors teachers’ ability to handle classes more efficiently by using a variety of pedagogies, creating a conducive learning environment, and
also providing individual attention to students, which in turn enhances the teachers’ productivity and the students’ performance. The major variable in the study is class size, which is considered as the number of students a teacher is responsible for in the class. The performance of students measured across various academic subjects is considered as the academic achievement of students. The school environment is an important factor that contributes to the learning and assimilating level of pupils. The school environment usually facilitates students’ learning, and environments can be either stimulating or unexciting, either favorable or obstructive to the development of students. If the school environment is not motivating and challenging, and does not inspire students to learn, it is considered a poor learning environment.

The second part of the article examines previous studies conducted on the impact of class size on students’ performance. Then, the study model follows, and finally, the paper concludes by discussing the implications of these results.

2 Literature Review

Class size is considered as the number of students a teacher is responsible for in the class. (Kedney, 1989). Many researchers emphasize that smaller classes are found to have greater chances for individualizing instruction and achieving a healthier classroom climate. Student attitude, individualization, student participation, quality of instruction, and teachers’ attitude, are all promoted positively by a reduction in class size (Smith and Glass, 1980).
However, do students really learn more in small classes? Much of the evidence in the literature of education provides a mixture of opinions and some of the literature is cited below:

According to Siegfried and Kennedy (1995), it is necessary for instructors to adjust their teaching methods, and class size alone will not have any impact on learning. The study suggested that it is mandatory to change the teaching strategies based on class size, otherwise the class size and student performance do not have any direct impact. The study also verified that the real effect of small class size comes through students’ work ethic (including attitude toward the subject, attentiveness, shyness in class, attendance, etc.).

Krueger (2000), Hruz (2000), and Bohrnstedt and Stecher (1999) also summarized studies on class size reduction. They mentioned that a class with a capacity of 15 showed higher achievement than their peers in larger classes in the first year of class reduction. More advantages and statistically significant results were observed in math classes than in reading classes. The study again mentioned that during the subsequent years, the small-class-size children could maintain their advantage but did not show any improvement in their achievement. Konstantopoulos and Hedges (2008) found that higher-ability students benefited more from being in a small class.

Many studies have been conducted to examine the impact of small class size on student achievement and have provided affirmative answers to this question, linking reduced class size to positive effects on student achievement (Biddle and Berliner, 2002; Finn and Achilles, 1990; Glass and Smith, 1979; Grissmer, 1999), particularly
in the early primary grades and for African-American and poor students (Bain et al., 1992; Nye et al., 2004; Smith et al., 2003). According to some reports, these effects are sustained beyond the ‘treatment’ years for students who are exposed to small classes (Ehrenberg et al., 2001; Finn et al., 2001; Nye et al., 2002). Positive outcomes on student and teacher attitudes have also been found in the context of smaller classes (Smith and Glass, 1980; Zahorik et al., 2003). Therefore, it would seem that CSR works to improve student achievement in the early grades and for students often thought to be at risk, and it enhances the affective experiences of both teachers and students. Correa (1993) and Lazear (2001) hypothesized a theoretical model to establish the role of class size in improving class productivity and function. These studies also emphasized that large class size leads to a decline in student learning. They recommended that small class size improves student-teacher interaction.

In general, in the majority of past studies, students in small classes outperformed students in larger groups. The outcome of CSR was a slight increase in test scores after two and three years, students received more teaching time during class hours, there were less disciplinary issues, and more parent-teacher contact time was reported. Overall, there was enhanced literacy instruction, student talk, and student participation in smaller classes.

Students’ interactions with their peers in classrooms help to improve their social skills and build healthy friendships that motivate them to attend classes. According to Hamm and Faircloth (2005), many students’ friendships are critical during their school life and move them towards psychological growth and maturity, which can
enhance their social skills and self-awareness, which in turn influences the development of self-evaluation and self-growth. The above study proved the unprecedented effect of the peer group in a child’s school life. CSR can sometimes affect students’ opportunity to mix with a larger number of peers.

Peer groups can influence students negatively as well. The association with friends who are not serious in studies can lead to negligence in studies and poor academic performance. According to a study by Olalekan (2016), being among peer group students makes them feel more comfortable and relaxed. The author also emphasized that brilliant students’ association with dull friends would influence their learning negatively. Similarly, an association with a brilliant peer group would have a positive effect on a dull member towards learning and stimulate his/her interest in learning. Olalekan (2016) stated that the nature of a peer group determines the impact on the motivation and achievements of its members. Any environment that does not motivate students’ educational needs is considered a poor learning environment.

Through the present study, the researchers explore the various effects of CSR that contribute to the academic success of elementary school students. This paper sought to conceptualize the effects of class size on teaching and learning processes along with the environment of elementary students, which is an under-researched area. More importantly, this study has also focused on the implementation of follow-up on the class size rules over the periods. To examine this, the following propositions were formulated and outlined as follows:

P1- CSR can be effective in increasing academic performance of those students
who are in the early elementary grades rather than in the late elementary grades.

**P2-** CSR can be effective for those who have poor learning environments.

**P3-** Class composition based on students’ understanding strengthens the positive effects of CSR on students’ academic performance.

**P4-** The optimal class size is small while introducing the policy, and the class size grows larger with time.

### 3 The Model

According to the human capital theory stated by Backer (1964), we assume that individuals accumulate their own human capital through education. In order to clarify the mechanism by which CSR affects each student’s performance and to find the optimal class size for various students, this research uses a simple model based on that of Lazear (2001).

First, we assume that the maximum value of human capital of individual $i$ acquired through education, $V_i$, is written as

$$V_i = A(\frac{\theta_i}{|\theta_i - \frac{1}{n} \sum \theta_i| + 1})^{\alpha} e_i^\beta,$$

where $A$ is an exogenous variable, $\theta_i$ is the individual’s ability to understand teaching,
and $0 < \theta_i < 1$ is satisfied. $\bar{\theta}$ is the average level of students’ ability to understand teaching in a classroom, and $e_i$ is the level of individual learning environments, such as the amount of provision of school supplies from family, or parents’ perception and attention towards their children’s learning needs. The function of human capital is based on the Cobb-Douglas production function and $0 < \alpha, \beta < 1$ are satisfied. Whether human capital can be maximized or not depends on the individual’s earnestness. That is, human capital per student acquired by education is shown as

$$V_i\bar{p}^n = A\left(\frac{\theta_i}{|\theta_i - \bar{\theta}| + 1}\right)^\alpha e_i^\beta \left(\frac{1}{n} \sum p_i\right)^n,$$

where $p_i$ is the level of an individual’s earnestness toward studying and $\bar{p}$ is the average level of earnestness in a classroom. $0 \leq p \leq 1$ is satisfied and $n$ is the number of students in a classroom$^1$. (2) clarifies that the average level of earnestness in the classroom affects individual human capital because the effect of the peer group on academic performance is observed in a classroom. When the average level of earnestness toward studying in a classroom is higher than a student’s earnestness toward studying, the student’s earnestness increases and vice versa. Moreover, when an individual’s ability to understand teaching gets closer to the average level of understanding in a classroom, individual human capital increases because the level of teaching and teaching style usually focus on the level of a student whose ability is average in a classroom.

$^1$The idea that the effect of earnestness on individual human capital decreases when the number of students in a classroom increases, is based on Lazear (2001).
Next, we consider the benefits from education. The operating cost of a classroom (such as the salary of a teacher and the cost of installing equipment for learning, such as a blackboard or air conditioners) is $W$, and the cost is paid by students in a classroom. The benefits from education per student, $\pi_i$, are as follows:

\[
\pi_i = V_i \bar{p}^n - \frac{W}{n} = A \left( \frac{\theta_i}{|\theta_i - \bar{\theta}| + 1} \right)^\alpha e_i \left( \frac{1}{n} \sum p_i \right)^n - \frac{W}{n},
\]

(3)

and we assume that the benefits from education are always positive numbers. That is, $\pi_i > 0$ is satisfied. From (3), we can observe that the value of benefits through education per student becomes the increasing function of $e_i$, and $p_i$ whereas it is the decreasing function of $W$. That is, individual learning environments and individual earnestness toward studying are the factors that boost the benefits through education, whereas the operation cost decreases the value of benefits.

Let us consider an optimal class size. The first-order condition of (3) for $n$ is shown as

\[
\frac{\partial \pi_i}{\partial n} = V_i \bar{p}^n \log \bar{p} + \frac{W}{n^2} = 0.
\]

(4)

\(^2\)In a real society, schools incur these costs through grant money provided by the government, and students do not seem to pay for them directly, especially in public schools. However, the grant money provided by the government is collected by way of tax. That is, citizens pay for the costs indirectly. Therefore, we assume that the operating cost is paid by each student.
From (4), we obtain the optimal class size as

$$n^* = \sqrt{\frac{-W}{V_i p^m \log p}}.$$  

(5)

From (3) and (4), it is found that the value of $n$ increases when the value of $p$ increases and vice versa (see Appendix A)\(^3\). Therefore, the higher the students’ earnestness toward study, the larger the optimal class size becomes. Moreover, we observe that $n$ is the increasing function of $W$ whereas $n$ is the decreasing function of $V_i$ from (5). That is, the more individual learning environments increases, the smaller the optimal class size becomes. In addition, the optimal class size becomes smaller when the deviation of individual ability to understand from the average level in a classroom is small. In contrast, the higher the operating cost, the larger the optimal class size becomes.

Next, we examine the benefits from education and the transition of the optimal class size. For simplicity, we assume that students receive education for two periods. The benefits from education can be rewritten as

$$\pi_{1i} + \pi_{2i} = V_{1i} \bar{p}^n - \frac{W}{n} + \delta(V_{2i} \bar{p}^n - \frac{W}{n})$$

$$= A \left( \frac{\theta_{1i}}{|\theta_{1i} - \theta_1| + 1} \right) \alpha^\beta_1 \left( \frac{1}{n} \sum p_{1i} \right)^n - \frac{W}{n} + \delta \left( A \left( \frac{\theta_{2i}}{|\theta_{2i} - \theta_2| + 1} \right) \alpha^\beta_2 \left( \frac{1}{n} \sum p_{2i} \right)^n - \frac{W}{n} \right),$$

(6)

where $\delta$ is the discounted present value, and $\pi_{ji}$, $V_{ji}$, $p_{ji}$ and $\theta_{ji}$ indicate the ben-

\(^3\)The analysis of the relationship between $n$ and $p$ is the same as that given by Lazear (2001).
e... ts from education, human capital, earnestness toward study and the ability to understand teaching of individual $i$ in period $j$, respectively.

The range of $\theta_i$ is small in the early elementary grades because the accumulation of knowledge is less at the elementary level and study content is easy to understand. On the contrary, the content will increase and become more advanced during late elementary grades. Therefore, the deviation of individual ability to understand from the average classroom is narrow in lower grades, whereas it is large in higher grades. That is,

$$\frac{\theta_{1i}}{|\theta_{1i} - \bar{\theta}_1| + 1} > \frac{\theta_{2i}}{|\theta_{2i} - \bar{\theta}_2| + 1},$$

is satisfied. The declined individual understanding of teaching in the second period decreases the level of earnestness toward study, $p_{2i}$. On the contrary, as benefits from education are the increasing function of $e_i$, improvement of individual learning environments in the first period boosts not only the level of $e_{2i}$ but also $p_{2i}$. The first-order condition of (6) for $n$ is as follows:

$$\frac{\partial (\pi_{1i} + \pi_{2i})}{\partial n} = V_i \bar{p}_1^n \log \bar{p}_1 + \frac{W}{n^2} + \delta (V_{2i} \bar{p}_2^n \log \bar{p}_2 + \frac{W}{n^2}) = 0.$$  \hspace{1cm} (8)

When the class size for two periods is decided before the first period and not changed, from (8), we obtain the optimal class size through two periods as

$$n^{**} = \sqrt{-\frac{(1 + \delta)W}{V_i \bar{p}_1^n \log \bar{p}_1 + \delta V_{2i} \bar{p}_2^n \log \bar{p}_2}}.$$  \hspace{1cm} (9)
4 Effects of CSR on students’ academic performance

The study has obtained four results by examining the effects of CSR on students’ academic performance. First, we introduce the following proposition from (7).

**Proposition 1** CSR can be effective in increasing students’ academic performance in those who are in the early elementary grades rather than in the late elementary grades.

**Proof.** Deviation of individual ability to understand classroom teaching in the early elementary grades is small compared to deviation in the late elementary grades because individual accumulation of knowledge about each subject is not large. Therefore, learning that focuses on students with an average rate of understanding can be effective in the early elementary grades rather than in the late elementary grades. In addition, a small-size class is amenable to multiple ways of teaching, such as adopting interactive teaching or assignments, that a large-size class cannot have. These various methods are effective for preventing deviations from becoming large. Moreover, individuals’ earnestness increases when their ability to understand teaching gets closer to the average level in a classroom because the contents in the subjects are suitable for them. Since we observe that less deviation from the average level in understanding and high earnestness increases the value of human capital from (1), the effects of CSR tend to be larger in the early elementary grades. ■
This model introduces the same result as those of some empirical studies, such as reduced class size leads to positive effects on student achievement (Biddle and Berliner 2002), particularly in the early primary grades and for African-American and poor students. Thus, students may benefit from smaller classes regardless of the teaching methods used by the teachers. Similar to earlier studies, the study also found that children in smaller classes were better achievers and concentrated longer than those students in large classes due to improvement of individuals’ learning environments and their high earnestness toward study.

Second, we consider the relationship between individuals’ learning environments and their academic performance. Individual learning environments also affect the value of individual human capital acquired by education. For example, when parents do not pay attention to their children’s studies or their families cannot afford to provide enough of school supplies, the students’ learning environments become poor. The value of human capital and the students’ earnestness toward studying is decreased. On the contrary, for the students whose families are rich, and the parents want their children to receive quality education, they always provide sufficient school supplies and many opportunities for their children to learn. The high level of learning environments not only improves the value of human capital directly, but will also elevate it indirectly by increasing their children’s earnestness toward studying. From this perception, we can obtain the following proposition:

**Proposition 2** CSR can be effective for those who have poor learning environments.
Proof. CSR can improve the level of the individual learning environment because the teacher in a classroom can easily grasp the individual learning environment in a classroom of smaller size. This will help the school to give the students and their parents some valid advice to improve the learning environment directly or support the students whose learning environments are poor. Moreover, better learning environments increase individual earnestness toward study. Since (2) shows that good individual learning environments and earnestness improve the value of human capital, we deduce that CSR can be more effective for those who have poor learning environments.

This result supports empirical studies, such as that by Tsavga (2011), that state that the learning environment plays a vital role in determining students’ success, as it determines how a student achieves his/her learning goals and addresses his/her learning tasks. Certainly, the environment plays a major role in molding individuals’ behavior so as to meet the demands of learning. Correa (1993) and Lazear (2001) recommended that small class size improves student teacher interaction, and leads to more teaching time during class hours, less disciplinary issues, and more reported parent-teacher contact time. Overall, this enhanced literacy instruction, student talk, and student participation in smaller classes is considered as creating a positive learning environment. A poor learning environment will not contribute to students’ motivation or learning experience.

Third, we focus on the relationship between class composition based on students’ understanding and the effects of CSR. We obtain the following proposition:
Proposition 3  Class composition based on students’ understanding strengthens the positive effects of CSR on students’ academic performance.

Proof. By class composition based on students’ understanding, the value of individuals’ ability to understand teaching tends to aggregate into the average level of understanding in a classroom. Therefore, the value of human capital increases as shown in (1). Moreover, the aggregated ability to understand teaching increases individual earnestness toward study because of the level and the teaching mode in a small-size class, which becomes suitable for students. We find that high earnestness increases human capital, from (2). Hence, class composition can improve the positive effects on students’ academic performance through CSR. ■

Finally, we calculate the optimal class size through two different periods, short and long periods, and analyze the transaction of the optimal class size. From (5) and (9), it is clear that $n^* > n^{**}$ is realized when

$$|V_1 p_1^n \log \bar{p}_1| < |V_2 p_2^n \log \bar{p}_2|,$$  

(10)

is satisfied and vice versa. That is, the optimal class size becomes smaller as long as individual learning environments, and earnestness toward studying increase by CSR and vice versa. From this fact, we obtain the following proposition:

Proposition 4  The optimal class size is small while introducing the policy and the class size grows larger with time.
Proof. When students start to learn, there is a possibility that some students’ learning environments are weak. Therefore, (10) is satisfied by CSR because it helps the learning environments to improve and individual earnestness toward studying increases. Moreover, since the deviation of students’ abilities to understand teaching from the average level in a classroom is narrow for the first time and students’ earnestness is high, CSR shows effectiveness. As long as the values of $e_i$ and $p_i$ increase, the optimal class size becomes small. On the contrary, the marginal rate of improvement of individual learning environments becomes low and students’ understanding largely deviates over time. In this case, students’ earnestness towards study becomes low and the effects of CSR become small. Therefore, the optimal class size increases with time. ■

5 Conclusion

This paper clarifies the effects of CSR on students’ academic performance theoretically by focusing on each student’s ability to understand teaching, the learning environment, and earnestness toward study. We obtained four propositions from our model. First, we found that CSR is more effective in improving the human capital of students who are in the early elementary grades rather than those in late elementary grades. Second, it was also effective for students whose learning environments were poor, rather than students whose learning environments were rich. These two results support the results of many previous empirical studies and have provided an
Third, we clarified the mechanism by which class composition enhances the effect of CSR and academic performance of students. As class composition usually corrects the deviation of individual ability to understand teaching from the average level of students’ understanding in a classroom, individuals can improve their earnestness toward study when class composition is considered. Therefore, class composition will strengthen the positive effects of CSR on students’ academic performance, which in turn will strengthen individual human capital.

This study will shed light on CSR in schools. Most of the schools had followed the rules strictly immediately after the CSR policy was introduced, and admitted only the recommended number of students. However, gradually, the number of students in each class increased, which in turn affected the efficacy of CSR implementation.

Fourth, we focused on the transition of optimal class sizes. In the initial period, the optimal class size was small, whereas it increased with time because the individual learning environment had already been organized well and there was little room for improvement, and individual understanding had deviated.

Conceivably, the main implication of this study is that smaller classes can benefit students at the elementary level in terms of active attention from teachers, but this may not be applicable at the secondary level.

In most cases, small classes allowed teachers to engage in more individualized teaching and created a difference to the curriculum. It is well known from research (Evertson and Randolph, 1989; Graue et al., 2008) that teachers do not always adapt
their teaching strategies to take advantage of small classes. Some teachers use the
same teaching strategies in both small and big size classes, which may not always be
effective. This study also recognizes the importance of identifying new pedagogical
approaches suitable for smaller classrooms, such as collaborative learning, since in
small classes, the opportunity for collaboration will naturally be minimal. Just by
increasing the amount of individualized attention or giving one-to-one instructions
will not benefit all students, especially at the secondary level.

Summarizing the above discussion, it can be concluded that all arguments favor
a small class size, which is more beneficial for elementary students and students with
poor learning environments. This study will help educational leaders to determine
whether class size reduction is worthwhile for elementary or secondary level, and
also determine the economic impact it creates on schools. In addition, research can
further explore the need to understand the instructional and classroom management
practices of teachers of small class size and the benefits it can bring to the students
during their formative years of education, and the impact it will have on the children
from a long-term perspective.

Appendix A

From (4), we obtain the following equation:

\[ W = -n^2 V_i \bar{p}^n \log \bar{p}. \]  \hspace{1cm} (11)

Substituting (11) into (3), it is satisfied that
\[ \pi_i = V_i \tilde{p}^n + \frac{n^2 V_i \tilde{p}^n \log \tilde{p}}{n} \]
\[ = V_i \tilde{p}^n (1 + n \log \tilde{p}) > 0. \quad (12) \]

Therefore, it can be written as \( 1 + n \log \tilde{p} > 0 \). Using the implicit function in (4), we introduce the following equation:

\[ \frac{\partial n}{\partial p} = \frac{\frac{\partial^2 \pi_i}{\partial n \partial p}}{\frac{\partial^2 \pi_i}{\partial n^2}} > 0. \quad (13) \]
References


