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Diminishing Marginal Returns and the Production of Education: An International Analysis

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Abstract

Diminishing marginal returns (DMR) to school inputs could explain a wide variety of findings in the research literature. One important example is the influential finding by Heyneman and Loxley that school inputs are the ‘predominant influence’ on achievement in developing nations, where input levels are low, even though the same school inputs have relatively little influence in developed nations, where input levels are higher. However, few studies of education production, including those related to the Heyneman–Loxley hypothesis, use functional forms that allow for DMR, and common tests for DMR appear to be invalid. Various tests are implemented using data from 32 countries. As is commonly found in the literature, the marginal effects of school inputs are frequently negative, precluding DMR. In those cases with positive marginal effects, there is more evidence for DMR than for increasing returns, but constant returns rarely

can be rejected. DMR therefore does not appear to explain the differences in results between developing and developed nations.

Key Words:

Economics of scale

resource allocation

economic development

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Notes

1. The average country in Europe spends approximately 3.6% of the Gross Domestic Product on primary and secondary education (Organization for Economic Cooperation and Development, 2003). The value is 4% for a sample of 10 developing nations.

2. For example, Murnane et al. (1995), Currie and Thomas (1999), and Neal and Johnson (1996) find a positive link between academic test scores and the wages of individual workers in the United States. Psacharopoulos (1985) finds a positive relationship between years of education and income in developing countries in an extensive review of research. Hanushek and Kimko (2000) find evidence that countries with higher academic achievement also have higher economic growth rates.

3. A related influential result is that there are diminishing economic returns to years of education, holding school inputs constant (Psacharopolous, 1985). This should not be confused with diminishing returns to school inputs in the production of achievement, which is the topic of the present study.

4. Some of these misspecifications are discussed later in the paper (for example, Dewey et al., 2000; Figlio, 1999; Hanushek et al., 1996).

5. Harris (2001) summarizes results of the Tennesseee and Wisconsin class size experiments (Nye et al., 1999; Molnar et al., 1999, respectively), as well as a meta-analysis of previous small-scale experiments (Glass and Smith, 1979). He finds that a reasonable estimate of the average effect of reducing class size by one student for one grade is 0.0008–0.0020 test score standard deviations. The same study compares these results with a sample of non-experimental estimates: Akerhielm (1995), Dolan and Schmidt (1987), Eide and Showalter (1998), Ehrenberg and Brewer (1994), Ferguson (1991), Goldhaber and Brewer (1997), and Hanushek et al. (1996). Harris finds that very few of these non-experimental estimates of the class size effect are within the range identified from the experimental literature; and nearly all are below it.

6. The results in the Tennessee STAR experiment are not available by race.

7. Hanushek and Luque write that ‘it has been conventionally held, particularly following Heyneman and Loxley (1983), that schools and school resources are more important than families in developing countries’ (2003, p. 498).

8. An alternative possibility, not tested by Heyneman and Loxley, is that there may be weaker correlations between measures of socioeconomic status and actual home environment in poor countries. Heyneman and Loxley seem to highlight this possibility when they write that ‘the pressure on students to do well on examinations does not appear to vary as markedly on the basis of parental socioeconomic status’ (1983, p. 1183). They provide no statistical tests of this, however.

9. One argument for testing input effects by national income level is that the latter may be a proxy for school input levels. Yet, if one is interested in DMR in school inputs, then it would seem better to interact school inputs with themselves directly, as in the analysis that follows. Income might also be seen as a measure of non-school inputs (socioeconomic status), but in this case it would seem preferable to use measures at the individual level, rather than national income, as in Baker et al. and Hanushek and Luque. For Baker et al., this is apparently a test of the ‘social reproductive process,’ referring to the tendency of societies to give greater educational opportunities to those children who already have the greatest advantage, but it is still unclear how their analysis tests for this. A clearer approach would be to test individual ways in which education might reinforce inequality (e.g., the correlation between school inputs and non-school inputs).

10. One possible reason for DMR that is unique to production functions in education is the possibly non-metric nature of output. While psychometricians do try to place achievement scores on a ‘developmental’ vertically linked scale, there is some controversy about how well this can be done and therefore about what differences in scores across students (or across time within students) actually mean (McCaffrey et al., 2003). The author wishes to thank an anonymous referee for raising this point.

11. Figlio’s plots the marginal effects of class size and teacher salaries as various input levels, and finds, for instance, that the class size effect is relatively unaffected by most input levels, except school size (number of students in the school). DMR does appear to be present in teacher salaries with respect to parent income levels and perhaps instructional hours. Figlio does find that the class size effect becomes larger in schools that have more students.

12. The standard errors for y_1, y_2, and y_3 were estimated using the ‘stdp’ command in Stata. Note that the subscript on the sample size becomes irrelevant because the sample size is the same for each prediction within each country.

13. To see why this is the case, note that as a matter of notation. Also, is true by assumption and is true because of the constant returns assumption. Thus, and, by substitution, it is therefore true that is exactly equal to $\Delta y_H^{CMR} - \Delta y_H^{DMR}$.

14. Hanushek et al. (1996) show that the studies finding the largest effects of school resources are based on data aggregated to the state level and, to a lesser extent, the district level. Such high levels of aggregation had been defended on the grounds that they reduce measurement error. They show both empirically and theoretically, however, that lower levels of aggregation reduce the effects of omitted variables; and the higher measurement error is likely to be inconsequential. Their empirical analysis therefore starts with a model of student-level test scores, explained by various student-level characteristics and school-level characteristics. This is the approach implied in the equations above and used throughout the present analysis. Hanushek and Luque (2003), in contrast, estimate a single equation in which student-level variables are aggregated upwards to the classroom level. No justification is given for this choice.

15. In the first test, Figlio includes a lagged dependent variable as an exogenous variable. This is not possible with the TIMSS data. He also runs the test excluding the lagged dependent variable, which is quite similar to the present specification. His test statistic (6.730) rejects the null at similar levels of significance.

16. I also tested whether the results were sensitive to the value of λ, but they are not. The correlation in the $\Delta y_L - \Delta y_H$ estimates using the base value $\lambda = 0.25$ with $\lambda = 0.5$ in Equation (7) is 0.907.

17. The input indices were created by placing each of the input variables on a 0–1 scale, summing and dividing by the number of variables (for school and non-school categories, respectively). The national income data are taken from World Bank (1996).
