Revisiting Catholic School Effects: an Application of a Mechanism-based Approach

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Abstract

This study examines school sector effects at the elementary school level. Revisiting this classical issue is warranted for two reasons. First, school reform in recent period implies institutional changes in public and Catholic schools, which may yield changes in sector effects. Second, previous studies provided insufficient explanations why the sector effects exist. By applying a front-door criterion (Pearl 2009), I examine the important school characteristics for student outcomes and identify which school characteristics bring about schooling effects at the elementary school level. I compare this approach with more frequently used approaches such as a back-door criterion and mediation analysis, which illustrates the strengths of the new approach. For this purpose, I use the Early Childhood Longitudinal Study, Kindergarten Class of 1988-89 (ECLS-K). This study enriches our understanding of school sector differences by specifying causal mechanisms and provides an alternative way of estimating causal effects beyond average treatment effects.

Introduction

This study will examine school sector effects at the elementary school level. Since James Coleman and his colleagues showed that Catholic schools were more effective than public schools in teaching mathematics and reading to equivalent students in high school level (e.g., Coleman and Hoffer 1987; Coleman, Hoffer, and Kilgore 1982; Hoffer, Greeley, and Coleman 1985), a large literature in sociology of education examined the Catholic school. A key issue is comparability of public school and Catholic school students after controlling for family background and measured motivation to learn (e.g., Morgan 2001). Students who are most likely to benefit from Catholic schools are more likely to enroll in Catholic schools. If students were assigned randomly to Catholic and public schools, both types may be shown to be equally effective on average. Self-selection mechanism may mislead a large Catholic school effect. In this study, I reexamine the debate over school sector effects at the elementary school level by focusing on the mechanisms through which the sector effects are generated.

There are two reasons for revisiting this debate. First, recent school reforms (standards based accountability reforms) yield institutional changes in the public and private sectors. It suggests that sector differences may have narrowed or disappeared in recent years. For example, Carbonaro (2006) found that public school students are either outperforming or doing as well as private school students at the kindergarten level. Therefore, it is warranted to see whether the same changes occurred at the elementary school level in recent years. Second, most research is too abstract to show schooling processes. Previous research has focused on the average school effect on students learning, not specifying the mechanisms involved. The average school effect may not be our fundamental interest. The primary focuses in the study of schooling effects are to find the important school characteristics for student outcomes and to identify the particular mechanism that generates how school characteristics bring about schooling effects. Controlling for observed and unobserved confounders cannot be an ultimate goal of this kind of research. Therefore, I will examine which school characteristics make Catholic/public schools effective and identify the mechanisms through which Catholic/public schools affect students' achievement.

Research Questions

Specifically, I will examine the following research questions.

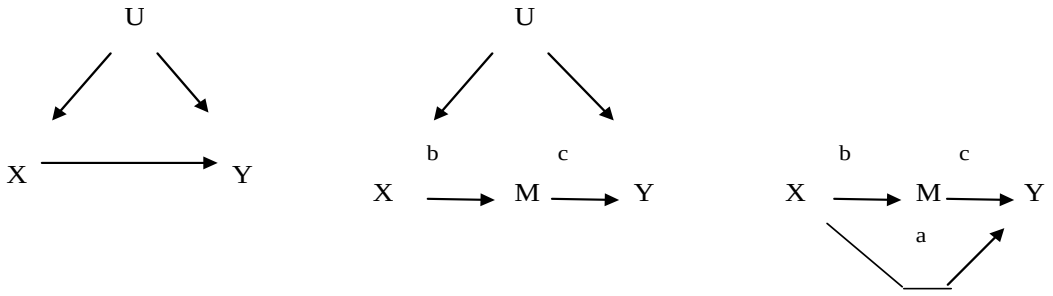
1) At elementary school level, do students who attend Catholic schools do better than they would do if they had instead attended public schools? Alternatively, do students who attend public schools better if they had instead attended Catholic schools?
2) Which school characteristics make Catholic/public schools effective? How can we identify the mechanisms through which Catholic/public schools affect students' achievement?

Methods: Front-door criterion

To examine schooling effects, Judea Pearl (2009)'s front-door criterion will be applied (See Figure 1). As pointed before, the average causal effect may not be a parameter of any fundamental interest. Moreover, an estimate of average causal effect of X on Y driven when controlling for all confounding variables does not provide the deep explanation of causal effect. If treatment effects are heterogeneous, then the average causal effect will be population specific. Usually the average causal effects are conditional average treatment effects of some form. The average causal effects of X on Y may be of limited use for predicting the outcomes of policy interventions, either for new populations or in different contexts. In addition, the average causal

effect of X on Y cannot show any particular mechanism that explains how X brings about Y (Morgan and Winship 2007).

Figure 1 Back-door criterion, front-door criterion, and mediation analysis



<Figure 1-A> *Back-door criterion*

<Figure 1-B> *Front-door criterion*

<Figure 1-C> *Mediation analysis*

Pearl's front-door criterion provides a framework for thinking about the estimation of causal effects when we are interested in how causes bring their effects. Therefore, I want to apply his approach to develop a framework for identifying school sector differences. This approach can provide a different strategy for identifying sector difference than the approach previously used in the literature. However, the front-door criterion is not completely new. This can be regarded as to clarify the previous mediation analysis framework. Using similar concepts in the mediation analysis, Pearl's approach shows how causal mechanisms can be used to identify causal effects even when there are unblocked back-door paths between a causal variable and an outcome variable. The basic idea behind the front-door criterion is to achieve identification by adding variables that are intermediate between the independent variables(X) and the outcome variable(Y). These variables would represent the mechanisms through which X affects Y.

Pearl's front-door approach is distinctive from other approaches in several aspects. In the back-door criterion (Figure 1-A), the covariance/correlation between X and Y does not provide a consistent estimate because of the backdoor path through U. If U is observed, then the effect of X on Y can be estimated by conditioning on U. If U is not observed, this strategy is not available. However, in the front-door criterion (Figure 1-B), if we can consistently estimate the effect of X on M (a single intermediate variable or a set of intermediate variables) and the effect of M on Y, getting estimates of *b* and *c*, then we can estimate the effect of X on Y as $b \times c$. This is the core idea underlying the front-door criterion. According to Pearl, both *b* and *c* can be estimated by a double application of the backdoor criterion. Firstly, we can consistently estimate the effect of X on M, because there are no backdoor paths between X and M. There is, though, a backdoor path between M and Y through X and U. Therefore, by conditioning on X, we can eliminate this backdoor path, which allows us to consistently estimate the effect of M on Y. However, the example in the figure assumes that X affects Y only through M. If all mediating variables are observed, the front-door method can be used to estimate the effect of X on Y through these variables. If there are unmeasured mediators, then it will be possible to identify only that component of the effect of X on Y that flows through the observed variables. As such, the model is only partially identified. Comparing with back-door criterion, the front-door criterion augments the causal model by including all intermediate variables between X and Y and identifying the effect of each of these variables on the outcome. In the front-door criterion, the

total effect of the variable of interest on the outcome can be estimated as the sum of the effects of the paths connecting them.

The mediation analysis has similarities with the front-door criterion. According to Baron and Kenny (1986), the total effect of the treatment is seen as the sum of direct and indirect effect. The three key parameters in this model are (1) the effect of X (treatment) on M (mediator), which is "*b*" in the figure, (2) the effect of M on Y conditional of X, which is "*c*", and (3) the effect of X on Y conditional on M, which is "*a*". The indirect effect is obtained as a product of the two effects *b* and *c* (See Figure 1-C). This approach is similar to the front-door criterion in that the mechanisms through which the effects of causes are realized. However, this is different from Pearl's approach because this allows for direct effects to remain in the model. To estimate the total effect of X on Y in this mediation analysis, the Structural Equation Model (SEM) can be used. In SEM approach, the total effect of X is thought to be the combination of direct and indirect effects of X on Y (Total effect = $bc + a$). If M is the set of mediator variables, the indirect effects of X on Y is the sum of all indirect effects (T= $b1c1+b2c2+\ldots+a$). This relation can be formally expressed by two linear equations (this is the simplest form, ignoring the nested design and assuming there is a single mediator variable).

$M=\alpha + bX + e$ ---------- (1)

$Y=\alpha + cM + aX + e$ ---------- (2)

Comparing with the front-door criterion, this model does not exclude the possibility that the treatment may directly influence outcomes without going through mediators. In other words, the front-door criterion assumes the M completely mediates the relationship between X and Y (the effect of X on Y controlling for M should be zero). To make the situation of complete mediation, the front-door criterion has the particular assumption that the mechanism is isolated and exhaustive.

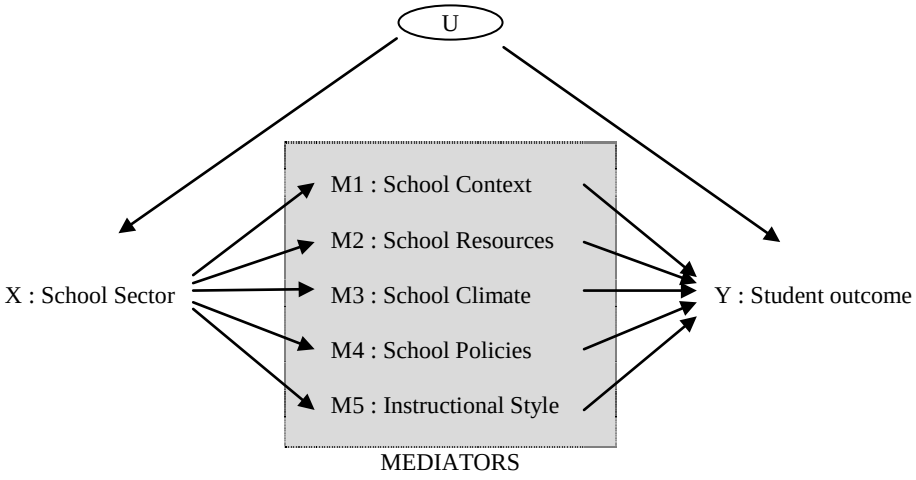
Therefore, in the view of front-door criterion, the methodological goal of this study is to make the connection between the SEM and potential outcomes approaches in the context of mediation analysis. Booil Jo (2008) compared structural equation modeling approach with principal stratification approach in terms of their assumptions and showed how to link the SEM with the principal stratification approaches. Furthermore, most potential outcomes approaches are designed for capturing average causal effects in individual level. However, in school setting, individuals are clustered within groups, and the target treatment is administered at the group level. Therefore, this study incorporates a multi-level modeling to handle the issues that occur when the treatment is administered at the group level (Krull & McKinnon 1999; Kenny, Korchmaroos & Bolger 2003; Bauer & Preacher 2006).

This study will focus on the following two. First, I will estimate the causal effects of school sector on students' learning in multiple ways (e.g., multiple regression, propensity score matching, mediation analysis, and front-door criterion) to assess the advantages and disadvantages of front-door approach. Assuming that the estimates from back-door criterion approach (multiple regression and propensity score matching) yields consistent estimates of average treatment effects, the comparison of total sector effects in front-door criterion approach with the back-door approach illustrates how exhaustively the causal mechanisms are specified in the model. Second, in front-door criterion, I will estimate the magnitudes of mediating effects in each pathway and compare them. This comparison will show why Catholic schools differ from public schools in helping students' learning in elementary schools. This also provides relevant empirical grounds to school reform debates by showing which school characteristics affect student learning.

Data: The Early Childhood Longitudinal Study, Kindergarten (ECLS-K)

The Early Childhood Longitudinal Study, Kindergarten Class of 1988-89 (ECLS-K), collected by the National Center for Education Statistics, is a nationally representative sample of children attending kindergarten in the fall of 1998. The data include not only child's direct academic assessments but also child, parent, teachers and school administrator surveys. From the parent survey, parents report the socioeconomic and demographic characteristics of the children. This information is very important to draw causal inference about the schooling effects because these covariates are likely to be associated with both the selection of school type and student performances. Moreover, from teachers' and school administrators', I will get the information on school characteristics, such as school context, school resources, school climate, school policies, and instructional style. These variables can be used as mediator variables in this study. Figure 2 illustrates a simple path model using ECLS-K data to examine the school sector effect.

Figure 2 Front-door approach in school sector effects



Contribution of this study

In a substantial point of view, this study will contribute to our understanding of school sector effects by showing the specific mechanisms underlying the sector effects. In a methodological point, this study will provide an alternative approach to the studies in previous done. By applying Pearl's front-door approach, this study will enrich causal analysis beyond estimating average treatment effects.

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