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Evaluating developmental education programs in higher education

A key benefit of the regression-discontinuity design is that it effectively assesses the extent that developmental programs result in improving student retention and academic success.

Should the nation's colleges and universities continue to fund and support developmental programs? This is a key policy question given the grim financial scenario at many institutions and the fact that developmental programs are often perceived as putting a significant drain on an often limited amount of resources (Cloud, 2002; Institute for Higher Education, 1998; Lazarick, 1997). Nonetheless, many institutions lack a true understanding as to whether developmental programs are effective in helping students persist (O'Hear & MacDonald, 1995a, 1995b). This brief provides institutional and state policy makers with a methodological tool, the regression-discontinuity design, to effectively assess the extent that developmental programs result in improving student retention and academic success.

This brief presents the results of a study which found that a developmental

mathematics program at a four-year institution is an effective mechanism for retaining students (Lesik, 2007). This study employed a regression-discontinuity model that researchers can use to establish a causal link between participation in a developmental program and student retention. Because a causal inference can be made, policy makers have an opportunity to base their decisions regarding the effectiveness of developmental programs strictly on the merits of the program, without bias. The basic theory behind the regression-discontinuity design will be described along with the findings. Finally, this brief closes with some implications for how the regression-discontinuity design can be a crucial tool for policy makers who are interested in making data-informed decisions about the effectiveness of their developmental programs, and how using such a research design can shape

educational policy and assess measurable outcomes

The National Center for Educational Statistics (2003) found that almost one-third of all entering college students are not academically prepared for college-level work, and therefore need some form of support to help them gain the skill-base necessary to succeed in college. Because so many students are entering college without the needed skill-base, developmental programs have become an integral part of the undergraduate curriculum at many institutions (Boylan, Bonham, & White, 1999; Jenkins & Boswell, 2002). The main purpose of developmental programs is to help underprepared students achieve their maximum potential by providing the necessary academic support services that are designed to improve basic skill competencies in subjects such as reading, writing, and mathematics (Lazarick, 1997). Devel-

opmental programs can help students who might not have the opportunity to earn a college degree by providing another chance to gain the skill-base needed to persist and succeed in college (Boylan, Bonham, & Bliss, 1994; Kulik, Kulik, & Shwalb, 1983).

Controversies surrounding developmental education

Using data to inform policy decisions regarding developmental programs in higher education is one of the top priorities on the agendas of many college and university administrations. On the one hand, many colleges and universities are facing budget cuts and demanding higher standards. On the other hand, developmental programs can be a necessity because there are so many academically underprepared students entering college. Since developmental programs can serve as a bridge that aligns high school preparation and college expectations, underprepared students can be given another opportunity to become ready to pursue college-level work (Lazarick,

1997). Furthermore, community colleges that have “open-door” admissions policies rely on developmental programs to fulfill their mission, and such programs can create a path of access to college for students who may not have the initial skill-base needed to persist through college (Testone, 2001). Effectively assessing developmental programs is necessary in order to balance the commitment to funding such programs, while also giving under-prepared students the opportunity to build their skills in order to succeed in college and eventually earn a college degree.

With such a strong presence of developmental programs at many institutions, little is known about whether these programs can be an effective tool that helps underprepared students stay enrolled in college and ultimately earn a college degree (Moore, Jensen, & Hatch, 2002). Balancing the need to commit a substantial amount of human and financial resources, while also providing underprepared students with the necessary support to build their skill-

base, has been an insurmountable challenge to many colleges and universities (O’Hear & MacDonald, 1995a, 1995b). In fact, many four-year institutions do not even offer developmental programs because of their high cost and because some administrators do not believe that they are beneficial to their students (Jenkins & Boswell, 2002).

Given that developmental programs are such a controversial topic in higher education, numerous research studies have been conducted to determine whether these programs can be an effective mechanism for retaining underprepared students (e.g. Feldman, 1993; Gates & Creamer, 1984; Hardin, 1998; Institute for Higher Education, 1998; Jacob & Lefgren, 2002; Snyder, Hackett, Stewart, & Smith, 2003). Despite political controversies and countless numbers of studies looking for ways to assess developmental programs, policy makers must filter through mounds of research hoping to gain some insight as to whether such programs are truly beneficial in keeping students in college. One of the biggest questions that policy makers face is whether their institution should even offer developmental programs, especially if they are uncertain about their effectiveness (Cloud, 2002; Jenkins & Boswell, 2002).

Limitations of traditional regression analysis

As policy makers look to make data-informed decisions, they rely on researchers to accurately quantify a phenomenon of interest. Researchers use statistical methods and techniques to aid them in making such quanti-

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By relying on more traditional methods, policy makers must make decisions based on analytical techniques that can only include observed variables, and thus can not assess the true impact that a developmental program has on student retention.

fications. Researchers interested in assessing the effect that developmental programs have on student retention typically develop some form of a multiple regression model by using either ordinary least squares or logistic regression analysis (e.g. Hoyt, 1999; Snyder et al., 2003). To model student retention, researchers can use regression analysis to develop a model that describes all the different factors that could impact whether a student remains enrolled in college over a fixed period of time. In order to determine the effect of participating in a developmental program, a dichotomous variable is usually included in the regression model as a way to represent whether a student participated in a developmental program along with a vector of observable control variables. Then, based on the results of the regression analysis, researchers will make conclusions about whether they believe the developmental program is effective in keeping students in college by interpreting the estimate of the coefficient of the dichotomous treatment variable.

Although typical regression modeling strategies such as logistic regression and ordinary least squares can be

useful in gaining a basic understanding of the relationship between participating in a developmental program and student retention, a cause and effect relationship can not be inferred. The reason a cause and effect relationship can not be inferred is because there is no way to control for every possible factor that could impact student retention. Furthermore, it can also be difficult to establish whether the measures used for the control variables are even reliable. Thus, it is virtually impossible to observe and accurately measure every single factor that could impact student retention and include such factors in a regression model. Short of performing a true random experiment, it is difficult to establish a cause and effect relationship between participating in a developmental program and student retention. It is no surprise that the findings of many research studies on the effectiveness of developmental programs at comparable institutions tend to be mixed and inconclusive.

Another limitation of many studies investigating the impact that developmental programs have on student retention is that many of these studies rely on statistical methods for cross-sectional data and do not model retention patterns over time. Whether students drop out of college at some fixed point in their college career is clearly of interest to policy makers. Yet, the timing of when a student is most at risk for dropping out of college for the first time can also be revealing (Singer & Willett, 2003). Knowing when a student is most at risk for dropping out of college for the first time can provide the faculty and staff at

the institution with an opportunity to develop interventions based on those crucial points in time.

Short of performing a true random experiment, it can be difficult to isolate the causal effect of participating in a developmental program, and most research designs do not account for the longitudinal nature of student dropout data. Because of these two limitations, any policy decisions based on the results of research studies that use traditional regression modeling strategies that do not take into account the longitudinal nature of student retention could be misguided. By relying on more traditional methods, policy makers must make decisions based on analytical techniques that can only include observed variables, and thus can not assess the true impact that a developmental program has on student retention.

The regression-discontinuity design

The regression-discontinuity design is a simple extension of regression analysis (Thistlethwaite & Campbell, 1960). The difference between using the regression-discontinuity design and traditional regression analysis is that the regression-discontinuity design relies on an exogenous, predetermined assignment variable with a fixed cutoff score (Reichardt, Trochim, & Cappelleri, 1995; Shadish, Cook, & Campbell, 2002; Trochim, 1984). Given an exogenous assignment variable, treatment and control groups can be established that are equivalent to each other and similar to what a true random experiment would generate (Shadish et al., 2002; vanDerKlaauw, 2002).

An exogenous assignment variable is readily available, since most institutions regularly use some form of a diagnostic test to gauge students' entering skill levels (e.g. Leake & Lesik, 2007; Lesik, 2006, 2007). Such a test is usually administered prior to when the students enroll at the university (Boylan et al., 1999). A diagnostic test can serve as an exogenous assignment variable provided that a uniform cutoff score is established and adhered to for all students and that the test is given prior to receiving treatment (Shadish et al., 2002; Trochim, 1984). The cutoff score of the assignment variable can be used to partition the sample into those students who may be able to benefit from participating in the developmental program and those students whose skill-base is appropriate for them to begin college-level work (Leake & Lesik, 2007; Lesik, 2006, 2007; Shadish et al., 2002; vanDerKlaauw, 2002).

The institution in this study relied on faculty members in the mathematics department to align the material on the diagnostic test with the content of the mathematics courses offered at the university. This allowed for a specific cutoff score on the diagnostic test to be established. Students who scored below the cutoff score were assigned to the developmental mathematics program because they did not show that they had the skill-base necessary to succeed in college. Students who scored above the cutoff were not so assigned because their test scores indicated that they had the necessary skill-base.

The region on either side of the cutoff score of the assignment variable

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is of great interest because it is within this region where the regression-discontinuity design can emulate a random experiment (Pettersson-Lidbom, 2003; Shadish et al., 2002; Trochim, 1984; vanDerKlaauw, 2002). If a predetermined cutoff score on an exogenous assignment variable is established and individuals who fall just above the cutoff are compared to those individuals who fall just below the cutoff, then these individuals should be similar to each other in every way except for the assignment to either the treatment or control group (Leake & Lesik, 2007; Lesik, 2006, 2007; vanDerKlaauw, 2002).

Given such an assignment variable, it is simple to run a regression-discontinuity analysis with virtually any type of regression model, and the interpretations are similar (i.e. Berk & DeLeeuw, 1999; Berk & Rauma, 1983; Leake & Lesik, 2007; Lesik, 2006, 2007; Moss & Yeaton, 2006). The only difference in using the regression-discontinuity design as compared to using traditional regression models is that the assignment variable is included as a covariate in a regression model along with the binary treatment indicator (Shadish et al., 2002; Trochim, 1984).

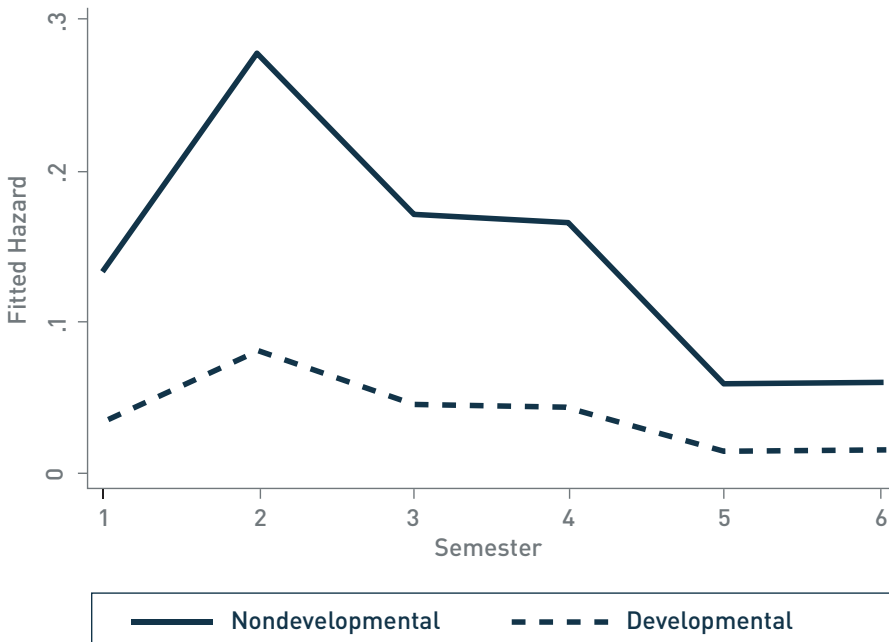
The regression-discontinuity design can be incorporated within virtually any type of regression modeling strategy such as ordinary least squares (e.g. Leake & Lesik, 2007; Moss & Yeaton, 2006), logistic regression (Berk & DeLeeuw, 1999; Berk & Rauma, 1983; Lesik, 2006), or as in the case for the study described herein, discrete-time survival analysis (Lesik, 2007). However, it can be a difficult challenge to identify and address any threats that may introduce bias in the estimate of the program effect when using the regression-discontinuity design. While it is true that the regression-discontinuity design is easy to incorporate within virtually any regression model, obtaining a valid estimate when using the design lies at the heart of the work and remains the biggest challenge.¹

Background of the study

The institution considered in this study is a large state university located in the northeast United States. The developmental mathematics program at this institution provides support to those students who enter the university who are identified as not having the skill-base needed to succeed in college level mathematics. The objective of the Lesik (2007) study was to determine if students who participated in a developmental mathematics program were more likely to persist over the course of their first three years in college as compared to nondevelopmental students.

¹ For a detailed description of how to address common threats to validity when using a regression-discontinuity analysis in practice, see Lesik (2008).

Figure 1: Fitted hazard function at the cutoff score of the assignment variable using a regression-discontinuity hazard model.



Source: This figure is reproduced with the kind permission of Springer Science and Business Media from *Research In Higher Education*, 48(5), 2007, Figure 3, page 602, *Do Developmental Mathematics Programs have a Causal Impact on Student Retention? An Application of Discrete-Time Survival and Regression-Discontinuity Analysis* by Sally A. Lesik.

The developmental mathematics program at this institution consisted of a single stand-alone course in intermediate algebra. Entering students were assigned to the course based on the score that they received on a diagnostic placement examination in mathematics taken prior to entering the university for the first time. The cutoff score for the examination was determined by the faculty of the mathematics department, and it was based on the level of difficulty of the questions given in the diagnostic test. Students who scored above the cutoff score were identified as having the necessary foundation in mathematics needed in college and were not assigned to the developmental mathematics course.

Findings

Figure 1 presents a close-up of the dropout profile at the centered cutoff score of 0. This graph shows the risk of dropout (y-axis) over the course of six semesters (x-axis) at the cutoff score of 0. The dashed line represents the dropout profile for those students who participated in the developmental course, and the solid line represents the dropout profile for those students who did not participate in the developmental course. It is at the centered cutoff score where the students who participated in the developmental course and the students who did not participate in the developmental course were equivalent in every respect. The difference in the risk of dropout is significant

at the 0.05 level (Lesik, 2007). These findings suggested that students who did not participate in the developmental program were approximately four times more likely to drop out of the university over the course of their first three years as compared to equivalent students who did participate in the developmental program.

Policy impact

If the true effectiveness of a developmental program cannot be established, then policy makers may decide that the human and financial resources that these programs demand are not being used wisely. However, the discontinuation of such programs based on perceptions of them being ineffective would cause a large number of students to miss out on an opportunity to earn a college degree if they are not given the chance to gain the skill-base necessary to succeed. Unless policy makers can obtain a true and unbiased estimate of whether their developmental programs are effective in helping underprepared students persist in college, then valuable resources may be diverted to other programs that may not help this given population.

The most significant policy impact from using the regression-discontinuity design is that the causal effect of participating in a developmental program on student retention can be established. Provided that the assignment to the treatment program is based on an exogenous assignment variable and that any threats to validity are identified and addressed appropriately, it is unlikely that any other factors could impact the estimate of the treatment

effect (Leake & Lesik, 2007; Lesik, 2006, 2007).

Using the regression-discontinuity design for evaluating developmental programs clearly has advantages over using traditional regression techniques. This is because the regression-discontinuity design emulates a random experiment at the cutoff score, and thus all possible factors that could impact the outcome measure will be insignificant. Policy makers can make decisions based on the merits of the developmental program itself, and not be concerned that any other mitigating factors may be having an impact on the estimate of the treatment effect. Thus, the regression-discontinuity design can provide researchers and policy makers with a valid assessment measure of the effectiveness of their developmental programs.

The findings from the regression-discontinuity analysis can be used to establish new policies and direct new and different evaluations. For instance, because participating in the program increases student retention, policy makers at the institution could consider raising the cutoff score so that more students will have the opportunity to participate in the course, and perhaps stay in college longer. By raising the cutoff score, policy makers may be able to increase student retention at their university. However, the drawback to implementing such a policy is that if the cutoff score was raised too high, there might be little effect on retention due to the content of the current developmental course not being aligned with the material on the placement examination.

Regression-discontinuity design challenges

One challenge when evaluating the findings from a regression-discontinuity design is to determine what specific aspects of the developmental mathematics program may cause students to persist. Are students persisting because they are developing a stronger foundation in mathematics? Or did the students become more connected with the university through their participation in the developmental course and decide to stay enrolled? One way to determine whether it is the actual content of the developmental mathematics course that contributes to increased retention is to run new and different evaluations to see if students who participated in the developmental program did better in their first college-level mathematics course. For instance, the Lesik (2006) study found that students who participated in the developmental mathematics program also did better in their first college-level mathematics course as compared to nondevelopmental students.

In addition to evaluating content factors of the program, faculty and administrators at the site met to share their opinions on why they believed the program was effective. Many attributed the success of the program to students gaining proficiency in mathematics. It was also believed that the program encouraged students to make use of the many different support services available at the university. Informally, the evaluation was conducted by giving a survey to developmental and nondevelopmental students asking them

to respond to questions regarding their knowledge and use of the different support services available at the university. These findings suggested that developmental students were better informed about the support services offered at the university, and more developmental students regularly used such services as compared to nondevelopmental students.

Summary

The regression-discontinuity design can be an invaluable tool that policy makers can use to evaluate their developmental programs based solely on the merits of the program without bias. Because a regression-discontinuity analysis emulates a random experiment, policy makers can determine whether the investment in their developmental program is worth the return. Furthermore, by establishing whether the developmental program has a causal impact on student retention, then policies can be developed and further evaluations can be conducted to try to isolate the specific aspects of the program that may be causing the effect.

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