Appendix B. Technical Appendix: Indiana SLDS Student Level Analysis

Introduction

Over the course of nearly two years, Research for Action (RFA) worked closely with Indiana's Commission for Higher Education to obtain, clean, and analyze Indiana's Statewide Longitudinal Data System (SLDS). During this iterative process, RFA worked to ensure the dataset was as accurate and complete as possible. We shared early results of our analyses with Indiana to ensure that we avoided any inadvertent errors in assumptions, coding, or analysis. This process, while time-consuming, allowed us to produce analyses that are accurate and complete. It is important to note that this process revealed a set of very serious limitations in Indiana's community college data, including a significant amount of missing data across multiple cohorts. As a result, we came to a mutual agreement with Indiana that analyses of community college data would be inappropriate at this time. Our university analyses utilize data on 334,207 first-time, undergraduate students during a ten-year period from 2005 to 2014. We examined descriptive trends across enrollment for first-time students including full-time and part-time status, and degree and non-degree seeking enrollment, proportion of Pell grant recipients, as well as trends in course completion milestones. We also conducted multivariate logit regression analyses focusing on bachelor's degree completion and high-impact degree completion and declaration.

The following outlines our methodological approach using SLDS.

Research Questions

1. Has the implementation of OBF impacted student outcomes, such as graduating on-time (within four years), declaring high-impact majors, and attaining high-impact degrees[1]?
2. How has the OBF impact on each student outcome changed over years of OBF implementation?
3. Has the implementation of OBF benefited underserved students (i.e., Pell recipients and underrepresented minority students)?

Data

Working closely with the Indiana's Commission, we obtained the Indiana SLDS data of all public university and community college students from the 2005 to 2014 academic years, providing us four years of pre-OBF implementation and six years of post-OBF implementation data. For our study, we used a subset of these data consisting of incoming first-time college students entering each academic year.

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[1] Indiana CHE provided RFA a list of degrees that classify as "high-impact" under Indiana's OBF model. This performance metric only applies to Research I institutions and so the sample for this analysis was restricted to students enrolled at Research I institutions.

Study Samples

The full student-level sample of Indiana's four-year sector public universities includes a total of 334,207 first-time, undergraduate students during a 10 year period from the 2005 to 2014 academic years. This student population includes undergraduate students seeking bachelor's degrees (93.1%), associate degrees (4.7%), certificates (0.3%), and students labeled as "unclassified undergraduate" (2.0%).

As shown in Table 1B below, about 78% of these first time students registered as full-time during their starting year, whereas the other 22% were registered part-time.

Table 1B. Undergraduate Enrollment of First-Time Students in Indiana's Public Four-Year Colleges and Universities, 2005 through 2014.

STARTING YEAR	FIRST-TIME, FULL-TIME		FIRST-TIME, PART-TIME		TOTAL	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
2005	24,468	76.6%	7,483	23.4%	31,951	100.0%
2006	25,804	77.4%	7,518	22.6%	33,322	100.0%
2007	26,738	78.6%	7,265	21.4%	34,003	100.0%
2008	26,823	79.8%	6,785	20.2%	33,608	100.0%
2009	28,474	81.3%	6,567	18.7%	35,041	100.0%
2010	26,481	76.0%	8,374	24.0%	34,855	100.0%
2011	25,419	75.9%	8,054	24.1%	33,473	100.0%
2012	24,819	74.1%	8,694	25.9%	33,513	100.0%
2013	24,659	76.9%	7,400	23.1%	32,059	100.0%
2014	25,506	78.8%	6,876	21.2%	32,382	100.0%
Total	259,191	77.6%	75,016	22.4%	334,207	100.0%

This full sample was used mainly for descriptive analyses that explored trends in first-time, undergraduate enrollment for full-time and part-time registration; underrepresented minority student enrollment; and the number of Pell Grant recipients in their starting year between the 2005 and 2014 academic years.

We also conducted multivariate logit regression analyses to examine the impact of OBF on bachelor's degree attainment, declaring a high-impact major, and high-impact degree attainment, controlling for various student-level characteristics including gender, race/ethnicity, age (i.e. adult student or not), and academic major. Since full-time and part-time students require a different timeframe to attain these outcomes, the four-year sector student sample was divided into two samples: full-time and part-time samples.

Full-Time Student Sample: The full-time student sample was restricted to the first-time, full time students who declared they were seeking a bachelor's degree during their first four years. Since these full-time students are expected to attain bachelor's degrees (including bachelor's degrees in high-impact majors) within the four-year timeframe, student cohorts from academic year 2012 or later years were excluded from the sample. Students in these later cohorts were not expected to graduate by the end of academic year 2014, which was the most recent year in our SLDS data set. The shaded column of Table 2 below reports numbers for our full-time analytical sample (first-time, full-time, BA/BS degree seeking

students) by their starting year (i.e., 2005 refers to the cohort of full-time students enrolling for the first time in academic year 2004-2005).

Table 2B. Full-Time Student Sample for the Four-Year Sector Analyses, 2005 through 2011.

STARTING YEAR	BA/BS DEGREE SEEKER		NON-BA/BS DEGREE SEEKER		TOTAL FIRST-TIME, FULL-TIME	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
2005	23,695	96.8%	773	3.2%	24,468	100.0%
2006	25,065	97.1%	739	2.9%	25,804	100.0%
2007	26,084	97.6%	654	2.4%	26,738	100.0%
2008	26,297	98.0%	526	2.0%	26,823	100.0%
2009	27,856	97.8%	618	2.2%	28,474	100.0%
2010	25,752	97.3%	729	2.8%	26,481	100.0%
2011	24,757	97.4%	662	2.6%	25,419	100.0%
Total	179,506	97.4%	4,701	2.6%	184,207	100.0%

Key student characteristics for students included in the full-time student sample are presented in Table 3B.

Table 3B. Characteristics of Full-Time Student Sample for the Four-Year Sector Analyses, 2005 through 2011.

	2005	2006	2007	2008	2009	2010	2011
Pell Recipient	29%	28%	29%	32%	35%	39%	40%
Female	52%	52%	52%	53%	53%	52%	53%
African-American	6%	6%	6%	6%	6%	7%	7%
Hispanic	3%	3%	3%	3%	3%	4%	4%
Asian	3%	3%	3%	3%	3%	3%	3%
White	86%	86%	85%	85%	83%	82%	81%
Other Race	2%	3%	3%	3%	3%	4%	5%
Adult	4%	4%	4%	3%	3%	4%	4%
Professional Major	47%	48%	48%	48%	47%	48%	49%
STEM Major	13%	13%	14%	14%	15%	15%	16%
Liberal Arts Major	39%	39%	38%	38%	38%	36%	35%

- In general, averages of most student-level covariates remained similar across different first time, full-time student cohorts between 2005 and 2011, except for proportions of Pell and white students.
  - The percentage of first-time, full-time undergraduate students receiving Pell their first four years increased significantly by over 11 percentage points during this period.
  - The percentage of white students decreased by 5 percentage points during this period.

Part-Time Student Sample: Similar to the full-time student sample, the part-time student sample was also restricted to first-time, part-time students who declared they were seeking a bachelor's degree at any time during their first four years. Table 4B below reports numbers for the part-time analytical sample by their starting year. Since part-time students are not

expected to graduate within four years, we use a six-year timeframe for such students. As such, student cohorts from 2010 or later academic years were excluded from the sample.

Table 4B. Part-Time Student Sample for the Four-Year Sector Analyses, 2005 through 2009.

STARTING YEAR	BA/BS DEGREE SEEKER		NON-BA/BS DEGREE SEEKER		TOTAL FIRST-TIME, PART-TIME	
	NUMBER	PERCENT	NUMBER	PERCENT	NUMBER	PERCENT
2005	6,365	85.1%	1,118	14.9%	7,483	100.0%
2006	6,484	86.3%	1,034	13.8%	7,518	100.0%
2007	6,282	86.5%	983	13.5%	7,265	100.0%
2008	5,989	88.3%	796	11.7%	6,785	100.0%
2009	5,729	87.2%	838	12.8%	6,567	100.0%
Total	30,849	86.6%	4,769	13.4%	35,618	100.0%

Key student characteristics for students included in the part-time student sample are presented in Table 5B.

Table 5B. Characteristics of Part-Time Student Sample for the 4-Year Sector Analyses, 2005 through 2009.

	2005	2006	2007	2008	2009
Pell Recipient	34%	35%	36%	39%	43%
Female	54%	53%	53%	52%	52%
African-American	10%	12%	11%	13%	12%
Hispanic	4%	4%	5%	5%	5%
Asian	2%	2%	2%	1%	1%
White	80%	79%	77%	76%	76%
Other Race	4%	3%	5%	4%	5%
Adult	33%	31%	30%	26%	32%
Professional Major	39%	39%	38%	38%	40%
STEM Major	10%	10%	10%	10%	11%
Liberal Arts Major	51%	51%	51%	52%	49%

- Similar to the full-time student sample, averages of most student-level covariates remained unchanged over time, but:
    - The percentage of students receiving the Pell grant increased by nine percentage points between 2005 and 2009
    - The percentage of students who are white decreased by four percentage points during this period

Outcome Measures

Our Indiana 4-year sector analysis examined the effects of OBF on the probability of students attaining bachelor's degrees, declaring a high-impact major, and attaining a bachelor's degree in a high-impact major. For the full-time student analyses, we estimated the effect of OBF on attaining each outcome within four years. For the part-time student population, we expanded the length of time to attain a bachelor's degree, to declare a high impact major, and to attain a bachelor's degree in a high-impact major to six years. Table 6B summarizes the studied outcome measures.

Table 6B. Outcome Measures

Full-Time Student Outcomes	Part-Time Student Outcomes
- Bachelor's degree completion within four years - Declare a high-impact major within four years - Bachelor's degree completion in a high-impact major within four years	- Bachelor's degree completion within six years - Declare a high-impact major within six years - Bachelor's degree completion in a high-impact major within six years

Analytical Model

Using the repeated cross-sectional data of the incoming four-year college student cohorts, we conducted an interrupted time series analysis to estimate the effect of the OBF implemented in 2009 on each of the student outcome measures listed above. We conducted separate analyses for the full-time and part-time student samples.

Analytical Model for the Full-Time Student Sample: Since all student-level outcome measures are binary variables (1=completed; 0=not completed), a logit regression model was used to estimate the effect of OBF on an outcome measure. For example, the logit of the probability of attaining a BA degree within four years for a full-time student i in year t can be written as follows:

$$logit(\pi_{it}) = \beta_0 + \beta_1 Time_{it} + \beta_2 POST1\_OBF_{it} + \beta_3 POST2\_OBF_{it} + \beta_4 POST3\_OBF_{it} + \sum_{k=1}^{K} \beta_{k+4} X_{k_{it}} + \varepsilon_{it},$$

where:

π_{it} = probability of achieving a given binary outcome, $\Pr(Y_{it} = 1)$, given the values of all explanatory variables. And, $logit(\pi_{it}) = \log\left(\frac{\pi_{it}}{1-\pi_{it}}\right)$.

Y_{it} = Indicator of bachelor's degree attainment for student i at year t (e.g., 1 if a full-time student completed a BA degree and 0 otherwise.)

$Time_t$ = A continuous variable indicating year t from the start of the observation period (academic year 2005)

$POST1\_OBF_{it}$, $POST2\_OBF_{it}$ & $POST3\_OBF_{it}$
= Dummy variables indicating 1st, 2nd, and 3rd year after the implementation of OBF, respectively

$X_{k\,it}$ = A vector of student-level covariates including gender, Pell grant recipient in the first four years, race/ethnicity, age, and major.

ε_{it} = Random errors

In this logit regression model, β_1 estimates the slope of the baseline trend in the log odds of achieving student outcome Y before OBF. And, β_2, β_3, and β_4 estimate deviations from the pre-OBF baseline trend (i.e., OBF impacts) that occurred in Years 1, 2, and 3 after the implementation of OBF, respectively. Note that this model estimates the impact of OBF as the change in the log odds of achieving the outcome in a given post-OBF year, which is not easily-interpretable for a lay audience. Thus, we reported all OBF impacts in terms of predicted probabilities (in percent) that were converted from log odds at the mean values of all covariates.

In addition to estimating the impact of OBF for the overall full-time sample, we also examined whether the estimated OBF effect varies across two specific student populations: economically disadvantaged student groups, as defined by Pell recipient status within the first four years, and underrepresented minority (black and Hispanic) students. We conducted these subgroup analyses by segmenting the above regression equation between Pell and non-Pell groups or between underrepresented race/ethnic minority (URM) and non-URM groups. In these analyses, the differential impact of OBF was evaluated between two student subgroups by examining the significance of interaction terms between a student subgroup dummy (e.g., a dummy indicator for Pell and non-Pell students) and the three post-OBF dummies.

Analytical Model for the Part-Time Student Sample: The part-time student analysis used the same logit regression as the one used for the full-time student analysis. However, the part-time logit regression model only included one post-OBF term because the part-time analysis used data on the 2005 through 2009 cohorts. Cohorts from 2010 or later years were excluded from the analyses because part-time students in these later cohorts were not expected to graduate by the end of 2014, which is the most recent year in our SLDS data set. Again, we estimated segmented regression models to examine differential effects of OBF between Pell and non-Pell students or between URM and non-URM students.

A full set of parameter estimates for the full-time sample are reported in Table 7B, and estimates for the part-time sample are reported in Table 8B.

Model Limitations

An interrupted time series analysis with no control group is susceptible to threats to internal validity caused by history. For example, there may have been another program related to college completion implemented in Indiana at the same time as OBF, which could lead us to overestimate the positive effects of OBF.

Our analysis is also susceptible to omitted variable bias. For example, our logit regression model does not control for institutional level covariates because we could not assign all students in each cohort to a single institution. Many students moved from their starting institution to another within the Indiana's public university system over time.

A key component of an interrupted time series analysis is having an accurate pre-OBF trend line. To this end, a longer pre-OBF period is always desired. Due to data constraints, however, we must base our pre-OBF trend line on only four pre-OBF periods (cohorts 2005 through 2008). As such, there is the possibility that our pre-OBF trend line does not provide a valid counterfactual.

Data Limitations

Because of missing or incomplete data for credit accumulation and student-level indicators of academic success prior to starting at a university, such as SAT scores or high school GPA, these factors were neither analyzed nor included in models as covariates. As for other covariates and outcome success rates, we rigorously examined descriptive statistics by cohort to identify any possible issues and compared the results with other sources, such as IPEDS/Delta Cost aggregates and results obtained from state websites and contacts.

Table 7B. Parameter Estimates of Logit Regression Model, Full-Time Student Sample

VARIABLES	(1) Graduated with Bachelor's Degree within 4 Years	(2) Majored in STEM within 4 Years	(3) Graduated with STEM Bachelor's Degree within 4 Years
Time Trend	0.066***	0.034***	0.085***
	(0.006)	(0.009)	(0.013)
Post OBF 2.0 Year 1	0.048*	0.029	0.080
	(0.021)	(0.029)	(0.041)
Post OBF 2.0 Year 2	0.116***	0.054	0.092
	(0.026)	(0.036)	(0.052)
Post OBF 2.0 Year 3	0.101**	0.119**	0.124*
	(0.032)	(0.043)	(0.063)
Female Indicator	0.426***	-1.122***	-0.638***
	(0.011)	(0.015)	(0.021)
Adult Indicator (at least 22 in entry year)	-0.163***	-0.532***	-0.205*
	(0.035)	(0.058)	(0.085)
Race: Dummy for Hispanic	-0.542***	0.056	-0.179**
	(0.032)	(0.042)	(0.065)
Race: Dummy for Black	-0.988***	-0.312***	-1.225***
	(0.029)	(0.037)	(0.083)
Race: Dummy for Asian	0.162***	0.666***	0.563***
	(0.029)	(0.031)	(0.041)
Race: Dummy for Other Race	-0.398***	0.167***	-0.042
	(0.031)	(0.039)	(0.057)
Professional Major Indicator	-0.182***	---	---
	(0.015)	---	---
Liberal Arts and Sciences Major Indicator	-0.406***	---	---
	(0.016)	---	---
Vocational Major Indicator	0.019	---	---
	(0.117)	---	---
Missing Indicator for Female	-0.643	-0.636	-0.283
	(0.447)	(0.499)	(0.743)
Pell Recipient in First Four Years	-0.674***	-0.017	-0.320***
	(0.012)	(0.016)	(0.024)
Constant	-0.744***	-0.929***	-2.333***
	(0.022)	(0.025)	(0.038)
Number of Observations	179,506	125,412	125,412

Notes: i) Standard errors in parentheses

ii) * $p<0.05$; ** $p<0.01$; *** $p<0.001$

iii) Indicators for major areas are not included in models (2) and (3) because these models examine the effect of OBF on attaining a BA degree in STEM or majoring in STEM.

Table 8B. Parameter Estimates of Logit Regression Model, Part-Time Student Sample

VARIABLES	Graduated with Bachelor's Degree within 6 Years	Majored in STEM within 6 Years	Graduated with STEM Bachelor's Degree within 6 Years
Time Trend	0.060***	0.131***	0.241***
	(0.018)	(0.027)	(0.056)
Post OBF 2.0 Year 1	0.086	-0.142	-0.146
	(0.063)	(0.092)	(0.176)
Female Indicator	0.077*	-1.237***	-1.195***
	(0.037)	(0.057)	(0.123)
Adult Indicator (at least 22 in entry year)	-0.155***	-0.179**	-0.159
	(0.043)	(0.066)	(0.134)
Race: Dummy for Hispanic	-0.300**	0.052	0.203
	(0.091)	(0.147)	(0.282)
Race: Dummy for Black	-0.663***	-0.059	-0.344
	(0.073)	(0.094)	(0.223)
Race: Dummy for Asian	0.874***	0.641***	1.174***
	(0.103)	(0.127)	(0.190)
Race: Dummy for Other Race	0.063	0.419***	0.749***
	(0.085)	(0.117)	(0.198)
Professional Major Indicator	-0.066	---	---
	(0.058)	---	---
Liberal Arts and Sciences Major Indicator	-0.563***	---	---
	(0.059)	---	---
Vocational Major Indicator	0.795*	---	---
	(0.398)	---	---
Pell Recipient in First Four Years	-0.055	0.015	-0.066
	(0.038)	(0.057)	(0.115)
Constant	-1.882***	-1.364***	-3.577***
	(0.073)	(0.079)	(0.173)
Observations	30,849	10,460	10,460

Notes: i) Standard errors in parentheses

ii) * $p<0.05$; ** $p<0.01$; *** $p<0.001$

iii) Indicators for major areas are not included in models (2) and (3) because these models examine the effect of OBF on attaining a BA degree in STEM or majoring in STEM.