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The Effect of Loan Debt on Graduation by Department: a Bayesian Hierarchical Approach

Using data from three cohorts at the University of Delaware, this study investigates the effects of student loan debt on six-year graduation by department over five years. The effects are estimated from five Bayesian hierarchical models, one model for each year. The Bayesian hierarchical model uses a partial pooling technique to address the over-fitting issue when estimating the effects of loan debt, and this technique is especially beneficial to departments with small enrollments. Similar to the observation that financial aid has different effects by racial and ethnic groups, and socioeconomic groups, findings suggest a pronounced department-level loan debt effect for first-year students that diminishes as students progress through their academic career. These findings suggest that a strategy that considers a students' academic department when designing a financial aid policy would optimize the efficiency of institutional financial resources. Moreover, universities exploring differential financial aid policies by department should start with randomized trials using first-year students.

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Increasing costs for higher education (College Board, 2020; Hemelt et al., 2018; Middaugh, Graham, and Shahid, 2003) leads to college students accumulating substantial amounts of loan debt. Student loans are the second largest category of debt that Americans take on - exceeding $1.6 trillion nationally in the fourth quarter of 2019 (Johnson, 2019; USAFacts, 2019). The financial burden of loan debt affects the students' persistence, graduation, and lives after graduation (Herzog, 2018; Noopila and Williams Pichon, 2020; Patel, 2020). Even some 2020 presidential candidates, notably Senators Bernie Sanders and Elizabeth Warren, proposed costly student loan debt forgiveness plans. arguing that students struggle with basic expenses due to repaying student loans (Johnson, 2019; Patel, 2020).

Unlike the federal government of the United States, postsecondary educational institutions do not have the resources to fully cancel students' loan debt. However, colleges and universities can certainly design financial aid policies that ensure better student outcomes. This paper will investigate the relationship between student loan debt and six-year graduation rates. Graduation rate is a standard measure of student outcomes. For example, the Integrated Postsecondary Education Data System (IPEDS) reports six-year graduation rates for first-time, full-time undergraduate students seeking a bachelor's degree at degree-granting institutions that participate in federal Title IV financial aid programs.

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Previous studies report mixed findings on the effect of loan debt on graduation. Loan debt has been seen as beneficial (Bowen, Chingos, and McPherson, 2009), detrimental (Chen and Hossler, 2017; Davidson and Holbrook, 2014; Franke, 2019; Jones-White et al., 2014), and non-significant (Dowd and Coury, 2006; Gross, Torres, and Zerquera, 2013). Given that loan debt is confounded with other factors such as student demographic characteristics, socioeconomic status, and academic performance we might expect these mixed results as different contexts and different controls will certainly alter findings.

Previously considered control factors include demographic characteristics, such as race, gender, and age; standardized tests, such as SAT/ACT scores and number of AP credits; academic performance, such as number of courses with C or D grade; socioeconomic status, such as adjusted gross income (AGI); and institutional type, if a study involves multiple institutions (Gross, Torres, and Zerquera, 2013; Jones-White et al., 2014; Noopila and Williams Pichon, 2020). In the literature, most studies focus on particularly relevant subsets of potential control factors. For instance, Gross et al. (2013) and Zhan et al. (2018) focused on the effect of loan debt by racial and ethnic group. The earlier study found that loan debt did not directly affect Latino/a students' likelihood of graduation. The latter study showed that racial minority students had higher levels of tolerance for loan debt when compared with their White counterparts. Another study focused on the effect of loan debt by students' economic background and institutional type (public/private, non-profit) (Dwyer et al., 2012) and found that the graduation rates of students in private, non-profit institutions and those from upper-income families attending public institutions were less affected from loan debt.

This paper builds on the previous literature by being the first to include a student's department when considering student loan effects on graduation rate. Similar to the observation that financial aid has different effects in different racial and ethnic groups or socioeconomic groups (Kim, 2012), the financial burden from loan debt will likely vary with income prospects (Witteveen and Attewell, 2019). For example, for bachelor's degree programs, the average median income is less than $21,000 for Drama/Theatre Arts and Stagecraft majors among public institutions one year after graduation, but it is more than $68,000 for Computer Engineering majors (U.S. Department of Education, 2019). According to the human capital model developed by Gary Becker (Becker, 1964), a student tends to drop out from school and enter the labor market when the marginal cost of education is higher than the expected benefit of education (Long, 2007). This is an undesirable outcome for the institutions because graduation rates are prominent in both state government funding criteria and popular-press school-ranking criteria (Lin, 2020).

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As will be shown, our findings suggest that institutions should consider students' departments when distributing institutional financial aid resources. Universities can pay special attention to students in departments where graduation rates seem to suffer under the burden of loan debt. One response might be to offer more institutional scholarships to students in those departments, hence better aligning debt burden with future outcomes. Our study also suggests that departmental variation in induced debt burden varies with academic level (e.g., freshman, sophomore, etc.), and hence, financial aid policy should consider differences between first-year students and more advanced students in the department.

In order to estimate the effect of control factors on graduation, previous studies typically use different variants of logit models. Standard dichotomous logit models are frequently used to estimate the effects of control factors (Dowd and Coury, 2006; Gross, Hossler, and Ziskin, 2007; Noopila and Williams Pichon, 2020). Jones-White et al. (2014) used a multinomial logit model for their outcome variable which had three levels, graduate from the initial university, graduate from a transfer university, or not graduate. Moreover, previous studies utilized event history models to investigate the effect of loan debt, in order to include time-varying covariates such as cumulative loan debt (Chen and Hossler, 2017; Gross, Torres, and Zerquera, 2013). However, event history models typically assume proportional hazard, such as the effects are time-independent for the time-varying covariates, while this study assumes the effects of the time-varying covariates are also time-varying.

Our study also contains a model within the logit-family of models. Specifically, we use a Bayesian hierarchical logit models to estimate loan debt effect on graduation by department. Since some departments have few students enrolled, we choose Bayesian estimation to overcome the challenges presented by small data. While classical regression methods of previous studies are susceptible to over-fitting due to small sample sizes, the Bayesian hierarchical approach uses partial pooling to overcome this difficulty (McElreath, 2015, p. 364). The input of the models includes students' information at the end of a spring semester, such as students' departments, cumulative loan debt, demographic characteristics, academic preparation, academic performance, and financial background. The output of the models is whether students graduate within six years. Since this study intends to propose different financial aid policies for enrolled students with different academic levels, separate models are built for first-year students, second-year students, third-year students, four-year students and fifth-year students, respectively.

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In summary, this study investigates the following two research questions in order to encourage institutions to consider students' departments in their financial aid policies:
1. Does loan debt have the same effect on six-year graduation for enrolled students in different departments in the same semester?
2. Does the effect of loan debt in a department change over time?

Prior Research

This section starts with a broad discussion of prior research on the effects of financial aid on student choices, and then narrows the discussion to look at the effect of loan debt on graduation. Two key aspects of prior research inspire this study. First, loan debt effect on college graduation is still inconclusive. Second, the effect of loan debt on college graduation can be different in different student groups. Hence, designing differential financial aid policies by department might prove an effective way to enhance students' outcomes and to deploy financial resources efficiently.

Financial Aid on Student Choices

The prior research on financial aid focused on federal and state financial aid policies, and the effect of those policies on sequences of student choices: whether to attend college, which college to attend, whether to persist, and which major to study (Dynarski and Scott-Clayton, 2013; St John, 1991). After reviewing the studies from 1970s to 2010s, St. John, Dynarski and Scott-Clayton summarized the following findings. First, increased financial aid, including loans, promotes the decision to attend college with larger effect sizes seen in middle-income student populations as compared to low-income student populations (Leslie and Brinkman, 1988; St John, 1990). Second, middle-income students prefer less expensive institutions if they need to finance the cost of attendance with loans (McPherson and Schapiro, 2010; van der Klaauw, 2002). Third, financial aid promotes persistence when studied nationally, but this retention-type of effect is not consistently seen in institutional research (Carroll, 1987; Leslie and Brinkman, 1988; Moline, 1987) or for late-year retention (St John, 1989). Fourth, loan debt does not affect the choice of major (St. John and Noell, 1987). Fifth, program complexity decreases the effectiveness of financial aid (Bettinger et al., 2012). At the end of his review, St. John calls for more research to help the design of both institutional financial aid policies and to refine both financing and enrollment management strategies.

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Effect of Loan Debt on graduation

Findings of the effect of loan debt on graduation have been inconclusive. Many previous studies found loan debt to be a detrimental effect on college graduation. Focusing on first-time students in their first term, Jones-White et al. concluded that loan aid encouraged college students to quit entirely or transfer to another institution (Jones-White et al., 2014). Specifically, the relative risk of not graduating from the first-entry institution increased by about 7.51%, with the increase of $1,000 in loan debt. While also studying first-time, first-year students, Gross et al. focused on the effect of loan debt on graduation by race/ethnicity in Indiana's public 4-year institutions (Gross, Torres, and Zerquera, 2013). They found a negative relationship between loan debt and graduation for African American or Black students. Specifically, the odds of graduation of an African American or Black student decreased by 0.2% with an increase of $100 in loans, compared to the white students. In studying the effect of financial aid on graduation of nontraditional students, Chen and Hossler found federal unsubsidized student loans had a detrimental effect on timely graduation (Chen and Hossler, 2017). Specifically, the probability of graduating within 6 years decreased by 1%, with the increase of $1,000 in unsubsidized loan debt.

Loan debt was also found to have an indirect effect on college graduation. Focusing on first-semester students in community colleges, Dowd and Coury observed no significant effect from subsidized loans on graduation within five years (Dowd and Coury, 2006). When investigating loan effect along with parental income and institution type, Dwyer, McCloud, and Hodson found the effect of loan debt was not significant for students in private schools (Dwyer et al., 2012). Different from that for African American or Black students, Gross et al., found that loan debt did not have a direct effect on graduation for Latino/a students (Gross, Torres, and Zerquera, 2013).

Surprisingly, a few studies report positive effects of loan debt. For example, Bowen et al. suggested that federal loans have a positive effect on graduation (Bowen, Chingos, and McPherson, 2009). However, the conjecture was based on the positive effect of loans on college attendance and was not supported by an empirical study.

Some studies found the relationship between loan debt and college graduation is nonlinear. Dwyer et al. discovered the effect was positive if borrowing less than about $10,000 and then turned to be negative if beyond $10,000 for public university students from modest economic backgrounds (Dwyer et al., 2012). Focusing on the difference by race and ethnicity, Zhan et al. confirmed the nonlinear relationship of the effect of loan debt on graduation (Zhan, Xiang, and Elliott III, 2018). They claimed loan debt has a positive effect

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on graduation until borrowing more than $18,452, $20,990, $23,971 for White, Black, and Hispanic students, respectively.

Another branch of the literature investigates the effects of loan debt on graduation for different student groups. Race/ethnicity is frequently used to group students when investigating these effects. The goal of these lines of inquiry is to find whether financial aid helps to improve equity in education. As mentioned earlier, although they found that loan debt did not have a direct effect on graduation for Latino/a students, Gross et al. found a negative relationship between loan debt and graduation for African American or Black students (Gross, Torres, and Zerquera, 2013). In Zhan et al.'s study, they find a consistent nonlinear relationship between loan debt and graduation among students with different race/ethnicity, but also find that racial minority students had a higher tolerance for loan debt when compared with White students (Zhan, Xiang, and Elliott III, 2018). In addition to race/ethnicity, institutional type is another popular factor used to group students. Institutional type is an important factor related to graduation rate (Gross, Torres, and Zerquera, 2013; Hussar et al., 2020), loan debt amount (NCES, 2020), and loan default (Hillman, 2014). Dwyer et al. found students with low and moderate incomes at public universities are negatively affected by loan debt, while loan debt does not affect graduation for students at private universities (Dwyer et al., 2012). Due to data availability, this study includes data from a single public institution and thus, does not include institutional type as a control variable.

Although students' major/department of study has been considered in the research related to loan debt amount (Burns and Webber, 2019; Harrast, 2004; George-Jackson, Rincon, and Martinez, 2012) and loan default (Gross et al., 2009; Hillman, 2014), no previous research studies the effect of loan debt by major/department on college graduation. We expect more studies will include this factor in the future. For example, in May 2019 and December 2019, the U.S. Department of Education has published preliminary and official files on loan debt and income by field of study (U.S. Department of Education, 2019). The files reveal that the accumulated loan debt and earning after graduation are significantly different in different fields of study. With the different expected income after graduation, students may feel different financial stress from loan debt. Students with excessive financial stress may choose to drop out (Fossey and Bateman, 1998). An institution could design a differential financial aid policy by field of study (Luna-Torres et al., 2018), according to the different effects of loan debt on graduation in different fields. However, since an institution is typically organized by department instead of field of study, it may be more practical to design the policy by department.

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Additionally, our study overcomes some (not all) of the generalizability concerns of previous studies by including multiple cohorts of students and studying them across multiple academic-levels. Jones-White et al. expressed concern that their results were based on only first-term financial aid information from a single cohort of students (Jones-White et al., 2014). Dowd and Coury obtained the data from Beginning Postsecondary Students Longitudinal Study (BPS 90/94). They expressed concern that the financial information of students might change in subsequent years but only the first-year financial information was available in BPS 90/94 (Dowd and Coury, 2006). This study includes five years of financial aid information from students admitted in three different fall semesters. In addition, we do not assume loan debt effect is the same over years, and the effects in different years are investigated in separate models.

Conceptual Framework

This study adapts the Student Adjustment Model to understand students' decisions regarding college graduation (Cabrera et al., 1992; Cabrera, Nora, and Castaneda, 1993; Cabrera, Stampen, and Hansen, 1990; Nora and Cabrera, 1996). In the 1990s, Carebra et al. developed the model by merging two theoretical models of college persistence, Tinto's Student Integration Model (Tinto, 1975, 1982, 1988, 1987) and Bean's Student Attrition Model (Bean, 1980, 1982, 1985; Bean and Metzner, 1985). The Student Adjustment Model was initially proposed to understand the persistence of college students, and it has been used in previous studies to understand degree completion (Gross, Torres, and Zerquera, 2013). The model hypothesizes that three categories of factors may contribute to higher education outcomes: individual, institutional, and environmental. The individual factors include personal background, such as gender and race/ethnicity; precollege characteristics, such as academic performance in high school; academic integration., such as satisfaction with course curriculum; and social integration, such as personal relationship with other students. The individual factors included in this study are age when matriculated, total SAT score, cumulative credits passed for GPA, count of classes with D, F, or W grade, credits registered in a spring semester, in-state residency, gender, underrepresented racial minority, and first-generation college student flag. The institutional factors include institutional fit, such as sense of belonging, and quality. The environmental factors include financial support and encouragement from friends and family. The environmental factors included in this study are cumulative loan debt, cumulative grant aid, cumulative scholarship aid, and adjusted gross income. While it is a comprehensive framework, the Student Adjustment Model assumes the effect of financial support, such as loan debt, is the same within the institution, which is not practical. To better understand the effect of loan debt on graduation, this study

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further includes the perspective of the human capital model in the conceptual framework (Chen and Hossler, 2017).

The human capital model was developed by Gary Becker (Becker, 1964) and has been used by many studies to understand college enrollment and outcomes (Charles and Luoh, 2003; Chen and Hossler, 2017; George-Jackson, Rincon, and Martinez, 2012; Lee, 2018; Venti and Wise, 1983; Willis and Rosen, 1979). The model suggests an individual will decide to enter the labor market instead of attending school if the marginal cost of education is higher than the expected benefit of education (Long, 2007). Loan debt increases the cost of education, and thus, potentially lowers the probability of persistence and graduation, especially when the loan burden is excessive (Fossey and Bateman, 1998). On the other hand, the expected benefit of college education is different for students in different departments. According to the most recent data published by the Department of Education, the median earnings one year after graduation could be less than $21,000 in some fields of study, and more than $68,000 in some other fields (U.S. Department of Education, 2019). Students may feel much less financial burden from loan debt if expecting much higher future income. Therefore, the effect of loan debt on graduation can be different in different departments, so department should be included as a factor in addition to other factors included in the Student Adjustment Model.

Empirical Model

Table 1 shows the list of independent variables in the empirical model. The model includes eight numerical variables ($X_1, X_2, \ldots, X_8$) and five categorical variables ($Y_1, Y_2, \ldots, Y_5$). More details for the independent variables are described in the data and variable section.

"Insert Table 1 here"

The study uses a Bayesian hierarchical logit model to estimate the effects on graduation for three reasons. First, a logit model has been proven to be a good method to estimate the loan effect in previous studies (Chen and Hossler, 2017; Davidson, 2015; Dowd and Coury, 2006; Dwyer, McCloud, and Hodson, 2012; Herzog, 2018; Letkiewicz et al., 2014). In a logit model, a student is assumed to graduate with a probability of θ. The logit of θ, ($log\frac{\theta}{1-\theta}$), is the logarithm of the odds of graduation, and the odds is the ratio of the probability of graduation over the probability of no graduation. The logit is assumed to be a linear combination of variables, as shown in the formula below.

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$$logit(\theta) = log\frac{\theta}{1-\theta} = \sum_{j=1}^{8}\beta_j\,[department] * x_j + \sum_{k=1}^{5}\alpha_k\,[department, y_k] \quad (1)$$

For a numerical variable X_j (j = 1, 2, …, 8), the corresponding coefficient β_j is a vector and $\beta_j[department]$ represents an element of the vector for a specific department. For example, the β for loan debt is a vector and each element in the vector represents the effect of loan debt in a department. For a categorical variable Y_k (k = 1, 2, …, 5), the corresponding coefficient α_k is a matrix and the value of each element is based on department and the value of Y_k. For example, the α for underrepresented racial minority is a matrix. Each element represents the effect of a specific underrepresented racial minority status in a specific department. Each row of the matrix represents the effects for students in a department with different underrepresented racial minority statuses. Each column represents the effects for students in different departments with the same underrepresented minority status.

Second, the uncertainty of an effect can be easily estimated by a Bayesian model (Crisp, Doran, and Reyes, 2018). The uncertainty of an effect is often characterized by the point estimate (mean or median), the standard deviation, and the corresponding credible interval. A Bayesian model assumes that an effect follows a distribution and the characteristics of uncertainty can be directly estimated from the fitted distribution. In addition to a point estimate and a credible interval, the distribution of the effect can be visualized to show its shape and spread, so the uncertainty is well described. For example, a density plot of the fitted distribution can show the uncertainty in the effect of the loan debt.

In a Bayesian analysis, our initial uncertainty, known as a prior distribution, is modelled using the language of probability distributions. For the unknown coefficient terms of Equation (1), we model the initial uncertainty as using normal distributions as shown in Equation (2). The prior distributions are updated to posterior distributions using data observed (McElreath, 2015, p. 27). The posterior distributions are the fitted distributions of the coefficients.

$$\begin{aligned}\beta_j[department] &\sim \text{Normal}(\mu_j[department], \sigma_j)\\ \alpha_k[department, y_k] &\sim \text{Normal}(\mu_k[department, y_k], \sigma_k')\end{aligned} \quad (2)$$

Third, and most importantly, a hierarchical model is used to address the problem of small samples, because some academic departments have less than 10 students enrolled in a semester. Without Bayesian methods, estimating the effect of a factor from such small sample size often leads to over-fitting. One way to avoid over-fitting is to assume the effect in a department is the same with the

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effect in the department's college where the sample size is larger. However, this strategy leads to under-fitting, since the effects could be different among departments. In order to balance between over-fitting and under-fitting, a hierarchical model uses partial pooling to borrow information from an upper-level factor, when estimating the effect for a lower-level factor (McElreath, 2015, p. 377). The smaller sample size the lower-level factor has, the larger influence the upper-level factor has in the estimation of the effect of the lower-level factor, and vice versa. In this case, portfolio is defined to be the upper-level for department. A portfolio is a group of departments. It is just the college of a department, except for the departments in the College of Arts and Sciences. The College of Arts and Sciences groups its departments into four portfolios. Similarly, the institution is the upper-level for portfolio. When estimating the effect of loan debt in a department, the influence of the effect in the corresponding portfolio is large if few students are enrolled in the department, and the influence is little if the department has many students.

In terms of model specification, the mean of the normal distribution ($\mu_j[department]$ in the above formula (Equation 2) for $\beta_j[department]$) represents the mean effect of a continuous variable X_j in a department. It is drawn from $\tilde{\beta}_j$, which is a vector and represents the effect on the portfolio-level. The $\tilde{\beta}_j[portfolio]$ represents the effect of a portfolio and is assumed to follow a normal distribution with a mean of $\hat{\beta}_j$. The $\hat{\beta}_j$ represents the institutional-level effect and is assumed to be normally distributed. The whole hierarchical structure implements the idea that the estimation of department-level effect is influenced by the portfolio level effect, and the estimation of the portfolio level effect is influenced by the institutional level effect. The assumption for the mean effect of a categorical variable Y_k in a department ($\mu_k[department, y_k]$) in the above formula (Equation 2) for $\alpha_k[department, y_k]$ is similar to that of $\mu_j[department]$. The value of $\mu_k[department, y_k]$ is based on department and the value of Y_k. It is drawn from $\hat{\alpha}_k$, which is a vector and represents the effect only based on department. The department-level effect $\hat{\alpha}_k$ is assumed to be influenced by the portfolio level effect $\hat{\beta}'_k$, and is assumed to follow a normal distribution. All standard deviation terms in the normal distributions are assumed to follow an exponential distribution with a parameter λ^*, which is assumed to follow a gamma distribution. The constant values of the parameters in the gamma, exponential, and normal distributions are chosen to reflect the domain knowledge that most students graduated within six years, and thus the density of the probability of graduation (θ) close to 1 should be high and the density close to 0 should be low. The model specification for the hierarchical structure is summarized below.

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$$
\begin{aligned}
\lambda^* &\sim \text{Gamma}(5,1) \\
\tau^* &\sim \text{Exponential}(\lambda^{*2}/2) \\
&where\ \lambda^*\ represents\ \lambda, \lambda', \lambda_p, \lambda_d, \lambda'_p, \lambda'_d, \\
\tau^*\ &represents\ \tau, \tau', \hat{\sigma}, \sigma, \widehat{\sigma'}, \sigma', respectively
\end{aligned}
$$

$$
\begin{aligned}
\hat{\beta}_j &\sim \text{Normal}(0.4, \tau) \\
\tilde{\beta}_j[portfolio] &\sim \text{Normal}(\hat{\beta}_j, \hat{\sigma}) \\
\mu_j[department] &= \tilde{\beta}_j[portfolio]
\end{aligned}
\qquad (3)
$$

$$
\begin{aligned}
\hat{\beta}'_k[portfolio] &\sim \text{Normal}(0.4, \tau') \\
\hat{\beta}'_k[department] &= \hat{\beta}'_k[portfolio] \\
\hat{\alpha}_k[department] &\sim \text{Normal}(\hat{\beta}'_k[department], \hat{\sigma}') \\
\mu_k[department, y_k] &= \hat{\alpha}_k[department]
\end{aligned}
$$

Figure 1 summarizes the Bayesian hierarchical logit model. The dependent variable, six-year graduation, is a binary variable following a Bernoulli distribution with a parameter θ, which is the probability of a student graduating within six years. The logit of θ is a linear combination of factors. The effects of the factors follow a hierarchical structure as described above.

"Insert Figure 1 here"

Data and Variables

Data for this study were pulled from the enterprise data warehouse of the University of Delaware, a public research university (Carnegie classification: R1) with a population of about 18,000 undergraduate students. In fall 2009, 2010, and 2011, the university admitted 3,807, 3,366, and 3,906 (totally 11,079) first-time, full-time students, respectively. The number of enrolled students decrease gradually to totally 9,408 at the end of the third spring semester, mainly because students dropped/transferred out from the University. Most students graduated at the end of the fourth spring semester, although there are about 12% of students in the cohorts graduated in their fifth year or sixth year. An academic year at the University of Delaware is from fall to summer. Since all data are measured at the end of students' spring semesters, as opposed to the end of an academic year which ends at the summer sessions, we will often make this explicit by including the word "spring" in reference to each cohort's data.

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The dependent variable in a model is whether a student graduated within six years since matriculation. We build separate models to predict graduation for students enrolled but not graduated at the end of each spring. Table 2 describes the dependent variables on a high level. For students who persist through the first three spring semesters, the chance to graduate within 6 years increases from 85.4% to 95.2%. For students who had not graduated at the end of the fourth spring semester but still would like pursue degrees, the chance to graduate within 6 years (since matriculation) decreases to 83.0%. The chance is even lower (58.0%) for students who were still pursuing their degrees after the fifth year.

"Insert Table 2 here"

Loan debt is the focal independent variable in this study. The cumulative loan debt of a student is computed at the end of each spring semester. Table 3 shows the summarized information of cumulative loan debt. Students who did not borrow loans were excluded in the table. For students who were enrolled at the end of the first spring, 5,875 or 55.1% of students accumulated loan debt. The overall average loan debt was $7,643, and $7,756, and $7,620, respectively, for those who do not graduate within six years and those who eventually graduate within six years. The headcount of students with loan debt decreased slightly from the first spring to the third spring, and then dramatically decreases at the end of the fourth spring due to graduation. The percentage of students with loan debt increased slowly each year. The overall average of cumulative loan debt increased each year for more than $5,000 in the first four years. The average loan debt of students who do not graduate within six years is higher than the overall average in the 1st year and the 4th year, and it is higher for students who graduate within six years in other years.

"Insert Table 3 here"

The loan debt effect is investigated by department. A student's department is where the student was enrolled in a semester. There are 53 departments in total. Table 4 shows the headcounts of students who were enrolled as bachelor's students and had not graduated at the end of each spring by department. The department names are replaced with unique numbers for privacy consideration, and similarly the headcounts are masked if enrollment is under 10. Some departments were more popular than the others. For instance, hundreds of students were enrolled in the department 0, while few students were enrolled in the department 1.

"Insert Table 4 here"

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The selection of control variables is based on prior research, domain knowledge of subject experts, and data availability. Total SAT score serves as a proxy of pre-college academic preparation. The total SAT score is the highest total SAT score if a student took SAT several times, and it could be converted from composite ACT score if a student submitted ACT scores. There are 324 students without a total SAT score and are excluded from the study. Most of them are international students.

In-state residency, gender, first-generation college student status, and underrepresented racial minority serve as demographic background indicators. They are dichotomous variables. In-state residency indicates whether a student was a Delaware resident (coded 1) and thus paid the in-state tuition rate. Female is coded 0 and male is coded 1 for gender. First-generation college student status indicates whether a student is a first-generation college student (coded 1) according to the highest education level of the student's parents. The definition of underrepresented racial minority can vary among institutions, and this study uses the definition at the University of Delaware. Underrepresented racial minority flag is coded 1 if a student had an ethnicity of Black, Hispanic, Native American Indian, Hawaiian, or other Pacific Islander.

Adjusted gross income (AGI), cumulative grant aid, and cumulative scholarship aid serve as students' financial background. The AGI is the sum of the AGI of a student and the parents if the student is a dependent, and it is the AGI of the student if they are independent. AGI is grouped into four categories, AGI unknown (AGI is missing), Low AGI (AGI < 61K), Medium AGI (AGI is less than the 3rd quartile), and high AGI (AGI is larger than or equal to the 3rd quartile). Grant aid is typically need-based aid, and scholarship aid is typically merit-based aid. Similar to the cumulative loan debt, the cumulative grant aid and cumulative scholarship aid are computed as of the end of each spring.

Count of classes with DFW grade (D or F grade, or withdraw), cumulative credits passed for grade point average (GPA), and credits registered in the current semester serve as college academic measures. A student needs to retake a class with D, F, or W grade, if a class is a pre-requisite of another class, or due to the departmental requirement, and thus the progress towards graduation is potentially delayed. Cumulative credits passed for GPA represents the overall progress towards graduation. Credits registered is the number of credits attempted in a spring, indicating a student's effort/attitude toward graduation. It should be noted that cumulative GPA is not included, similar to the study by Jones-White et al. (Jones-White et al., 2014). Although GPA is a strong factor on the academic performance, it does not directly represent the progress toward graduation. The DFW count and cumulative credits better capture the progress.

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The summary statistics of the control variables are shown in Table 5, for students who were enrolled as bachelor's students and had not graduated at the end of the first spring. The average SAT score was 1288. About one third of the students were in-state (32%). There were fewer male students (42%) than female. There are 13% and 11% of students who are first-generation college students and underrepresented racial minority students, respectively. On average, a student passed 29 credits by the end of the first spring, with only 0.33 classes with DFW grade. One student accumulated 112 credits in the first year, because the student was a long-time continuing education student in the university and transferred all the credits after being admitted as a first-time, full-time, degree-seeking student. Students tend to register for 15 credits in the spring. We did not know 21% of students' AGIs, 14% of the students had low AGIs (less than $61,000), 47% of them had medium AGIs (between $61,000 and third quartile), and the rest 18% students had high AGIs (above third quartile). On average, the students were awarded $1,930 and $2,850 from grant and scholarship aid, respectively, including students who did not obtain any grant or scholarship aid. The summary statistics for other springs are in Appendix A.

"Insert Table 5 here"

All numeric factors, namely cumulative loan debt, total SAT score, cumulative credits passed for GPA, count of classes with DFW grade, credits registered in a spring, cumulative grant aid, and cumulative scholarship aid, are standardized before using as input of a model. Specifically, they are subtracted by mean and then divided by standard deviation. Standardization brings the factors to the same scale, in order to avoid biased estimation of the coefficients in a model (McElreath, 2015, p. 111).

Results and Discussion

The posterior distributions of the effects were estimated in RStudio (version 1.2.1335) using the greta package (version 0.2.5) (Golding, 2019) and TensorFlow Probability (0.5.0) (Abadi et al., 2016). The effects of variables are estimated using four Markov chains. Each chain contains a warm-up period of 3,000 steps followed by a sampling period of 1,000 samples. In total, 4,000 samples are drawn from posterior distributions.

The results are interpreted in terms of odds ratio. In this study, odds is the probability of six-year graduation over the probability of not graduating within six years, and the odds ratio is the ratio of two different odds. An odds ratio larger than 1 indicates a positive effect on the six-year graduation, while an odds ratio

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less than 1 indicates a detrimental effect. Given that the research questions focus on the loan debt effect on six-year graduation, the discussion is mainly limited to the results of loan debt effect. The comprehensive results including odds ratios of all factors by department are available upon request.

The First Spring

Loan debt is a detrimental effect on six-year graduation on the institutional level for students who were enrolled as bachelor's students and had not graduated at the end of the first spring. Figure 2 shows the 90% credible intervals of the odds ratios for the factor effects on the institutional level, where department is not considered in the model. The effects of loan debt, grant aid, and merit aid are calculated with respect to each additional $1,000. The vertical line represents an odds ratio of 1. The odds ratio for loan debt is statistically less than 1 (odds ratio: median = 0.98, 5% quantile = 0.97, 95% quantile = 0.99). If we further assume the probability of six-year graduation without loan debt is 80%, the probability decreases to 79.7%, with the additional $1,000 loan debt and holding other factors constant. Based on the institutional level results, the university could design a universal financial aid policy to help students with loan debt, in order to reduce their financial burden and increase their change to graduate within six years. However, the following results show the financial aid policy can be more efficient if considering the department level effect.

"Insert Figure 2 here"

Loan debt has distinctively different effects among departments for students who were enrolled as bachelor's students and had not graduated at the end of the first spring. The difference is described using the following three figures: Figure 3, Figure 4 and Figure 5. Figure 3 shows the 90% credible intervals of the odds ratios for the loan debt effect by department, with respect to each additional $1,000 loan debt. The vertical line represents an odds ratio of 1. The odds ratio is statistically less than 1 for 15 of the 52 departments, for example, department 35 (odds ratio: median = 0.93, 5% quantile = 0.9, 95% quantile = 0.96). Specifically, the odds ratio of six-year graduation tends to be 0.93 for students in the department 35 with each additional $1,000 loan debt, holding other factors constant. If we further assume the probability of six-year graduation without loan debt is 80%, the probability decreases to 78.8%, with the additional $1,000 loan debt. Note that the decrease of the probability is more severe for the department, compared to the overall institution. On the other hand, the credible intervals of the odds ratios span across 1 for 37 departments, for example, department 47, indicating the loan debt is neither a positive nor a detrimental effect for the students in the department.

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"Insert Figure 3 here"

The difference of the loan debt effects between departments can also be viewed by the density plots of the posterior distributions of the odds ratios. For example, Figure 4 shows the density plots of the odds ratios of department 35 and department 47. The two density plots barely overlap, indicating the loan debt has distinctively different effects in the two departments. Moreover, the density plots agree with the 90% credible intervals of the odds ratios. The estimated odds ratios for department 35 are always smaller than 1, indicating a detrimental effect for six-year graduation. On the other hand, although the estimated odds ratios are more likely to be larger than 1 for department 47, the proportion of estimated odds ratios less than 1 is not neglectable, and thus we cannot conclude the loan debt is a positive or detrimental effect on six-year graduation.

"Insert Figure 4 here"

If choosing the loan debt effect in department 35 as reference, students in twenty-six departments were affected differently. Figure 5 shows the 90% credible intervals of the odds ratios of the loan debt effect, compared with the department 35. Here an odds ratio larger than 1 indicates the loan debt effect is more positive or less detrimental in a department than that in the department 35. For example, the odds ratio tends to be 1.11 between department 47 and department 35, indicating students in the department 47 are less detrimentally affected by loan debt than those in the department 35. On the other hand, the credible intervals span across 1 for 25 departments, indicating the loan debt has similar effects in the departments with that in the department 35.

"Insert Figure 5 here"

Based on the results above, the university should design a differential financial aid policy by department for the first-year students, along with other existing factors when awarding financial aid packages. The university could offer more institutional scholarship aid to the students in the 15 departments where the loan debt is a significant detrimental effect on six-year graduation, in order to slow the accumulation of loan debt. From the students' perspective, the differential financial aid policy more efficiently reduces their financial burden, and thus help them focus more on academic progress and continue to pursue a degree. From the institutional perspective, the policy helps to enhance the overall six-year graduation rate which is a critical performance measurement of a four-year institution.

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The Second Spring

Similar to the effect for the first-year students, loan debt is still a detrimental effect on six-year graduation on the institutional level for students who remained enrolled as bachelor's students and had not graduated at the end of the second spring. Figure 6 shows the 90% credible intervals of the odds ratios for the factor effects on the institutional level. The odds ratio for loan debt is statistically less than 1 (odds ratio: median = 0.97, 5% quantile = 0.98, 95% quantile = 1.00). If we further assume the probability of six-year graduation without loan debt is 80%, the probability decreases to 79.8%, with the additional $1,000 loan debt and holding other factors constant. Without considering the department effect, it is reasonable to conclude more financial aid in terms of grant and scholarship should be awarded to students with loan debt, in order to reduce the detrimental effect of loan debt. However, the following results show this is not an efficient policy.

"Insert Figure 6 here"

Loan debt is generally not a detrimental effect for the students who remained enrolled as bachelor's students and had not graduated at the end of the second spring, according to figure 7. Figure 7 shows the 90% credible intervals of the odds ratios for the loan debt effect by department, with respect to each additional $1,000 loan debt. The odds ratio is statistically less than 1 for only three departments, for example, department 36 (odds ratio: median = 0.97, 5% quantile = 0.95, 95% quantile = 0.99). The credible intervals of other fifty departments span across 1, indicating the loan debt does not directly affect the six-year graduation.

"Insert Figure 7 here"

Moreover, loan debt does not have distinctively different effects among departments for second-year students. The 90% credible intervals of the odds ratios overlap with each other, indicating similar loan debt effects among departments. The difference of the loan debt effect between department 35 and department 47 is shown again using density plots in Figure 8. Different from the first spring, the two density plots of odds ratios almost overlay with each other, indicating the loan debt has very similar effects in the two departments. However, we alert the results may change if the institution applies differential financial aid policy by department for the first-year students. For example, the extra financial aid to the first-year students in department 35 helps some students remain enrolled who would stop to pursue a degree otherwise, but they would face the delayed financial burden if the extra help is removed in their second year. As a result, we propose the university to use a differential financial aid policy for the first-year

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students, and then use randomized experimental design to investigate whether similar differential policy should still be applied for the second-year students.

"Insert Figure 8 here"

The Third, Fourth, and Fifth Spring

Different from the first and second springs, loan debt does not show detrimental effect on six-year graduation anymore for students who remained enrolled as bachelor's students but had not graduated at the end of the third, fourth, and fifth spring. The graphs of the 90% credible interval of odds ratio of the factors for the three springs are shown in appendix B. The credible intervals for the loan debt effect span across 1, indicating the loan debt does not directly affect six-year graduation.

The departmental level effects agree with the institutional level effects for the same group of students. The graphs of 90% credible intervals of the odds ratios of loan debt effect by department are in appendix B. All departments' 90% credible intervals for the loan debt effect span across 1, indicating the loan debt does not directly affect six-year graduation. Loan debt shows similar effects on six-year graduation among departments, since the intervals overlap with each other. Similar to the argument for the second year's results, if the university starts to implement differential financial aid policy by department for the first-year students, loan debt can still be a detrimental effect in later years if extra aid is not awarded in the later years. Again, the university needs to investigate whether extra aid to some departments' students will just delay the detrimental effect of loan debt.

Change of Loan Debt Effect Over Years

For 13 departments, loan debt changes from detrimental effect in the first spring to indirect effect in the second spring on six-year graduation. Figure 9 shows the change of the 90% credible intervals of the odds ratios from six of the departments over years. The odds ratios for the first spring are statistically less than 1 according to the intervals, indicating a detrimental effect. On the other hand, the intervals span across 1 for the other springs, indicating an indirect effect.

For other department, loan debt does not directly affect six-year graduation for all years, with three exceptions (results available upon request). The loan debt remains as a detrimental effect in the second spring for the department 9 and the department 36, and then becomes a non-significant effect afterwards. The loan debt changes from a non-significant effect in the first spring

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to a detrimental effect in the second spring for department 10, and then changes back to a non-significant effect afterwards.

Therefore, the effect of loan debt on graduation changes over years in the same department. In many cases it changes from detrimental effect in the first spring to non-significant effect afterwards. Similar to earlier proposition, the university should focus on helping the first-year students to slow their debt accumulation, since a differential policy by department should utilize the financial resource efficiently. The university needs to investigate whether the differential is needed in the following years.

"Insert Figure 9 here"

Limitations

Our study is limited to one institution during the period between 2009 and 2016. The inferences may not apply to other institutions or other time periods. Students in another institution may have distinctively different socio-demographic background, may have different needs to borrow loans, and may be affected by loan debt differently. Nevertheless, we want to introduce the first effort to study the loan debt effect by department on graduation and are curious to see whether other institutions have a similar pattern.

Second, the effects of factors are estimated from students who remain enrolled in the institution. That is to say, a student in the model for the first spring may not be in the models for the following springs, if the student dropped out or graduated. As a result, the discussion on the change of the effects over years is only applied to students who remained enrolled.

Last, not all potential control factors are included in the model due to data availability. For example, the factors related to campus involvement were not in the models, such as attendance to on-campus events, usage of library and gym, and visits to student career center. These factors help a student to build a strong bond with the campus community, and thus are helpful on retention and eventually graduation. For another example, the average or median postgraduation salary by department is not included in the study. Including this covariate can help to determine whether the department factor is just a surrogate of the expected salary after graduation. As a result, an institution needs to use randomized experimental design to assure the efficacy of a differential financial aid policy by department.

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Nexus: Connecting Research and Practice

Bayesian hierarchical models are useful tools to estimate the effects of loan debt on the six-year graduation by department. The hierarchical structure uses partial pooling technique to estimate the department level effects. More specifically, the estimated portfolio level effects influence the estimation of the department level effects. The less students enrolled in a department, the more the estimated department level effect is influenced by the estimated portfolio level effect, and vice versa. This strategy was particularly critical for departments with low enrollment, in order to avoid the over-fitting issue due to small sample size.

Loan debt affects six-year graduation differently for the first-year students in different departments. The loan debt is a detrimental factor in some departments, while it has no direct effect in the others. The university is currently using the universal financial aid policy for all departments. The results suggest that a differential policy with department as one of the factors will be more useful to help students' graduate on time. The accumulation of loan debt can be slowed by offering more institutional scholarship to the first-year students. For institutions with increasing institutional financial aid budget over years, the proposal should lead to faster increase of institutional financial aid for departments where students tend to suffer more from loan debt than the other departments, while it should not lead to decrease in the other departments. For institutions with stable institutional financial aid budgets and abundant overall institutional budgets, the proposed policy suggests increasing the institutional financial aid budget, so the strategy proposed for the first case can be used. On the other hand, it should be alerted if the policy leads to redistribution of a finite institutional financial aid budget, because the enrollment could hurt for departments which do not benefit from this policy. Moreover, an institution should pay attention to potential equity impacts when adjusting the institutional financial aid policy, particularly for underserved departments or students.

Different from the first-year students, the study finds that the loan debt has similar effect on six-year graduation among departments for the second, third, fourth, and fifth year students. The loan debt effect typically becomes or remains non-significant on six-year graduation for the second year students and thereafter. That is to say, students who remain enrolled in the following years become insensitive to loan debt as long as they overcome the financial stress from loan debt in the first year, under the current universal financial aid policy. The findings help to explain the inconclusive relationship between loan debt and on-time graduation in previous research, since the relationship can be different between different student populations, even for students in the same university but at different academic stages. If the differential policy is implemented, students in

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some departments will receive extra scholarship to slow the accumulation of loan debt, and thus less financial burden helps them to remain enrolled and continue to pursue a degree. The university needs to investigate whether the differential policy is needed for the following years, in case the extra aid in the first year just delays the detrimental effect of loan debt. Moreover, the policy may encourage increased enrollments in departments who benefit from it, but institutions should monitor whether the proposed policy affects the pattern of the major change, if the policy is only applied to the first-year students. We hope this study will be a step stone to future experiments and research on the differential financial aid policy.

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Table 1 The list of independent variables in the model

Variable Code	Variable Description
X_1	Cumulative loan debt
X_2	Age when matriculation
X_3	Total SAT score
X_4	Cumulative credits pass for GPA
X_5	Count of classes with D, F, or W grade
X_6	Credits registered in a spring
X_7	Total grant aid
X_8	Total scholarship aid
Y_1	In-state residency
Y_2	Gender
Y_3	Underrepresented minority
Y_4	First Generation College Student
Y_5	Adjusted gross income (AGI)

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Table 2 Summary of the enrollment headcounts, six-year graduation headcounts, and six-year graduation rates for students who were still enrolled as bachelor's students and had not graduated at the end of each spring

	Enrollment headcount	Graduated within 6 years	% Graduated within 6 years
End of Spring 1	10,657	9,098	85.4
End of Spring 2	9,887	9,044	91.5
End of Spring 3	9,408	8,955	95.2
End of Spring 4	1,859	1,543	83.0
End of Spring 5	369	214	58.0

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Table 3 Headcount, percentage, and average loan debt of students who were enrolled as bachelor's students, had not graduated, and accumulated loan debts at the end of each spring semester

	Headcount	Percentage	Mean (All Enrolled)	Mean (Not Graduated 6 within years)	Mean (Graduated within 6 years)
End of Spring 1	5,875	55.1	$7,643	$7,756	$7,620
End of Spring 2	5,697	57.6	$15,849	$15,811	$15,854
End of Spring 3	5,609	59.6	$24,502	$22,953	$24,588
End of Spring 4	1,165	62.7	$30,632	$31,426	$30,460
End of Spring 5	258	69.9	$32,433	$32,050	$32,731

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Table 4 Headcounts of students who were enrolled as bachelor's students and had not graduated at the end of each spring by department

	End of Spring 1	End of Spring 2	End of Spring 3	End of Spring 4	End of Spring 5
0	445	567	606	104	22
1	PrivacySuppressed	PrivacySuppressed	PrivacySuppressed	PrivacySuppressed	PrivacySuppressed
2	11	19	30	PrivacySuppressed	PrivacySuppressed
3	223	187	176	29	PrivacySuppressed
4	45	35	34	6	PrivacySuppressed
5	48	63	72	18	PrivacySuppressed
6	132	131	118	34	PrivacySuppressed
7	21	20	20	PrivacySuppressed	PrivacySuppressed
8	18	22	22	PrivacySuppressed	PrivacySuppressed
9	266	368	374	62	10
10	281	528	541	107	16
11	260	324	335	99	22
12	55	97	119	35	PrivacySuppressed
13	612	436	377	65	13
14	92	97	89	18	PrivacySuppressed
15	19	15	12	PrivacySuppressed	PrivacySuppressed
16	312	248	215	40	PrivacySuppressed
17	156	137	127	18	PrivacySuppressed
18	392	375	340	66	11
19	351	387	324	31	PrivacySuppressed
20	127	123	114	42	PrivacySuppressed
21	77	164	186	68	12
22	171	142	131	35	10
23	18	PrivacySuppressed	PrivacySuppressed	PrivacySuppressed	PrivacySuppressed
24	241	275	288	67	18
25	72	82	78	17	PrivacySuppressed
26	24	32	30	PrivacySuppressed	PrivacySuppressed
27	221	218	207	20	PrivacySuppressed
28	149	148	135	29	PrivacySuppressed
29	24	26	26	10	PrivacySuppressed
30	26	32	30	PrivacySuppressed	PrivacySuppressed
31	187	198	201	65	16
32	251	323	323	63	PrivacySuppressed
33	223	277	296	56	16
34	479	499	486	59	PrivacySuppressed
35	123	127	133	53	12

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36	305	19	PrivacySuppressed	PrivacySuppressed	PrivacySuppressed
37	98	133	135	PrivacySuppressed	PrivacySuppressed
38	181	150	137	36	PrivacySuppressed
39	390	325	297	56	12
40	75	80	82	18	PrivacySuppressed
41	140	133	126	18	PrivacySuppressed
42	22	18	15	PrivacySuppressed	PrivacySuppressed
43	39	38	32	12	PrivacySuppressed
44	24	23	25	11	PrivacySuppressed
45	373	369	354	58	15
46	547	515	463	91	13
47	376	384	375	45	PrivacySuppressed
48	21	18	19	PrivacySuppressed	PrivacySuppressed
49	380	408	389	48	PrivacySuppressed
50	224	280	290	81	14
51	1305	258	51	14	PrivacySuppressed
52	PrivacySuppressed	PrivacySuppressed	11	PrivacySuppressed	PrivacySuppressed

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Table 5 Descriptive statistics of student characteristics at the end of the first spring

	Mean	SD	Min	Max
Total SAT score	1288	122	740	1590
Age when matriculation	18	0.60	16	35
In-state residency	0.32		0	1
Male	0.42		0	1
First-generation college student	0.13		0	1
Underrepresented racial minority student	0.11		0	1
Cumulative credits passed for GPA	29	5.16	0	112
Count of classes with DFW grade	0.33	0.77	0	7
Credits registered in a spring	15	1.64	0	22
AGI unknown	0.21		0	1
Low AGI	0.14		0	1
Medium AGI	0.47		0	1
High AGI	0.18		0	1
Total grant aid (in $1,000s)	1.93	3.97	0	24.24
Total scholarship aid (in $1,000s)	2.85	5.59	0	45.8

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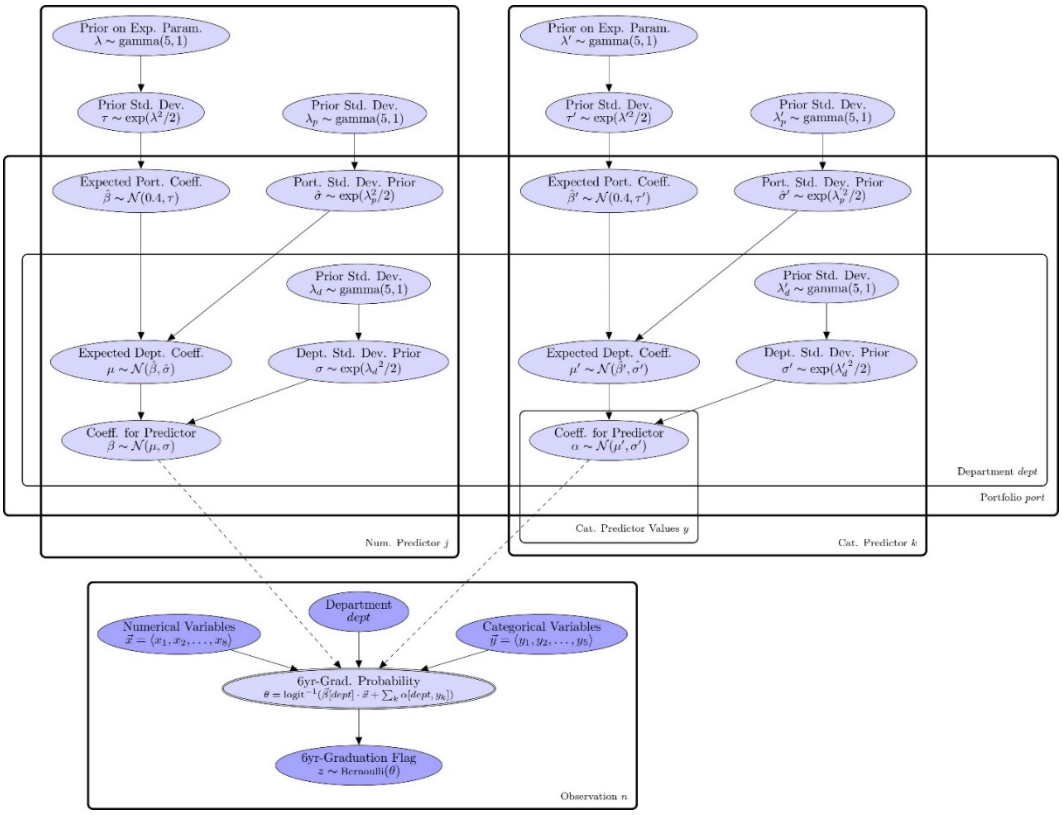

Fig. 1 The illustration of the Bayesian Hierarchical Logit model

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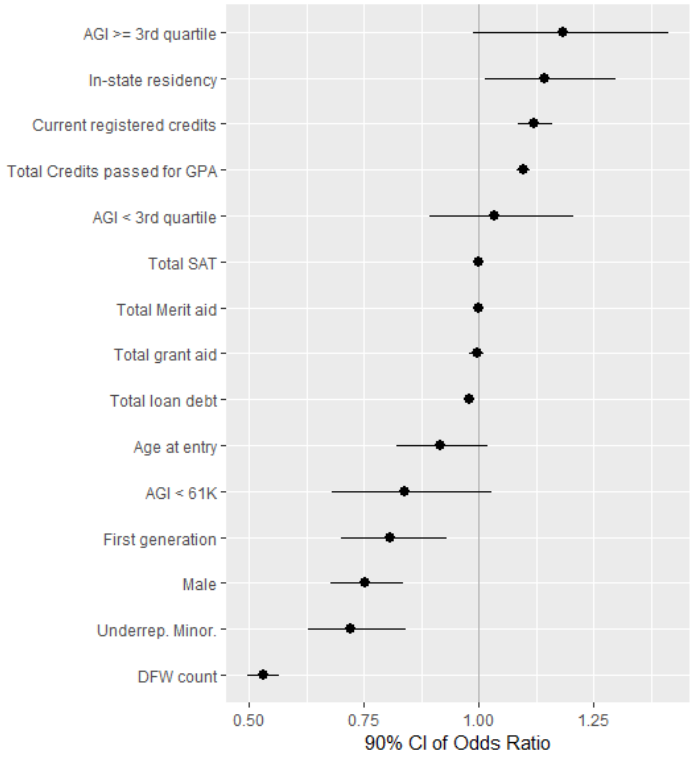

Fig. 2 The 90% credible intervals of the odds ratios for the factor effects on institutional level for the first spring

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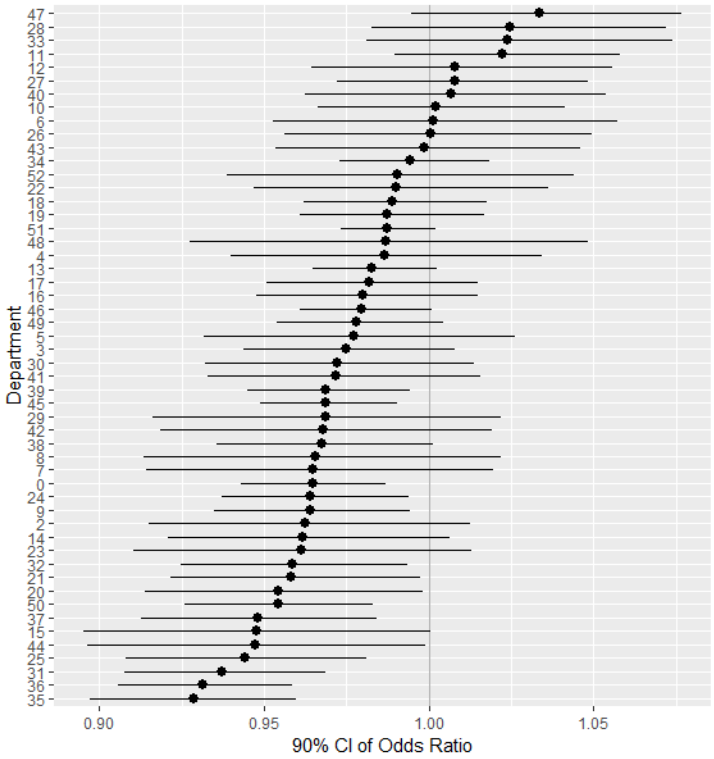

Fig. 3 The 90% credible intervals of the odds ratios for the loan debt effect by department for the first spring

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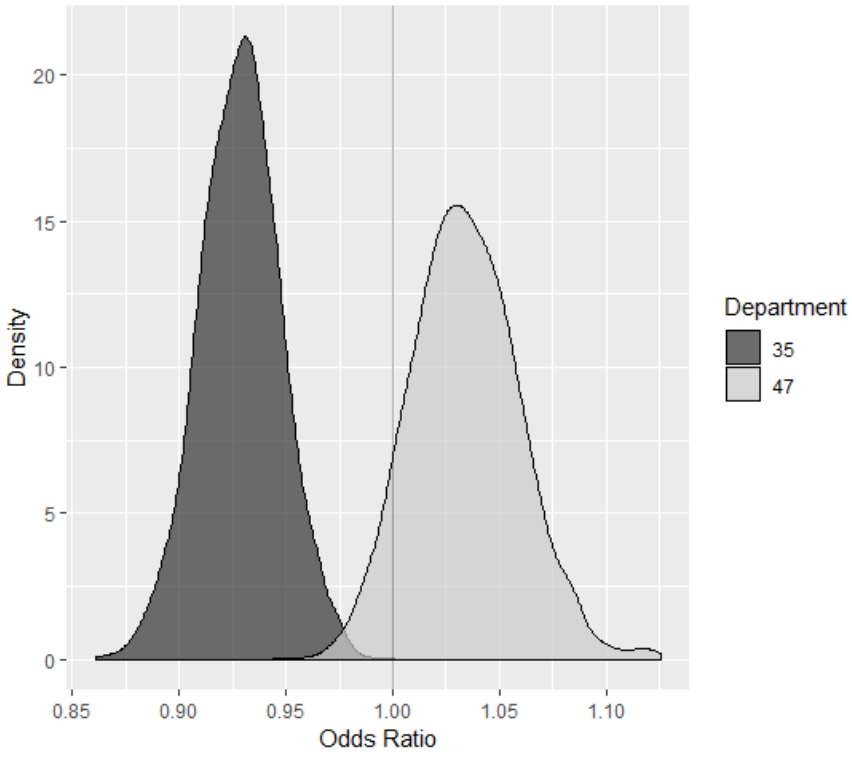

Fig. 4 The density plots of the odds ratios of loan debt effect in department 35 and department 47 for the first spring

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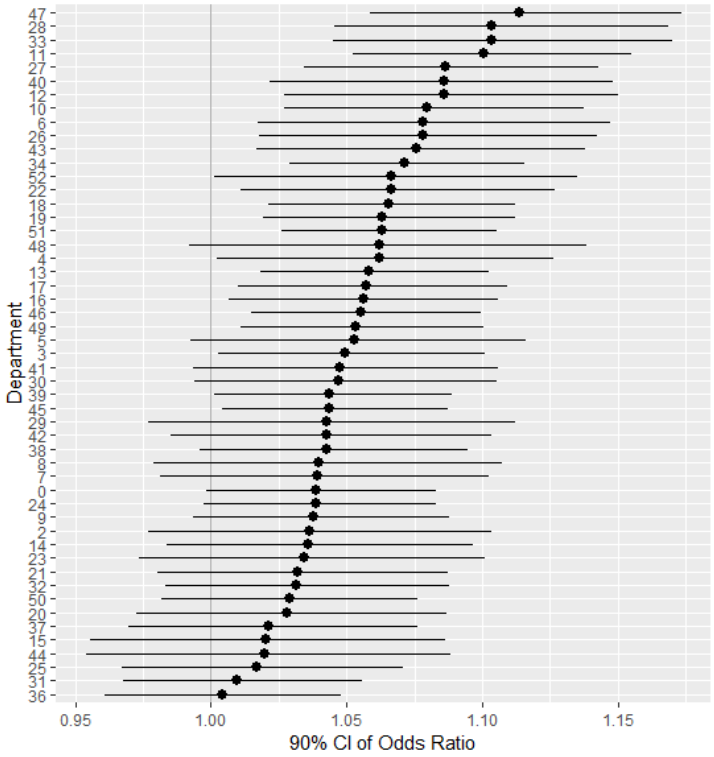

Fig. 5 The 90% credible intervals of the odds ratios of loan debt effect for the first spring, using department 35 as reference

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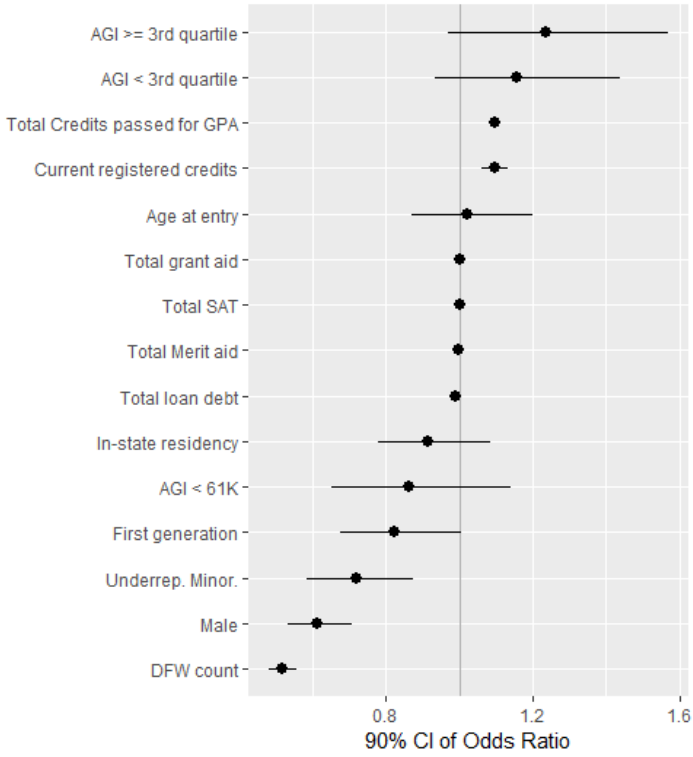

Fig. 6 The 90% credible intervals of the odds ratios for the factor effects on institutional level for the second spring

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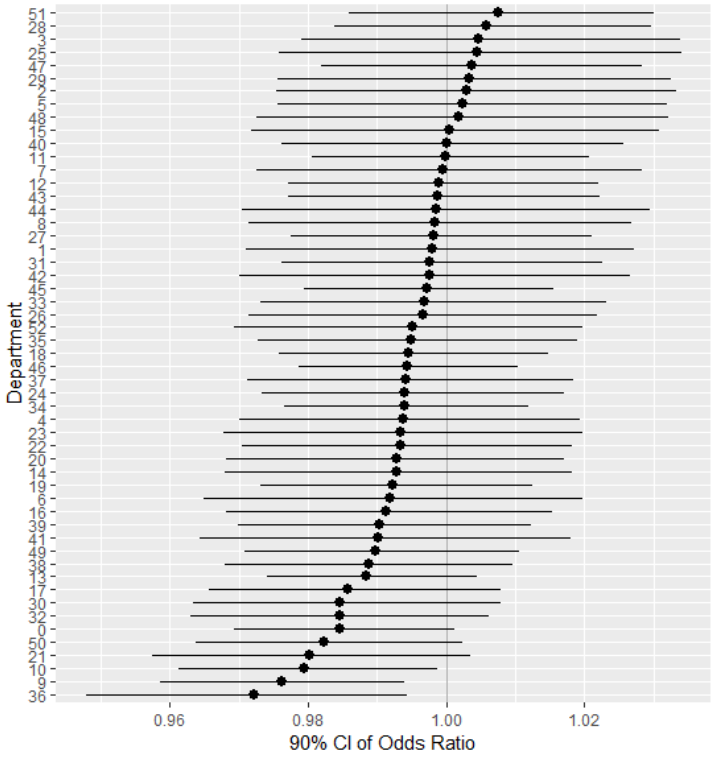

Fig. 7 The 90% credible intervals of the odds ratios of loan debt effect by department for the second spring

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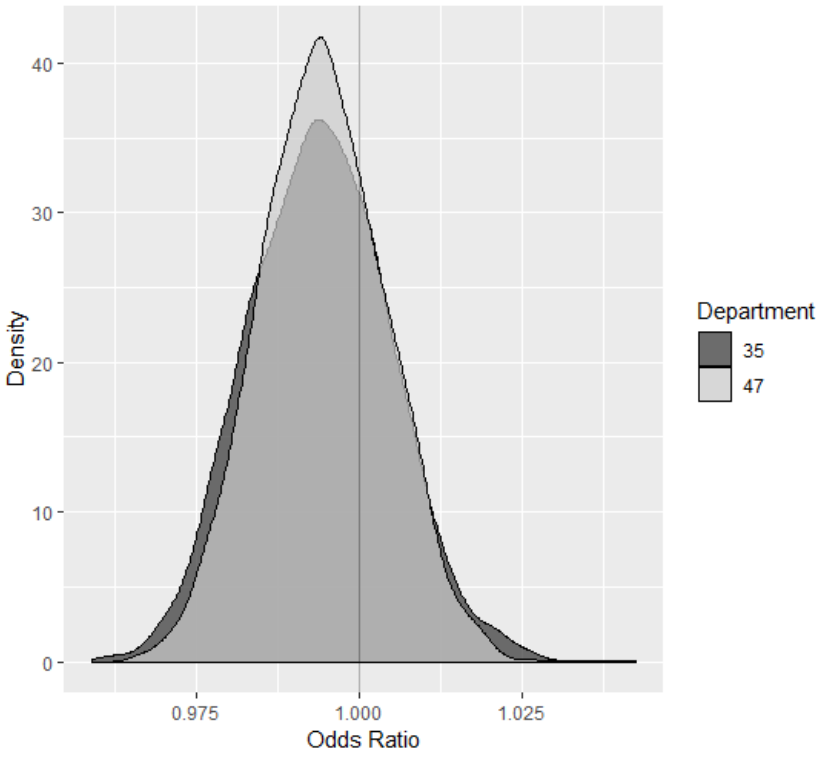

Fig. 8 The density plots of the odds ratios of loan debt effect in department 35 and department 47 for the second spring

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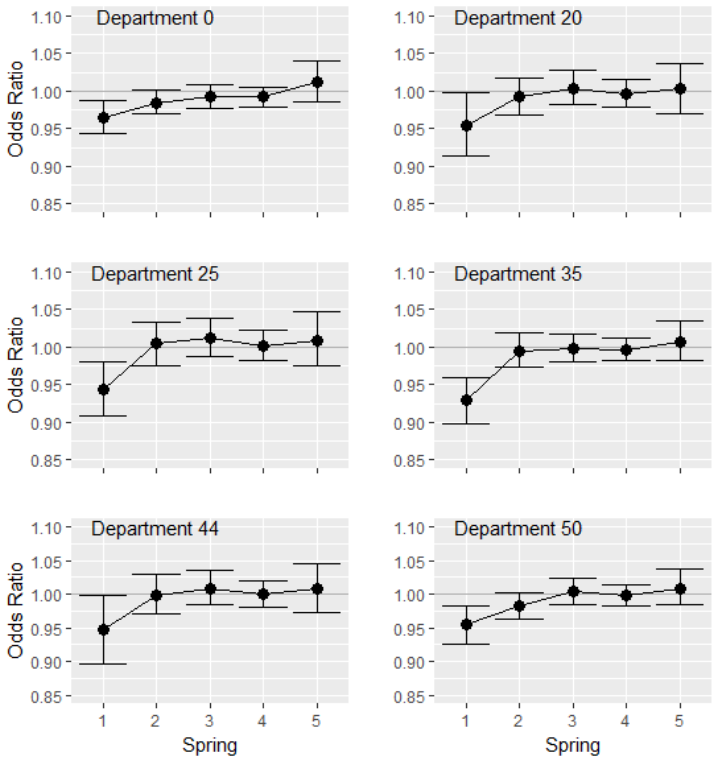

Fig. 9 The change of the 90% credible intervals of the odds ratios of loan debt effect over years in selected departments

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Appendix A

Table 6 Descriptive statistics of student characteristics at the end of the second spring

	Mean	SD	Min	Max
Cumulative loan debt (in $1,000s)	9.13	12.69	0	80.38
Total SAT score	1291	121	750	1590
In-state Residency	0.32		0	1
Male	0.42		0	1
First Generation College Student	0.12		0	1
Underrepresented minority Student	0.11		0	1
Cumulative credits passed for GPA	60	8.42	0	143
Count of classes with DFW grade	0.29	0.73	0	6
Credits registered in a spring	14.89	1.89	0	22
AGI unknown	0.20		0	1
Low AGI	0.13		0	1
Medium AGI	0.47		0	1
High AGI	0.20		0	1
Total grant aid (in $1,000s)	3.53	7.35	0	50.18
Total scholarship aid (in $1,000s)	5.63	11.38	0	95.49

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Table 7 Descriptive statistics of student characteristics at the end of the third spring

	Mean	SD	Min	Max
Cumulative loan debt (in $1,000s)	14.61	19.56	0	123.34
Total SAT score	1291	120	750	1590
In-state Residency	0.32		0	1
Male	0.41		0	1
First Generation College Student	0.12		0	1
Underrepresented minority Student	0.10		0	1
Cumulative credits passed for GPA	91	11.32	12	174
Count of classes with DFW grade	0.22	0.66	0	7
Credits registered in a spring	14.70	2.45	0	22
AGI unknown	0.19		0	1
Low AGI	0.12		0	1
Medium AGI	0.46		0	1
High AGI	0.22		0	1
Total grant aid (in $1,000s)	4.91	10.4	0	73.67
Total scholarship aid (in $1,000s)	8.49	17.27	0	154.92

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Table 8 Descriptive statistics of student characteristics at the end of the fourth spring

	Mean	SD	Min	Max
Cumulative loan debt (in $1,000s)	19.20	24.21	0	155.79
Total SAT score	1242	127	750	1590
In-state Residency	0.52		0	1
Male	0.57		0	1
First Generation College Student	0.18		0	1
Underrepresented minority Student	0.15		0	1
Cumulative credits passed for GPA	107	17.79	20	203
Count of classes with DFW grade	0.68	1.14	0	9
Credits registered in a spring	13.76	3.28	0	22
AGI unknown	0.22		0	1
Low AGI	0.18		0	1
Medium AGI	0.45		0	1
High AGI	0.15		0	1
Total grant aid (in $1,000s)	8.12	15.88	0	104.4
Total scholarship aid (in $1,000s)	8.16	27.09	0	203.44

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Table 9 Descriptive statistics of student characteristics at the end of the fifth spring

	Mean	SD	Min	Max
Cumulative loan debt (in $1,000s)	22.68	26.02	0	170.01
Total SAT score	1237	130	910	1580
In-state Residency	0.62		0	1
Male	0.62		0	1
First Generation College Student	0.22		0	1
Underrepresented minority Student	0.17		0	1
Cumulative credits passed for GPA	110	24.36	38	219
Count of classes with DFW grade	0.90	1.28	0	5
Credits registered in a spring	11.13	5.18	0	19
AGI unknown	0.20		0	1
Low AGI	0.25		0	1
Medium AGI	0.41		0	1
High AGI	0.14		0	1
Total grant aid (in $1,000s)	11.74	21.81	0	133.65
Total scholarship aid (in $1,000s)	4.11	11.84	0	108.04

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Appendix B

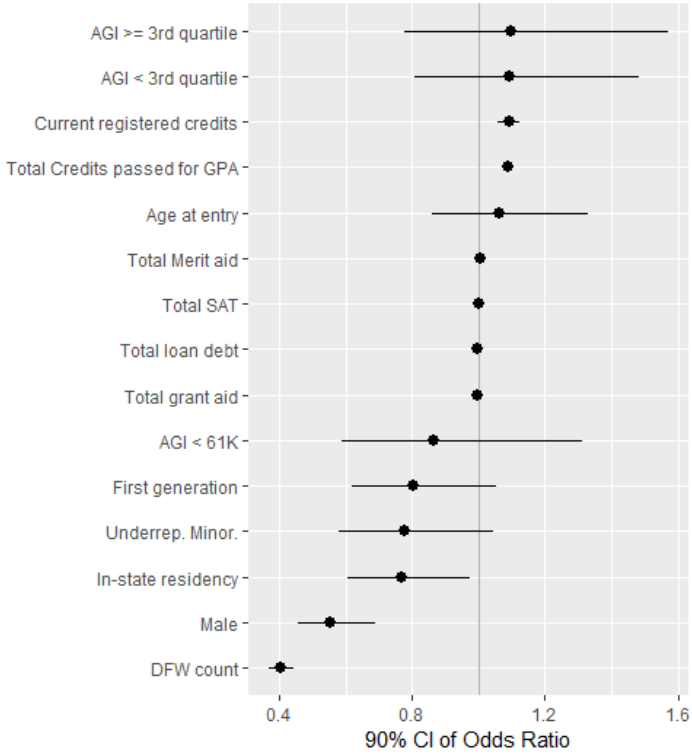

Fig. 10 The 90% credible intervals of the odds ratios for the factor effects on institutional level for the third spring

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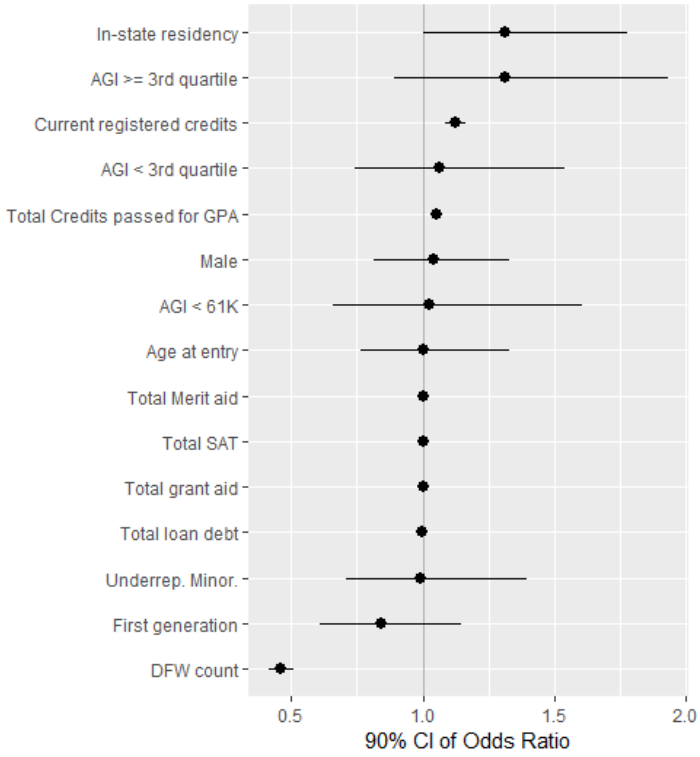

Fig. 11 The 90% credible intervals of the odds ratios for the factor effects on institutional level for the fourth spring

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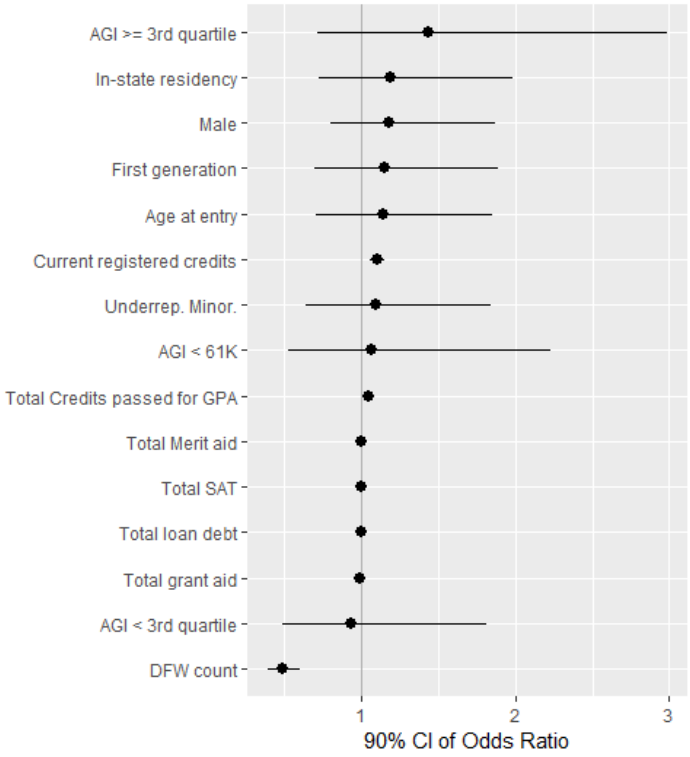

Fig. 12 The 90% credible intervals of the odds ratios for the factor effects on institutional level for the fifth spring

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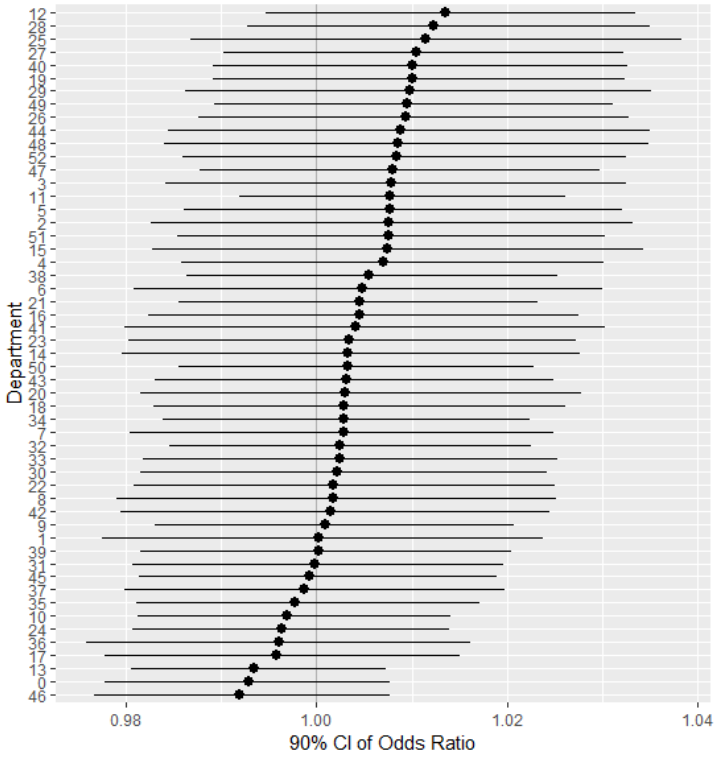

Fig. 13 The 90% credible intervals of the odds ratios of loan debt effect by department for the third spring

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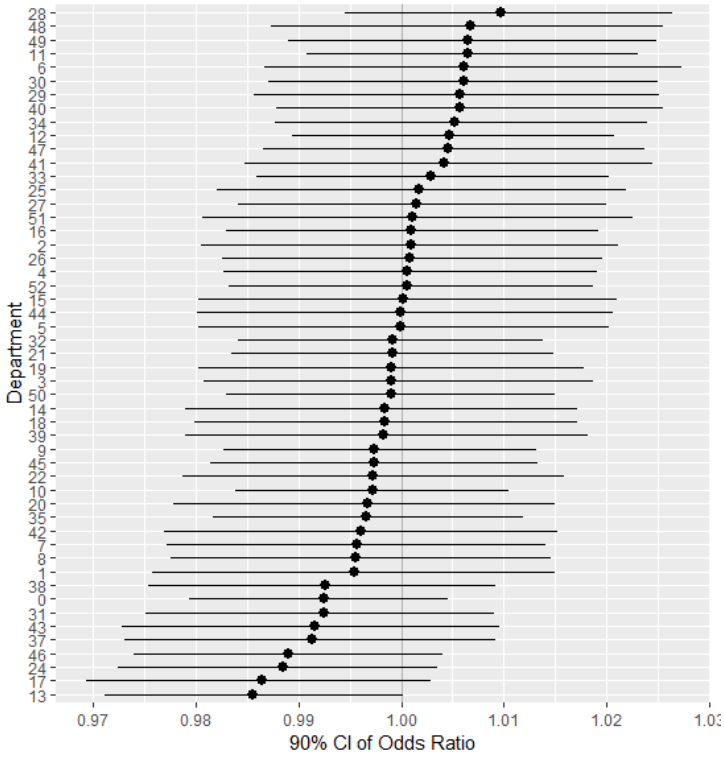

Fig. 14 The 90% credible intervals of the odds ratios of loan debt effect by department for the fourth spring

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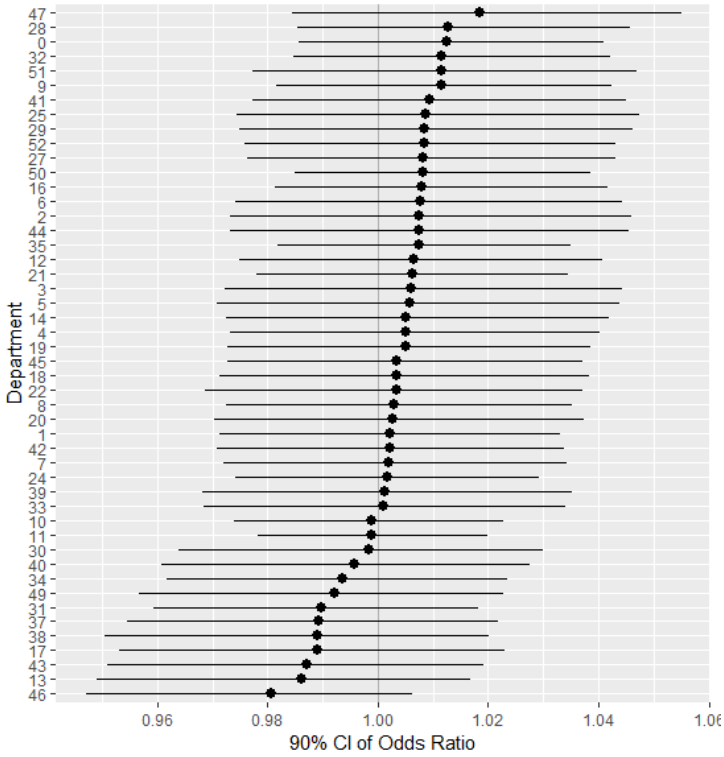

Fig. 15 The 90% credible intervals of the odds ratios of loan debt effect by department for the fifth spring