When They Will Pay: Understand Deposit Decisions in College Admission

Chuan Cai, Adam Fleischhacker

## Abstract

Using data from out-of-state students at the University of Delaware, this study investigates effects of various factors on students’ deposit decisions who were admitted for Fall 2020, Fall 2021, and Fall 2022. The effects are estimated from three Bayesian hierarchical piecewise exponential models, one model for each year. Piecewise exponential models faciliate the estimation of the baseline hazard and time-varying effects. The Bayesian hierarchical framework is introduced to balance between underfitting and overfitting, especially on the time-varying effects. The baseline hazard represents students’ baseline desire to pay deposits, and we find they consistenly grows as the deposit deadline approaches, but the growth path differs each year. Findings suggest that some factors such as gender and recruitment events consistently have time-varying effects during the admission season between February and May, while the effects of some other factors such as financial aid are relatively stable within a year but can change over years. We discuss the potential reasons for the change of the effects from economic, sociological, and psychological perspectives. The findings are shared with the Admissions Office to better understand when students would like to pay deposits, so they can adjust marketing and recruitment stratigies promptly.

Keywords: college admission yield, time-varying effect, piecewise exponential model, Bayesian hierarchical model

## Introduction

Recruitment of new students is a major challenge for many higher education institutions, as they must balance revenue goals, academic standards, and student body diversity (Adams-Johnson et al. 2019; Maldonado, Armelini, and Guevara 2017). The recruitment process includes several steps, such as answering inquiries from prospective students, reviewing applications, making admission decisions, encouraging deposit payments, and assisting with matriculation (Litten et al. 1983). Although matriculation is the ultimate goal, deposit payments are a critical focus for the Admissions Office, as they are a strong indicator of a student’s likelihood to enroll. Other offices/departments in an institution also pay attention to deposit situation. For exmaple, the Budget Office would like to use deposits paid to estimate the tuition revenue from new students. If the deposits paid are far away from the admission targets, the Budget Office has to update budgetary planning in the spring. Similarly, the Department of Residence Life and Housing needs to work on the potential shortage of dorm space in the spring, if too many deposits are paid. As a result, the Admissions Office tracks deposits usually by week in the spring and desires to understand admitted students’ decision to pay deposits, not only whether they will pay, but also when they will pay, so they can adjust marketing and recruitment stratigies promptly (DesJardins 2002; Goenner and Pauls 2006).

Previous studies have greatly contributed to our understanding of student enrollment decisions and have informed the development of marketing and recruitment strategies. DesJardins (2002) utilized predictive models to segment admitted students and recommended focusing on those with enrollment probabilities close to 0.5. Maldonado et al. (2017) developed nested logit models to predict the enrollment probabilities of admitted students, allowing decision makers to allocate resources for admission activities. Goenner and Pauls (2006) used predictive models to determine the enrollment probabilities of prospective students, helping the University of North Dakota allocate recruitment efforts by geographic area. Braunstein et al. (1999) studied the impact of financial factors on the enrollment decisions of admitted students and provided insight into how various types of financial aid affected students from different socio-economic backgrounds. Johnson (2019) investigated the factors that influenced the enrollment decisions of out-of-state students, identifying multiple potential destinations and providing insights into why students accepted or declined an offer of admission.

Our study focuses on understanding the factors affecting when admitted students will pay their deposits, as opposed to simply whether they will enroll by using the cross-sectional methods used in previous studies. To accomplish this, we utilize event history analysis, which is a commonly used tool for modeling students’ journey from enrollment to graduation (Chen and Hossler 2017; Gross, Torres, and Zerquera 2013; Zhan, Xiang, and Elliott III 2018). However, we use piecewise exponential models for the event history analysis instead of proportional hazard models for two reasons. First, we desire to estimate students’ baseline deposit behavior regardless of students’ characteristics. Second, we assume that it is possible that the factors related to deposit decisions have time-varying effects. Additionally, we employ a Bayesian hierarchical framework to balance overfitting and underfitting of the time-varying effects (McElreath 2020). The study uses three years of admission data from 2020 to 2022 provided by the Admissions Office at the University of Delaware (UD). The input variables for the Bayesian hierarchical piecewise exponential models were gathered through a review of previous studies (Paulsen 1990) and suggestions from the Admissions Office. These variables can be grouped into economic factors (e.g. offered financial aid), sociological factors (e.g. gender), and psychological factors (e.g. delay in reviewing admission decisions).

This study aims to address the following two research questions in order to understand the factors that impact admitted students’ deposit decisions and support the Admissions Office’s recruitment efforts: 1. Do the factors influencing deposit decisions exhibit varying effects over the course of a year? 2. If the effects remain constant throughout the year, do they change from one year to the next?

## Theoretical Backgound and Pratical Application

### Admission Funnel

From the perspective of the institution, the admission process consists of six stages: prospects, inquiriers, applicants, admitted students, depositors, and matriculants (Litten et al. 1983). In the prospect stage, the Admissions Office identifies potential students who may be interested in attending the institution. During the inquiry stage, the Admissions Office communicates with students who have expressed interest and works to increase their interest in the institution and encourage them to apply. In the application stage, the Admissions Office processes and reviews completed applications and notifies students of any missing information. In the admit stage, the Admissions Office decides to offer admission, waitlist, or reject applications. During the deposit stage, the Admissions Office interacts with admitted students through campus tours and other admission events, and the Student Financial Services (SFS) office provides financial aid packages in an effort to encourage students to accept the offer of admission. In the enrollment stage, the Admissions Office works with other offices to support new student orientation, course registration, and on-campus residency. There are several key rates to monitor in the admission process, including conversion rate (the proportion of applicants from inquiries), selection rate (the proportion of admitted students from applicants), yield rate (the proportion of depositors from admitted students), and melt rate (the proportion of matriculants from depositors). At the University of Delaware (UD), with the melt rate typically close to 100%, the deposit stage or yield rate largely determines the number of new students enrolling each fall.

### College Choice

From a student’s perspective, the college choice process consists of three stages: college aspiration formation, search and application, and selection and attendance (Hossler and Gallagher 1987; Paulsen 1990). In the formation stage, students determine whether to pursue higher education, with factors such as family background (Stage and Hossler 1989; Carpenter and Fleishman 1987), teacher and counselor encouragement (Portes and Wilson 1976; Conklin and Dailey 1981), and academic aptitude and achievement (Tuttle 1981; Davies and Kandel 1981) influencing their decision. During the search and application stage, students compile a list of colleges to apply to, typically starting in junior year of high school and completing applications in senior year (Gilmour Jr et al. 1981). In addition to input from parents, counselors, and peers, colleges also reach out to prospective students through publications such as guidebooks and campus events (Goenner and Pauls 2006). In the final stage, selection and attendance, students make the decision of which college to attend, based on their demographic background, socio-economic status, academic preparation, and institution characteristics such as cost, financial aid, academic programs, academic reputation, and location (DesJardins 2002; Goenner and Pauls 2006).

Many studies have utilized cross-sectional methods to examine students’ enrollment decisions in the selection and attendance stage. DesJardins (2002) employed a logistic regression model to predict the enrollment probabilities of students admitted to a public institution in the Midwest in 1999 and 2001. Variables included students’ demographic and socio-economic background, high school characteristics, application timing, and personal intention. The students were divided into deciles based on their predicted enrollment probabilities, and the study suggested that it was more efficient to target the “fence-sitting” groups rather than those with very high enrollment probabilities. Goenner and Pauls (2006) utilized logistic regression models with Bayesian model average techniques to predict the enrollment probabilities of 15,827 inquirers interested in attending the University of North Dakota in 2003 and to allocate recruitment efforts by geographic areas. They investigated the effects of inquiry contact methods, geographic factors, geodemographic factors, academic factors, and some interaction terms. The study suggested that recruitment efforts should be concentrated in geographic areas with high enrollment probabilities. Johnson (2019) examined the enrollment decisions of 42,950 out-of-state students admitted to a public research university from 2012 to 2016. He utilized mixed multinomial models and National Student Clearinghouse data to identify the students’ destinations among five options: the study institution, another out-of-state public institution, an in-state public institution, a private institution, or a 2-year college. Factors included demographic characteristics, high school information, family background, financial aid offered, and admitted academic discipline. The study found that higher family incomes, being a family member of an alumnus, graduating from a feeder high school, being offered higher merit scholarships, or borrowing more loans increased students’ likelihood of attending the institution. A surprising finding was that Pell-eligible students’ enrollment decisions were not affected by grants in financial aid packages. Maldonado et al. (2017) used nested logit models to predict the enrollment decisions of 25,325 prospective students to four bachelor’s programs in a small private Chilean university. The three possible outcomes were applied, admitted but not enrolled, and admitted and enrolled. The hierarchical models were deemed necessary because the latter two outcomes were more similar and should be grouped together. Factors included marketing efforts from the institution, students’ socio-economic background, and stated preferences. The study found that on-campus activities and talks at secondary schools were more effective in encouraging enrollment than career fairs, male students were more likely to attend engineering and law programs, and students’ online activities and stated preferences indicated their interests in attending the institution or individual programs. Braunstein et al. (1999) used logistic regression to model the enrollment decisions of 7,104 students admitted to Iona College in three academic years. The variables were grouped into three categories: demographic and social background, academic achievement and preparation, and financial aid. The study found that the demographic and social background did not affect students’ enrollment decisions, but financial aid had a positive effect. The enrollment probability increased by 1.1% to 2.5% for every additional $1,000 offered, with loans having more influence than grants and work study having the least influence.

### Conceptual Framework

Our conceptual framework is rooted in the theory of college choice (Chapman 1979; Hossler, Braxton, and Coopersmith 1989) and prior studies on students’ enrollment decisions. Students’ decisions to accept admission offers are influenced by economic, sociological, and psychological factors (Paulsen 1990). According to the theory of human capital (Becker 2009), students evaluate the cost-benefit ratio of attending an institution based on economic factors. Sociological factors, such as sociological background (Johnson 2019) and status attainment (Hossler, Schmit, and Vesper 1999), also play a role in students’ choice of institution. Psychological factors, including the institutional environment and climate, impact students’ perceptions of student-institution fit (Paulsen 1990). Our hypothesis is that these factors not only influence whether students choose to pay deposits but also when they choose to pay. Admitted students are more likely to pay deposits sooner if they perceive the institution as a good investment, a source of status attainment, and/or a good fit for them.

With guidance from the theory of college choice and prior research, we categorize variables into three groups. The economic factors include offered financial aid and socio-economic status, i.e., Pell eligibility and expected family contribution (EFC). Financial aid can impact students’ enrollment decisions by reducing the cost of attendance, so we hypothesize that students are more likely to make a deposit when more financial aid is offered. We use the total financial aid offered instead of breaking it down by aid type, such as grant and scholarship, loan, and work study (Braunstein, McGrath, and Pescatrice 1999), because SFS suggests that the amounts of different aid types are correlated with each other. For example, the amount of federal loans depends on the grants and scholarships already offered. For example, the amount of federal loans depends on the grants and scholarships already offered.

The sociological factors include students’ demographic characteristics, i.e., home distance from the university, gender, and racial ethnicity. These factors reflect the influence of parents, peers, counselors, and teachers on students’ enrollment decisions (Johnson 2019). We hypothesize that these factors will have varying effects on students’ deposit decisions.

Finally, psychological factors reflect students’ desire to attend the institution (Paulsen 1990), and include admission to the Honors program, match between applied and admitted majors, attendance at recruitment events, and prompt review of admission decisions (Maldonado, Armelini, and Guevara 2017). Students who have a strong interest in the institution are more likely to pay deposits earlier, and we hypothesize that these interests are stronger when students are admitted to the Honors program, willing to be admitted to a different major, attend recruitment events, and promptly review their admission decisions.

## Data and Variables

This study uses admission data of 60,285 admitted out-of-state students who intended to matriculate as first-time first-year students at the University of Delaware (Carnegie classification: R1), a public research university with an undergraduate population of around 18,000 students, during the Fall semesters of 2020, 2021, and 2022. The information was obtained from the Admissions Office and UD’s enterprise data warehouse. To track the students’ deposit decisions, the study period is defined from February 1 to the deposit deadline of May 1. February 1 is chosen as the starting point because the Admissions Office had made most admission decisions by then. The study period is further divided into eight intervals, February, March 1 to March 15, March 16 to March 31, April 1 to April 7, April 8 to April 14, April 15 to April 21, April 22 to April 28, and April 29 to May 1. The dataset is constructed as a student-period file with one row per student and period. Table 1 shows the number of observations and deposits by period each year. The number of observations increases from period 1 to either period 3 or period 4, reflecting the admission of students who were admitted after February. However, the number of observations decreases thereafter because students who paid deposits are no longer tracked. The number of deposits increases in April, especially after April 21, indicating the deadline effect on students’ deposit decisions.

[Insert Table 1 Here]

Table 2 describes the depedent and independent variables in the models. The depedent variable is whether a student paid a deposit by May 1. Of the 60,285 admitted students, 8,482 or 14.1% of made a deposit. The independent variables include the economic factors, sociological factors, and psychological factors. Three variables are continuous, Financial Aid, EFC, and Home Distance, with only Financial Aid having varying values by period. The rest of the variables are binary. On average, financial aid covers 28.6% of the Cost of Attendance (COA), and EFC covers 118.1% of COA. Of the 60,285 admitted students, 6,256 or 10.4% were eligible for Pell grants, 21,732 or 36.0% were male, 2,280 or 3.8% were African American, 3,457 or 5.7% were Asian, 5,072 or 8.4% were Hispanic, 44,164 or 73.3% were White, 1,813 or 3.0% were multi-ethnic, 17,478 or 29.0% attended early events for prospects, 6,998 or 11.6% were admitted to the Honors program, 2,913 or 4.8% were admitted to a different major than the one applied for, 3,443 or 5.7% visited campus, 3,127 or 5.2% attended the Decision Day event, and 24,449 or 40.6% did not review the admission decisions within two days.

[Insert Table 2 Here]

## Statistical Model

We develop Bayesian hierarchical piecewise exponential models to analyze students’ deposit decisions. These models, which are a type of discrete event history analysis, have a constant hazard function within each discrete time interval (Austin 2017; DesJardins et al. 1994; Friedman 1982). In this study, an event occurs if a student pays deposit between Februrary 1 and May 1. Otherwise, the admitted student is “censored” on May 1 or “survives” from the desire to pay deposit. Equation (1) defines the logarithm of the hazard function to be the sum of baseline hazard and a linear combination of student attributes, where represents the value of variable j for student i in a period, and represents the effect of the variable j in the period. The cumulative hazard, calculated as the product of the hazard function and the period length (), is used to derive the logarithm of the survival function () in Equation (2). Finally, Equation (3) calculates the probability of a student paying a deposit in a period () as one minus the survival function. In this model, the hazard function reflects the driving force behind a student’s deposit decision, while the cumulative hazard represents the accumulated force over time. If a variable has a positive effect on the deposit decision, a higher value of that variable will increase the driving force and, as a result, increase the probability of the student paying a deposit, as described by the three equations.

(1)

(2)

(3)

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We introduce the Bayesian hierarchical framework to estimate the unknown coefficients and in Equation (1). Bayesian analysis models our initial uncertainty, or prior distribution, using probability distributions (McElreath 2020). For the baseline hazard , we model the initial uncertainty using normal distributions as shown in Equation (4). The is the maximum likehood estimates for . We choose to be 0.1 to make it a strong prior distribution. The prior distributions will be updated to posterior distributions using the observed data, and the data must show strong evidence for the posterior distributions to deviate from the prior distributions. The hierarchical structure is setup for estimating . At the higher level, the variables have time-independent effects , i.e., the average effects over all periods. We assume are normally distributed with means being 0 as shown in Equation (5). This serves to reduce overfitting for the higher-level effects, because the observed data need to show enough support for non-zero parameter estimates. At the lower level, the variables have time-varying effects . We assume are normally distributed with means being as shown in Equation (6). This also reduces overfitting, because the observed data need to show enough support for to deviate from . The standard deviations and control the uncertainty of these assumptions, and we model their uncertainty using exponential prior distributions with a rate parameter of 0.5 (Equations (7) and (8)). In summary, if the observed data support it, the posterior distributions of the higher-level effects will deviate from the zero-mean prior distributions, and the posterior distributions of the lower-level effects will deviate from the prior distributions centered at the higher-level effects, leading to variables with time-varying effects on deposit decisions.

(4)

(5)

(6)

(7)

(8)

## Results and Discussion

We estimate the posterior distributions of the variable coefficients and their means using the DynamicHMC package in Julia (version 1.7.2). We run three Markov chains to estimate the posterior distributions, each consisting of 1,000 samples after a series of warm-up steps to find an appropriate step size for the “No-U-Turn Sampler” (Betancourt 2017; Hoffman, Gelman, et al. 2014). We derive the point estimates and credible intervals from the posterior distributions.

The results are interpreted based on the credible intervals of estimated coefficients and the corresponding hazard functions. If all credible intervals span across zero, the variable is considered not important in the deposit decision. A variable is defined to have a time-varying effect if the credible intervals do not overlap in at least two periods. Otherwise, the variable is defined to have a time-independent effect. The effect of a variable is measured by the hazard ratio, which is the exponential of the product of the variable change and its estimated coefficient, holding other variables and their coefficients constant according to Equation (1). The hazard ratio for the baseline hazard is the exponential of the difference between the estimated hazards in two periods. For binary variables, the ratio is the exponential of the estimated coefficient in the period, with a positive relationship between the ratio and the estimated coefficient. A variable has a positive effect on the deposit decision if the hazard ratio is larger than 1 or the estimated coefficient is larger than 0, and vice versa.

### Fall 2020

Table 3 shows the lower bounds of 95% credible intervals, the means, and the upper bounds of 95% credible intervals of parameter estimates for students who were admitted for Fall 2020, including the baseline hazard and the variables. The baseline hazard differs among periods. For example, the 95% credible interval (-8.22, -7.88) in first period does not overlap with interval (-5.98, -5.65) in the last period. The baseline hazard shows a fluctuating increasing trend from period 1 to period 8. The largest increase is between period 6 and period 7, which implies that students experience deadline pressure in the fourth week of April. The hazard ratio is 9.30 between the first and the last periods, indicating a much higher probability of deposit payment in the last period than in the first period.

[Insert Table 3 Here]

Five of the sixteen variables have time-varying effects, and they are Gender, White, Early Event, Decision Day, and Delay Review. The 95% credible intervals of Gender do not overlap between the first (-0.58, -0.04) period and the last period (-0.01, 0.32), indicating the effects are different in the two periods. The parameter estimates of Gender show an increasing trend, indicating the female students tend to pay deposit earlier than the male students. For example, the hazard ratio is 0.73 in the first period, indicating female students are more likely to pay deposits in the period. However, the hazard ratio changes to 1.16, indicating male students are more likely to pay in the last period. This finding would be neglected, if we assume variables to have time-independent effects. The point estimate for Gender would be close to 0 at -0.0079, indicating gender plays little role for deposit decisions. The parameter estimates of Delay Review also show an increasing trend. Students tend not to pay deposits in early periods, if they postpone to review admission decisions for at least two days, but the delay does not matter in later periods. In contrast, the parameter estimates are positive but with a declining trend for early events and decision day event, indicating that the encouragement from attending the events fades over time. The parameter estimates of White fluctuate among periods. White students are more likely to pay deposits in some periods but not in the other periods.

Eight variables have time-independent effects on deposit decisions, and they are Financial Aid, Pell, EFC, Home Distance, Hispanic, Honors Program, Major Change, and Campus Tour, because all corresponding 95% credible intervals overlap with each other. Financial aid does not matter except in the first period. It is not surprising in 2020, because students’ decisions are more affected by Covid-19 than financial burdens. In contrast, Pell eligibility does not matter until the last period. The hazard ratio is 1.45 in the last period, indicating Pell elgilible students are more likely to pay deposits than non-Pell elgilible students. This makes sense to the Admissions Office, because Pell eligible students would like to delay any financial expense until they cannot. This also suggests to them that the recruitment effort for Pell students may not appear effective until the last period. Other variables have important effects in more than one period. The parameter estimates of EFC and Home Distance are negative in some periods, indicating students with lower income and those closer to UD are more likley to pay deposits. On the other hand, the parameter estimates of Hispanic and Honor Program are positive in some periods, indicating Hispanic students and students who are admitted to the Honors program are more likely to pay deposits. Lastly, the parameter estimates of Major Change and Campus Tour are positive in all periods, indicating students are consistently more likely to pay deposits if they are willing to be admitted a major different than an applied major, or they attend campus tours.

Three variables do not have important effect on deposit decisions in any period, and they are Asian, African American, and Multi-Ethnic. The credible intervals of the parameter estimates span across zero in all periods, indicating the three factors do not matter when making deposit decisions.

### Fall 2021

Table 4 shows the lower bounds of 95% credible intervals, the means, and the upper bounds of 95% credible intervals of parameter estimates for students who were admitted for Fall 2021, including the baseline hazard and the variables. Similar to 2020, the baseline hazard varies across periods, with non-overlapping 95% credible intervals. For instance, the first period has an interval of (-8.39, -8.04), while the last period has an interval of (-6.10, -5.78). The baseline hazard exhibits an increasing trend, indicating an increasing likelihood of deposit payments over time. The hazard ratio is 9.68 between the first and the last periods, indicating students are much more likely to pay deposits in the last period than the first period.

[Insert Table 4 Here]

Five variables exhibit time-varying effects on deposit decisions: Home Distance, Gender, Early Event, Decision Day, and Delay Review. Four of these variables, Home Distance, Gender, Early Event, and Delay Review, show similar patterns with the previous year. Specifically, students who live closer to UD are more likely to pay deposits, female students tend to pay earlier than males, the impact of attending early events wanes over time, and students who delay reviewing their admissions decision tend not to pay deposits in the first two periods. However, the variable Decision Day exhibits a new pattern: while attending Decision Day events remains a positive factor for deposit decisions, its effect does not show a decreasing trend. The hazard ratio decreases from 3.90 in period 1 to 2.53 in period 4, before increasing to 4.71 in period 7. This is due to UD hosting another Decision Day event in April, which causes the effect to fade after February and then increase in April.

Most of other variables have time-independent effects, except for White and Multi-Ethnic, and they are Financial Aid, Pell, EFC, Asian, African American, Hispanic, Honors Program, Major Change, and Campus Tour. Unlike the previous year, students are incentivized by financial aid in all periods, which suggests that financial burden had been a more pressing concern than COVID-19. For instance, in period 7, a 10% increase in financial aid, or about $5.3K with a cost of attendance of $53,422 in 2021, results in a hazard ratio of 1.19. Assuming a student has a 15% chance of paying the deposit, their likelihood increases to 17.5% with the additional 10% financial aid, assuming other factors remain constant. Honors Program also exhibits a different pattern, with parameter estimates turning negative in most periods, indicating that students are less likely to pay deposits if admitted to the Honors Program. This change could be due to the change of admission policies, according to the Admissions Office. Furthermore, Asian and African American have become important factors in 2021, and students belonging to these racial-ethnic groups are less likely to pay deposits in some periods. EFC, Hispanic, Change Major, and Campus Tour continue to have similar effects as in the previous year, i.e., students are more likely to pay deposits if they come from lower-income families, are Hispanic students, have been admitted to a major different from their applied major, or have attended campus tours.

### Fall 2022

Table 5 shows the lower bounds of 95% credible intervals, the means, and the upper bounds of 95% credible intervals of parameter estimates for students who were admitted for Fall 2022, including the baseline hazard and the variables. The baseline hazard still shows an increasing trend, and students are mostly likely to pay deposit in the last period. The hazard ratio between the first and the last periods is 74.44, which is much higher than the previous two years. This is mostly due to the much lower baseline hazard in the first period, i.e., is -9.79 in 2022 vs -8.21 and -8.05 in 2021 and 2020, respectively.

[Insert Table 5 Here]

Seven variables exhibit time-varying effects: EFC, Gender, White, Early Events, Change Major, Decision Day, and Delay Review. The patterns for EFC, Gender, Early Events, and Decision Day remain consistent with the previous year. That is to say, female students tend to pay deposits earlier than male students, the encouragement from attend early events fades over time, and students are encouraged to pay deposits from individual Decision Day events. EFC and Change Major become variables with time-varying effects, but their general patterns do not change much from the previous years. Lower-income students are more likely to pay deposits in the last period, and students are more likely to pay deposits when admitted majors differ from their applied majors. Similar to 2020, White students are more likely to pay deposits in some periods and exhibit similar behavior to non-White students in other periods.

Six variables have time-independent effects: Financial Aid, Pell, Home Distance, Hispanic, Honors Program, and Campus Tour. Financial Aid remains as a positive factor, although only in half of the periods, and with smaller hazard ratios than in 2021. For example, the hazard ratio decreases from 1.19 in 2021 to 1.06 in 2022 for period 7. With the same assumption with 2021, an additional 10% in financial aid would increase the chance of paying the deposit from 15% to 15.9%. Pell-eligible students exhibit a similar behavior to that of 2020, with a higher likelihood of paying deposits in the last period. The other variables have similar patterns to the previous year. That is, students are more likely to pay if they live closer to UD, are Hispanic, and attend campus tours, but being admitted to the Honors program does not encourage early deposit payment.

Three variables do not have important impact on deposit decisions, and they are Asian, African American, and Multi-Ethnic. The list is the same with 2020.

### Comparison Among the Three Years

To compare the results among the three years, we focused on the baseline hazard and one variable from each of the three factor groups: Financial Aid from economic factors, Gender from sociological factors, and Decision Day from psychological factors. The parameter estimate distributions for each variable are shown in Figure 1 as boxplots. The baseline hazard for all three years shows an increasing trend, with students being less likely to pay deposits in the early periods and more likely in the latter periods. This is within expectation, because students would like to compare institutions’ admission offers but do not want to miss the deposit deadline. However, the growth path of the baseline hazard differs among the years. In 2020, the hazard slowly increases in the first six periods, jumps in period 7, and the difference between period 7 and period 8 is not large. In 2021, the hazard slowly increases in the first three periods, jumps in period 4, and remains relatively stable until the jump in the last period. In 2022, the hazard is much lower in the first period, catches up and fluctuates in the following several periods, and jumps to the strongest in the last period. The uncertainty of the baseline hazard makes it difficult for the Admissions Office to decide how many students to admit after February. For example, the first six periods suggest that the yield will be low in 2022, so more students need to be admitted to hit admission targets, but the last two periods, especially the last period, do not support the decision.

[Insert Figure 1 Here]

Financial aid has had a varying impact on deposit decisions over the past three years. In 2020, the boxplots locate close to zeros, indicating financial aid does not affect students’ deposit decisions after February. Financial aid is supposed to reduce students’ cost of attendence, but financial burden was not what students paid attention to due to Covid-19. However, as the pandemic-related concerns decreased in 2021, the boxplots move up above zero, indicating that financial aid became a positive factor in encouraging students to accept admission offers. Institutional grants and scholarships are the primary source of financial aid offered, and it is encouraging for the admissions office to see that students value and respond positively to the institution’s financial support. For 2022, the boxplots barely overlap with those in 2021 except the first period, and they move closer to zero, indicating students have weaker response to financial aid in 2022 than 2021. This presents a challenge to the SFS team responsible for packaging students’ financial aid. If the budget for institutional aid remains the same, but its impact on deposit decisions is not stable year over year, how can the team work more effectively with the admissions office to optimize the distribution of grants and scholarships to increase yield? We observe that the effect of financial aid has been relatively stable within a year, so one possible solution is to monitor the effect of financial aid on deposit decisions early, and adjust the financial aid policies promptly, or adjust the expectation of the financial aid to increase deposits.

Unlike financial aid, gender has consistent effects across the three years in terms of the general pattern, but the effects vary by period within each year. Female students tend to pay deposits earlier than male students, as shown by the rising boxplots over periods in all three years. In the first few periods, the boxplots are mostly below zero, indicating that male students are less likely to pay deposits early on. The boxplots then gradually rise and are mostly above zero in the last periods, suggesting that male students are more likely to pay deposits towards the end of the deposit period. That is to say, the deadline effect plays a more important role to male students than females, or female students are more eager to accept UD’s admission offers. We suspect this is due to the larger population of female students at UD, e.g., 59% of undergraduate students pursing bachelor’s degrees are female at UD in Fall 2021. For comparison, it is 47% and 49% in Penn State University and University of Maryland in Fall 2021, respectively. According to the College Choice thoery, students perfer an institution with matching sociological pattern, so female students are more likely consider UD as a good fit and thus are more willing to pay deposits early. This finding is surprising to the Admissions Office, but it would be overlooked if we assume that factors do not have time-varying effects. Models that make this assumption estimate the average effect across periods and would suggest that gender has no impact on deposit decisions, as the average parameter estimates would be close to zero, as seen in the boxplots.

The Admissions Office’s Decision Day event has been effective in encouraging admitted students to pay their deposits, as indicated by the boxplots consistently being above zero in all periods across the three years. Moreover, the boxplots reflect stimulation from individual events from Februaries and Aprils. The boxplots also reveal the impact of individual events held in February and April. In 2020, due to Covid-19, only one Decision Day event was held in February and those in April were canceled. The boxplots suggest that the effect of the event diminishes over time, indicating that while the event may initially increase students’ desire to pay their deposits, the effect decreases if they do not do so shortly after the event. In 2021, UD has multiple Decision Day events in February and April. The boxplots indicate that the effect fade after February but increase again in April. In 2021, multiple Decision Day events were held in both February and April, and the boxplots show a decrease in effect after February followed by an increase after the April event. This trend is more pronounced in 2022, where there is a large jump in effect after the April event following a decrease between February and April.

Other variables are briefly discussed here, and their boxplots can be found in the appendix. In 2020 and 2022, Pell eligibility does not affect the deposit decisons until the last period when Pell eligible students are more likely to pay deposits, but this does not apply to 2021. EFC does not matter in most periods in the three years, but the negative parameter estimates in a few periods indicate that students in higher income families are less likely to pay deposits. Home distance had a negative effect on deposit decisions in all three years, indicating that students living closer to UD were more likely to pay deposits. In terms of racial ethnicity, Hispanic students are more likley to pay deposits in at least two periods each year, Multi-Ethnic students do not show preference in all three years, Asian and African American students are less likely to pay deposits in some periods in 2021 but they do not show preference in 2020 and 2022, and White students are more likely to pay deposits in half of the periods in 2020 and 2022 but they do not show preference in 2021. Students who attended early events are more likely to pay deposits in all three years, but the effect tend to be stronger in 2020 and 2022 than 2021. Students who are admitted to the Honors program are more likley to pay deposits in some periods in 2020, but it becomes a negative factor in 2021 and 2022. Students with admitted majors different than applied majors are more likley to pay deposits in all three years. Campus tours encourage students to pay deposits in all three years. Lastly, students who delay to review admission decisions are less likely yo pay deposits in the early periods, but this effect fades over time, particularly in 2022.

## Limitations

Our study is limited to out-of-state students who intended to matriculate at UD between Fall 2020 and Fall 2022. Inferences drawn from our findings may not apply to other institutions or to in-state students who applied to UD, as they may have different socio-demographic backgrounds and respond differently to admission policies. Nonetheless, our study represents the first effort to examine time-varying effects on students’ deposit decisions, and we hope that our results can provide insight for other institutions to better understand their own recruitment efforts.

Second, this study is not able to include all potential factors in the models due to data availability, e.g., students’ online activities on the admissions website. However, beginning in 2022, we have access to week-by-week data on students’ online activities on the admissions website, including how much time they spent on financial aid and major finder. This may provide insight into their interests regarding the institution. We anticipate incorporating this data into our future analysis to better understand the impact of these activities on students’ decisions.

## Conclusion

This study provides valuable insights for the Admissions Office to better understand admitted students’ deposit decisions and adjust their recruitment strategies accordingly. While this study is limited to one institution for out-of-state students who intended to matriculate between Fall 2020 and Fall 2022, the findings shed light on the time-varying effects of various factors on students’ deposit decisions, which can be useful for other institutions in similar contexts. The results from the Bayesian hierarchical piecewise exponential models validate our hypothesis that students behave or respond to recruitment efforts differently in different periods during the admission season. For example, female students are more likely to pay deposits in early periods than male students, while in later periods male students become more likely to pay. This finding would be neglected if we assume time-independent effects in the event history analysis. Moreover, Pell eligible students are most likely to pay deposits in the last period, because they would like to delay any financial expense as much as possible. The Admissions Office could potentially help these students pay earlier by designing policies such as partially waiving their deposits. Regarding campus events, the findings show that students do respond to early events for prospects and Decision Day events for admitted students. These events act as impulse forces that encourage students to pay deposits, and their effects decrease over time. Therefore, the encouragement from early events fades over time, since they all happen before the first period, and the strongest effects of Decision Day events are observed in the periods when the events occur. These findings confirm the Admissions Office’s efforts to help students recognize UD as an excellent institution for their undergraduate study.

It’s important to note that students’ behaviors can change over the course of the three-year study period, influenced by factors such as macro environment and admission policies. For example, financial aid changes from an irrelevant factor to positive factor from 2020 to 2021 and 2022, likely due to the change of students’ concern over Covid-19. Another surprising finding was that being admitted to the Honors program changed from an encouragement to a discouragement factor from 2022 to 2021 and 2022. This was likely due to a policy change in the admissions process, and the Admissions Office may want to review and potentially improve the policy. The role of students’ racial ethnicities in their deposit decisions also varied across the years. For instance, Asian and African American students did not show a clear preference for paying deposits in 2020 and 2022, but tended not to pay in certain periods in 2021. In contrast, White students were more likely to pay deposits in 2020 and 2022, but showed no clear preference in 2021. However, Hispanic students were consistently more likely to pay deposits in all three years.

On the other hand, some consistent patterns exist among the three years. Students are more likely to pay deposits in the later periods, because they want to wait for the best admission offers but do not want to miss the deposit deadline. Students are more likely to pay deposits if they show interests to UD, including being willing to be admitted to majors different than the applied majors, and attending campus events such as campus tours and events for prospects and admitted students. Students are less likely to pay deposits, if being from higher income families, living further away from UD, or delaying to review the admission decisions. Although students’ socio-economic and demographic backgrounds cannot be changed, we suggest the Admissions Office to survey students who show interests to UD and better target future prospects with similar characteristics.

## Reference

Adams-Johnson, Susan, Jeff Cranmore, Anna MJ Holloway, and Joel D Wiley. 2019. “Higher Education Recruitment in the United States: A Chronology of Significant Literature.” *Journal of Educational Administration and History* 51 (3): 213–38.

Austin, Peter C. 2017. “A Tutorial on Multilevel Survival Analysis: Methods, Models and Applications.” *International Statistical Review* 85 (2): 185–203.

Becker, Gary S. 2009. *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*. University of Chicago press.

Betancourt, Michael. 2017. “A Conceptual Introduction to Hamiltonian Monte Carlo.” *arXiv Preprint arXiv:1701.02434*.

Braunstein, Andrew, Michael McGrath, and Donn Pescatrice. 1999. “Measuring the Impact of Income and Financial Aid Offers on College Enrollment Decisions.” *Research in Higher Education* 40 (3): 247–59.

Carpenter, Peter G, and John A Fleishman. 1987. “Linking Intentions and Behavior: Australian Students’ College Plans and College Attendance.” *American Educational Research Journal* 24 (1): 79–105.

Chapman, Randall G. 1979. “Pricing Policy and the College Choice Process.” *Research in Higher Education* 10 (1): 37–57.

Chen, Jin, and Don Hossler. 2017. “The Effects of Financial Aid on College Success of Two-Year Beginning Nontraditional Students.” *Research in Higher Education* 58 (1): 40–76.

Conklin, Mary E, and Ann Ricks Dailey. 1981. “Does Consistency of Parental Educational Encouragement Matter for Secondary School Students?” *Sociology of Education*, 254–62.

Davies, Mark, and Denise B Kandel. 1981. “Parental and Peer Influences on Adolescents’ Educational Plans: Some Further Evidence.” *American Journal of Sociology* 87 (2): 363–87.

DesJardins, Stephen L et al. 1994. “Studying the Determinants of Student Stopout: Identifying" True" from Spurious Time-Varying Effects.”

DesJardins, Stephen L. 2002. “An Analytic Strategy to Assist Institutional Recruitment and Marketing Efforts.” *Research in Higher Education* 43 (5): 531–53.

Friedman, Michael. 1982. “Piecewise Exponential Models for Survival Data with Covariates.” *The Annals of Statistics* 10 (1): 101–13.

Gilmour Jr, Joseph E et al. 1981. “How High School Students Select a College.”

Goenner, Cullen F, and Kenton Pauls. 2006. “A Predictive Model of Inquiry to Enrollment.” *Research in Higher Education* 47 (8): 935–56.

Gross, Jacob PK, Vasti Torres, and Desiree Zerquera. 2013. “Financial Aid and Attainment Among Students in a State with Changing Demographics.” *Research in Higher Education* 54 (4): 383–406.

Hoffman, Matthew D, Andrew Gelman, et al. 2014. “The No-u-Turn Sampler: Adaptively Setting Path Lengths in Hamiltonian Monte Carlo.” *J. Mach. Learn. Res.* 15 (1): 1593–623.

Hossler, Don, John Braxton, and Georgia Coopersmith. 1989. “Understanding Student College Choice.” *Higher Education: Handbook of Theory and Research* 5: 231–88.

Hossler, Don, and Karen Gallagher. 1987. “Studying Student College Choice: A Three-Phase Model and the Implication...-SuperSearch Powered by Summon.” *College and University* 62: 201–21.

Hossler, Don, Jack Schmit, and Nick Vesper. 1999. *Going to College: How Social, Economic, and Educational Factors Influence the Decisions Students Make*. JHU Press.

Johnson, Iryna Y. 2019. “Destinations of Admitted Out-of-State Students: A Case of One Institution.” *Research in Higher Education* 60 (3): 315–37.

Litten, Larry H et al. 1983. “Applying Market Research in College Admissions.”

Maldonado, Sebastián, Guillermo Armelini, and C Angelo Guevara. 2017. “Assessing University Enrollment and Admission Efforts via Hierarchical Classification and Feature Selection.” *Intelligent Data Analysis* 21 (4): 945–62.

McElreath, Richard. 2020. *Statistical Rethinking: A Bayesian Course with Examples in r and Stan*. Chapman; Hall/CRC.

Paulsen, Michael B. 1990. *College Choice: Understanding Student Enrollment Behavior. ASHE-ERIC Higher Education Report No. 6.* ERIC.

Portes, Alejandro, and Kenneth L Wilson. 1976. “Black-White Differences in Educational Attainment.” *American Sociological Review*, 414–31.

Stage, Frances K, and Don Hossler. 1989. “Differences in Family Influences on College Attendance Plans for Male and Female Ninth Graders.” *Research in Higher Education* 30 (3): 301–15.

Tuttle, Ron. 1981. “A Path Analytic Model of the College Going Decision.”

Zhan, Min, Xiaoling Xiang, and William Elliott III. 2018. “How Much Is Too Much: Educational Loans and College Graduation.” *Educational Policy* 32 (7): 993–1017.