



Implications of losing a need- and merit-based scholarship on the educational trajectory: a curricular analytics approach

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Abstract

Understanding how students with low socioeconomic status finance their tuition over time can help us comprehend the impact of students' decisions on their subsequent curricular progress, graduation, or dropout. This work presents a curricular analytics approach using process mining techniques to study educational funding trajectories as processes. Specifically, the SCHOLARSHIP-LOAN-SELF-FUNDED model is designed to reveal educational funding trajectories and obtain aggregate information. Academic and tuition records of 2484 undergraduate students from a private Chilean university who started their programs with a government need- and merit-based tuition aid were analyzed. Students who lost their scholarships were more likely to drop out, whereas students who maintained this aid were more likely to graduate on time. Curricular progress per semester was slower after scholarships ended or after the students lost them and stayed. Financial aid was associated with students' curricular progress and linked to their permanence and graduation time. Higher education institutions should consider the eligibility criteria and maintenance requirements of financial assistance when designing their curricula.

Keywords Educational trajectories · Financial aid · Process mining · Educational data mining · Curricular analytics

Introduction

In recent years, scholarships incorporating a need-based component have emerged as key catalysts for expanding access to higher education, particularly among students with a low socioeconomic status (SES) (Nguyen et al., 2019; Santelices et al., 2016). The growing demand for aid has placed pressure on governments to optimize resource utilization and align incentives more effectively (Dynarski & Scott-Clayton, 2013). These pressures have led to design adjustments in scholarship programs, such as introducing performance requirements for scholarship maintenance. These adjustments have had significant impacts

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on low-SES students. While the introduction of performance requirements may promote timely graduation, it also introduces complexities that can adversely affect overall progression and graduation rates (Scott-Clayton & Schudde, 2020).

Researchers have investigated the impact of these aids on persistence, academic progress, and degree completion. Regarding eligibility criteria, research has shown that need-based scholarships, compared to merit-based scholarships, have a more significant impact on persistence and degree completion (Nguyen et al., 2019), although a combination of need- and merit-based scholarships can also have positive effects (Nguyen et al., 2019). It has also been found in previous research that students who receive scholarships and have additional support mechanisms, such as mentoring and wraparound services, exhibit higher levels of persistence and degree completion (Nguyen et al., 2019). With respect to loans, researchers have identified factors leading low-SES students to make suboptimal decisions, such as loan aversion (Lim et al., 2019) and the selection of institutions or programs that are less demanding or have shorter durations (Nguyen et al., 2019), prioritizing immediate benefits over long-term benefits. Moreover, part-time work (Thies, 2022), aversion to debt (Lim et al., 2019), liquidity constraints associated with remaining needs (Dente & Piraino, 2011), and enrollment intensity (Goldrick-Rab et al., 2016) have been found to be factors that could explain differences in dropout and on-time graduation rates between low-SES students and their high-income peers.

Nevertheless, there remains limited understanding of student behavior following the loss (Carruthers & Özek, 2016) or completion (Mabel, 2020) of their scholarships. Henry et al. (2004) found that scholarship loss is associated with reduced curricular progress and a decreased likelihood of graduation. Other researchers have shown that implementing a performance standard of renewal for need-based scholarships might positively affect academic progress (Scott-Clayton & Schudde, 2020). Mabel (2020) examined the impact of implementing time limits on need-based scholarships. However, to our knowledge, no previous research has elucidated students' dynamic behavior after losing need- and merit-based scholarships with a maintenance renewal standard, specifically in regard to curricular progress and degree completion.

In this article, we aim to research the educational funding trajectories of Chilean students who have received the Bicentennial Scholarship and to analyze the relationship between the loss of this benefit and dropout rates, curricular progress, and graduation. This study uses a purposively selected case, employing a curricular analytics approach that leverages the advantages of utilizing high-quality institutional administrative data, as well as the ability to analyze population-level data (Figlio et al., 2016). To achieve this goal, we propose a model to reveal educational funding trajectories and obtain aggregate information following an adapted version of PM², a process mining methodology (Maldonado-Mahauad et al., 2018). By integrating curriculum and financial data, we aim to gain a comprehensive understanding of the dynamic behavior of students regarding tuition financing and their progression through curricula. Specifically, we ask the following research question: What is the relationship between the loss of a need- and merit-based scholarship and the educational funding trajectories of students in terms of means of funding, curricular progress, and graduation rates? We expect the obtained results to contribute to both the related research field and the formulation of effective policies in this domain.

We conducted this study at a medium-sized Chilean university that embraces both education and research. Although the Chilean context might have its own distinctive characteristics, we believe that this analysis is attractive to a broader international audience. Governments are imposing accountability requirements on higher education institutions (HEIs) that receive public funds (Lang, 2022), and the consequences of the successive changes in

how students finance their tuition in higher education in Chile have aroused international interest (Espinoza et al., 2022; Larraín & Zurita, 2008; Santelices et al., 2016).

Literature review

Effects of financial aid on progress and degree completion

The rational choice model of educational decisions (Breen & Goldthorpe, 1997) defines three factors that influence commitment at a given transition point: the cost of continuing to study, the perceived probability of success, and the perceived returns of each educational outcome. Low-SES students often underestimate the returns of higher education and overestimate enrollment costs, leading them to make biased decisions (Geven & Herbaut, 2019). To address this issue, governments offer various forms of financial aid, including scholarships and loans, to low-SES students. Scholarships and loans offer students different incentives to pursue their studies (Cho et al., 2015). Scholarships do not require repayment, reducing the cost of obtaining a degree from a student's perspective. Loans may provide fewer incentives for degree completion, especially when students face liquidity or borrowing constraints (Johnson, 2013).

Governments offer different types of scholarships based on eligibility criteria. Students receive need-based scholarships based on their financial needs, such as having a low family income. Conversely, students receive merit-based scholarships based on their high school GPA or university entrance exams. Scholarships that have both need-based and merit-based components are called need- and merit-based scholarships (Nguyen et al., 2019). There is a rapidly expanding academic literature focused on understanding the effects of scholarships on enrollment, student persistence, and degree completion (Nguyen et al., 2019). Most related research has shown that scholarships with a need-based component have greater effects on persistence, and a combination of need and merit has proven to have even greater positive effects (Nguyen et al., 2019).

There is an expanding body of literature examining how students behave after the loss (Carruthers & Özek, 2016; LaSota et al., 2021) or completion (Mabel, 2020) of their scholarships. Several researchers have found that scholarship loss is associated with reduced curricular progress and a lower likelihood of graduation (Carruthers & Özek, 2016; Mabel, 2020). Carruthers and Özek (2016) found, specifically for Georgia's HOPE scholarship, that a possible explanation for this lies in students exhibiting reduced engagement with college and increased engagement with work after experiencing scholarship loss. Research has shown that implementing a performance standard of renewal on need-based scholarships might improve academic progress (Mabel, 2020). However, if the standard is overly strict, it may have a negative impact on enrollment, progression, and graduation, particularly for the most disadvantaged students (Scott-Clayton & Schudde, 2020). Mabel (2020) found that implementing time limits on need-based scholarships could produce both positive and negative effects. On the positive side, these limits encourage students to complete their studies sooner. On the negative side, they also contribute to an increase in dropout rates.

The availability of well-designed loans could minimize a negative impact on students who lose their scholarships. For instance, loans that incentivize repayment could help prevent excessive debt among academically underperforming students or in higher education programs with a low economic return (Lochner & Monge-Naranjo, 2016). However, it is also important to consider the characteristics of students that influence their willingness to

take on loans. Among these are debt aversion, the educational level of their parents, and the income level of their family (De Gayardon et al., 2019).

Recent research has shown that interventions that combine outreach and financial aid can have positive effects on graduation rates (Geven & Herbaut, 2019). These activities include counseling and guidance, tutoring, transportation, and school supplies.

Financial aid in the Chilean higher education system

In Chile, both public universities and private institutions with a longer history have been receiving government funding since their inception. These universities are members of the Council of Chancellors of Chilean Universities (Consejo de Rectores de Universidades Chilenas, hereinafter CRUCH) (Santelices et al., 2016). Only in recent years (after the period covered by this study) has the Chilean government started opening up funding opportunities to include other private universities.

The Bicentennial Scholarship (BS) is a need- and merit-based scholarship provided by the Chilean government (Santelices et al., 2016). During the period of our research, this scholarship was restricted to students from universities affiliated with CRUCH who exhibited high-level academic performance in national admission exams (70th percentile or higher) and came from the two lowest income quintiles (Schmidt et al., 2019). Both universities and the government actively encouraged all eligible students to apply for the BS. The BS and government loans cover tuition fees only up to a reference amount determined by the Ministry of Education (Santelices et al., 2016) for each degree program. Typically, there is a difference ranging from 10 to 20% between reference tuition and full tuition (Dooner & Mena, 2006), which amounts to approximately US\$500–1000 per year. Low-SES students who have the BS usually cover the remaining difference with a loan, although some of them pay for it by themselves. Students who lose the BS and use a government loan must cover the difference between the reference tuition and full tuition by themselves. In addition to tuition, students with the BS receive two additional scholarships. The Scholarship for Higher Education Living Expenses (BMES) provides approximately US\$30 per month for discretionary use. The Food Scholarship for Higher Education (BAES) offers approximately US\$50 per month exclusively designated for meal-related expenses. When students lose the BS, they also lose the BMES but might retain the BAES if they use a government loan. Although the amount of the BMES is only US\$30 per month, students may face financial challenges in covering transportation and other living expenses. To meet the maintenance requirements and retain the BS, a student must pass 70% of their enrolled courses each year (60% in the first year). Students know these requirements when applying for the scholarship, but universities also reinforce this message through their student services offices. There are other public scholarships that can be used by students who are enrolled at the university where this study was conducted, but all of them only partially cover tuition (Cáceres-Delpiano et al., 2018), and students use them in combination with government loans as the main funding mechanism.

CRUCH university students mainly have access to two loan types: The Solidary Fund of University Loans (Fondo Solidario de Crédito Universitario, hereinafter FSCU) and Government Guaranteed Loans (Crédito con Aval del Estado, hereinafter CAE) (Cáceres-Delpiano et al., 2018). The FSCU was created in 1994 and is managed by the government; its loan interest rate is 2%, and loan payments depend on income. However, this type of loan is available only to students at CRUCH universities. The CAE was created in 2005 and is managed by private financial entities; its loan interest rate was 6% during the time period

in which this study was conducted, and it is available for the entire Chilean higher education system, not only for CRUCH universities (Larraín & Zurita, 2008). Like the BS, these loans cover tuition fees only up to the reference amount, and students are responsible for financing the remaining difference themselves.

According to the government, these tuition aids have two main effects on students: they increase the enrollment rate and improve the retention rate in higher education (Meneses & Blanco, 2010).

Method

Data

We conducted this study at a medium-sized traditional private university in Chile that is affiliated with CRUCH. The study analyzed a sample of 2484 students, representing 40% of the population with lower socioeconomic status (SES), who received the BS when they were admitted to their academic programs. These students belonged to cohorts 2004 to 2009, and the observation period ranged from the beginning of 2004 to the end of 2018. A total of 46.6% of the students were women, and the mean age at first enrollment was 19.4 years ($SD = 1.7$). The students were enrolled in a broad range of International Standard Classification of Education (ISCED) fields of education (Schneider Silke, 2013): 32.5% in health and welfare; 24.8% in engineering; 17.8% in social science, business, and law; 10% in agriculture; 7.3% in science; 6.6% in education; and 1% in humanities and arts.

We analyzed anonymized student data provided by the institution, including enrollment records, government loans and scholarship assignments, records of expelled students, and grades obtained in each course. This information also included the curriculum structure and nominal duration of each program, with undergraduate programs ranging from 8 to 14 semesters (median = 10).

Methodological approach

Learning analytics (LA) is a growing research area that focuses on measuring, collecting, analyzing, and reporting data about students and their learning processes (Viberg et al., 2018). Curricular analytics (CA) has emerged as a subfield of LA that aims to use evidence to drive curriculum decision-making and program improvement (Pinnell et al., 2017). The ability to analyze data at the population level (Figlio et al., 2016) is a characteristic of CA that enhances the internal validity of the findings.

In this study, we are interested in understanding the educational funding trajectories of students who begin their programs with the BS using a curricular analytics approach through process mining (PM). PM aims to extract knowledge from event logs obtained from information systems to discover process models, verify conformance, and suggest improvements, acting as a bridge between data science and process science (van der Aalst, 2016). Through PM, we can see educational funding trajectories as a set of events that occur while students remain in a given program. Statistical methods complement PM analysis, strengthening our findings (Ramaswami, 2019). We expect that this novel approach will contribute to gaining a comprehensive understanding of the outcomes associated with the loss of need- and merit-based scholarship in terms of funding, curricular progress, and graduation rate.

In this study, we introduce the SCHOLARSHIP-LOAN-SELF-FUNDED model with the aim of systematizing the analysis of educational funding trajectories using PM techniques. This model represents students' educational funding trajectories as a sequence of records that show the main means of funding that each student used to finance each semester. Table 1 shows the three means of funding that were included.

Analytical strategy

We conducted this research following an adapted version of the PM² methodology (Maldonado-Mahauad et al., 2018). This methodology defines the following four stages: data extraction, event log generation, discovery, and analysis. The process models that were obtained provide graphic representations of the educational funding trajectories of the students; nodes represent events (milestones) relevant to their educational funding trajectories, while arrows represent transitions between events. For this research, we labeled nodes based on the number of students, as well as the percentage of progress or the duration of funding for students. To label arrows, we use the number and percentage of students who had a transition between each pair of events.

Data extraction

First, we filtered anonymized records provided by the institution, considering only students who started their programs supported by the BS. Next, we categorized the final state events based on the data extracted from the academic records. Table 2 describes those events. We then examined a range of student data, including enrollment records, government loan and scholarship assignment records, records of expelled students, and grades obtained in each course.

Event log generation

In this stage, to facilitate subsequent discovery and analysis through PM, the data should be modeled as an event log (Van der Aalst, 2019). Formally, an event log is defined as a set of executions of the process (namely, cases), where each one is an ordered sequence of actions that occurred during that execution (namely, events) (Van der Aalst, 2019). Therefore, to define an event log, (1) how to identify a case and (2) how to specify a sequence of events must be defined.

As mentioned in the methodological approach subsection, the SCHOLARSHIP-LOAN-SELF-FUNDED model proposes analyzing educational funding trajectories

Table 1 Main means of funding used by students

Means of funding	Criteria
SCHOLARSHIP	The student has primarily financed the tuition for this semester with the Bicentennial Scholarship
LOAN	The student has primarily financed the tuition for this semester mainly with a government loan, specifically the FSCU or CAE
SELF-FUNDED	The student has not financed the tuition for this semester with either the BS or a government loan

Table 2 Criteria used to define the final state of a student

Final state event	Criteria
EARLY-DROPOUT-EXPELLED	The student stayed at most 2 years and then were expelled from the program due to poor academic performance
EARLY-DROPOUT-VOLUNTARY	The student stayed at most 2 years and then voluntarily dropped out of the program
LATE-DROPOUT-EXPELLED	The student was expelled from the program due to poor performance and had more than 2 years of academic records
LATE-DROPOUT-VOLUNTARY	The student neither enrolled in 2019 nor graduated before that date but had more than 2 years of academic records
LATE-GRAD	The student graduated in a period longer than the nominal duration of the undergraduate program
ON-TIME-GRAD	The student graduated in a period equal to or lower than the nominal duration of the undergraduate program

through PM. The event log consists of educational funding trajectories, where each case represents a student enrolled in a specific undergraduate program, and each event represents a record in the educational funding trajectory of that student. Table 3 describes the attributes included for each event.

To construct the educational funding trajectories, we followed these steps. First, we recorded the main means of funding tuition for each semester during which a student had academic activity, as defined in Table 1. Next, we added an initial state for each student, representing enrollment (ENR) in an undergraduate program. Then, we built funding events, grouping the semesters in which each student had maintained the same means of funding tuition. Additionally, for the case of students who lost their BS, we added a SCHOLARSHIP-LOST event after the end of the semester when the BS was lost. For students who had the BS and met the maintenance requisites but who stayed longer than the nominal duration of the curriculum, we added a SCHOLARSHIP-END

Table 3 Description of the attributes of all events contained in the event log

Event log attributes	Description
Student-ID	This serves as a label that denotes a sequence of events (van der Aalst, 2016). In this context, it corresponds to the educational funding trajectory of a given student. It is composed of the student identifier and the identifier of the undergraduate program to which the student belongs
Event	We defined three types of events: enrollment, funding, and final state. For each educational funding trajectory, the enrollment event (ENR) corresponds to the entry into the academic program, and the last state event corresponds to one of the six final states, as defined in Table 2
Percentage-of-progress	This quantifies a student's advancement in the curriculum of their program, calculated as the approved credits relative to the total program credits
Gender	This represents a student's gender
ISCED	This represents the ISCED field to which an undergraduate program belongs
Start-date	These timestamps correspond, in this context, to the start and end dates of each semester, respectively
End-date	

event after the end of the semester when the BS ended. Finally, we added a final state at the end of each trajectory. Table 2 describes the criteria used to define each final state.

Table 4 shows, as an example, the educational funding trajectory for one student, namely, 11. In this example, student 11 stayed in his or her academic program for three semesters, using the Bicentennial Scholarship for the first two semesters, making 8% progress in the study plan. This student lost the Bicentennial Scholarship at the end of the second semester and continued with a LOAN for another semester, making 4% progress in the study plan and then dropping out voluntarily.

In this research, we employed a Directly-Follows Graph (DFG) to represent the educational funding trajectories. A DFG consists of nodes representing events in the funding trajectory and directed edges (transitions) that represent direct relationships among these events (Van der Aalst, 2019). DFGs are among the most popular and widespread process modeling notations (Van der Aalst, 2019). Figure 1 shows the DFG for student 11 according to the information provided in Table 4.

Model discovery

The event log was loaded in R using bupaR, an integrated collection of R packages that creates a framework for the reproducible analysis of processes in R, which includes both graphical and analytical tools (Janssenswillen et al., 2019). We created models that group educational funding trajectories by final state event.

Data analysis

To address the research question, we developed models using the event log, considering different perspectives. These models enabled us to perform three distinct analyses based on the final state achieved. First, we explored the trajectories involving the maintenance or loss of the BS. For students who were unable to maintain the BS, we analyzed the tuition funding methods they opted for upon completion or loss of the BS. Second, we examined the curricular progress before and after losing the BS. Third, we explored the curricular progress before and after ending the BS. The variables considered were the number and percentage of students who reached different states and were involved in different transitions, the number of semesters that each student stayed in a particular state, and the percentage of progress that the students had when using each tuition funding method. We incorporated these variables into the models using nodes or transitions based on the specific focus of the analysis.

Table 4 Example of educational funding trajectory

Student ID	Event	% of progress	Start date	End date
11	ENR	-	01 January 2015	01 January 2015
11	SCHOLARSHIP	8%	01 January 2015	31 December 2015
11	SCHOLARSHIP-LOST	-	31 December 2015	31 December 2015
11	LOAN	4%	01 January 2016	30 June 2016
11	EARLY-DROPOUT-VOLUNTARY	-	30 June 2016	30 June 2016

Fig. 1 Example of an educational funding trajectory according to the SCHOLARSHIP-LOAN-SELF-FUNDED model. The DFG shows the funding trajectory for the student presented in Table 4. A darker node represents greater curricular progress per semester

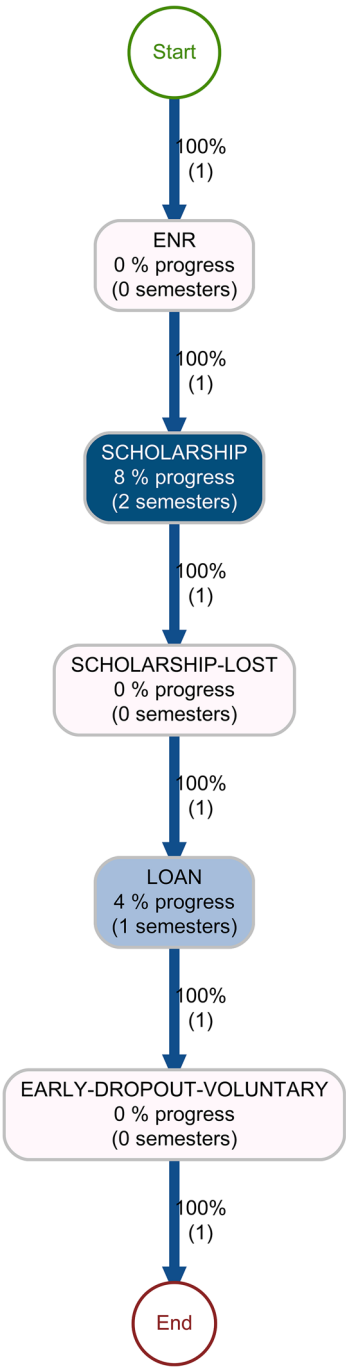


Table 5 Filters and properties applied to the event logs to perform each analysis to answer the research question

Analysis	Node type	Transition type	General filters	Figure or table	Additional filters	Finding
Maintenance or loss of the BS	Number of students	-	Final states: EARLY-DROPOUT-EXPELLED, EARLY-DROPOUT-VOLUNTARY, LATE-DROPOUT-EXPELLED, LATE-DROPOUT-VOLUNTARY, LATE-GRAD, ON-TIME-GRAD	Figure 2 Table 6	Include transition SCHOL-ARSHIP > SCHOLARSHIP-LOST Include transition SCHOL-ARSHIP > SCHOLARSHIP-END Do not include transitions SCHOLARSHIP > SCHOLARSHIP-LOST or SCHOLARSHIP > SCHOLARSHIP-END	F1
Curricular progress of those who lost the BS	Average progress per semester Average number of semesters	Percentage of students Number of students	Final states: EARLY-DROPOUT, LATE-DROPOUT, LATE-GRAD, ON-TIME-GRAD Includes transitions SCHOL-ARSHIP > SCHOLARSHIP-LOST Do not include transitions SCHOLARSHIP-LOST > {EARLY-DROPOUT, LATE-DROPOUT, LATE-GRAD, ON-TIME-GRAD}	Figure 3 Figure 4 Figure 5 Figure 6	Includes transitions SCHOL-ARSHIP-LOST > LOAN Includes transitions SCHOL-ARSHIP-LOST > SELF-FUNDED	F2

Table 5 (continued)

Analysis	Node type	Transition type	General filters	Figure or table	Additional filters	Finding
Curricular progress of those for whom the BS ended	Average progress per semester	Percentage of students	Final states: EARLY-DROPOUT, LATE-DROPOUT, LATE-GRAD, ON-TIME-GRAD	Figure 7		F3
	Average number of semesters	Number of students	Include transitions SCHOLARSHIP > SCHOLARSHIP-END Do not include transitions SCHOLARSHIP-END > {EARLY-DROPOUT, LATE-DROPOUT, LATE-GRAD, ON-TIME-GRAD}	Figure 8		

Table 5 describes the different analyses performed to address the research question, including the identification of the educational funding trajectory models created: primary and secondary node types, primary and secondary transition types, and filters applied. The filters that were applied to the model helped us analyze the behavior of students who met specific criteria. We used general filters for an overall analysis of each finding and additional filters to select specific transitions. The combination of these filters facilitated the construction of figures and tables that supported the findings.

For the first analysis, regarding the maintenance or loss of the BS, general filters correspond to the final state events, as defined in Table 2, whereas additional filters correspond to the conditions associated with the maintenance, loss or ending of the BS. For the second analysis, which focused on students who lost the BS, general filters enabled us to identify students who lost the BS but remained in their programs for at least one semester afterward. Additional filters allowed us to identify those who chose LOAN or SELF-FUNDED after losing the BS. For the third analysis, which focused on students for whom the BS had ended, we employed general filters to identify students whose BS had ended but who remained in their programs for at least one semester afterward.

We utilized four distinct tools to analyze educational funding trajectories: We analyzed the maintenance or loss of the BS with a Sankey diagram (Soundararajan et al., 2014). In this kind of diagram, flows represent the relationship between different nodes in a network; the thickness of the flow is proportional to the magnitude of the relationship. In our case, nodes represent events in the educational funding trajectory of students, and flows represent the transitions between those events. We analyzed the curricular progress of the students who changed their funding method using DFGs (Van der Aalst, 2019) and classification and regression trees (CART). To evaluate the statistical significance of the results, we applied the Fisher test.

Results

In this section, we present the three main results obtained in the discovery and analysis stages of the PM² methodology to answer the research question.

(F1) The maintenance or loss of the BS relates to the final state reached

Figure 2, depicted through a Sankey diagram, illustrates that a high proportion of the flow passing through SCHOLARSHIP-LOST resulted in dropout. Figure 2 also shows that the proportions of flows from SCHOLARSHIP-LOST to each state that represents dropout are remarkably similar (all of the values are presented in Table 6). In contrast, most of the flow originating from SCHOLARSHIP-END leads to LATE-GRAD. This indicates that a significant number of students who fulfilled the maintenance requirements but stayed in the curriculum longer than the nominal duration ended up graduating late (80.5%, as shown in Table 6). Finally, Fig. 2 illustrates the main flow originating from Maintain SCHOLARSHIP leading to either on-time graduation (ON-TIME-GRAD) or voluntary early dropout (EARLY-DROPOUT-VOLUNTARY). Table 6 shows the specific percentages for these states: 22.5% for EARLY-DROPOUT-VOLUNTARY and 68.8% for ON-TIME-GRAD.

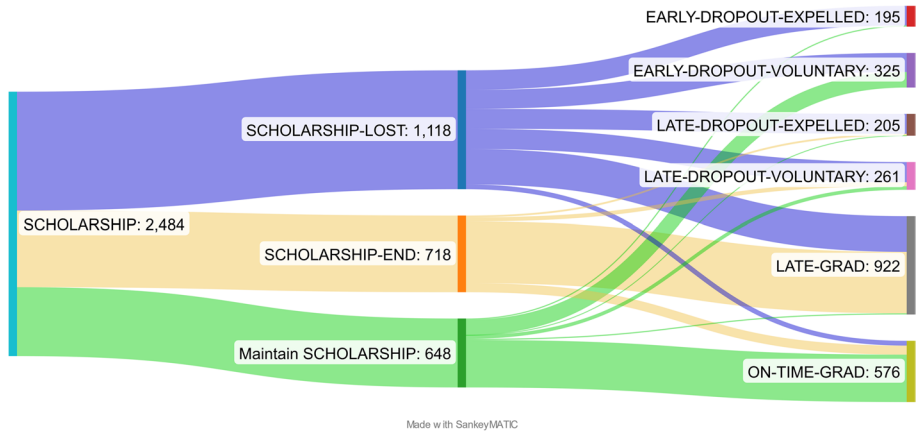


Fig. 2 A Sankey diagram that represents the educational funding trajectories according to the SCHOLARSHIP-LOAN-SELF-FUNDED model. It includes only the events associated with the scholarship, as well as the final states reached by the students

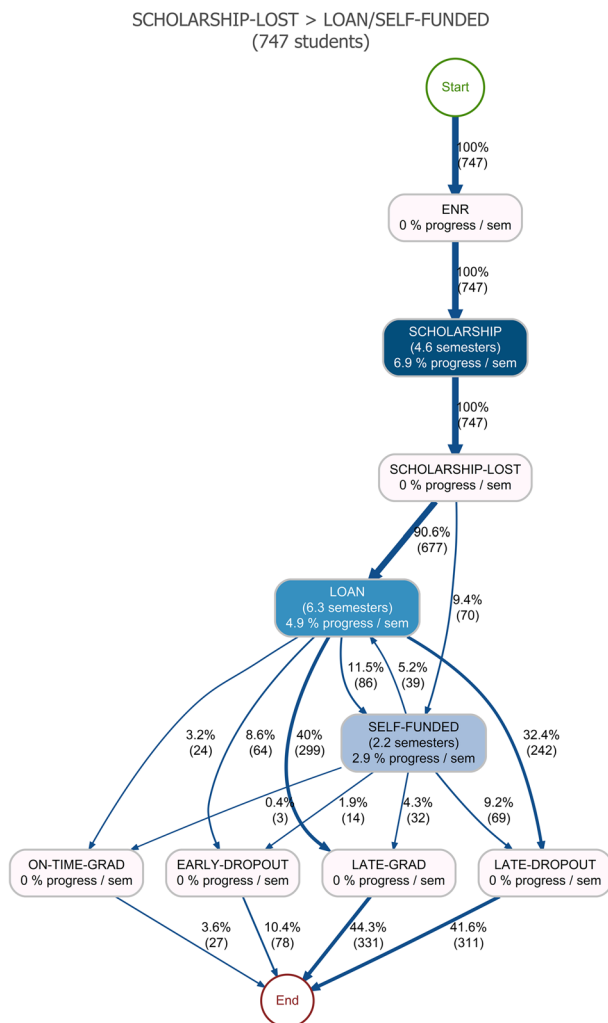
(F2) Scholarship loss relates to changes in curricular progress and graduation rates

Figure 3 shows that for students who did not drop out immediately after losing their BS, the average curricular progress per semester was slower than before. When students had the BS, the average curricular progress per semester was 6.9%. Then, 90.6% of the students transitioned from SCHOLARSHIP-LOST to LOAN, experiencing an average curricular progress of 4.9% per semester, while for those who transitioned to SELF-FUNDED, this figure was only 2.9%. The differences were statistically significant ($p < 0.01$).

The graduation rate was lower for students who chose to finance tuition themselves after losing the BS. Figure 4 shows that 49.6% of the students who had SCHOLARSHIP-LOST > LOAN transitions graduated (3.1% finished ON-TIME-GRAD and 46.5% LATE-GRAD), while Fig. 5 shows that 31.5% of the students who had SCHOLARSHIP-LOST > SELF-FUNDED graduated (8.6% finished ON-TIME-GRAD and 22.9% LATE-GRAD). The differences were statistically significant ($p < 0.01$). Even though Figs. 4 and 5 include transitions from LOAN to SELF-FUNDED or from SELF-FUNDED to LOAN, these transitions occur at a low frequency.

Figure 6 illustrates a CART that provides insights into the factors influencing the final state of students who lost their BS but remained in their programs. Three key variables were considered in this CART model: cumulative progress at the time of BS loss, ISCED field, and gender. At the initial level, cumulative progress less than 16% at the time of scholarship loss indicates a higher likelihood of dropping out (42.2%), while higher cumulative progress suggests a greater chance of late graduation (53.4%). Gender becomes a distinguishing factor only at the third level, among those with accumulated progress between 7 and 16%. Female students exhibited an early dropout rate of 40.9%, whereas male students experienced late dropout at a rate of 56.1%. For students with accumulated progress greater than or equal to 26%, the ISCED field became influential. Among those studying agriculture, arts and humanities, education, and sciences, 51.9% experienced late dropout. In contrast, students from other ISCED fields exhibited a late graduation rate of 63.2%.

Fig. 3 Only students who had a SCHOLARSHIP > SCHOLARSHIP-LOST transition and direct transitions from SCHOLARSHIP-LOST to LOAN or SELF-FUNDED were included. A darker node represents greater curricular progress per semester

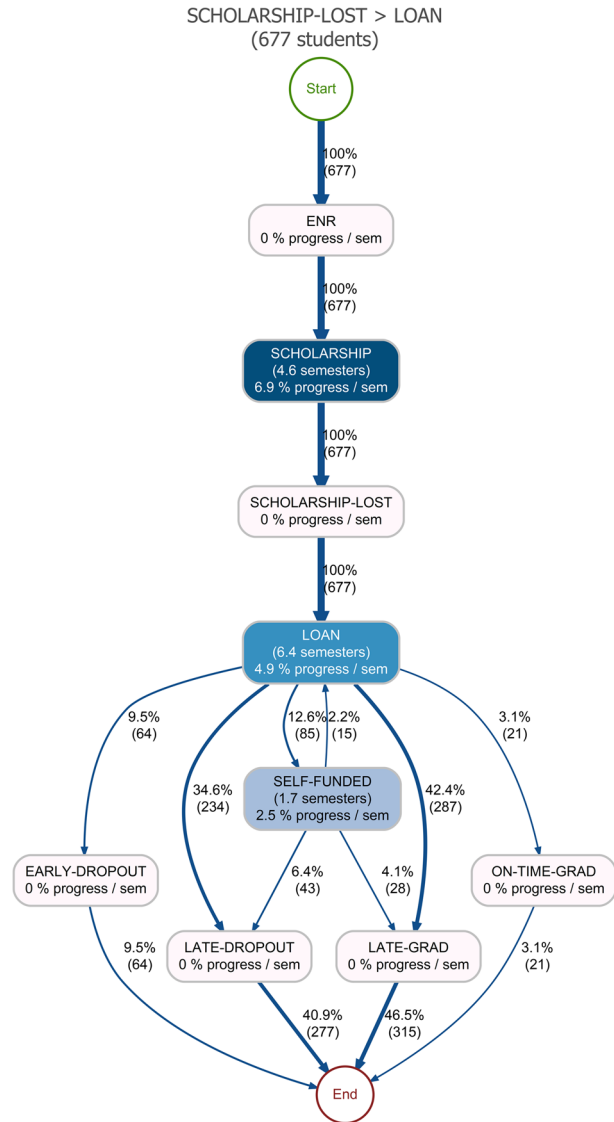


(F3) The students for whom the BS had ended subsequently experienced slower curricular progress

Figure 7 shows that the average curricular progress per semester after the SCHOLARSHIP-END event was slower than before. While the students maintained the BS, they had on average 9% progress per semester. After SCHOLARSHIP-END, students who chose to use a LOAN to continue had, on average, 3.9% progress per semester. The students who opted to be SELF-FUNDED had, on average, only 2.1% progress per semester. The differences were statistically significant ($p < 0.01$).

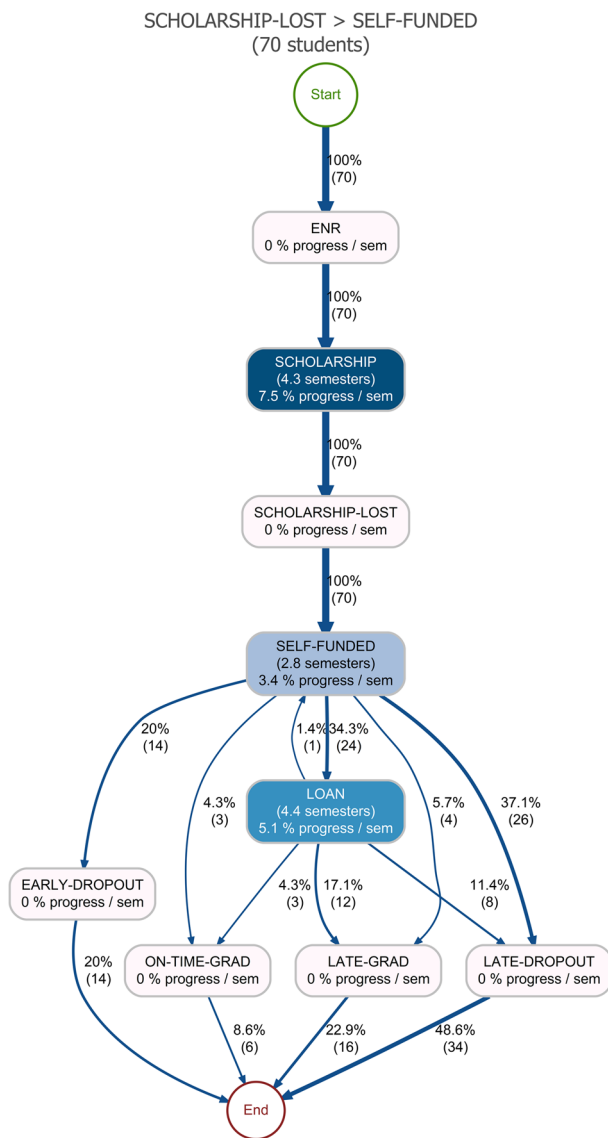
Figure 8 illustrates a CART analysis revealing factors influencing the funding method chosen after the BS ended. Three key variables were identified in the model: cumulative progress at the time of BS ending, gender and ISCED field. At the first level, cumulative progress less than 98% at the time of BS ending indicates a higher likelihood of choosing a LOAN. Below this cumulative progress, the ISCED field influences this decision. Students in the arts and

Fig. 4 Only students who had a SCHOLARSHIP-LOST > LOAN transition were included. A darker node represents greater curricular progress per semester. The thickness of the arrows represents the percentage of students who had transitions between two nodes



humanities, education, engineering, industry and construction, and health and social services chose LOAN in 88.1% of the cases, while students from the sciences, agriculture, social sciences, commercial education, and law chose LOAN in 47.1% of the cases (SELF-FUNDED in 52.9% of the cases). The model revealed no significant relationship between gender and funding method.

Fig. 5 Only students who had a SCHOLARSHIP-LOST > SELF-FUNDED transition were included. A darker node represents greater curricular progress per semester. The thickness of the arrows represents the percentage of students who had transitions between two nodes



Discussion and Conclusion

By analyzing the educational funding trajectories for students who began with the BS, this study advances the academic understanding of how the different means of financing tuition are related to dropout, academic progress, and graduation.

The main contribution of this work is to examine the relationship between the loss of a need- and merit-based scholarship and students' educational trajectories in terms of funding, curricular progress, and graduation rates, addressing this through a curricular analytics approach and discussing the results obtained through recent research. This

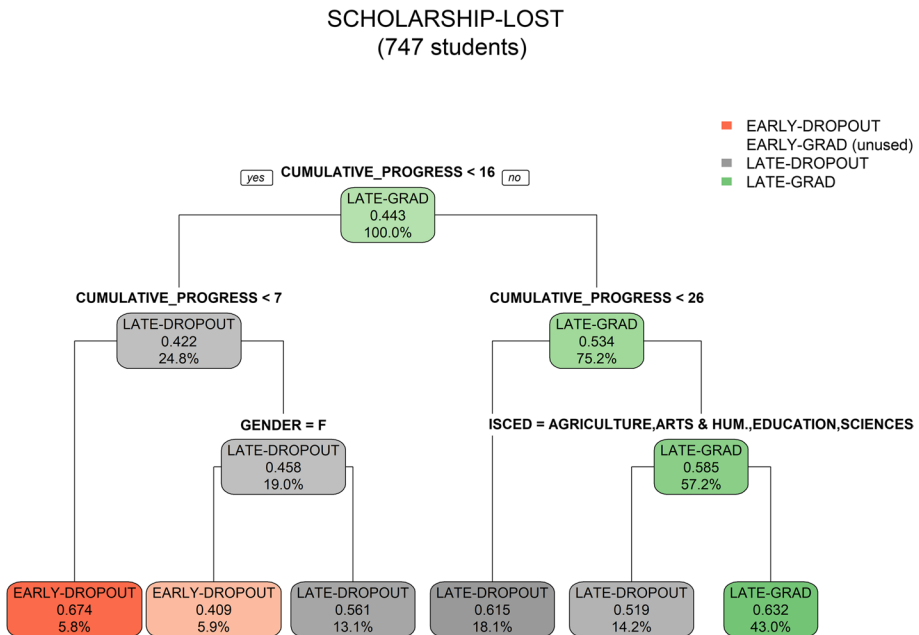


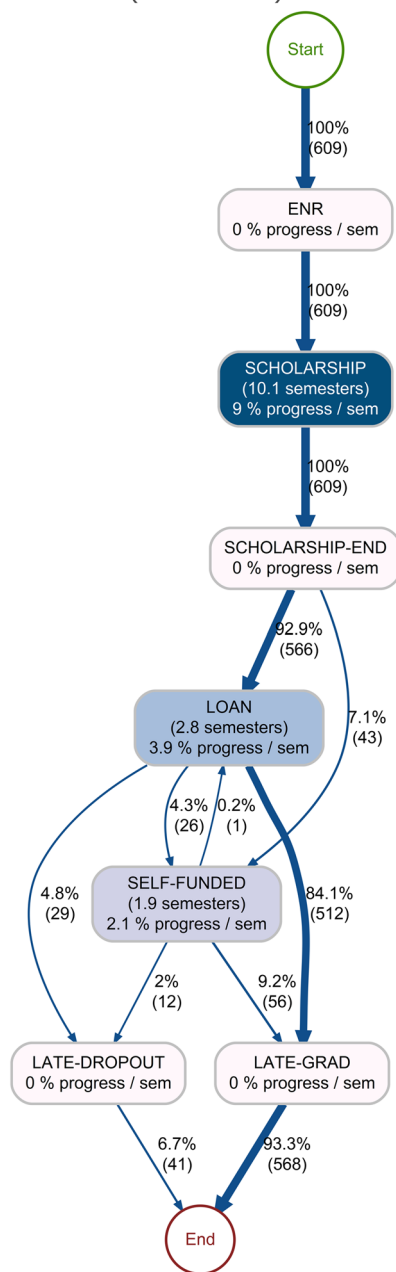
Fig. 6 Classification and regression tree (CART) that includes students who had a SCHOLARSHIP-LOST > LOAN or SCHOLARSHIP-LOST > SELF-FUNDED transition. The outcome is the final event in the educational funding trajectory. The variables are cumulative progress at the time of BS loss, student's gender, and ISCED field

approach can aid in understanding the educational funding trajectories of students from a longitudinal perspective, helping to elucidate their decision processes.

Next, the findings of this research are discussed, considering the previous literature. First, the maintenance or loss of the BS relates to the final state reached (**F1**). According to the rational choice model of educational decisions (Breen & Goldthorpe, 1997), the cost of education and the perceived returns relate to commitment. For students who lost the BS, government loans in Chile covered tuition only up to the reference amount, leaving the students or their families responsible for the remaining difference. Consequently, most students who lost their scholarships dropped out afterward. In addition to the difference between full tuition and the reference amount, a fear of debt and a perception of low utility in taking on debt, particularly among low-SES students, may influence dropout decisions (Long, 2021). These cultural factors are often transmitted along family lines (Almenberg et al., 2021). On the one hand, the majority of students who maintained the scholarship successfully graduated. However, nearly half of the students reached the time limit of the BS before graduation. Imposing lifetime aid limits, as suggested by Mabel (2020), can enhance commitment to on-time graduation. For those whose scholarship ends before graduation, government loans are an alternative. Based on this, we can hypothesize that students who made significant progress while on the BS are likely to exhibit greater commitment to completing their studies, driven by the desire to minimize future study costs (Zainol et al., 2018). The significance of this finding is that it links the maintenance or loss of a Chilean need- and merit-based scholarship to dropout and graduation rates, despite these outcomes occurring several semesters after

Fig. 7 Only students who had a SCHOLARSHIP > SCHOLARSHIP-END transition and direct transitions from SCHOLARSHIP-END to LOAN or SELF-FUNDED were included. A darker node represents higher curricular progress per semester

SCHOLARSHIP-END > LOAN/SELF-FUNDED
(609 students)



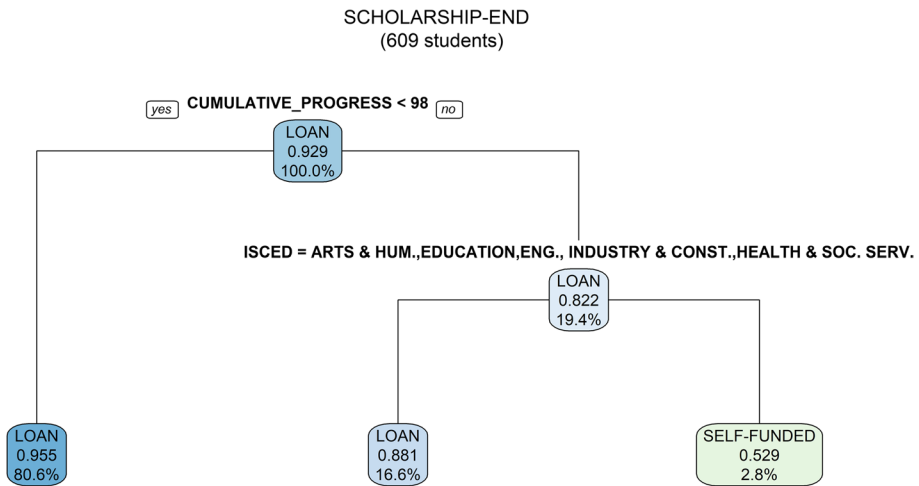


Fig. 8 Classification and regression tree (CART) that includes students who had a SCHOLARSHIP-END > LOAN or SCHOLARSHIP-END > SELF-FUNDED transition. The outcome is the funding method chosen after ending BS. Variables are cumulative progress at the time the BS ended and the ISCED field

changes in funding. Policy-makers can benefit from understanding the long-term effects of need- and merit-based scholarships on dropout, progress, and degree completion.

Second, curricular progress per semester was slower after students lost the BS (**F2**) or after their BS ended (**F3**). Low-SES students may have financial needs beyond tuition that are not met with scholarships (Dente & Piraino, 2011; Zembrodt, 2019). Low-SES students may need to finance transportation, school supplies, or living expenses. In particular, the literature states that part-time work could reduce progress in their studies (Thies, 2022) and the likelihood of degree completion (Almenberg et al., 2021) because students may underestimate the academic costs of working while studying (Long, 2021). Therefore, students may require assistance in effectively balancing their part-time work commitments with their academic load to fulfill the maintenance requirements of the BS.

Although more than 90% of students whose BS ended or was lost opted for a loan to finance their studies, those whose BS ended exhibited a greater decline in semester progress than those who lost their BS. A possible explanation for this is that students whose BS ended were closer to graduation, leading a higher proportion to seek part-time or full-time employment (Carruthers & Özek, 2016). While more than 90% of students whose BS ended eventually graduated, the restrictive duration of the BS, limited to the nominal duration of the curriculum, proved detrimental, leading to delays in graduation. Figure 7 illustrates this behavior, showing that students whose BS ended need an average of 2.8 semesters to complete the final 11% of the curriculum. This observation aligns with the findings of Mabel (2020).

In addition to borrowing, there are two main differences between the BS and the Chilean government loans. First, the students must finance the remaining difference between full tuition and reference tuition by themselves. Second, they are not eligible for the BMES scholarship. When students have to engage in part-time work or lack sufficient funds for living expenses, they can compromise their dedication to their studies. This could have implications not only for their curricular progress but also for their degree of attainment.

Table 6 Number and percentage of students who started with the BS, broken down by final state and last event associated with the BS

Final state	SCHOLARSHIP-LOST		SCHOLARSHIP-END		Maintain SCHOLARSHIP		Total	
	# Students	% Students	# Students	% Students	# Students	% Students	# Students	% Students
EARLY-DROPOUT-EXPELLED	184	16.5%	0	0.00%	11	1.7%	195	7.9%
EARLY-DROPOUT-VOLUNTARY	179	16.0%	0	0.00%	146	22.5%	325	13.1%
LATE-DROPOUT-EXPELLED	187	16.7%	17	2.4%	1	0.2%	205	8.3%
LATE-DROPOUT-VOLUNTARY	190	17.0%	38	5.3%	33	5.1%	261	10.5%
LATE-GRAD	333	29.8%	578	80.5%	11	1.7%	922	37.1%
ON-TIME-GRAD	45	4.0%	85	11.8%	446	68.8%	576	23.2%
Total	1118		718		648		2484	

Among students who lost the BS but remained in their programs, those with less cumulative progress were more likely to drop out. Interestingly, within this group, female students tended to drop out earlier than male students, possibly due to their greater aversion to debt (Almenberg et al., 2021). Among students who lost the BS with cumulative progress above 26% but continued in their programs, dropout rates varied across ISCED areas. Students in agriculture, arts and humanities, education, and sciences had higher dropout rates. Two hypotheses for this are differences in financial literacy and subjective evaluation of loan costs and benefits (Cho et al., 2015).

The contribution of these findings is that they quantify, for this study, the average reduction in curricular progress after the loss or the end of this need- and merit-based scholarship according to the main means of funding chosen by the students.

In conclusion, the findings presented in this study have both theoretical and practical implications for dropout and late graduation associated with funding. HEIs should design curricula considering the maintenance requisites of financial aid. In this case, students must pass at least 70% of the enrolled courses each year to maintain the BS. Therefore, these requisites should be considered in study plan design so that multiple high-failure rate courses are not taken within the same semester. Universities should implement mentoring and support programs to prevent the loss of the BS. According to Nguyen et al. (2019), providing multidimensional support, such as proactive advising, academic tutoring, and supplementary services, can help students maintain academic performance and meet maintenance requirements. It can also guide students in addressing their unmet financial needs (Zembrod, 2019). Carruthers and Özek (2016) suggest the idea of implementing “nudges” (small economic incentives) as a cost-effective approach to improving students’ adherence to requirements. Finally, promoting financial literacy among low-SES students can foster a more informed approach to managing debt (Almenberg et al., 2021; Long, 2021). Governments should balance the eligibility criteria and maintenance requisites to encourage progress and on-time graduation without increasing early loss or dropout (Mabel, 2020).

PM supports a comprehensive understanding of students’ dynamic behavior over time, including the identification of decision points and the events preceding and following them. Moving forward, future research should aim to apply the SCHOLARSHIP-LOAN-SELF-FUNDED model in diverse contexts, encompassing variations in curricula, student profiles, and financial aid designs. Researchers can also utilize this technique as a complement to causal studies and enrich their understanding by integrating qualitative research. We believe that researchers can use this technique to identify decision points and understand the events preceding and following those decision points, the frequencies of transitions between states, and the variables that they could then use in a causal study. Qualitative methods can also be integrated with PM (Koorn et al., 2021) and used to elucidate how psychological characteristics, contextual information, and other factors, such as debt aversion, part-time work, and liquidity constraints, influence academic progress and persistence.

We identified three main limitations of this study that readers should consider. First, our results are related to a specific study that included curricula and educational policies in force at a Chilean university. This context-specific nature of the study may limit the external validity of the findings. Nevertheless, we believe that researchers can use the SCHOLARSHIP-LOAN-SELF-FUNDED model in diverse contexts. Furthermore, we believe that the main findings of this research are likely to hold true for other need- and merit-based scholarships, as supported by the current literature. In summary, this article contributes to the understanding of how governments should participate in financing university education, a topic of significant relevance not only in Chile but also in countries such as the

United States (Long, 2021), Canada (Lang, 2022), and the UK (Marginson, 2018). Second, the information we had regarding the students and their educational trajectories was limited to the curriculum, the BS, and government loans. There could be additional variables influencing educational trajectories apart from the funding, which is the focus of this study. For example, we lacked contextual information about the students, including their physical and mental health, parental support, and living conditions. Third, the conclusions obtained through PM depend on the completeness of the information used (Bose et al., 2013). In this particular case, there was no available information regarding transferred students, and it is possible that the institution recorded transfer credits as approved within the new program. However, less than 5% of the students were transfer students; therefore, we expect that the effect on the progress analysis is negligible.

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- Data curation: Juan Pablo Salazar-Fernandez.
- Software: Juan Pablo Salazar-Fernández.
- Methodology: Juan Pablo Salazar-Fernandez, Jorge Munoz-Gama, and Marcos Sepúlveda.
- Writing—original draft: Juan Pablo Salazar-Fernandez.
- Writing—review and editing: Juan Pablo Salazar-Fernandez, Marcos Sepúlveda and Jorge Munoz-Gama.
- Supervision: Marcos Sepúlveda and Jorge Munoz-Gama.
- Validation: Marcos Sepúlveda and Jorge Munoz-Gama.

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Data availability Due to institutional restrictions, the anonymized student data is not available. However, the event log and the supporting R code for the findings of this study are accessible upon reasonable request to the corresponding author, Juan Pablo Salazar-Fernandez.

Declarations

Conflict of interest • Juan Pablo Salazar-Fernandez has received research support from National Agency for Research and Development (ANID) – Scholarship Program/Doctorado Nacional 2015 – 21150985.

• Juan Pablo Salazar-Fernandez receives a salary from Universidad Austral de Chile. He is an assistant professor.

• Marcos Sepúlveda has received research support from National Agency for Research and Development (ANID)/FONDECYT—Chile Regular Project—1200206.

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