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The Vertical Transfer Pipeline and Its Leaks: Tracking Students From Associate's Programs to Bachelor's Degrees

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Abstract

This longitudinal study of 17,455 students, the majority from underrepresented groups, investigated leaks in the vertical transfer pipeline from associate's-degree program entry to bachelor's-degree receipt. Investigated were both the size of the leaks and some associated variables. Pipeline progress examinations included quantification of early persistence, plus application to, enrollment and persistence in, and graduation from, bachelor's programs. The examined associated variables included student demographic characteristics and possible pipeline leak malleable factors: academic preparation and performance and financial need. Overall, only 23% of the original cohort received a bachelor's degree after eight years. In addition, this study is the first to identify and quantify the transfer melt leakage point (students accepted for vertical transfer who do not enroll in bachelor's programs), and the first to have quantified transfer shock (a transfer-related decrease in GPA) in a large general cohort (shown by 16 percentage points of the cohort). Variables involving quicker degree progress (e.g., being exempt from remediation and enrolling full-time) were negatively associated with pipeline leaks. Together the results provide guidance for policymakers and practitioners regarding how to increase vertical transfer pipeline output and increase bachelor's degrees by community college students, particularly those from underrepresented groups, thus increasing higher education equity.

Keywords: transfer, associate's degree, bachelor's degree, graduation, equity

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The Vertical Transfer Pipeline and Its Leaks: Tracking Students From Associate's Programs to Bachelor's Degrees

College students who transfer between institutions constitute a substantial population on which to focus the facilitation of postsecondary success. Nearly 40% of students transfer between colleges at some point during their college careers (National Student Clearinghouse Blog, 2018). The largest proportion of these transfer students consists of vertical (or upward) transfer students who transfer from an associate's- to a bachelor's-degree program (Shapiro et al., 2018; Turk & Chen, 2017). This relatively large proportion is not surprising given that about 42% of postsecondary students begin college in associate's-degree programs (Shapiro et al., 2018) and over 80% of those students have a goal of attaining at least a bachelor's degree (Horn & Skomsvold, 2011), which usually necessitates vertical transfer. Attaining a bachelor's degree is consequential: The median annual earnings of workers with bachelor's degrees are $15,000 higher than those of workers with only associate's degrees (Ma et al., 2019). The present study examined the vertical transfer pipeline, quantitatively tracking the progress of a cohort of students from community college entry to bachelor's degree receipt and identifying variables associated with that progress. The study's goal was to obtain information that can assist administrators, staff, and policymakers in maximizing students' progress through the pipeline.

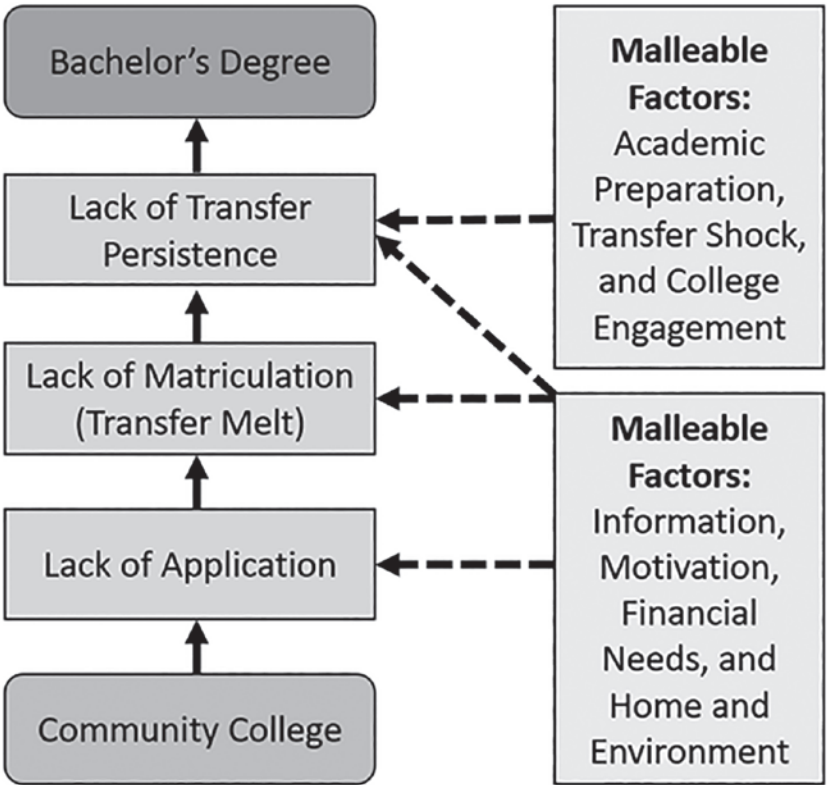
The Vertical Transfer Pipeline Leaks

Unfortunately, the vertical transfer pipeline has large leaks. Six years after entering community college, only 11% of students have attained a bachelor's degree (National Center for Education Statistics, 2020). Figure 1 is a conceptual diagram of the vertical transfer pipeline and some of its leaks: lack of application, lack of matriculation (transfer melt), and lack of transfer persistence.

Lack of application refers to cases in which an associate's-degree student does not apply to transfer to a bachelor's program. There has been limited quantitative study of application or lack of application to transfer. Within a California program guaranteeing transfer admission to a University of California campus, 8,187 students applied in 2017 and 13,031 applied in 2021 (Burke, 2022). Using national data, Nietzel (2022) reported that over a third of 372 community college students in the Transfer Scholars Network program applied for transfer to that network's bachelor's-degree colleges. However, no studies have examined the number of students in a general cohort who did and did not apply for vertical transfer.

Transfer melt is our new term for cases in which an associate's-degree student is accepted to transfer to a bachelor's program but does not matriculate. Transfer melt is analogous to the term summer melt, used to describe high school graduates who are accepted to college but do not matriculate (Castleman & Page, 2014). As for lack of application,

Figure 1. Leaks in the Vertical Transfer Pipeline Plus Malleable Factors That May Affect Pipeline Leaks



there are some relevant California data concerning transfer melt. Burke (2022) reported that, in fall 2021, 13,031 California community college students who had a transfer admission guarantee applied to transfer to a University of California institution, about 99% were accepted, and 82% enrolled in a University of California institution (enrollments in other institutions were not reported). Burke further reported, concerning California community college students more generally, that 38,917 applied to transfer to the University of California, about 72% were accepted, and about 72% of those accepted actually enrolled in a University of California institution (again, enrollments in other institutions were not reported). A 2017 report from the National Association for College Admission Counseling (NACAC) stated that 65% of all students (not just community college students) who applied to transfer to a bachelor's program actually enrolled (Clinedinst & Koranteng, 2017). However, no studies have examined the number of community college students in a general cohort who did and did not enroll anywhere after acceptance to a bachelor's program.

The third leakage point is *lack of transfer persistence*—cases in which students vertically transfer but do not complete a bachelor's degree. There have been many studies of lack of transfer persistence. For example, in 2021, the National Student Clearinghouse (NSC), which regularly issues reports on student success measures, reported that the one-semester persistence rate for all vertical transfer students was 89%. In a 2020

report, the National Center for Education Statistics (NCES) reported that 43% of students who had transferred vertically earned a bachelor's degree within six years of beginning college, and another 15% were enrolled in a bachelor's program.

The leaks in the vertical transfer student pipeline disproportionately harm Black, Hispanic, and financial-aid-recipient students (Logue, 2021). Although students from these groups are overall underrepresented in higher education, there are higher percentages of them in associate's than bachelor's programs (National Center for Education Statistics, 2021; Radwin et al., 2018). Therefore, anything that makes it more difficult for vertical transfer students to receive a bachelor's degree compared to students who start college in a bachelor's program will be more likely to harm students from those underrepresented groups, an example of higher education inequity. Consider, for example, the lack of application and transfer melt leakage points which, by definition, do not exist for students who begin college in bachelor's programs.

Malleable Factors

To help students successfully traverse the vertical transfer pipeline, we need to know what aspects of students' environments that can be changed are likely to decrease the pipeline leaks. In other words, what are the pipeline leaks' malleable factors (Sutcliffe & Condliffe, 2020)? Figure 1 lists some possible malleable factors including, at all stages of the pipeline, the information students receive about transfer, factors affecting students' motivation and financial needs, and other aspects of students' home environments. In the posttransfer part of the pipeline, Figure 1 also lists factors related to students' academic preparation, transfer shock (a decrease in grade point average [GPA] after transferring; Hills, 1965), and college engagement.

Malleable Factors Related to All Pipeline Stages

Many malleable factors can be subsumed under Laanan's concept of Transfer Student Capital, which consists of all knowledge and experience that transfer students have. The greater a student's Transfer Student Capital, the more likely a student is to transfer and graduate successfully (Laanan et al., 2010–2011). The accumulation of transfer student capital is a function of the frequency and quality of advising, and of other sources of transfer-related information (e.g., from websites or orientations), as well as of the transparency and simplicity of transfer procedures and the availability of other transfer student support services. Transfer student capital and its components have been reported as critical in transfer student success (e.g., Hayes et al., 2020; Schudde et al., 2020). A related concept, navigational capital ("skills of maneuvering through social institutions" including "through institutions not created with Communities of Color in mind;" Yosso, 2005, p. 80) may be particularly relevant for college student populations with relatively high frequencies of students from underrepresented groups.

Another possible malleable factor relates to students' financial needs. Many organizations and policymakers have emphasized the importance of attending to these needs for transfer students to be successful (e.g., Tackling Transfer Policy Advisory Board, 2021; Turk & Chen, 2017; Wyner et al., 2016). In a large survey, vertical transfer students have reported more food insecurity than other students (Logue et al., 2022a). Based on interviews and focus groups with 33 pre- and post-vertical transfer students, Nahlik et al. (2023) concluded that both sending and receiving vertical transfer institutions need to provide clear information on financial aid processes. Rutschow et al. (2017) demonstrated that financial aid, such as statewide scholarship programs, seemed to facilitate successful vertical transfer.

Possibly related to the potentially malleable factors of motivation and engagement, students have more opportunities to engage with college if they attend full- rather than part-time, accumulate more credits, and enroll continuously (Anzelone et al., 2020). In addition, being assigned to remediation is negatively associated with vertical transfer student success (e.g., Chen & Simone, 2016).

There have also been studies of aspects of students' home and nonacademic environments—some of them malleable and others not—that may be associated with vertical transfer success. One example is the amount of work a student does outside of college, which has a complex relationship with whether a student transfers (National Center for Education Statistics, 2020). In addition to traditional employment, one survey found that approximately one third of vertical transfer students were caring for someone more than 10 hours per week (Logue et al., 2022a). Transportation time and cost have been relatively unexplored variables. Even public transportation costs can add up quickly when a student is having to commute among home, school, and work. In addition, most students experience major life events, such as financial disruption or the death of a close family member, events that can derail the college careers even of students with many resources (Cox et al., 2016). Although some of these environmental factors are not malleable, at least not by institutions of higher education, their negative effects can be meliorated, such as by providing students with books and childcare; a free van to campus can make a difference (Moore & Molless, 2022). More generally, completing college as quickly as possible (by enrolling full-time and not stopping out) can help maximize vertical transfer and graduation—the longer college takes, the more opportunity there is for students to experience events that will make it difficult or impossible for them to continue their educations (Park, 2015).

Malleable Factors Related to Posttransfer Pipeline Stages

Academic knowledge and preparation have also been named as critical in posttransfer student success. One survey found that bachelor's college faculty often believe that vertical transfer students are not well prepared and that getting good grades posttransfer is uncommon (Rabinowitz et al., 2023). However, given that about half of students who leave college are in good academic standing, it has been argued that variables other than academic preparation are critical in posttransfer student success (Abele, 2021). Monaghan and Attewell (2015) found that institution-effected credit loss, not

inadequate academic preparation, was primarily related to vertical transfer students' lack of success. Consistent with these findings, research has found that whether or not vertical transfer students transfer having attained the associate's degree is not related to the attainment of a bachelor's degree (Turk, 2018; Wang et al., 2017).

Since Hills (1965) found that transfer shock is associated with a decreased probability of graduation, another possible set of malleable factors, those related to transfer shock, have been extensively studied. Some studies have found that, on average, students' GPAs decrease by approximately one point after transfer (Lui, 2013), the degree of grade decrease differs by discipline (Cejda, 1997), and that there is a recovery phase after transfer shock, with transfer students tending to do as well or better than non-transfer students by the end of the second posttrransfer semester (Glass & Harrington, 2002). Other studies, however, have not found strong evidence of transfer shock (e.g., Aulck & West, 2017). A recent study of more than 25,000 students who had transferred to a large, flagship university, almost three quarters of whom were White, found that 63% of the sample experienced a GPA drop (transfer shock) in the semester following transfer, and the larger the GPA drop, the more likely a student was to leave college (Jaggars et al., 2023).

A sense of belonging, as well as what could be considered its cause or expression, college engagement, have also been studied as possible vertical transfer success malleable factors, particularly following transfer. A sense of belonging results from "the perceptions of belonging students derive from their daily interactions with other students, faculty, staff, and administrators on campus and the messages those interactions convey about their belonging" (Tinto, 2017, p. 258). Multiple studies have shown that a sense of belonging is associated with college student success, including in transfer students (e.g., Anistranski & Brown, 2023; Moore, 2022; Nora & Rendon, 1990). Racial-ethnic minority students and first-generation college students have been found to demonstrate a greater sense of belonging when enrolled in associate's, as compared to bachelor's, programs (Gopalan & Brady, 2020), possibly due to the greater ability of racial-ethnic minority students in associate's programs to maintain connections with their ethnic communities and identities, reinforcing these students' sense of self-worth (Gummadam et al., 2016). Similarly, Logue et al. (2022a) found, in a sample of vertical transfer students, a majority of whom were from underrepresented groups, greater reported belongingness and college engagement in associate's, as opposed to bachelor's, programs. All these findings have particular salience for vertical transfer students, who begin college in an associate's program and transfer to a bachelor's program.

Demographic Characteristics

Most of the studies reviewed here have examined the relationships between various student demographic characteristics (e.g., students' age, gender, and race/ethnicity) and transfer student success. These demographic variables are not malleable factors.

However, information about these variables' relationships with transfer student success, especially when combined with research on other malleable variables, can assist practitioners and policymakers in identifying ways to enhance transfer student success in particular populations and situations.

Strategies for Studying the Vertical Transfer Pipeline

One way to examine transfer student success would be to determine, at a particular point in time, how many students have succeeded in reaching various stages of the pipeline, i.e., the enrollment and transfer status of each student (a cross-sectional analysis). An example of such an analysis is shown in Table 1. This analysis shows that in fall 2019, 54.8% of the bachelor's-degree students in The City University of New York (CUNY) system were transfer students of some sort, and 29.5% of the bachelor's students had previously matriculated at a CUNY community college (i.e., they were CUNY vertical transfer students). These data demonstrate that CUNY's enrollment consists substantially of transfer students, and that many CUNY vertical transfer students are able to traverse the pipeline to bachelor's program enrollment. However, although this information is useful, such an analysis cannot provide us with information about the different vertical transfer pipeline leakage points—how likely students are to leak out of the pipeline at different points, and what variables are associated with each of the leaks. There can be many students at the end of the pipeline despite many leaking out while traversing it.

To determine how likely students are to leak out of the vertical transfer pipeline at different points, a longitudinal analysis is needed—an analysis that closely tracks, for multiple years, the same cohort of students, starting with initial community college entry, and includes examination of variables associated with those leaks. Such an analysis would provide us with information that could be useful in decreasing the leaks.

There have been multiple previous longitudinal quantitative studies of transfer student success (e.g., Bahr et al., 2022; Jaggars et al., 2016; Monaghan & Attewell, 2015; Pretlow et al., 2022; Spencer, 2023). These studies tracked, for long periods, community college students' progress, including whether they attained bachelor's degrees. The data have included enrollment and graduation rates, but not any data specifically addressing lack of application, transfer melt, or transfer shock (however Zhang, 2022, did find a positive association between posttransfer GPA and completion of a STEM bachelor's degree). Although these studies followed large numbers of students over long periods of time, they did not assess leaks and malleable factors at specific points of the vertical transfer pipeline.

Table 1. Cross-Sectional Analysis of Fall 2019 CUNY Degree-Seeking Undergraduate Students, by Current Degree Program and Stage in the Transfer Pipeline

ASSOCIATE'S	
First-time Freshmen	18,516
Advanced Standing New Transfers	7,110
Continuing/Other	51,188
Subset: Started as freshman in CUNY CC	37,247
Semester 1–3	12,228
Semester 4–8	19,833
Semester 9+	5,186
Associate's total = 76,814	

BACHELOR'S	
First-time Freshmen	15,185
Advanced Standing New Transfers	14,286
Subset: Have prior CUNY CC enrollment	8,544
Continuing/Other	77,874
Subset: 1st CUNY bachelor's semester was as FTF	33,370
Subset: Have prior CUNY CC enrollment	23,158
Bachelor's total = 107,345	

Associate's total + Bachelor's total = 184,159

Note. Data compiled by CUNY's Office of Applied Research, Evaluation, and Data Analytics (OAREDA). Included: data from CUNY's School of Professional Studies, which only accepts transfer students. Not included: data from CUNY's School of Labor and Urban Studies, which was founded in 2018 and as of Fall 2021 had only 51 bachelor's-degree students, and (consistent with the current paper's longitudinal analysis) data from CUNY's three comprehensive colleges, because these colleges offer both associate's and bachelor's programs and therefore some vertical transfer students at these colleges do not have to transfer between campuses as would a typical vertical transfer student. CC = community college; FTF = first-time freshmen.

Overall Goal and Research Questions

Given the frequency of vertical transfer, its critical role in higher education equity, and the limited nature of previous vertical transfer longitudinal quantitative studies, we conducted an eight-year, longitudinal study of 17,455 first-time college students in CUNY community colleges. Our overall goal was to quantify how many of these students progressed past major leakage points in the pipeline to a bachelor's degree and to identify variables associated with that progress, examining both leaks and some malleable factors. Our specific research questions included:

(1) Which stages of the vertical transfer pipeline evidence the largest leaks?
(2) Does GPA change immediately following transfer and do any such changes relate to vertical transfer success?
(3) Which types of students are most likely to leak out of the pipeline?

By conducting the first quantitative, longitudinal study of multiple, specific leakage points along the vertical transfer pipeline, we sought information that would help guide administrators, staff, and policymakers in maximizing the receipt of bachelor's degrees by community college students. After describing our methods, we present, first, overall longitudinal data, and then results for several pipeline individual leakage points, including results concerning variables associated with students reaching each of those points.

Methods and Results

Research Site

This research was conducted at CUNY, a higher education system that includes seven associate's-degree-granting community colleges and 13 bachelor's-degree-granting colleges. In fall 2019 (towards the end of the tracking period for the current study, and prior to the start of the COVID-19 pandemic), CUNY had 184,159 total degree-seeking undergraduates, of which 41.7% were enrolled in associate's programs and 58.3% in bachelor's programs (see Table 1). At CUNY, over 50% of the graduates of each of the colleges offering bachelor's (but not associate's) degrees consists of transfer students (Z. Tang, personal communication, June 14, 2021). More than 20,000 total students transfer into CUNY associate's or bachelor's programs each year, and the largest proportion of these (about one third) consists of within-CUNY vertical transfer students (CUNY Office of Institutional Research and Assessment, 2020b). At least two thirds of CUNY community college freshmen state that their goal is to attain at least a bachelor's degree (Logue et al., 2022a; C. Chellman, personal communication, November 2, 2021). Except for a few programs, CUNY community college students are not guaranteed acceptance to CUNY bachelor's programs. Consistent with national data, there are higher percentages of students from underrepresented groups in the CUNY community colleges than bachelor's colleges: The 2019 associate's program

percentages of Black/Hispanic, Pell recipient, first-generation, and first-language-other-than English college students were 67, 66, 65, and 42, respectively, while in the bachelor's programs they were 52, 58, 58, and 37, respectively (CUNY Office of Institutional Research and Assessment, 2020a). CUNY has a centralized data system, allowing the tracking of students for the full duration of their college trajectories. CUNY presents a unique opportunity for studying transfer, due to the university's large and diverse student population, system structure, and data availability (Vickery, 2023).

At CUNY each college sets its own admissions criteria, including for transfer admissions. In fall 2013, when the cohort studied in the present research entered college, CUNY effected a new set of transfer credit policies (Logue, 2017). Since that semester, all CUNY courses have transferred to all other CUNY colleges with at least elective credit. In addition, all bachelor's and Associate in Arts (AA) and Associate in Science (AS) degree requirements have included the same 30-credit common core (general education) requirement, and bachelor's degrees have included an additional 6–12-credit general education requirement. Notably, Associate in Applied Science (AAS) degree programs (which are considered terminal, not transfer, degrees) do not have these general education requirements so that, unlike AA and AS students, a CUNY AAS student often has many general education courses to complete after transferring to a bachelor's program, even if that student has attained their associate's degree. Also, in fall 2013, for the 10 bachelor's majors with the most transfer students, CUNY established a set of 3–5 courses that each college with the associate's or bachelor's version of that major must offer, so that students could start a major at any of those colleges and finish it seamlessly at any other CUNY college with that major. These policies facilitate credit transfer within the CUNY system. Transfer is likely to be more difficult for other transfer paths without such policies.

Dataset Construction and Cohort Characteristics

As described in the following sections, tracking a cohort of community college students through the vertical transfer pipeline requires many technical decisions regarding how to obtain, count, and analyze student data. To begin, we defined our cohort of interest as all fall 2013 full- and part-time first-time freshmen enrolled in any associate's-degree program at any of CUNY's seven community colleges (N = 17,455). We constructed a dataset for these students from several administrative sources containing enrollment and demographic student data. The enrollment data included semester-by-semester enrollment, grades, credits accumulated, and degrees earned through spring 2021 (eight academic years of data). The dataset also included information concerning vertical transfer applications to colleges within CUNY. For every semester after fall 2013 through spring 2020 we determined whether any cohort student applied to a bachelor's degree program through the central CUNY admissions process (less than 1% of the starting cohort applied to transfer to a bachelor's program after spring 2020).

To capture data concerning nonCUNY enrollment and graduation for students who transferred outside the CUNY system, the dataset also included data through spring 2021 from the NSC.

As shown in Table 2, students in our analysis cohort were a mean of 20.1 years old at college entry and were diverse in terms of racial/ethnic group (the cohort was 43.6% Hispanic, 27.9% Black, and approximately 14% each Asian and White). Most students (74.6%) were Pell recipients at college entry. Mean high school GPA was 75.7 (on a 100-point scale), and most students (73.2%) were assessed as needing remediation in at least one subject at college entry.

Table 2. Characteristics of Freshmen in Fall 2013 CUNY Community Colleges (N= 17,455)

Demographic characteristics	
% female	52.9
% American Indian	0.4
% Asian/Pacific Islander	14.3
% Black	27.9
% Hispanic	43.6
% White	13.8
Mean age in years at college entry (SD)	20.1 (4.4)
% Pell at college entry	74.6
% full-time at college entry	88.6
% AAS student at college entry	21.9
Academic preparation	
Mean high school GPA (SD)	75.7 (7.4)
% assigned to remediation: any	73.2
% assigned to remediation: math	67.4
% assigned to remediation: reading	23.7
% assigned to remediation: writing	27.1

Note. Missingness: Race/ethnicity data in CUNY's institutional databases are imputed so that there are no missing values. For Table 2, Pell status was missing for 3,549 students (888 students with an award amount of zero were counted as not receiving Pell), high school GPA was missing for 3,991 students, and remediation assignment status was unknown for 1,667 students (these cases were treated as not being assessed as needing remediation).

Overall Vertical Transfer Pipeline (Using CUNY and NSC data)

Figure 2 shows the percentages of students in the initial cohort who were still on the pathway to bachelor's completion at some of the key points along eight years of the pipeline. Each subsequent bar in this figure represents the percentage of the initial cohort that we were able to count as persisting until the given point. Note that the time periods from one bar to the next are not equal, and that the largest percentage drops (between the first and second bars, and between the second-to-last and last bars) are for the longest pipeline periods.

In the early semesters of college, we see high enrollment decreases—36.9% of students ceased attending before completing their second year of college. Regarding specific transfer-related events, 49% of students in the starting cohort (approximately three quarters of students who persisted until Semester 4) applied for transfer. A total of 44.4% of the initial cohort transferred to a bachelor's program. Of everyone in the initial cohort, 37.6% persisted to Semester 2 of a bachelor's program (84.7% of students who transferred). Finally, 23.3% of the initial cohort (62.1% of those who persisted to Semester 2) eventually earned a bachelor's degree. The following sections examine pipeline stages in detail.

Challenges Before Transfer

Persistence to Semester 4 (Using CUNY and NSC Data)

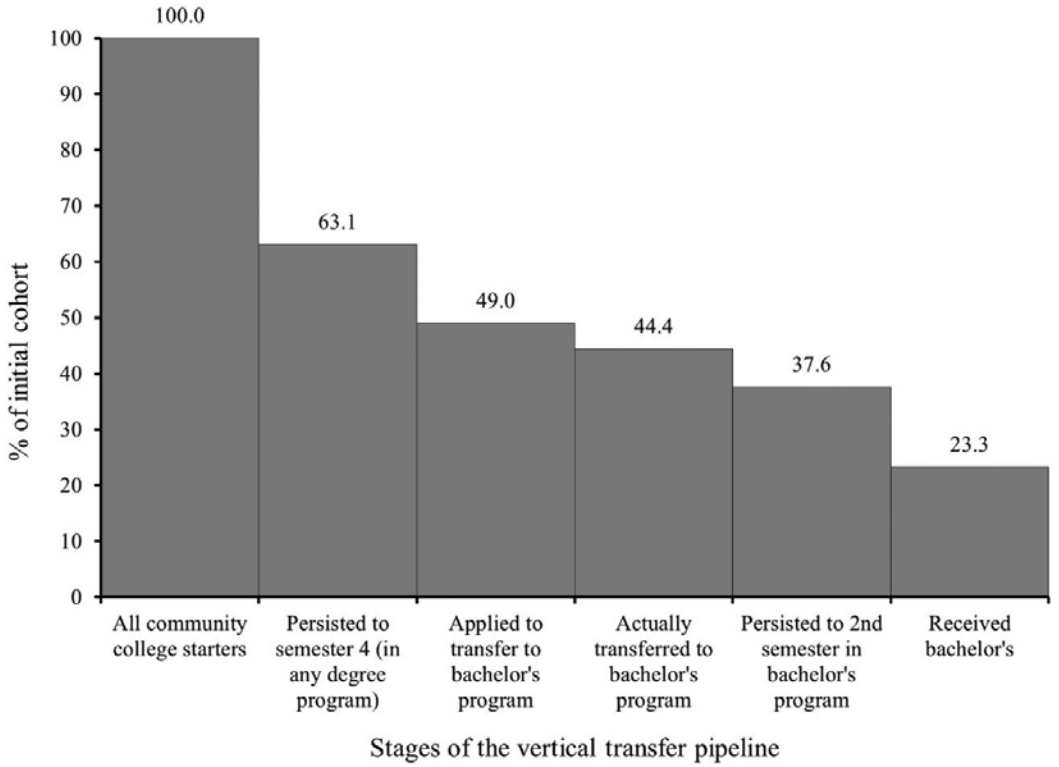
The first three semesters of community college stand out as a time of large enrollment decreases. As shown in Table 3, the largest share of students ceased attending after the very first semester, with sizable additional numbers of students ceasing attending each following semester. Persistence after one year was 69.6% which, although higher than the national data of just under 60% for first-time 2013 community college students (National Student Clearinghouse Research Center, 2015), still represented a loss of almost one third of the initial cohort.

We conducted a probit regression to determine the association of various student characteristics with whether a student persisted to the fourth semester after beginning college. The model for this regression can be expressed as:

$$P(Y_i = 1 \mid X_i) = \Phi(b_0 + b_1 Demo_i + b_2 PERF_i + b_3 STATUS_i). \quad (1)$$

In this model, the outcome is the probability of student *i* persisting to Semester 4 given characteristics of the student; Φ denotes the cumulative standard normal distribution function; $Demo_i$ is a vector of student *i*'s demographic characteristics (which include gender, race/ethnicity, age at college entry, and an indicator for being a Pell grant

Figure 2. Percentage of Students From the CUNY Fall 2013 Community College Cohort Who Persisted to Particular Stages of the Vertical Transfer Pipeline Through Spring 2021



Note. Enrollment and graduation data are from CUNY and the NSC. Application data are from CUNY's central application system and are also inferred from students who enrolled in CUNY and nonCUNY bachelor's programs. Note that, although this inference method captures more applications for the dataset, applications were still undercounted (there are no records—inferred or otherwise—of nonCUNY applications that do not result in a student attending a nonCUNY college or of unsuccessful within-CUNY transfer applications that bypassed CUNY's central application system). Further, Figure 2 does not show transfer admissions and therefore cannot be used to quantify transfer melt. For a detailed analysis of transfer melt see Figure 3. In addition, with regard to Figure 2, given CUNY has a wide range of criteria for admission to its bachelor's programs depending on the college, no attempt was made to exclude from this figure associate's-degree students who were not qualified to apply to transfer to bachelor's programs. The bar for students who persisted to the 2nd semester in a bachelor's program includes all students who were enrolled in the second semester after transfer, not just those who had done so after transferring by fall 2017, as shown in Table 5. Included in this bar are students who were not actually enrolled in that semester but reenrolled later and graduated.

Figure 3. Number of Students Admitted Centrally to a CUNY Bachelor's Program each Semester, With the Percentages of Those Students Who Did ("Enrollee") or Did Not ("Melter") Enroll in a CUNY or NonCUNY Bachelor's Program

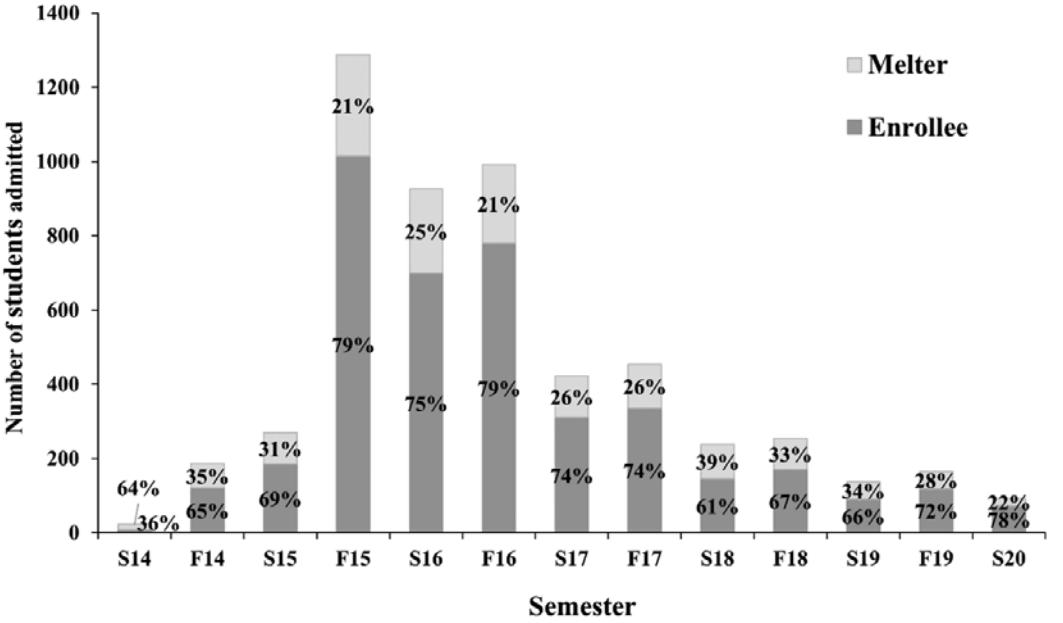


Table 3. Students From Fall 2013 Cohort Who Persisted in a CUNY or NonCUNY College to a Particular Semester

Semester	Semester 1	Semester 2	Semester 3	Semester 4
N	17,455	14,535	12,157	11,011
% of initial	100	83.3	69.6	63.1

Note. Students who were not attending in Semester 4, but who reappear at a later point (N = 1,322) were included in the count of persisters to Semester 4.

recipient at college entry); $PERF_i$ is a vector of variables measuring student *i*'s first semester academic performance, including first-semester GPA and first-semester credits (standardized in the estimation); $STATUS_i$ is a vector of student *i*'s college entry status, including a dummy variable equal to 1 if the student was assessed as needing remediation at college entry, a dummy variable equal to 1 if student *i* was an AAS student at college entry, and a dummy variable indicating if a student was full-time at college entry; b_0 is the intercept; and b_1, b_2, and b_3 are vectors of coefficients. The model also included initial community college fixed effects.

The model's resulting marginal effects at means are shown in Table 4. Female students were more likely to persist compared to male students, and White students were more likely to persist than Black and Hispanic students. Regarding academic performance, a student's first-semester GPA and number of credits earned in the first semester were

positively associated with persistence. In addition, students who were full-time were more likely to persist.

Application to Transfer (Using CUNY and NSC Data)

The decrease between the percentage of the original cohort who persisted to Semester 4 (in any program) and who applied to transfer to a bachelor's program is large (14.1 percentage points, the difference between the second and third bars in Figure 2). Note that students who had already transferred by Semester 4 (N = 838) were included in the count of applicants. Also, NSC data do not include students' transfer applications.

Table 4. Probability of Persisting to Semester 4: Marginal Effects From Probit Regression

	Marginal effects	Robust SE
Demographic characteristics		
Female	0.060**	(0.008)
Black	−0.043**	(0.013)
Hispanic	−0.057**	(0.013)
Asian/Pacific Islander	0.030	(0.016)
American Indian	0.011	(0.064)
Age at college entry	−0.008**	(0.001)
Pell grant recipient (at college entry)	0.014	(0.009)
First semester academic performance		
First semester GPA (z)	0.188**	(0.007)
First semester credits (z)	0.122**	(0.007)
College entry status		
Any remediation	0.019	(0.010)
AAS student	−0.012	(0.010)
Full-time	0.068**	(0.013)
Observations	17,454	
Pseudo R-squared	0.1923	

*$p < .05$, **$p < .01$.

Note. The reference groups for this regression are: for gender, male; for race/ethnicity, White; for Pell recipient, nonPell recipient; for assessed remedial need, no assessed remedial need; for AAS student at college entry, nonAAS student at college entry; for full-time at college entry, part-time at college entry. GPA = grade point average; AAS = Associate in Applied Science.

However, we were able to infer a total of 2,336 applications to nonCUNY bachelor's programs, as well as a total of 1,314 applications to CUNY bachelor's programs (that were not made through CUNY's central admissions process), based on the presence of a bachelor's enrollment record (with no application record). Finally, all application counts are underestimates because it is not possible to measure unsuccessful transfer applications outside of CUNY, or within-CUNY unsuccessful transfer applications that bypass CUNY central admissions.

We conducted a probit regression predicting whether a student who had persisted to Semester 4 applied to transfer (including CUNY and nonCUNY inferred applications). The model used (Equation 2) was:

$$P(Y_i = 1 \mid X_i) = \Phi(b_0 + b_1 Demo_i + b_2 PERF_i + b_3 STATUS_i), \quad (2)$$

identical to Equation 1 except that the outcome was the probability of student *i* applying for transfer to a bachelor's program (given the characteristics of the student). In this regression, for students whose first-semester GPA was missing, their first-semester GPA was assigned as 0.0 and then, to distinguish students with a missing first-semester GPA from those with an actual 0.0 GPA in their first semester, an indicator for missing GPA was also included in the model.

This regression's results are shown in Table 5. Again, certain student populations were more likely than others to progress to the next pipeline stage. Female students were more likely to apply to transfer than male students. Black students and Hispanic students were less likely to apply to transfer than White students. First-semester GPA, first-semester credits, and enrolling full-time were all positively associated with applying to transfer. In contrast, older students, students who had been assessed as needing remediation, and students who initially entered an AAS program, were less likely to apply to transfer.

The most frequent CUNY application time points were two to three years after associate's-program entry. The single most frequent application semester was fall 2015, two years after community college matriculation, with 1,438 applications filed at that time. There were over 1,000 applications each for the following two semesters (spring 2016 and fall 2016). Overall, students were more likely to apply to transfer for fall than spring semesters.

Challenges After Transfer Admission

Enrollment in Bachelor's Programs and Transfer Melt (Using CUNY and NSC Data)

Most students who applied centrally for transfer to CUNY bachelor's programs actually transferred to bachelor's programs, both because most students (88.3%) who applied to

Table 5. Probability of Applying to Transfer: Marginal Effects From Probit Regression

	Marginal effects	Robust SE
Demographic characteristics		
Female	0.116**	0.009
Black	−0.071**	(0.015)
Hispanic	−0.078**	(0.015)
Asian/Pacific Islander	0.025	(0.017)
American Indian	−0.001	(0.069)
Age at college entry	−0.008**	(0.001)
Pell grant recipient (at college entry)	0.009	(0.011)
First semester academic performance		
First semester GPA (z)	0.100**	(0.007)
First semester credits (z)	0.094**	(0.007)
College entry status		
Any remediation	−0.031**	(0.011)
AAS student	−0.072**	(0.011)
Full-time	0.048**	(0.017)
Observations	11,011	
Pseudo R-squared	0.1060	

**$p < .01$.

Note. The reference groups are the same as in Table 4. GPA = grade point average; AAS = Associate in Applied Science.

bachelor's programs were admitted, and because most students who were admitted to bachelor's programs enrolled. More specifically, of 4,888 students admitted centrally to a CUNY bachelor's program, 78% enrolled in a CUNY bachelor's program, and an additional 4.4% enrolled in a nonCUNY bachelor's program. Thus, a total of 82.9% of CUNY students admitted centrally to a CUNY bachelor's program actually enrolled in a CUNY or nonCUNY bachelor's program. The 17.1% who did not enroll in a CUNY or nonCUNY bachelor's program despite being admitted centrally to a CUNY bachelor's program constitute transfer melt.

As shown in Figure 3, beginning with fall 2014 (spring 2014 had too few CUNY central admissions to bachelor's programs—22—for the data to be reliable), 21.1% to 39.3% of central admissions to a CUNY bachelor's program were not followed by CUNY or nonCUNY bachelor's program enrollment. Transfer melt appeared to happen less frequently during the semesters in which transfer was most common (two

to three years after entry to the community college). Transfer melt also tended to be higher for spring than fall semesters.

Persistence in Bachelor's Programs (Using CUNY and NSC Data)

Table 6 shows the percentages of students who transferred to a CUNY or nonCUNY bachelor's program who were still enrolled (in any CUNY or nonCUNY bachelor's program) or had received a bachelor's degree up to eight semesters after becoming a transfer student, with Semester 1 being a student's first semester as a transfer student (e.g., for someone who became a transfer student in spring 2016, Semester 2 is fall 2016). Enrollment is measured at the beginning of a given semester, and degrees awarded includes all CUNY and nonCUNY bachelor's degrees awarded by the end of a given semester. Students who were not attending in Semester 2 of a bachelor's program, but who went on to receive a bachelor's degree (N = 195), were included in the count of persisters to Semester 2 in a bachelor's program.

Table 6. Outcomes for Students From the Fall 2013 Community College Cohort Who Transferred to a CUNY or NonCUNY Bachelor's Program by Fall 2017 (N = 6,039)

	Posttransfer Semester							
	Sem 1	Sem 2	Sem 3	Sem 4	Sem 5	Sem 6	Sem 7	Sem 8
% still enrolled in bachelor's program (CUNY/nonCUNY) without bachelor's degree earned	100	85.8	77.1	71.8	56.1	39.8	26.6	19.2
% awarded CUNY bachelor's degree	0.0	0.0	1.0	11.6	22.9	33.5	39.4	44.6
% awarded nonCUNY bachelor's degree	0.0	0.0	0.3	2.3	4.1	6.4	7.7	9.0

As shown in this table, a substantial number of vertical transfer students leave college in the initial semesters following enrollment in bachelor's programs. Of the 6,039 students who transferred to a CUNY or nonCUNY bachelor's program by fall 2017 and whose outcomes we can therefore track for at least eight semesters, 85.8% were still enrolled in a bachelor's program one semester after becoming a transfer student and 77.1% were still enrolled in a bachelor's program two semesters after becoming a transfer student, showing the particularly large enrollment loss in the semester after becoming a transfer student.

A substantial share of students who cease attending return to a CUNY or a nonCUNY bachelor's program in a later semester. Of the 858 successful transfers who were not enrolled in Semester 2 after transfer, 420 (49.0%) reenrolled in a bachelor's program in a later semester, and of the 1,377 successful transfers who were not enrolled in Semester 3 after transfer, 571 (41.5%) reenrolled in a bachelor's program in a later semester.

As expected, vertical transfer students in the analysis cohort began graduating with bachelor's degrees approximately two years after enrollment in a bachelor's program. However, initial degree award rates were not high. Two years after becoming a transfer student in a CUNY or nonCUNY bachelor's program, only 13.9% had earned a bachelor's degree from a CUNY or a nonCUNY institution; three years after, 40.0% had done so; and four years after, 53.6% had done so.

Transfer Shock (Using CUNY Data)

Transfer shock is not a pipeline leakage point, and instead constitutes student behavior that is related to student success and that can be affected by multiple events in the environment. Therefore, transfer shock can be conceptualized as a malleable factor (as in Figure 1).

We found substantial variation in students' GPA change after transfer to a bachelor's program, with many students' GPAs increasing, and many decreasing, upon transfer (the latter constituting transfer shock; see Figure 4). For stability in measurement, we used students' cumulative GPA before transfer in comparison to their first-semester GPA after transfer (the measure termed GPA Change 2). As shown in Table 7, 40.4% of transfer students saw an increase in GPA, with those students demonstrating a mean posttransfer GPA that was 0.45 points higher than before transfer. However, a decline in GPA was more common than an increase: 58.8% of transfer students saw a decrease

Figure 4. Relative Frequency of Specific GPA Change Values (GPA Change 1 = GPA in the Semester Immediately Prior to Transfer—Cumulative GPA in the Preceding Semester; GPA Change 2 = GPA in the First Semester Following Transfer—Cumulative GPA Prior to Transfer)

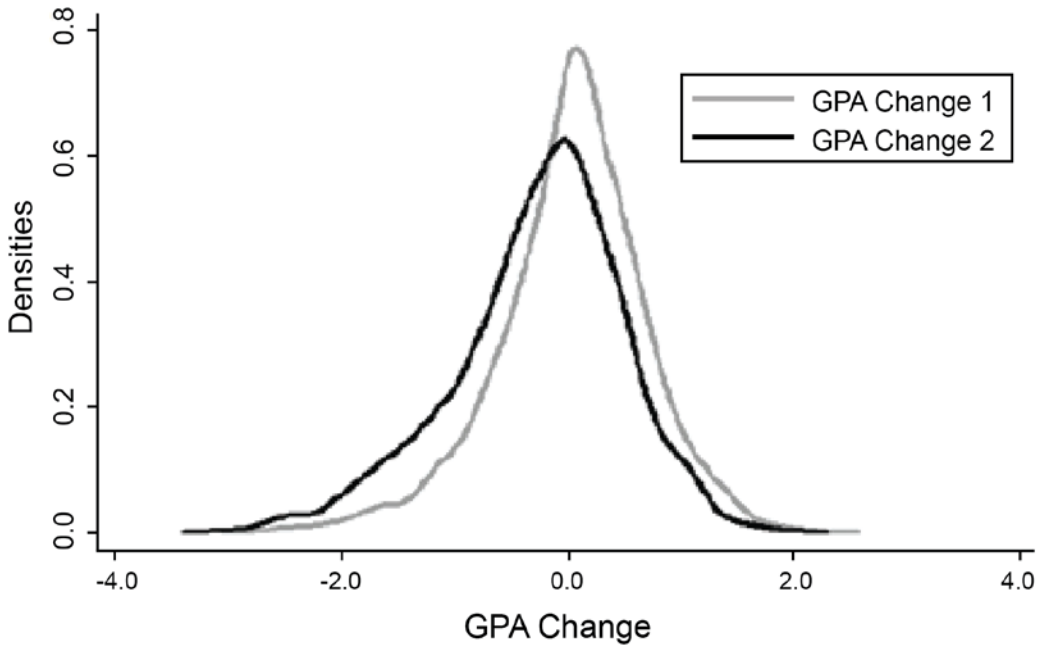


Table 7. Comparison of Direction of GPA Change 1 and GPA Change 2

GPA Change	GPA Change 1 = Pretransfer semester GPA minus previous semester cumulative GPA (% of Students)	GPA Change 2 = Posttransfer semester GPA minus pretransfer cumulative GPA (% of Students)
Decreased	42.4	58.8
Increased	56.6	40.4
Did not change	1.0	0.8

in GPA, with a mean posttransfer GPA that was 0.72 points lower than before transfer. There was more variation in the size of the GPA change among those whose GPA decreased, with 24.0% of this group seeing a drop smaller than 0.25 GPA points and 26.6% seeing a drop larger than one point.

Some of the variation we saw in GPA Change 2 might represent routine semester-to-semester fluctuation in grades. For comparison, 56.6% of students showed an increase and 42.4% showed a decrease in GPA during the immediately prior semesters when they did not transfer (the measure termed GPA Change 1). This suggests that not all 58.8% of students who saw a decrease in GPA with transfer experienced this decrease due to transfer. Rather, the transfer-related decrease occurred in 16.4 percentage points more students than we would expect in any semester-to-semester transition. However, among those whose GPAs decreased, GPAs decreased more with transfer, with a mean decrease of 0.72 with transfer and 0.53 without transfer. The difference between GPA Changes 1 and 2 is statistically significant ($t[5169] = 22.1$, $p < .001$, $d = .41$). However, there is substantial overlap between the GPA Change 1 and the GPA Change 2 distributions (Figure 4).

We also investigated which types of students were most likely to demonstrate transfer shock (a decrease in GPA Change 2). We used an Ordinary Least Squares regression model examining GPA Change 2 as a function of various student demographic characteristics, academic performance at the sending college, and transfer behavior (e.g., whether someone had a period of nonenrollment in college before transferring), including both sending and receiving college fixed effects. The model for this regression is:

$$Y_i = b_0 + b_1 Demo_i + b_2 CC_i + b_3 TRANS_i + e_i, \quad (3)$$

Where Y_i indicates the amount of GPA change upon transfer for student i (positive or negative); $Demo_i$ is a vector of student i's demographic characteristics, which include gender, race/ethnicity, age at transfer, and an indicator for being a Pell grant recipient at college entry; CC_i is a vector of variables that measures a student's academic performance in community college including pretransfer cumulative GPA and pretransfer cumulative credits (standardized in the estimation); $TRANS_i$ is a vector of transfer

behavior variables for student *i*, including dummy variable indicators for a student entering community college in an AAS program, holding an associate's degree at the time of transfer, having a period of nonenrollment before transfer, and being a full-time student in the first bachelor's program semester, as well as a continuous variable indicating in which semester student *i* transferred (Semester 1 is fall 2013 because all of the cohort's members began college that semester, Semester 2 is spring 2014, Semester 3 is fall 2014, etc.); b_0 is the intercept; b_1, b_2, and b_3 are vectors of coefficients; and e_i is an error term. The model also included sending and receiving college fixed effects.

Given that our outcome is first-semester posttransfer GPA minus cumulative pretransfer GPA (GPA Change 2, with a negative value indicating transfer shock), the resulting coefficients for the binary variables describe how the value of this GPA difference compares to the value of this GPA difference in the reference groups. The coefficients for the continuous variables show how much GPA change is associated with one unit increase in a variable (one year for age, one standard deviation for GPA and pretransfer credits, and one semester for semester of transfer). As shown in Table 8, after taking into account demographic characteristics, community college academic performance, and transfer behavior, there is less transfer shock for female than male students, and more transfer shock for Black than White students. In addition, the later the semester in which a student transferred, the less transfer shock.

Persistence in Bachelor's Programs and GPA Change (Using CUNY and NSC Data)

As shown in Figure 2, by the second semester posttransfer, only 37.6% of the original community college cohort was enrolled in a CUNY or nonCUNY bachelor's program. We conducted a probit regression to investigate the relationship between GPA Change 2 and persistence to the second semester of a CUNY bachelor's program, using students from the fall 2013 cohort who initially transferred to a CUNY bachelor's program by fall 2020 (and whose immediate posttransfer GPAs we could therefore track, as well as their two-semester transfer outcomes). Equation 4 shows the regression model used:

$$P(Y_i = 1 \mid X_i) = \Phi (b_0 + b_1 GPA_i + b_2 Demo_i + b_3 CC_i + b_4 TRANS_i). \quad (4)$$

This model is similar to Equations 1 and 2 except that the outcome is the probability of student *i* persisting to the second semester of a bachelor's program, and GPA_i is a vector of a variable indicating both (a) the amount of GPA change student *i* showed upon transfer (GPA change amount) and (b) the difference in GPA change upon transfer and GPA change for the preceding semester transition (GPA change difference). GPA change amount was divided into nine levels, with category (5) (*greater than or equal to −0.10 and less than or equal to 0.10*) being used as the reference category. GPA change difference was calculated by subtracting GPA change amount at transfer from GPA change amount one semester before transfer. For example, if a student's GPA decreased for two consecutive semesters by a similar amount, the GPA change difference value

Table 8. Ordinary Least Squares Regression Estimates of Change in GPA During Transfer (GPA in the First Semester After Transfer Minus Cumulative GPA Before Transfer; GPA Change 2)

	Coefficient	Robust SE
Demographic characteristics		
Female	0.068**	(0.021)
Black	−0.074*	(0.036)
Hispanic	−0.063	(0.034)
Asian/Pacific Islander	−0.008	(0.035)
American Indian	0.069	(0.127)
Age at transfer	0.002	(0.002)
Pell grant recipient (at college entry)	−0.038	(0.024)
Academic performance in community college		
Pretransfer cumulative GPA (z)	0.021	(0.014)
Pretransfer cumulative credits (z)	−0.076**	(0.012)
Transfer pathway factors		
AAS student at college entry	0.018	(0.027)
Associate degree holder at transfer	0.049	(0.028)
Semester of transfer	0.042**	(0.005)
Had a period of nonenrollment before transfer	0.026	(0.028)
Started in bachelor's program full-time	−0.004	(0.030)
Constant	−0.700**	(0.089)
Observations	5,326	
R-squared	0.111	

*$p < .05$, **$p < .01$.

Note. The reference groups for this regression are: for associate degree holder at transfer, student without associate's degree; for period of nonenrollment before transfer, no period of nonenrollment before transfer; and for started in bachelor's program full-time, started in bachelor's program part-time. GPA = grade point average; AAS = Associate in Applied Science.

would be close to 0, suggesting that the decrease in GPA with transfer was not an unusual event for that student. The model also included receiving college fixed effects.

The results (see Table 9) show that a student whose GPA decreases between 0.5 and 1.0 at transfer (i.e., whose GPA Change 2 is between −0.5 and −1.0, indicating transfer shock) has a 5.0 percentage points lower probability of persisting to the second semester of a bachelor's-degree program compared to a student who has no or a small

Table 9. Probability of Persisting to Semester Two in Bachelor's Program: Marginal Effects From Probit Regression

	Marginal effects	Robust SE
GPA Change [a,b]		
GPA Change 2 ≥1.0	0.033**	(0.010)
GPA Change 2 [0.5, 1.0)	0.016	(0.010)
GPA Change 2 [0.25, 0.5)	0.015	(0.011)
GPA Change 2 [0.1, 0.25)	0.005	(0.012)
GPA Change 2 (–0.25, –0.1]	0.009	(0.013)
GPA Change 2 (–0.5, –0.25]	–0.019	(0.013)
GPA Change 2 (–1.0, –0.5]	–0.050**	(0.014)
GPA Change 2 ≤ –1.0	–0.121**	(0.021)
GPA change difference	0.001	(0.005)
Demographic characteristics		
Female	0.012	(0.007)
Black	–0.015	(0.011)
Hispanic	–0.010	(0.010)
Asian/Pacific Islander	–0.004	(0.012)
American Indian	–0.004	(0.063)
Age at transfer	–0.001	(0.001)
Pell grant recipient (at college entry)	–0.012	(0.008)
Academic performance in community college		
Pre-transfer cumulative credits (z score)	0.004	(0.004)
Pre-transfer cumulative GPA (z score)	0.017**	(0.004)
Transfer behavior factors		
AAS student (at college entry)	0.009	(0.009)
Associate's degree holder (at transfer)	0.008	(0.009)
Semester of transfer	–0.009**	(0.002)
Had a period of nonenrollment before transfer	–0.056**	(0.007)
Started in bachelor's program full-time	0.059**	(0.008)
Observations	5,126	
Pseudo R-squared	0.1453	

*$p < .05$, **$p < .01$.

[a] GPA Change 2 is the difference between first-semester posttransfer GPA and cumulative GPA prior to transfer.

[b] GPA change difference is the difference between GPA Change 2 and GPA change calculated one semester earlier (GPA Change 1).

Note. Reference groups are the same as in Table 8. GPA = grade point average; AAS = Associate in Applied Science.

decrease in GPA after transfer. Moreover, for a student with a GPA change amount that is more negative than 1.0, compared to a student with no or a small decrease in GPA, the probability of persisting is 12.1 percentage points lower. In other words, the more transfer shock, the less likely a student will persist. In addition, persistence was positively associated with having a relatively high GPA prior to transfer, as well as with starting in the bachelor's program full-time, being female, or having a relatively high pretransfer cumulative GPA; and negatively associated with transferring after more semesters or having a period of nonenrollment between enrollment in the sending and receiving institutions.

Graduation and GPA Change (Using CUNY and NSC Data)

As shown in Figure 2, by eight years after initial entry to community college, 23.3% of the original cohort had graduated with a CUNY or nonCUNY bachelor's degree. We conducted a probit regression to investigate the relationship between GPA Change 2 and graduation at CUNY, this time using students from the fall 2013 cohort who transferred to a CUNY bachelor's program by fall 2017 (and whose transfer outcomes we could therefore track for four years). Equation 5 shows the regression model used:

$$P(Y_i = 1 \mid X_i) = \Phi(b_0 + b_1 GPA_i + b_2 Demo_i + b_3 CC_i + b_4 TRANS_i). \quad (5)$$

This model is similar to Equation 4 except that the outcome is the probability of student *i* graduating with a bachelor's degree within four years after transfer.

The results (see Table 10) show that a student whose GPA decreases between 0.25 and 0.5 at transfer (i.e., whose GPA Change 2 is between –0.25 and –0.5, indicating transfer shock) has an 8.1 percentage points lower probability of graduating with a bachelor's degree compared to a student who has no or a small decrease in GPA after transfer. Moreover, there is a larger decrease in the likelihood of receiving a bachelor's degree the larger the transfer shock: Compared to a student with no or a small decrease in GPA after transfer, the probability of graduating with a bachelor's degree is 18.4 percentage points lower when GPA Change 2 is between –0.5 and –1.0, and 34.9 percentage points lower when GPA Change 2 is more negative than –1.0. In addition, graduation was positively associated with having a relatively high number of accumulated credits and GPA prior to transfer, starting in the bachelor's program full-time, being female or of Asian/Pacific Islander race/ethnicity, or having an associate's degree prior to transfer; and negatively associated with transferring after more semesters or having a period of nonenrollment between enrollment in the sending and receiving institutions.

Table 10. Probability of Receiving a Bachelor's Degree Within 4 Years After Transfer: Marginal Effects From Probit Regression

	Marginal effects	Robust SE
GPA Change [a,b]		
GPA Change 2 ≥1.0	0.109*	(0.044)
GPA Change 2 [0.5, 1.0)	0.061*	(0.030)
GPA Change 2 [0.25, 0.5)	0.007	(0.030)
GPA Change 2 [0.1, 0.25)	0.017	(0.032)
GPA Change 2 (–0.25, –0.1]	–0.029	(0.033)
GPA Change 2 (–0.5, –0.25]	–0.081**	(0.029)
GPA Change 2 (–1.0, –0.5]	–0.184**	(0.029)
GPA Change 2 ≤ –1.0	–0.349**	(0.033)
GPA change difference	0.005	(0.012)
Demographic characteristics		
Female	0.105**	(0.017)
Black	0.000	(0.027)
Hispanic	–0.001	(0.024)
Asian/Pacific Islander	0.073**	(0.027)
American Indian	0.129	(0.130)
Age at transfer	–0.001	(0.002)
Pell grant recipient (at college entry)	–0.018	(0.019)
Academic performance in community college		
Pre-transfer cumulative credits (z score)	0.072**	(0.012)
Pre-transfer cumulative GPA (z score)	0.113**	(0.010)
Transfer behavior factors		
AAS student (at college entry)	–0.031	(0.021)
Associate's degree holder (at transfer)	0.075**	(0.021)
Semester of transfer	–0.029**	(0.008)
Had a period of nonenrollment before transfer	–0.092**	(0.023)
Started in bachelor's program full-time	0.174**	(0.023)
Observations	4,255	
Pseudo R-squared	0.1559	

*$p < .05$, **$p < .01$.

[a] GPA Change 2 is the difference between first-semester posttransfer GPA and cumulative GPA prior to transfer.

[b] GPA change difference is the difference between GPA Change 2 and GPA change calculated one semester earlier (GPA Change 1).

Note. Reference groups are the same as in Table 8. GPA = grade point average; AAS = Associate in Applied Science.

Discussion

As compared with a cross-sectional analysis, this eight-year, longitudinal study of 17,455 students, the majority being from underrepresented groups, and who began their postsecondary careers in community colleges, yielded much new detailed information about the vertical transfer pipeline. This information includes the size of particular pipeline leaks, as well as information about some of the variables associated with those leaks. Using this information, we can provide unique guidance regarding how to decrease the pipeline's leaks and thus increase higher education equity.

The Leaks

Although the largest leaks were after the first three semesters, likely before students had even applied to transfer, there were still substantial leaks at the point of application to a bachelor's program, initial enrollment in a bachelor's program, continuing enrollment in a bachelor's program, and bachelor's graduation. Even though as much as a third of the starting cohort may never have intended to obtain a bachelor's degree, the cumulative effect of these leaks on the final pipeline output was substantial. Only 23.3% of students received bachelor's degrees within eight years after entering community college (cf. the 11% six-year national rate, National Center for Education Statistics, 2020). Even when students succeeded in transferring to a bachelor's program, only about half of them attained their bachelor's degrees within four years of transfer.

If a student in our cohort remained enrolled through Semester 4 after entering college, that student was likely to transfer to a bachelor's program (about three quarters of these students did so). Further, the applications tended to occur at what would be considered appropriate times: 2–3 years after entering community college. However, about one quarter of students who reached Semester 4 did not apply to transfer. Although some of these students never intended to transfer, our study has verified lack of application as a pipeline leak (see Figure 1).

Even if a student applied to transfer to a CUNY bachelor's program and was accepted, approximately 17% of such students did not matriculate in either a CUNY or a non-CUNY bachelor's program (transfer melt). This is the first documentation of both the existence and size of transfer melt, showing that transfer melt can represent a substantial vertical transfer pipeline leak. Transfer melt occurred more in spring than fall semesters, perhaps because the amount of time needed to complete the transfer process is shorter for CUNY spring than fall transfer admission.

Unfortunately, even after successful transfer to and initial enrollment in a bachelor's program, our results show that still more vertical transfer students leaked out of the pipeline, particularly in the first one to two semesters after becoming a transfer student. However, close to half of the students who leaked out in the early posttransfer semesters reenrolled in a later semester. These findings support Attewell and Lavin's (2007)

finding that CUNY students may take many more than the traditional number of semesters to graduate, likely related to their challenging environmental circumstances.

The cumulative effect of all these leaks in the pipeline, including lack of application, lack of matriculation (transfer melt), and lack of persistence in a bachelor's program, is substantial: Less than one quarter of our initial cohort had received a bachelor's degree within eight years of entering college. Even if a substantial portion of these nongraduated students were to receive their bachelor's degrees at a later point, a great many students were not able to earn, for a great many years, the salary associated with a bachelor's degree, despite their original educational aspirations. Enrolling first in a community college to save bachelor's tuition is not an optimal financial strategy if it takes many years to obtain the bachelor's degree (Belfield et al., 2017; Handel, 2016).

It should also be noted that, among those students who transferred to a bachelor's program by fall 2017, few of them (only 13.9%) graduated within two years. Most students took more than three years after transferring to receive their bachelor's degrees. These data are not consistent with the standard conception of a 2+2 articulation between a community and a bachelor's college (Vandal et al., 2021).

Variables Associated With the Leaks

Our study also examined variables associated with these pipeline leaks. As part of that investigation, we showed that transfer shock did not occur frequently (Bahr et al., 2013). About 16 percentage points more of transferring students showed a decrease in GPA with transfer (transfer shock) than would have shown a decrease in GPA in a non-transfer semester-to-semester transition. The lack of a high frequency of transfer shock suggests that the term transfer shock may be ill-advised because it may imply that transfer students' GPAs generally decrease in the first posttransfer semester (Gentsch et al., 2022), as many bachelor's-college faculty believe (Rabinowitz et al., 2023). As in Jaggars et al. (2023), our findings did show that the greater the transfer shock, the less likely students were to persist in a bachelor's program and to graduate with a bachelor's degree.

Examining additional variables' associations with the pipeline leakage points revealed some consistent findings concerning student characteristics. First, male, Black, and Hispanic students in our cohort were less likely to persist to the fourth semester of college, to apply for transfer to a bachelor's program, and, even if they did transfer, male and Black students were more likely to show transfer shock, in comparison to female and White students. Male students were also less likely to graduate with a bachelor's degree.

We also found that students were more likely to persist in college, and to apply to transfer to a bachelor's program, if they had accumulated relatively more credits, had a relatively higher GPA in their first college semester, and began college full-time. Thus,

early college behaviors seem to be related to successful transfer. Further, students who were older, had been assessed as needing remediation, and who had initially entered college in a (terminal) AAS program were less likely to apply to transfer.

Academic performance and characteristics were also associated with posttransfer success, with pretransfer cumulative credits being negatively associated with transfer shock, and pretransfer cumulative GPA and/or pretransfer cumulative credits being positively associated with persistence after transfer to a bachelor's program and bachelor's graduation. Further, the more semesters after college entry that a student transferred to a bachelor's program, the less likely that student was to show transfer shock and the more likely not to persist or graduate. Finally, persisting in a bachelor's program and graduating with a bachelor's degree were negatively associated with having a period of nonenrollment between enrollment in the transfer sending and receiving colleges, and graduating with a bachelor's degree was positively associated with having an associate's degree prior to transfer to a bachelor's program (contrasting with the results of Turk, 2018, and Wang et al., 2017).

It may seem contradictory that having an associate's degree prior to transfer was positively associated with bachelor's graduation, while transferring after more semesters in an associate's program was negatively associated. However, given the fact that full-time enrollment was positively associated with staying in the vertical transfer pipeline at all investigated pipeline leakage points, what our results may show is that students who attend part-time for many semesters, and do not receive their associate's degree despite those many semesters of enrollment, are also less likely to receive their bachelor's degrees, even if they transfer. These results are consistent with others showing higher graduation rates in programs such as CUNY's Accelerated Study in Associate Programs (ASAP) which requires full-time enrollment (Weiss et al., 2019).

Of the many investigated variables, there was only one that was not significantly associated with any of the pipeline leakage points or with transfer shock: being a Pell grant recipient upon initial entry to college (which characterized three quarters of our cohort). Some possible reasons include that students' financial status may have changed over the eight years of the analysis, Pell effects may largely be due to their correlation with race/ethnicity and race/ethnicity was taken into account in our regression models, and/or nonreceipt of Pell in our cohort may have been due to factors other than income, such as citizenship status. Thus, the lack of significant relationships with Pell status in the present study may have been due to a methodological limitation.

Possible Interventions

Our findings suggest multiple possible interventions to decrease leaks in the vertical transfer pipeline. These interventions can be conceptualized as increasing students' transfer student capital (Laanan et al., 2010–2011), as well as navigational capital (Yosso, 2005), by means of changes in the malleable factors of Figure 1.

The largest leak was lack of persistence through the first three semesters of the pipeline. More than 30% of our cohort had ceased attending before the third semester, indicating a need for early interventions, and the potential large return on investment for colleges addressing leaks at that early pipeline point. There is an extensive research literature on increasing college student success. For example, student success has been shown to be greater with more intense enrollment patterns (National Student Clearinghouse Research Center, 2018), including for vertical transfer students. Our results also suggest that increasing full-time enrollment and supporting students in achieving higher GPAs would be useful. Enrollment intensity and early pipeline retention of potential vertical transfer students can be increased, for example, using programs similar to CUNY's ASAP which requires, and incentivizes, full-time enrollment (Weiss et al., 2019). Also useful for decreasing early pipeline leaks is assigning students only to corequisite, as opposed to traditional prerequisite, remediation. The present study's cohort, having entered college in fall 2013, would have been assigned only to traditional, prerequisite remediation. Corequisite remediation, in which students with assessed remedial need are given additional academic support while taking a college-level English or math course, can increase both associate's and bachelor's graduation rates, likely through speeding time to degree completion (Douglas et al., 2023). The efficient use of time can be critical in academic success.

Examining later leakage points, ones specifically related to transfer, lack of application could be decreased by providing more information about transfer opportunities. This can take many forms, beginning with providing additional information on the web, which has been identified as students' primary source of transfer-related information (Logue et al., 2022a; for examples of inadequate and useful web-based transfer information, see Logue et al., 2023; Tichenor et al., 2023). Another strategy would be to make applications easier to complete by simplifying application forms or prefilling some application items, or even having applications occur by default for particular transfer pathways. Such actions exemplify a well-known behavioral science technique for increasing the probability of specific behaviors (Thaler & Sunstein, 2008). The partnership between Northern Virginia Community College (NOVA) and George Mason University illustrates many of these points (Wyner, 2022).

Transfer melt might represent a promising point of intervention because these students have not only applied for transfer and been accepted but have already earned a couple years of college credits. Ensuring that students who have been accepted for vertical transfer are supported in all the steps related to bachelor's matriculation, from application to registration, and that these steps occur quickly and efficiently, could decrease transfer melt. Currently, transfer students, for example, are often not allowed to register until months after continuing students have registered (Logue et al., 2022a; Wang, n.d.). As a result, students may not be able to obtain class schedules that are compatible with their work and caregiving schedules, register for the course sections with the most highly reputed professors, or even obtain any classes that will satisfy their major requirements. Such events could discourage potential transfer students from matriculating. Ensuring that vertical transfer students are given good class schedules

could thus help decrease transfer melt. Another strategy for decreasing transfer melt would be to increase vertical transfer students' sense of belonging at their intended new institutions, where belongingness tends to be less than at their community colleges (Gopalan & Brady, 2020; Logue et al., 2022a). This could be done, for example, by engaging new transfer students with the facilities and people at their new institutions in the months prior to the new transfer students' first posttransfer semester.

The lengthy and/or delayed transfer processes that may contribute to transfer melt may also contribute to transfer shock. If students are unable to obtain a desirable schedule their first semester after transferring, this may contribute to their receiving lower grades the first semester after transfer (i.e., transfer shock). Other aspects of the environment that may contribute to transfer shock, as well as to persistence in the bachelor's program and then bachelor's graduation, include adequate orientation for new transfer students and supportive posttransfer advising services. Glass and Harrington (2002) recommended that four-year institutions help transfer students adjust more effectively to the academic and social life of the receiving college through counseling, tutoring, and other outreach. Reeves et al. (2023) found that a near-peer mentoring program increased STEM vertical transfer students' research participation as well as sense of belonging at a research university. Students from underrepresented groups have been shown to have a greater sense of belonging in community colleges, as opposed to bachelor's colleges, and so helping vertical transfer students adjust to their new environments may help them perform well and continue in college (Gopalan & Brady, 2020).

However, it should be emphasized that, despite all these potential challenges for vertical transfer students, GPA increased for 40.4% of our cohort at the point of transfer. A large proportion of vertical transfer students who persist until entry into a bachelor's program are clearly sufficiently prepared to succeed. For those whose GPA decreases upon transfer, given that this predicts lack of persistence in and failure to graduate from a bachelor's program, perhaps such students should be targeted for additional support—an early alert system similar to what is often used for nontransfer students (Hanover Research, 2014).

Our results showed consistent significant associations between pipeline outcomes and several student demographic characteristics, particularly gender and race/ethnicity. These results can help practitioners target interventions to the populations that most need them, or to institutions that have high percentages of such populations.

Possible Limitations

This research has several limitations. First, although based on a large cohort of almost 18,000 students, the results may not apply to colleges that are not part of a single urban system, or to different sorts of undergraduate populations. However, the current results may be extremely useful if goals include increasing higher education equity through

facilitating the college success and graduation of underrepresented students in urban and/or less selective institutions. A second limitation is that, as would be the case for any longitudinal study, there have been changes in higher education since our cohort entered college in 2013. At CUNY, ASAP has grown (Weiss et al., 2019), traditional prerequisite remediation has been removed ("CUNY Ends," 2023), and from 2020–2022 instruction was modified due to the COVID-19 pandemic. Thus, the results reported here may not characterize some aspects of current higher education, even at CUNY. Third, our dataset did not include (rarely available) information about individual students' intent to transfer, information that may have helped explain why certain students did or did not leak out of the transfer pipeline. Fourth, the present results regarding relationships between multiple variables and vertical transfer student success, while suggestive and consistent with other research, were not obtained through experimental methods that would permit causal inferences. Fifth, the current research does not address perhaps the most impactful malleable factor for causing pipeline leakage: loss of degree-applicable credit upon transfer (see Monaghan & Attewell, 2015; Spencer, 2023; United States Government Accountability Office, 2017). A quantitative study of credit loss among our cohort's students was not possible due to the nearly uniform unavailability of data showing changes in the degree applicability of credits directly as a function of transfer (Logue et al., 2022b). However, even without such a study, clearly better information, including at early stages of the pipeline, about if and how particular courses transfer, would address this malleable factor (Sutcliffe & Condliffe, 2020).

Conclusions and Contributions

Despite these limitations, the current study is the first to obtain detailed longitudinal information on multiple possible leaks in the vertical transfer pipeline. This research is the first to quantify the size of this pipeline's leaks and the relationships of many variables with those leaks. This study has identified and characterized for researchers, practitioners, and policymakers many potential challenges faced by vertical transfer students, helping to explain the many pipeline leaks and suggesting specific ways in which those leaks can be decreased, including how decreasing the various leaks might be prioritized. This information will help higher education achieve the goal of ensuring that students who begin their postsecondary experience in a community college will face no more challenges in obtaining a bachelor's degree than students who begin in a bachelor's program. Achievement of this goal will increase the proportion of bachelor's degrees held by students from underrepresented groups and thus increase higher education equity.

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