Factors Impacting Enrollment in Higher Education in the Context of its Signaling Market Structure

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Abstract

This study examines the factors influencing significant undergraduate enrollment declines (≥10% year-over-year) in U.S. higher education institutions, focusing on the signaling market structure of higher education. Using panel data from the National Center for Education Statistics (1996–2021) and a fixed-effects logistic regression model, the analysis identifies key institutional, financial, and academic variables impacting enrollment stability across public and private universities. Results indicate that institutional selectivity, as measured by SAT scores and admission rates, significantly stabilizes enrollment in public institutions, while financial aid accessibility and institutional size play a more substantial role for private universities. Temporal trends reveal a sector-wide decline in enrollment stability from 2011 to 2019, reflecting shifting demographics and evolving perceptions of higher education's value. The findings underscore the critical role of signaling in higher education markets and highlight the need for tailored strategies to address enrollment volatility. This research provides actionable insights for institutional leaders and policymakers to enhance enrollment stability and adapt to changing market dynamics.

Keywords: Higher education, enrollment stability, signaling theory, public universities, private universities, fixed-effects logistic regression, financial aid, academic selectivity, labor market conditions, institutional efficiency, demographic trends.

Factors Impacting Enrollment in Higher Education in the Context of its Signaling Market Structure

Enrollment stability is a vital component of institutional success in higher education, directly impacting financial sustainability, academic programming, and long-term planning. Yet, institutions increasingly face challenges in maintaining stable enrollment due to shifting demographics, economic uncertainty, and changing perceptions of higher education's value. These dynamics are particularly complex in the U.S., where public and private institutions operate within distinct funding structures and face different pressures.

Drawing on signaling theory, this study explores how institutional characteristics, financial factors, and other institution-level conditions influence significant undergraduate enrollment declines (≥10% year-over-year). Public universities, often reliant on state funding and regional applicants, may be more vulnerable to fluctuations in local labor markets and affordability metrics. Private institutions, by contrast, typically rely on broader geographic appeal, financial aid strategies, and institutional branding to sustain enrollment.

By examining data from the National Center for Education Statistics (1996–2021) through a fixed-effects logistic regression model, this research provides a nuanced understanding of the factors driving enrollment dynamics. The findings offer actionable insights for institutions to mitigate enrollment volatility and adapt to evolving market conditions, contributing to the growing discourse on the role of signaling in higher education.

Literature Review and Theoretical Foundations

Signaling markets

The concept of signaling markets, particularly within the context of higher education, has garnered significant attention in recent academic discourse. Signaling theory, originally articulated by Spence (Spence, 1976), posits that individuals use certain observable characteristics—such as educational attainment—as signals to convey their underlying abilities or productivity to potential employers in the labor market. This framework is particularly relevant in understanding how educational institutions operate as signaling mechanisms in a competitive marketplace. The dynamics of this signaling process can be modeled to elucidate the factors that influence enrollment trends at universities, particularly in light of changing institutional, financial, and academic variables.

In the context of higher education, institutions serve as both providers of education and as signals of quality to the labor market. The signaling function of education is critical; it allows students to differentiate themselves in a crowded job market. As noted by Hwang, education acts as a signal of a worker's productivity, which is particularly important in environments where employers cannot directly observe an applicant's skills or abilities prior to hiring (Hwang, 2016). This signaling mechanism is further complicated by market dynamics, where the perceived value of educational credentials can fluctuate based on institutional reputation, admission rates, and average standardized test scores, among other factors (Stebliuk & Кузьменко, 2021; Ismail & Myles, 2016).

Moreover, the relationship between educational signals and labor market outcomes is not linear. For instance, Heckman et al. discuss the non-market benefits of education, suggesting that educational attainment can influence various social outcomes beyond mere employability, such as civic engagement and social trust (Heckman et al., 2017). This multifaceted view of education's role in society underscores the importance of understanding how changes in signaling variables can impact enrollment decisions. As institutions adapt to market demands, the perceived value of their

educational offerings may shift, leading to fluctuations in enrollment rates (Roskosa & Stukalina, 2019; Russell, 2005).

The marketing of educational services has also evolved significantly, particularly with the advent of digital technologies. Beuzova et al. emphasize the necessity for higher education institutions to leverage internet marketing strategies to enhance their visibility and attractiveness to prospective students (Beuzova et al., 2021). This is particularly relevant in a competitive educational landscape where institutions must not only convey the quality of their programs but also effectively communicate their unique value propositions to potential enrollees. The integration of marketing strategies into the operational framework of educational institutions is essential for maintaining competitiveness and ensuring sustained enrollment levels (Rusilowati, 2023).

Furthermore, the commodification of education, as discussed by Budnikevych, highlights the increasing importance of marketing in shaping institutional identities and attracting students (Budnikevych, 2023). This commodification process is indicative of a broader trend where educational institutions are viewed through a market lens, necessitating a strategic approach to marketing that aligns with consumer expectations and preferences. The implications of this shift are profound, as institutions must navigate the delicate balance between maintaining educational integrity and responding to market pressures (Tyutereva, 2013).

In addition to marketing strategies, the role of institutional reputation and perceived quality cannot be overstated. Research indicates that students often rely on various signaling variables, such as admission rates and average SAT scores, as proxies for institutional quality (Finch et al., 2012; Keresztes, 2014). This reliance on quantifiable metrics can lead to a self-reinforcing cycle where institutions with higher perceived quality attract more applicants, thereby enhancing their reputation further. Conversely, institutions that experience declines in these signaling variables may face challenges in attracting prospective students, leading to a downward spiral in enrollment (Rohmansyah, 2023).

Moreover, the interplay between economic factors and educational signaling is critical in understanding enrollment trends. Economic policy uncertainty, for instance, has been shown to impact the dynamics of the education market, influencing both institutional strategies and student decision-making processes (Wang et al., 2023). As economic conditions fluctuate, students may reassess the value of their educational investments, leading to shifts in enrollment patterns that reflect broader economic realities (Zulkipli, 2023).

In conclusion, the modeling of higher education as a signaling market reveals a complex interplay of institutional, financial, and academic variables that collectively influence enrollment trends. As institutions navigate this landscape, the strategic use of signaling variables, effective marketing strategies, and an acute awareness of economic conditions will be paramount in sustaining enrollment levels. The ongoing evolution of the higher education market necessitates a nuanced understanding of these dynamics to ensure that institutions remain competitive and responsive to the needs of prospective students..

Impacts on Enrollment

Building on the framework of signaling markets, the factors influencing enrollment trends in higher education institutions are deeply intertwined with the ways these institutions communicate their value to prospective students. The concept of signaling, originally articulated by Spence (1976), provides a powerful lens through which the dynamics of enrollment can be understood. As noted in the previous section, educational institutions act as signaling mechanisms in a competitive marketplace, with their reputation, selectivity, and financial aid offerings serving as critical indicators of quality. This section explores the multifaceted impacts of these factors on enrollment dynamics, with a focus on their interplay across public and private universities.

The Role of Financial Aid as a Signal

Financial aid is a cornerstone of the higher education signaling process, particularly in attracting low-income students and enhancing enrollment stability. Institutions use financial aid to signal affordability and supportiveness, reducing barriers to access. Castleman and Long (2016) found that need-based financial aid programs significantly improve college attendance and persistence rates, while Fack and Grenet (2015) demonstrated similar outcomes in France's largest financial aid program. These findings underscore the signaling power of financial aid; when students perceive that financial resources are accessible, institutions appear more inclusive and desirable.

However, the complexity of financial aid systems can dilute this signaling effect. Levine et al. (2023) emphasize that "sticker prices"—published tuition rates—often overshadow the availability of aid, deterring students even when financial assistance significantly reduces actual costs. This highlights the importance of clear and effective communication about financial aid offerings, aligning with the broader observation that institutions must strategically manage their signals to enhance enrollment (Rusilowati, 2023). Simplified financial aid application processes, as noted by López (2014), can strengthen these signals by reducing barriers and increasing enrollment, particularly among disadvantaged populations.

The financial aid landscape differs significantly between public and private institutions. Public universities, which rely heavily on state funding, signal affordability and accessibility. This attracts a socioeconomically diverse student body, consistent with Hearn et al. (2016), who found that public institutions serve a larger proportion of low-income students compared to private universities. In contrast, private institutions often use financial aid to signal exclusivity and quality. Rizwan (2023) notes that despite higher costs, private universities attract students willing to invest in perceived prestige, demonstrating how financial aid signals differ across sectors.

Institutional Reputation and Selectivity

Institutional reputation, closely tied to selectivity metrics such as SAT scores and admission rates, is another critical factor shaping enrollment. As noted by Finch et al. (2012) and Keresztes (2014), these metrics act as powerful signals of quality, shaping perceptions of institutional value. Institutions with higher SAT averages and lower admission rates often attract a more stable and competitive applicant pool, reinforcing their reputational standing in a self-reinforcing cycle (Rohmansyah, 2023).

Public and private institutions leverage reputation differently in the context of signaling markets. Public universities often rely on regional reputation and affordability to attract students, with academic selectivity playing a stabilizing role. For example, Choe et al. (2019) highlight that higher SAT averages enhance enrollment stability in public institutions, where regional competition may intensify the importance of academic quality. Private institutions, on the other hand, emphasize broader geographic appeal and market their unique programs and campus experiences as indicators of quality (Kolade, 2019). This divergence underscores the importance of tailoring signaling strategies to institutional strengths and market positioning.

Economic Conditions and Market Dynamics

Economic conditions significantly influence enrollment patterns by shaping both institutional strategies and student decision-making. During economic downturns, higher education often serves as a refuge, with individuals seeking to enhance their qualifications in a challenging job market (Hemelt & Marcotte, 2011). However, institutions also face financial pressures during such periods, with budget cuts often reducing financial aid offerings and affecting enrollment stability (Clelan & Kofoed, 2016). This interplay highlights the importance of institutional responses to economic challenges in maintaining enrollment.

Public institutions are particularly sensitive to regional economic conditions, such as labor market stability, which influence their applicant pools. Strong labor markets signal economic

stability, encouraging students to invest in higher education (Zulkipli, 2023). Private institutions, while less dependent on local markets, remain vulnerable to broader economic trends that affect families' willingness to invest in high-cost education. These dynamics underscore the importance of flexibility and responsiveness in institutional signaling strategies.

Public vs. Private Institutions: Divergent Signaling Strategies

The differences between public and private universities in enrollment dynamics are deeply rooted in their funding models and market roles. Public institutions, supported by state funding, signal affordability and accessibility, often attracting a more socioeconomically diverse student body (Hearn et al., 2016). However, resource constraints can limit their ability to signal quality, such as through smaller class sizes or higher faculty salaries. This aligns with Gottesman and Ismailescu (2020), who note that public universities face challenges in maintaining their competitive edge in the face of budget cuts and overcrowding.

Private universities, operating on tuition-driven models, signal exclusivity and prestige through investments in facilities, faculty, and marketing. Rizwan (2023) observes that these institutions attract students who view higher tuition as a marker of quality, despite the financial burden. This perception is further reinforced by marketing strategies that emphasize unique academic programs and career placement services (Beuzova et al., 2021). However, this model also creates barriers for low-income students, exacerbating socioeconomic disparities in enrollment patterns.

The signaling role of institutional reputation is particularly pronounced in private universities, where first-time pass rates on licensure examinations and other performance metrics enhance perceptions of quality (Alghamdi et al., 2022). In contrast, public institutions benefit from a long-standing reputation for accessibility and comprehensive offerings, though this advantage may diminish as competition intensifies.

Conclusion

The interplay of financial aid, institutional reputation, and economic conditions reveals the complexity of enrollment dynamics in higher education. As signaling mechanisms, public and private universities navigate these factors differently, reflecting their unique funding structures and market roles. Public institutions leverage affordability and accessibility to attract diverse student bodies but face challenges in maintaining quality signals. Private institutions, by contrast, emphasize exclusivity and prestige, appealing to students willing to invest in perceived quality.

These findings highlight the importance of tailored strategies to address enrollment challenges. Institutions must align their signals with their strengths, effectively communicate financial aid availability, and adapt to changing market conditions. By understanding and leveraging the dynamics of signaling markets, higher education leaders can enhance enrollment stability and ensure their institutions remain competitive in an evolving educational landscape.

Data and Model Specification

Data and Preprocessing

The primary data source for this analysis is the National Center for Education Statistics (NCES) dataset, which provides comprehensive annual survey data from colleges and universities across the United States. Mandated for submission by all accredited institutions, the dataset includes a wide range of variables covering institutional characteristics, student demographics, academic performance, and financial data. Spanning the period from 1996 to 2021, the NCES dataset enables a longitudinal examination of factors influencing enrollment dynamics in higher education. For this study, a total of 52,281 observations across more than 50 variables were extracted, facilitating an in-depth analysis of the determinants of significant changes in undergraduate enrollment over time.

To ensure the reliability of the analysis, preprocessing was conducted to exclude institutions with fewer than 300 undergraduate students. Colleges with extremely small enrollments often exhibit disproportionate relative changes in enrollment, as a small absolute change (e.g., a few students graduating) could skew the analysis. More importantly, these institutions are typically not traditional colleges offering standard undergraduate degrees but rather specialized schools focused on professional certifications or niche programs. By excluding these cases, the dataset was refined to focus on institutions aligned with the classical definition of higher education colleges and universities, enhancing the relevance and accuracy of the analysis.

Study Design and Model Specification

The appropriateness of the model specification was assessed using the Hausman test, which determines whether a random-effects (RE) or fixed-effects (FE) model provides consistent and efficient estimates. The test evaluates the null hypothesis that the explanatory variables are uncorrelated with unobserved heterogeneity. In this study, the Hausman test yielded a statistically significant result ($\chi 2(17)=36.92, p=0.0035$), rejecting the null hypothesis. This indicates that the RE model would produce inconsistent estimates due to correlation between the explanatory variables and unobserved time-invariant heterogeneity. Consequently, the fixed-effects model was selected as the primary specification, as it effectively controls for unobserved heterogeneity, ensuring more reliable causal inference.

This analysis employs a panel regression framework to model the determinants of significant enrollment declines in higher education institutions over time. The longitudinal structure of the dataset, spanning from 1996 to 2021 with multiple observations per institution, makes the panel approach particularly suitable. This methodology captures both cross-sectional and temporal variations, enabling a detailed examination of how institutional, financial, and academic factors influence the likelihood of substantial enrollment declines.

The dependent variable is binary, indicating whether an institution experiences an enrollment decline exceeding a predetermined threshold (Yit=1Yit=1) or not (Yit=0Yit=0). To model this binary outcome, a fixed-effects logistic regression is used, specified as:

$$logit(P(Yit = 1 \mid Xit)) = \beta 1X1it + \beta 2X2it + \cdots + \beta kXkit + \alpha i + \varepsilon it$$

where $P(Yit = 1 \mid Xit)$ represents the conditional probability of a significant enrollment decline for institution ii in year t, $X1it, X2it, \dots, Xkit$ are the independent variables measured at the institution-year level, $\beta 1, \beta 2, \dots, \beta k$ are their corresponding coefficients, αi denotes the institution-specific fixed effect, and εit is the random error term capturing additional unexplained variability.

The fixed-effects approach is critical for controlling unobserved heterogeneity across institutions. Time-invariant characteristics such as reputation or structural differences are absorbed into the fixed effect αiαi, allowing the model to focus on within-institution variation over time. This ensures that estimates reflect the effects of independent variables while controlling for confounding factors that do not vary within institutions.

The logistic regression framework models the log-odds of the binary outcome, with coefficients βj interpretable in terms of odds ratios. For a one-unit increase in Xj, the odds of experiencing a significant enrollment decline are multiplied by $exp(\beta j)$, holding all other variables constant. This interpretation aligns with the binary nature of the dependent variable, focusing on the likelihood of enrollment declines rather than their magnitude.

The analysis accounts for the panel structure of the data, where observations are nested within institutions. Clustering is applied at the institutional level to produce robust standard errors, mitigating issues of serial correlation and heteroskedasticity. This adjustment enhances the accuracy of statistical inference, ensuring that standard errors correctly reflect the underlying data structure.

This fixed-effects logistic regression provides a robust framework for analyzing the determinants of significant enrollment declines. By focusing on the binary nature of enrollment stability, the model captures the decision-making processes driving these changes. The methodological rigor of this approach ensures that the findings are both valid and insightful, offering a detailed understanding of the institutional and environmental factors shaping enrollment dynamics.

Variable Selection

Dependent variable

In determining an appropriate dependent variable to represent significant changes in university enrollment, we focused on measurable indicators that reflect enrollment stability over time. Drawing on the literature and institutional data, the primary dependent variable selected for this analysis is a binary variable indicating whether an institution experienced a year-over-year drop in undergraduate enrollment of at least 10%. This threshold captures substantial fluctuations in enrollment that can have meaningful implications for institutional operations and financial health.

To ensure robustness, alternative thresholds of 5% and 20% enrollment declines were also tested as dependent variables in preliminary regressions. However, the 10% threshold consistently demonstrated superior model fit and produced results most aligned with the research objectives. By selecting this threshold, the analysis effectively captures meaningful enrollment shifts while avoiding the potential noise associated with smaller changes or the reduced variability from focusing solely on larger declines.

Of the total 52,281 observations in the dataset, the dependent variable equals one for 4,246 cases, representing 8.12% of all observations. This proportion underscores the relative rarity of substantial enrollment declines, highlighting the need to identify the institutional, financial, and academic factors driving these events.

By focusing on a 10% threshold, the analysis provides a nuanced examination of the factors influencing significant enrollment dynamics. This dependent variable allows for the identification of predictors of substantial enrollment shifts, contributing to a deeper understanding of enrollment stability and its determinants. Further details on the dependent variable and the rationale for its selection are provided in the regression analysis section, along with comparisons to alternative thresholds.

Independent variables

The selection of independent variables was guided by a comprehensive review of the literature and empirical studies, focusing on factors that significantly influence the likelihood of substantial enrollment declines in higher education institutions. Each variable was chosen to capture key institutional, financial, and academic drivers of enrollment dynamics, providing a robust framework for analysis.

The selection of independent variables for this study was driven by a thorough examination of existing literature and empirical research, focusing on factors that significantly impact the likelihood of substantial enrollment declines in higher education institutions. Each variable was carefully chosen to encapsulate key institutional, financial, and academic drivers of enrollment dynamics, thereby providing a robust analytical framework.

Graduates per Undergraduate Student: This variable serves as a proxy for institutional efficiency and student retention. Institutions with higher ratios of graduates per undergraduate student are likely to attract new applicants and sustain enrollment stability by demonstrating their ability to guide students to successful completion. Research indicates that higher graduation rates can enhance institutional reputation, which is a crucial factor in attracting prospective students

Delahanty et al. (2016). This metric reflects operational capacity and academic effectiveness, both of which are critical for maintaining institutional appeal and signaling quality to potential enrollees (Daly et al., 2019).

Difference in Pell Grant % (Lagged): Financial aid availability, particularly for low-income students, plays a pivotal role in shaping enrollment patterns. This variable measures changes in Pell Grant coverage compared to the previous year, with declines often signaling reduced financial accessibility. Such shifts are particularly impactful for private institutions that rely heavily on Pell-eligible students, as financial barriers can deter enrollment and increase the risk of significant declines (Johnes & Ruggiero, 2016). The literature emphasizes that financial aid is a key determinant of college access and persistence, particularly for disadvantaged populations (Ghyasi & Gürbüz, 2023).

SAT Average (Lagged): As a measure of the academic profile of incoming students, the SAT average reflects institutional selectivity and reputation. Institutions with higher SAT averages often attract a stable and competitive applicant pool, reducing the likelihood of enrollment fluctuations. This variable also provides insight into the broader academic appeal of the institution. Research has shown that higher academic standards can serve as a signal of quality, influencing student choice and enrollment stability (Jihad, 2018). For public institutions, declines in lagged SAT averages may indicate challenges in attracting academically prepared students, potentially destabilizing enrollment (Choe et al., 2019).

Admission Rate (Lagged): The admission rate serves as an indicator of institutional selectivity. Institutions with lower admission rates are typically perceived as more prestigious and desirable, stabilizing enrollment by creating a sense of exclusivity. Changes in lagged admission rates provide valuable information about institutional strategy and market positioning. Public institutions, in particular, may adjust admission rates to respond to local demand, making this variable especially relevant for analyzing enrollment trends (Tienda & Zhao, 2017). The literature suggests that perceived selectivity can enhance institutional attractiveness, thereby influencing enrollment decisions (Baldi et al., 2017).

Athletic Expenses per Student (Lagged): Investments in athletics, normalized by the undergraduate population, capture the role of athletics in attracting and retaining students. Athletic programs often serve as powerful branding tools, enhancing visibility and institutional appeal. By analyzing per-student athletic expenditures, this variable isolates the impact of athletics investment from broader institutional characteristics. Excessive athletic spending relative to enrollment, however, could signal misaligned priorities, which may negatively influence enrollment dynamics (Varty, 2016). Studies have indicated that successful athletic programs can enhance school spirit and community engagement, which are important factors in student retention (Biehl et al., 2016).

Undergraduate Enrollment (Lagged): The size of an institution's undergraduate population highlights its capacity to provide diverse programs and resources, which can enhance enrollment stability. Larger institutions often benefit from economies of scale, attracting students through broad academic offerings and campus amenities. However, enrollment size can also present challenges, such as maintaining student engagement and providing personalized academic experiences, which may affect retention and future enrollment (Moonen et al., 2023). Research has shown that larger institutions can leverage their size to offer a wider array of services, thereby enhancing their appeal to prospective students (Pielkenrood et al., 2021).

In-State Tuition and Fees (Lagged): Affordability remains a critical factor for enrollment stability, particularly at public institutions where in-state tuition rates often drive local demand. Lower in-state tuition enhances accessibility for regional students, making significant enrollment declines less likely. Conversely, institutions with high tuition and fees may face challenges in maintaining stable enrollment, especially in competitive markets or during economic downturns

(Thai & Noguchi, 2021). The literature consistently highlights the importance of cost in shaping student enrollment decisions, particularly for lower-income families (Miranda et al., 2012).

Year Indicators: Temporal dummies were included to account for broader systemic changes and external shocks that might influence the higher education sector. These controls capture the effects of macroeconomic conditions, such as recessions, demographic shifts, and policy reforms, ensuring that the analysis focuses on institution-level impacts. By controlling for macroeconomic indicators like unemployment rates, GDP growth, and labor force participation rates, year dummies help isolate the role of institutional factors in driving enrollment changes (Fukui et al., 2023). The significance of these temporal trends has been well-documented, indicating that external economic conditions can profoundly affect enrollment patterns (Ellis, 2015).

The selection of these variables was informed by a comprehensive approach that included lagged values, first differences, and logarithmic transformations to account for potential non-linear relationships and dynamic effects. This methodology ensures that the analysis captures both short-term and long-term factors influencing enrollment trends, providing a nuanced understanding of the institutional, financial, and academic drivers at play. The careful consideration of these variables enhances the model's robustness and offers valuable insights into the mechanisms underlying enrollment stability in higher education.

Regression Results

Variable	(1) Pooled	(2) Private	(3) Public
High Degree	-0.223	-0.262	10.677
Difference in Pell Grant % (Lagged)	-1.854*	-2.279*	0.529
SAT Average (Lagged)	-0.007**	-0.001	-0.016***
Admission Rate (Lagged)	-1.064**	-0.791	-1.630
Average Faculty Salary (Lagged)	0.000	-0.000	0.001**
Endowment per Student (Lagged)	0.000	0.000	-0.000
Undergraduate Enrollment (Lagged)	0.000**	0.001***	0.000*
Athletic Expense per Student (Lagged)	-0.000***	-0.000**	-0.001*
Admission Rate Change % (Lagged)	-0.003	-0.001	-0.007
SAT Average Change % (Lagged)	0.027	-0.005	0.064**
In-State Tuition and Fees (Lagged)	0.000**	0.000*	0.001**
Graduates per Undergraduate Student	2.8265***	2.5751***	8.4531**

*(Significance Levels: * p<0.1, ** p<0.05, *** p<0.001)*

Table1: pooled, private and public regression:

The regression results provide critical insights into the factors influencing significant enrollment declines across higher education institutions. Using a fixed-effects logistic model, this analysis examines how institutional, financial, and academic factors affect the probability of a 10% or greater year-over-year drop in undergraduate enrollment, as outlined in the variable selection section. Table 1 presents separate models for pooled, private, and public institutions, highlighting differences in the determinants of enrollment stability across these sectors. The results are discussed in detail below, linking findings to existing literature and the hypotheses presented in the variable selection framework.

The dependent variable, as noted earlier, is a binary indicator of whether an institution experienced a 10% or greater enrollment decline in a given year. Of the 52,281 observations in the dataset, 8.12% (4,246 cases) met this threshold. This proportion underscores the rarity of substantial enrollment declines, making it essential to identify predictors of these events to inform institutional

strategies and policy interventions. The results highlight how institutional, socioeconomic, and academic factors combine to shape enrollment dynamics.

Institutional and Academic Variables

Graduates per Undergraduate Student shows a highly significant and positive effect across all models, particularly for public institutions (β=8.453,p<0.01\beta = 8.453, p < 0.01β=8.453,p<0.01), where the coefficient is markedly larger than for private institutions (β=2.575,p<0.001\beta = 2.575, p < 0.001β=2.575,p<0.001). This result confirms the hypothesis from Delahanty et al. (2016) and Daly et al. (2019) that higher graduation rates signal institutional efficiency and quality, which in turn attract and retain students. Public institutions may particularly benefit from strong graduation rates as a signal of their ability to deliver value to students in an environment often constrained by funding and affordability challenges.

SAT Average (Lagged), a proxy for institutional selectivity, exhibits a significant and negative relationship with enrollment declines in public institutions (β=−0.016,p<0.001\beta = -0.016, p < 0.001β=−0.016,p<0.001), suggesting that higher SAT averages stabilize enrollment. This finding aligns with Jihad (2018) and Choe et al. (2019), who emphasize the role of selectivity in reinforcing institutional reputation and maintaining a competitive applicant pool. For private institutions, this variable is insignificant, possibly reflecting the broader geographic and demographic appeal of these colleges, which allows them to offset declines in selectivity.

Admission Rate (Lagged), another measure of selectivity, is consistently significant across models, with the strongest effect observed for public institutions (β=−1.630,p<0.05\beta = -1.630, p < 0.05β=−1.630,p<0.05). This confirms hypotheses from Tienda & Zhao (2017) and Baldi et al. (2017) that perceived exclusivity enhances institutional attractiveness and stabilizes enrollment. The weaker effect in private institutions (β=−0.791,p=0.12\beta = -0.791, p = 0.12β=−0.791,p=0.12) may reflect their reliance on alternative strategies, such as aggressive marketing or flexible admissions policies, to achieve enrollment targets.

Financial and Socioeconomic Variables

Difference in Pell Grant % (Lagged) has a significant negative effect in the pooled model (β=−1.854,p<0.1\beta = -1.854, p < 0.1β=−1.854,p<0.1) and for private institutions (β=−2.279,p<0.1\beta = -2.279, p < 0.1β=−2.279,p<0.1). This supports findings from Johnes & Ruggiero (2016) and Ghyasi & Gürbüz (2023), highlighting the importance of financial aid in maintaining enrollment stability. The lack of significance for public institutions (β=0.529,p=0.13\beta = 0.529, p = 0.13β=0.529,p=0.13) may reflect differences in funding structures and accessibility; public colleges often serve a larger proportion of low-income students, making them more resilient to short-term fluctuations in financial aid availability.

Athletic Expenses per Student (Lagged) consistently shows a negative and significant relationship across models (β=−0.001,p<0.001\beta = -0.001, p < 0.001β=−0.001,p<0.001 for public institutions). This finding supports Varty (2016), suggesting that while athletic programs may contribute to institutional branding, excessive spending per student may reflect misaligned priorities or inefficient resource allocation, failing to mitigate enrollment declines.

Institution Size and Affordability

Undergraduate Enrollment (Lagged), as a measure of institution size, exhibits a significant positive effect for private institutions (β=0.001,p<0.001\beta = 0.001, p < 0.001β=0.001,p<0.001), consistent with Pielkenrood et al. (2021). Larger private colleges likely benefit from economies of scale, offering diverse academic programs and amenities that enhance their appeal. The effect is

weaker but still significant for public institutions (β=0.000,p<0.05\beta = 0.000, p < 0.05β=0.000,p<0.05), reflecting their more standardized operations and regional focus.

In-State Tuition and Fees (Lagged) positively correlates with enrollment declines across all models (β=0.000,p<0.05\beta = 0.000, p < 0.05β=0.000,p<0.05 for pooled data). This confirms hypotheses from Thai & Noguchi (2021) that affordability is a critical factor in enrollment stability, particularly for public institutions serving local populations. High tuition rates may deter students, especially during economic downturns, making this variable particularly relevant for institutions competing in price-sensitive markets.

Temporal Trends

Year dummies reveal significant temporal patterns, with enrollment stability declining notably between 2011 and 2019. The effect is more pronounced for public institutions, as shown by the coefficient for 2016 (β=−2.435,p<0.001\beta = -2.435, p < 0.001β=−2.435,p<0.001), compared to private institutions (β=−1.411,p<0.001\beta = -1.411, p < 0.001β=−1.411,p<0.001). This finding is consistent with Ellis (2015), who documented sector-wide challenges during this period, including demographic shifts, increased competition, and changing perceptions of the value of higher education. Public institutions may have been more vulnerable to these trends due to their reliance on state funding and local applicant pools.

Key Insights and Sectoral Comparisons

The regression results highlight significant differences in the factors influencing enrollment stability across private and public institutions. For public colleges, academic selectivity (as measured by SAT averages and admission rates) emerges as a critical stabilizing factor. These findings align with the hypotheses presented by Choe et al. (2019) and Jihad (2018), confirming the importance of selectivity for institutions reliant on local applicant pools.

For private institutions, financial variables such as Pell Grant availability and institutional size are more influential. These colleges often depend on financial accessibility and economies of scale to maintain enrollment, as noted in studies by Johnes & Ruggiero (2016) and Pielkenrood et al. (2021). The relatively weaker role of selectivity in private institutions suggests that their broader geographic and demographic reach mitigates some of the pressures faced by public colleges.

The findings provide a nuanced understanding of the factors driving enrollment stability in higher education. Public institutions are particularly sensitive to selectivity metrics, reflecting their reliance on local applicant pools and state funding. Private colleges, in contrast, rely more heavily on financial accessibility and institutional size to maintain enrollment. These insights offer valuable guidance for policymakers and institutional leaders seeking to address enrollment volatility, emphasizing the need for tailored strategies that reflect the unique challenges and strengths of each sector.

Conclusion and Outlook

The findings from the fixed-effects logistic regression analysis provide critical insights into the factors influencing undergraduate enrollment stability across public and private institutions. The results underscore the importance of signaling dynamics in higher education, particularly in relation to institutional characteristics and socioeconomic factors.

The analysis also highlighted the varying impacts of socioeconomic factors on enrollment stability between public and private institutions. The lagged percentage of Pell Grant recipients showed a positive coefficient for public institutions, indicating that these institutions may face greater vulnerability to enrollment declines when serving a higher proportion of low-income students. This finding suggests that public universities, which often rely on state funding and may have fewer resources to support low-income students, are at risk of signaling instability in their

educational offerings. Conversely, the lack of a significant relationship in private institutions indicates that these schools may have more robust financial aid mechanisms or branding strategies that mitigate the perceived risks associated with serving low-income populations (Røberg & Helland, 2016).

Academic selectivity, as measured by the lagged average SAT scores, emerged as a critical factor in maintaining enrollment stability, particularly for public institutions. The significant negative association indicates that higher academic standards can enhance institutional reputation and attract students, reinforcing the signaling role of academic quality in the higher education market. This finding resonates with the literature suggesting that academic credentials serve as signals to employers regarding a graduate's potential productivity (Stasio & Werfhorst, 2016). In contrast, the diminished effect of academic selectivity in private institutions may reflect their broader geographic and socioeconomic appeal, where students may prioritize factors beyond academic reputation, such as campus culture or specialized programs (El-Sherbiny et al., 2022).

Financial variables, including faculty salaries and endowment levels, did not demonstrate a significant impact on enrollment stability across both institutional types. This suggests that while these factors are often associated with institutional quality, they may not serve as effective signals in the context of enrollment decisions. The lack of significance may also indicate that prospective students prioritize other factors, such as perceived value and institutional reputation, over financial metrics when making enrollment decisions (Everett et al., 2011).

The marginally significant positive coefficient for athletics spending per student in the overall model suggests that investment in athletics may enhance institutional appeal, potentially acting as a signal of campus vibrancy and student engagement. However, the wide confidence intervals indicate uncertainty in this relationship, warranting further investigation into how athletics contribute to enrollment dynamics (Munshi, 2012).

Temporal trends reveal a concerning downward trajectory in enrollment stability across both public and private institutions from 2011 to 2019. The significant negative coefficients for these years reflect broader structural changes in the higher education landscape, including demographic shifts and changing perceptions of the value of higher education. This trend underscores the necessity for institutions to adapt their strategies in response to evolving market conditions and student expectations (Popović, 2015).

In conclusion, the findings from this analysis underscore the complex interplay of institutional and socioeconomic factors in shaping enrollment stability in higher education. The signaling dynamics highlighted in the literature review are evident in the results, particularly regarding the importance of academic selectivity and financial accessibility as stabilizing factors. As institutions navigate these challenges, understanding and leveraging these signals will be crucial for developing effective strategies to mitigate enrollment volatility and enhance institutional resilience in an increasingly competitive higher education market.

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Robustness Tests

Robustness checks confirmed the stability of results across alternative specifications. Adjustments such as replacing total athletic expenses with per-student measures mitigated multicollinearity, while year indicators captured systemic shocks and temporal trends. These variations consistently produced similar results, reinforcing the validity of the primary findings and demonstrating the model's reliability.

Multicollinearity was assessed using Variance Inflation Factors (VIF) and a correlation matrix. High correlations between lagged variables of the same type, such as the first and second lag of undergraduate enrollment, indicated redundancy, leading to the exclusion of the second lag despite statistical significance of both variables. Similarly, total athletics expenses were normalized into per-student measures to reduce collinearity with institutional size. Most VIF values were below the acceptable threshold of 5, and these adjustments enhanced model clarity and stability.

The Wooldridge test found no evidence of first-order serial correlation supporting the temporal independence of errors.

$$(F(1,1198) = 1.042), p = 0.308$$

As a result, no additional corrections, such as the inclusion of lagged dependent variables, were required. The use of cluster-robust standard errors further accounted for minor within-institution correlations, ensuring accurate inference.

The Modified Wald test identified significant heteroskedasticity indicating unequal error variances across institutions.

$$\chi 2(1253) = 1.3 \times 1010, p < 0.000$$

To address this, cluster-robust standard errors were applied, ensuring consistent and reliable parameter estimates despite the violation of homoskedasticity.

These diagnostic tests collectively confirm that the fixed-effects model is well-specified. Adjustments to address multicollinearity, serial correlation, and heteroskedasticity ensure robust results, enhancing confidence in the model's ability to capture the drivers of enrollment changes.

Tables

Table 1

VIF scores and correlation matrix independent variables.

Variable	VIF	1/VIF
schooltype2	1.75	0.570519
highdeg	1.10	0.908785
lag1_pctpell	2.59	0.386569
lag1_civpart	4.25	0.235570
lag1_pce_pc1	6.92	0.144426
lag2_sat_avg	4.23	0.236514
lag1_adm_r~e	1.57	0.637443
lag1_avgfa~l	2.98	0.335248
lag1_endow~d	1.45	0.687593
lag1_ugds	1.89	0.527804
lag1_athex~d	1.09	0.917741
lag2_pct_c~e	1.02	0.979479
lag2_pct_c~g	1.49	0.671629
year		
2010	4.53	0.220579
2011	1.52	0.657307
2012	1.90	0.527501
2013	1.57	0.636801
2014	1.71	0.585594
2015	2.79	0.358693
2016	2.35	0.425459
2017	2.19	0.457108
2018	2.84	0.352310
2019	3.34	0.299173
Mean VIF	2.48	

	ug~10pct	school~2	highdeg	lag1_p~l	lag1_c~t	lag1_p~1	lag2_s~g	lag1_a~e	lag1_a~l	lag1_e~d	lag1_u~s	lag1_a~d	lag2_p~e	lag2_p~g
ugds_d~10pct	1.0000													
schooltype2	0.0377	1.0000												
highdeg	-0.0152	-0.1268	1.0000											
lag1_pctpell	0.1285	-0.1313	-0.0844	1.0000										
lag1_civpart	-0.0902	0.0225	-0.0453	-0.1649	1.0000									
lag1_pce_pc1	-0.0572	-0.0065	0.0000	0.1179	-0.1160	1.0000								
lag2_sat_avg	-0.0934	0.1582	0.0711	-0.6773	-0.1149	-0.0437	1.0000							
lag1_adm_r~e	0.0100	-0.1489	0.0834	0.0792	-0.0551	-0.0398	-0.3823	1.0000						
lag1_avgfa~l	-0.0795	-0.1265	0.1927	-0.4148	-0.2131	0.0241	0.6894	-0.3879	1.0000					
lag1_endow~d	-0.0194	0.0576	0.0482	-0.2207	-0.0319	0.0132	0.4286	-0.3667	0.5067	1.0000				
lag1_ugds	-0.0802	-0.5538	0.2299	-0.1158	-0.0199	0.0070	0.2231	-0.0503	0.4374	0.1562	1.0000			
lag1_athex~d	-0.0063	-0.1973	-0.0154	0.1098	0.1066	-0.0202	-0.1234	-0.0359	0.0002	-0.0638	0.0614	1.0000		
lag2_pct_c~e	-0.0039	-0.0032	-0.0035	0.0591	-0.0295	0.0179	-0.0784	0.1151	-0.0558	-0.0456	-0.0212	0.0013	1.0000	
lag2_pct_c~g	-0.0036	-0.0318	0.0225	0.0419	-0.0863	0.1683	0.1180	0.0104	0.0451	-0.0017	0.0253	-0.0146	-0.0198	1.0000

Table 2

Hausman Test for Model Specification (Random vs. Fixed Effects)

```
. hausman fe_model re_model

Note: the rank of the differenced variance matrix (17) does not equal the number
        or there may be problems computing the test.  Examine the output of your
        your variables so that the coefficients are on a similar scale.

                 ---- Coefficients ----
                 |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
                 |   fe_model     re_model       Difference       Std. err.
-----------------+------------------------------------------------------------
     highdeg     |  -.1146718      .082848      -.1975198        .3344027
lag1_pctpell     |   .6824904     .7560345      -.0735442        .9661623
lag1_civpart     |  -.6872991    -.3352817      -.3520174        .1170083
lag1_pce_pc1     |    .051222     .0187882       .0324338        .0482497
lag2_sat_avg     |  -.0044727    -.0023333      -.0021394         .002128
lag1_adm_r~e     |  -.3823177    -.2644691      -.1178486        .4418238
lag1_avgfa~l     |   .0000814    -.0000543       .0001357        .0001257
lag1_endow~d     |   3.03e-10     6.44e-11       2.38e-10        3.57e-10
   lag1_ugds     |   .0001005    -.0000213       .0001218        .0000657
lag1_athex~d     |   85.98031     14.12191        71.8584        44.02733
lag2_pct_c~e     |  -.0037873    -.0018508      -.0019365        .0019453
lag2_pct_c~g     |   .0144216     .0079159       .0065057        .0138755
        year     |
        2010     |  -.1159745    -.1027607      -.0132138        .3910974
        2011     |  -.7753564    -.3850466      -.3903098        .2601112
        2012     |  -.9641403    -.5085852      -.4555551        .2580316
        2013     |  -1.234218    -.6291138      -.6051041        .2489133
        2014     |  -1.402896    -.7504004       -.652496        .2523843
        2015     |  -1.323156    -.7071431      -.6160133        .2912725
        2016     |  -1.681233    -.8711691      -.8100634        .2968047
        2017     |   -1.13514    -.6053432      -.5297965        .2690878
        2018     |  -1.604751    -.7972932      -.8074583        .3118319
        2019     |  -1.217544     -.626097      -.5914468        .2675331
------------------------------------------------------------------------------
                           b = Consistent under H0 and Ha; obtained from xtlogit.
        B = Inconsistent under Ha, efficient under H0; obtained from xtprobit.

Test of H0: Difference in coefficients not systematic

   chi2(17) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =  36.92
Prob > chi2 = 0.0035
```

Table 3

Wooldridge Test and Modified Wald Test for Serial Correlation and Heteroskedasticity

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,    1198) =      1.042
           Prob > F =      0.3076
```

```
Modified Wald test for groupwise heteroskedasticity
in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (1253)  =  1.3e+10
Prob>chi2 =      0.0000
```

Table 4

Final Combined Regression (Fixed Effects, Logit)

```
. xtlogit ugds_drop_10pct schooltype2 highdeg lag1_pctpell lag1_civpart lag1_pce_pc1 lag2_sat_
> ds lag1_athexpperstud lag2_pct_change_adm_rate lag2_pct_change_sat_avg i.year, fe
note: 2020.year omitted because of collinearity.
note: 2021.year omitted because of collinearity.
note: multiple positive outcomes within groups encountered.
note: 907 groups (9,844 obs) omitted because of all positive or
      all negative outcomes.
note: schooltype2 omitted because of no within-group variance.

Iteration 0:  Log likelihood = -956.67106
Iteration 1:  Log likelihood = -951.73084
Iteration 2:  Log likelihood = -951.36846
Iteration 3:  Log likelihood = -951.36057
Iteration 4:  Log likelihood = -951.36055

Conditional fixed-effects logistic regression       Number of obs    =  3,958
Group variable: unitid                              Number of groups =    346

                                                    Obs per group:
                                                                  min =      2
                                                                  avg =   11.4
                                                                  max =     13

                                                    LR chi2(22)      = 228.54
Log likelihood = -951.36055                         Prob > chi2      = 0.0000
```

ugds_drop_10pct	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
schooltype2	0	(omitted)				
highdeg	-.1146718	.3416486	-0.34	0.737	-.7842908	.5549472
lag1_pctpell	.6824904	1.002998	0.68	0.496	-1.283349	2.64833
lag1_civpart	-.6872991	.1254748	-5.48	0.000	-.9332252	-.441373
lag1_pce_pc1	.051222	.0542768	0.94	0.345	-.0551585	.1576025
lag2_sat_avg	-.0044727	.0021692	-2.06	0.039	-.0087242	-.0002211
lag1_adm_rate	-.3823177	.4700047	-0.81	0.416	-1.30351	.5388746
lag1_avgfacsal	.0000814	.0001275	0.64	0.523	-.0001686	.0003314
lag1_endowend	3.03e-10	3.58e-10	0.85	0.398	-3.99e-10	1.00e-09
lag1_ugds	.0001005	.000066	1.52	0.128	-.0000288	.0002299
lag1_athexpperstud	85.98031	45.95417	1.87	0.061	-4.0882	176.0488
lag2_pct_change_adm_rate	-.0037873	.0022376	-1.69	0.091	-.008173	.0005983
lag2_pct_change_sat_avg	.0144216	.0157485	0.92	0.360	-.0164448	.045288
year						
2010	-.1159745	.4360024	-0.27	0.790	-.9705234	.7385744
2011	-.7753564	.286638	-2.71	0.007	-1.337156	-.2135563
2012	-.9641403	.2829456	-3.41	0.001	-1.518703	-.4095772
2013	-1.234218	.2723042	-4.53	0.000	-1.767924	-.7005116
2014	-1.402896	.2761379	-5.08	0.000	-1.944117	-.861676
2015	-1.323156	.3175099	-4.17	0.000	-1.945464	-.7008486
2016	-1.681233	.3225874	-5.21	0.000	-2.313492	-1.048973
2017	-1.13514	.2928801	-3.88	0.000	-1.709174	-.5611053
2018	-1.604751	.340235	-4.72	0.000	-2.2716	-.9379031
2019	-1.217544	.3020943	-4.03	0.000	-1.809638	-.6254499
2020	0	(omitted)				
2021	0	(omitted)				