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Tuition increases and university behavior

Theory and evidence on student enrollment

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Research Summary

Why was the research done?

Governments around the world are working to achieve two key goals: expanding access to university education and managing the rising costs of delivering it. At the same time, public funding for higher education has been reduced or capped in many countries, placing growing financial pressure on universities. These institutions must now find ways to fund both high-quality teaching and world-class research, often turning to alternative sources of revenue—most notably, by increasing international student enrollment. In this context, it is crucial to understand how universities respond to changes in tuition, especially when it comes to domestic student enrollment.

What were the key findings?

Our research offers new insights into how universities behave in systems where tuition is regulated and domestic students can defer payments through income-contingent loans. Both our theoretical model and empirical analysis suggest that universities respond strategically to financial incentives. In contrast to what standard economic models might predict, we find that universities often expand enrollment in response to higher tuition or funding—particularly by shifting focus toward higher-tuition fields of study and adjusting admission strategies to attract more students. These behaviors highlight the significant role universities play in shaping access to higher education. Our model also emphasizes the complex objectives universities face: delivering education, conducting research, and managing finances. Empirical evidence shows that research funding is positively linked to both domestic and international enrollment, suggesting that education and research goals are deeply connected in shaping university strategy.

What does this mean for policy and practice?

These findings help policymakers and education leaders better understand how universities adjust to funding pressures and policy changes. They show the importance of designing funding systems that recognize the multiple roles universities play—and that support both broad access to education and the sustainability of research excellence.

Citation

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We acknowledge the Traditional Custodians of the lands on which we work and live across Australia.
We pay our respects to Elders past and present and recognise their continued connections
to land, sea and community.

Tuition Increases and University Behavior: Theory and Evidence on Student Enrollment

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Abstract

This paper considers the role universities play in determining their enrollment when faced with government regulated domestic tuition. Our theoretical framework posits that domestic student enrollment increase and international student enrollment decrease or remain unchanged when domestic tuition increases. Using 30 years of data, we find higher tuition increases domestic enrollment, mediated by an expectation that students may respond negatively to increased tuition. Universities shift enrollment toward higher-revenue fields. The results for international student enrollment is mixed, depending on the research intensity of the university.

Key Words: post-secondary education, university enrollment, tuition, government funding, university regulation

JEL Classification: I23, I28, I22

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1 Introduction

Most countries face a dual challenge: building a highly skilled workforce while managing the rising costs of delivering university education. Universities not only bear the increasing expense of providing high-quality instruction but also the growing financial demands of sustaining world-class research. At the same time, many governments have reduced or constrained public funding for higher education, prompting universities to respond and often turning to alternative revenue sources – most notably, expanding international student enrollment.

With the high and increasing cost of delivering a university degree, how can governments ensure a highly skilled workforce while enabling universities to manage these costs? This paper highlights the importance of considering the role universities play in encouraging greater participation by students in the face of increasing tuition. This paper goes beyond studies that focus on human capital formation and explanations for gaps in university participation from a student perspective. We demonstrate that even in a regulated environment, there are potential mechanisms (e.g. admission policies, decisions on program enrollment) that can result in universities encouraging participation when tuition increases. Utilizing both university and individual level data, we examine the impact of tuition and government subsidy changes on student enrollment.

We explore the effects of funding changes on enrollment in a system dominated by public universities, where all domestic students can defer tuition payments until they are earning an income.[1] Given the insurance feature of an income contingent loan repayment system, overall enrollment levels should, in theory, remain stable provided any tuition increases reflect a positive return to education. Missing from this expectation, however, is the potentially important role that universities may play in shaping enrollment outcomes. Existing studies that measure the effect of tuition on enrollment are complicated by the fact that universities set tuition, even when subject to extensive government regulation. Australia presents a unique institutional setting: tuition rates for domestic students are centrally determined by the federal government and, moreover, are uniform across all universities. This setting creates a valuable opportunity to isolate the effect of university behavior on enrollment.

This paper contributes to our understanding of university behavior by introducing a theoretical framework that considers explicitly how universities might respond to funding changes. The framework assumes that universities pursue a dual objective, delivering quality teaching (as reflected in the student educational experience) and conducting research (captured by research expenditure). The theoretical framework reflects core institutional features of the Australian university system, which is highly regulated for domestic students. Prior to 1997, a single tuition rate applied to all undergraduate programs. Since then, the federal government introduced multiple tuition rates that vary by discipline, with a student facing, in most years, one of three tuition rates.[2] In addition

[1] This deferral is facilitated through a government-managed income contingent loan system. Our empirical analysis focuses on Australia, where income contingent loans have been universally available since their introduction in 1989.

[2] Technically, tuition is determined at the course level, meaning that the total tuition charged depends on how each course is classified within a given discipline and its associated tuition rate. For example, a student enrolled in one

to tuition revenue, universities receive direct government subsidies for each domestic student they enroll. The formula for calculating these subsidies has evolved, ranging from negotiated "block grants" to discipline specific per student funding. The government also plays a role in setting the total number of subsidized domestic student places at each university, further shaping institutional incentives.

At first glance, these centralized controls suggest universities have limited discretion over enrollment. Universities, however, retain control over their admission processes which can vary across disciplines. While constrained in the aggregate number of subsidized domestic students, universities can reallocate places across disciplines in response to internal priorities. For international students, universities face few restrictions on tuition rates or on the growth of international student enrollment. These conditions suggest that university actions may mediate the effects of tuition changes by students on university enrollment and may shape the composition of enrollment across fields of study.

Our theoretical framework allows us to assess how university behavior will affect student enrollment in response to changes in tuition and government funding. The model yields four key results. First, student enrollment rise with increases in regulated tuition and per-student government subsidies under an assumption that students do not respond to tuition (Result 1).[3] Second, if tuition negatively affects student decisions independently of university decisions, the overall effect is ambiguous (Result 2). Third, when tuition varies by program and costs are not separable across programs, increases in one program's tuition raise its own enrollment while potentially lowering others (Result 3). Fourth, if international tuition reduces international enrollment, increases in domestic funding raise domestic enrollment but have limited or negative effects on international enrollment (Result 4). Fifth, if a university's choice in research spending attracts international enrollment, then an increase in domestic funding will have an ambiguous effect on domestic enrollment but increase international enrollment (Result 5).

Empirical analysis using university and individual level data broadly supports these predictions. Analyses focused on Results 1 and 2 show that higher tuition and subsidies increase domestic enrollment. Student reactions vary based on the different tuition bands. There is also evidence that student enrollment has grown primarily through an increase in commencing enrollment by students older than 19. Most students commence university between the ages of 17 and 23.

We explore Result 3 by separating the major fields of study for students into tuition groupings. A few fields can be classified as only low tuition rates or as only medium tuition rates. The other fields are associated with multiple tuition rates. The analysis supports the Result 3 hypothesis by demonstrating a limited to null effect of increased low tuition rates on enrollment for the only low tuition fields and a positive effect of increased medium tuition rates on enrollment for the only medium tuition fields. These results point to a conclusion that universities shift enrollment

English course and one economics course would pay less in tuition than a student enrolled in two economics courses.

[3] The strong assumption of no student reactions is based on the context of this study is one where all domestic students may defer the payment of tuition through an income contingent loan system.

emphasis toward higher-revenue fields.

Consistent with Result 4, increases in domestic tuition does not raise international enrollment across all universities. There is some evidence that international enrollment for the top research universities increase with increases in tuition and increases in government subsidies for domestic students which aligns with Result 5.

The remainder of this paper is structured as follows. Section 2 presents a brief review of the relevant literature. Section 3 provides an overview of the Australian university system. Section 4 presents our theoretical framework. Section 5 describes the data used in our empirical analysis. Section 6 explores the effect of tuition and subsidies on overall domestic enrollment. Section 7 explores the differential effects of changes in tuition and subsidies on program enrollment. Section 8 explores the effect of changes in domestic tuition and subsidies on international enrollment. Section 9 concludes.

2 Related Literature Review

Our paper relates to several strands of the literature that focus on student enrollment decisions, income contingent loan systems, and university behavior. This section synthesizes key findings across these areas and reviews how tuition influences enrollment decisions, particularly when financial aid mechanisms such as income contingent loans are in place.

2.1 Determinants of Enrollment

A substantial body of research has examined the determinants of higher education enrollment, highlighting the role of expected returns, financial costs, and behavioral frictions in shaping students' decisions.

Classic models of university attendance assume that education is a key driver of human capital formation, yielding economic benefits, individually and to society. Empirical evidence supports the view that private returns to higher education are generally positive. Moretti (2004) highlights significant social returns associated with increased college participation. Moretti's model and empirical approach build on the theoretical foundations established by scholars such as Acemoglu and Angrist (2000), Katz and Murphy (1992), and Freeman (1986). Altonji (1993) and Altonji et al. (2012) document significant earnings premiums are associated with college degree attainment.

More recent research, such as Leigh (2025), reinforces findings of returns to education from college participation in the Australian context. Wiswall and Zafar (2021) show that students' own beliefs about returns to education play a central role in enrollment decisions, underscoring the importance of both perceived and actual payoffs for degree attainment.

A vast literature documents significant gaps in university enrollment and/or unexplained differences in the selection of the quality of institutions attended, even after controlling for disparities in cognitive ability (see, e.g., Dynarski et al. (2021), Cohodes and Goodman (2014), and Hoxby and Avery (2013)). Behavioral factors, such as an over reliance on pre-college routines and aversion to debt, have been identified as contributing to lower than expected college participation rates (see, e.g., Mullainathan and Shafir (2013) and Lillis and Tian (2008)).

Tuition fees and associated costs present direct barriers to enrollment, particularly for students from low-income backgrounds. Dynarski (2002), Dynarski et al. (2021), and Deming and Walters (2017) show that reducing tuition or providing aid significantly increases college attendance. Long (2004) demonstrates that the format of financial aid influences college enrollment, with in-kind tuition subsidies significantly increasing enrollment among low-income students. Andrews and Stange (2019) show that despite higher prices, low-income students shifted toward higher-return majors due to increased targeted grant aid and institutional price discrimination.

Hübner (2012) and Helmet and Marcotte (2016) provide causal estimates using variation in fee structure, while Görgen and Schienle (2019) employ modern machine learning techniques to estimate heterogeneous responses to tuition changes. Lillis (2008) and Long (2004) offer evidence highlighting how the burden of upfront costs and concerns about debt deter prospective students, even when repayment schemes are income contingent.

Behavioral frictions such as myopia about the benefits of education and not understanding financial aid may also distort enrollment decisions. Levine et al. (2023) and Miller and Park (2022) show that students are more responsive to "sticker prices" than to net prices, suggesting a misunderstandings about the availability or structure of financial aid. Similarly, Bettinger et al. (2012) demonstrate that providing simplified financial aid information can significantly increase application and enrollment rates.[4]

2.2 Enrollment in the Context of Income Contingent Loans

Income contingent loan systems reduce the financial risk associated with higher education by linking repayments to future income, thereby offering an "insurance" mechanism that cushions borrowers against poor labor market outcomes. Such a system should increase higher education participation, especially among students with limited resources or from low-income family backgrounds. Because repayment obligations depend on income rather than fixed schedules, the perceived cost of borrowing and thus the disincentive to enroll is mitigated. Chapman and Ryan (2002, 2005) find no negative effect on enrollment by low-income students after Australia switched from no tuition to tuition with income contingent loans.

Concerns about adverse selection are less relevant in systems where income contingent loans are universally available. In such contexts, all students face the same terms, and the government bears

[4] Other important factors influencing enrollment include institutional quality (Dynarski et al. 2021; Cohodes and Goodman, 2014; Hoxby and Avery, 2013) and geographic proximity to universities (Barrios-Fernandez, 2022), which can affect both access and preferences.

the risk of lower than expected repayment. Congressional Budget Office (2020) emphasize this in their analysis of U.S. income-driven repayment plans, noting that broad eligibility and automatic enrollment can offset concerns about self-selection into loan schemes by lower-income or risk-averse students.

Despite an extensive U.S. literature on student loan effects under mortgage-style repayment systems (see Looney and Yannelis (2024) and Black et al. (2023)), few studies examine enrollment behavior under income contingent loan frameworks. Some recent contributions have begun to fill this gap. Britton and Gruber (2019) explore the U.K. experience, highlighting that income contingent repayment plans do not distort labor supply. In Australia, de Silva (2024) examines income contingent loan impacts on longer-term labor market outcomes, although not directly on enrollment behavior. Similarly, Herbst (2023) investigates income-driven repayment type programs in the U.S., focusing on their distributional and repayment effects. There is also a related theoretical literature studying the optimal design of income-based student loans (see, e.g., Gary-Bobo and Trannoy (2015) and Del Rey and Racionero (2010)).

An emerging literature explores how offering income related repayment options affects students' loan choices and broader welfare. Abraham et al. (2020), Cox et al. (2020), and Mueller and Yannelis (2022) show that the availability of income driven repayment plans influences repayment plan selection, with some evidence of better alignment between borrower circumstances and loan terms. Meanwhile, studies like Boutros et al. (2024) and Matsuda and Mazur (2022) model the welfare implications of income contingent repayment, suggesting that such systems can enhance equity without major efficiency losses.

Although income contingent loans may encourage participation by reducing the financial risk of enrollment, concerns remain about potential moral hazard issues related to the influence of softer repayment terms on a reduction in effort in school or on post-graduation labor supply. These dynamics, however, relate more to post-schooling outcomes than to initial enrollment decisions. For instance, de Silva (2024) and Fu et al. (2025) examine the impact of student debt on job search behavior and labor market outcomes but do not directly assess enrollment responses to loan terms.

2.3 University Behavior and Enrollment

Universities play an active role in shaping enrollment outcomes through their responses to market incentives, funding constraints, and regulatory environments. The literature on university behavior and enrollment covers papers that model behavior and empirical analyses of university responses to financial and competitive pressures.

Several papers have used a general equilibrium model approach to better understand university behavior. For example, Epple et al. (2006) model competition among private and public colleges, showing how tuition policies and financial aid affect student sorting and welfare. Fu (2014) develops a structural model of college competition, incorporating student preferences and institutional quality, demonstrating how policy changes impact both university strategy and student outcomes.

In settings with unregulated or market-based tuition pricing, universities engage in competition across multiple margins that cover tuition, student selectivity, program offerings, and targeted recruitment strategies. Bound et al. (2009) show that increased demand for higher education in the U.S. has been absorbed disproportionately by less-selective institutions which has permitted top-tier institutions to become more selective in their admissions. Card and Lemieux (2001) document increased post-secondary education participation as a result of rising returns to education, leading to capacity pressures and changing admission patterns. Hoxby (2009) provides evidence of growing stratification in the U.S. college market, with high-ability students increasingly sorting into more selective institutions. Kim and Stange (2016) show that tuition deregulation led institutions, particularly selective ones, to significantly increase tuition and adopt differential pricing across programs.

Kolpin and Stater (2024) examine how universities allocate resources toward recruitment to attract students. Kaganovich and Su (2019) study curriculum differentiation as a competitive tool to match student demand and institutional positioning. Groen and White (2004) analyze how admission standards differ between in- and out-of-state applicants, reflecting institutional financial incentives. Knight and Schiff (2019) further explore how non-resident tuition levels influence out-of-state enrollment, showing that higher tuition reduces non-resident applications, with varied effects by institutional type.

In systems with regulated tuition, universities compete with peer institutions on non-price margins such as admissions, research, and curriculum quality. De Fraja and Iossa (2002) develop a model of strategic interaction among universities, where institutions choose admission standards and research investments to maximize prestige under budget constraints. Eisenkopf and Wohlschlegel (2012) examine curriculum design in competitive settings with regulated prices, showing how differentiation can emerge even when tuition is fixed. Del Rey (2001) and Beath et al. (2012) analyze the trade-off between teaching and research, showing that funding structures and performance incentives can drive resource reallocation within universities.

In response to declining public funding, universities increasingly turn to international students as a source of revenue, particularly in tuition-regulated systems. Bound et al. (2020, 2021) document expanded international enrollment by U.S. public universities to offset revenue losses resulting from reductions in state funding, often without increasing domestic enrollment. Their findings suggest international students serve as a financial buffer, helping institutions maintain operations and quality amid funding shortfalls.

A strategy of supplementing revenues with an increase in international students willing to pay a tuition that is greater than domestic tuition raises a concern about the potential crowding out of domestic students. Machin and Murphy (2017) examine the impact of the growth of international students on domestic enrollment in the U.K. during a period when U.K. universities faced both regulated maximum undergraduate tuition rates and maximum places for undergraduate domestic students. They find no crowd out of domestic student enrollment from increases in international student enrollment. They also find a positive effect from increasing international student enrollment on graduate student enrollment, for which there were no regulated constraints on the number of available places for domestic graduate students. Similarly, Shin (2017) analyzes U.S. graduate programs from 1995 to 2005 and finds that increases in international student numbers increased domestic enrollment, although the magnitude and nature of the effects vary across fields and institution types.

2.4 Summary

Tuition increases and information frictions reduce enrollment, especially among low-income students. Behavioral biases can result in circumstances such as when actual tuition paid is less than observed posted tuition (e.g. sticker prices). Universal income contingent loans offer financial insurance and may stabilize enrollment, even in the case of rising tuition, as shown from research on the schemes in place in Australia, the U.K., and the U.S. The effects of moral hazard and student responsiveness to tuition, especially when tuition varies across fields of study, however, remain understudied.

Institutional responses to tuition changes are also rarely linked to enrollment, leaving gaps in understanding how policy, student behavior, and university strategy interact. This point is particularly true as it it relates to university reactions to changes in tuition.

3 Australian University System

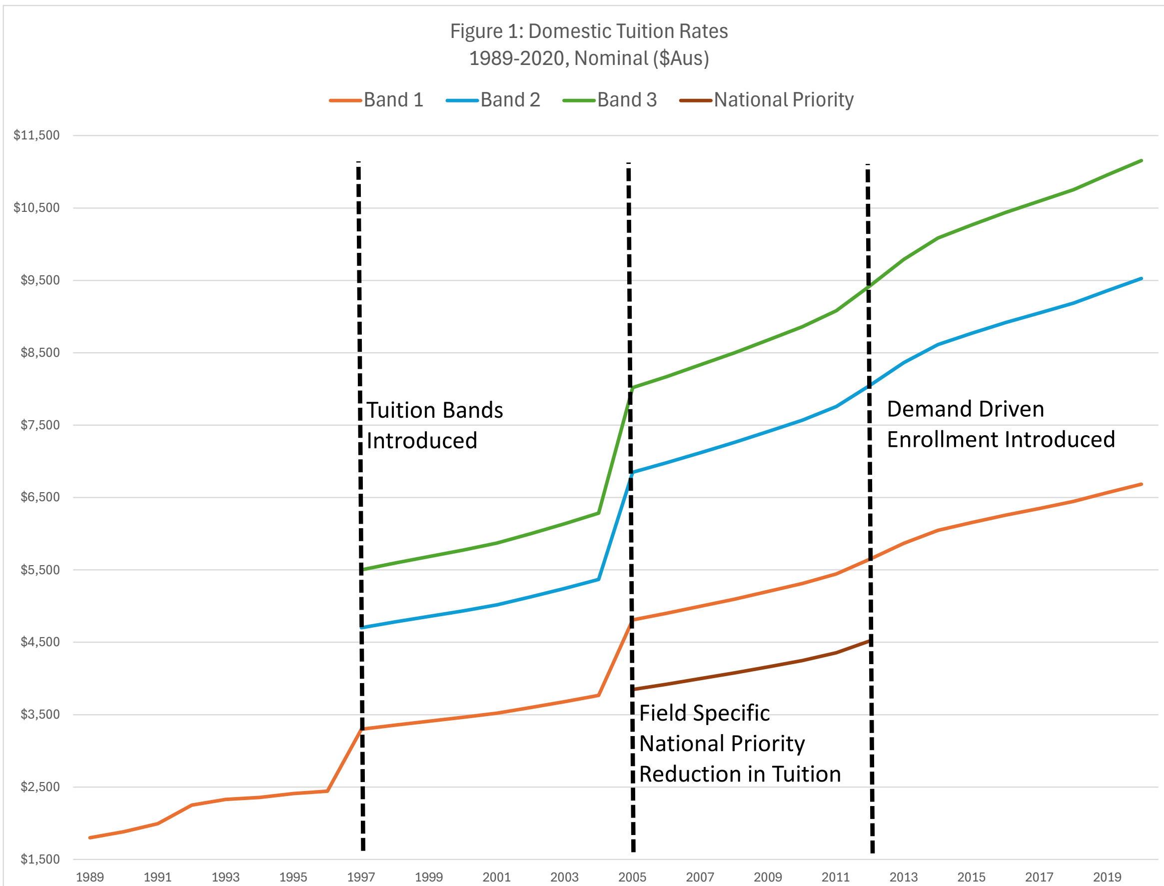
This section provides a brief overview of the government's role in the funding and regulation of Australian universities and the evolution of domestic and international student enrollment over the past thirty years. For a more in-depth review of the Australian university system, see Meek and Hayden (2005) and Norton (2020).

3.1 Government Funding and Regulation

Australian universities are funded and regulated by the federal government, which deviates from many countries where oversight is primarily at the state level.[5] Funding consists of revenues from tuition and associated fees (domestic and international), government subsidies that are linked to domestic student enrollment, public and private research funding from peer-reviewed awarded grant programs and special initiatives, and research contracts, donations, and endowments from individuals, foundations, and industry.

[5]Most universities are publicly provided. There are, however, a few private universities, with most of the private universities focusing on teaching.

Undergraduate teaching costs are covered primarily by tuition revenue and government subsidies for domestic student enrollment.[6] Prior to 1989, domestic students (Australian citizens and permanent residents) paid no tuition. Tuition and an option to defer the payment of the tuition through an income contingent loan repayment scheme were introduced in 1989. The federal government sets domestic tuition, and this tuition is applied universally across all universities.[7] The tuition charged between 1989 and 1996 was transparent. As illustrated in Figure 1, all undergraduate students were charged the same tuition up to 1996. In nominal terms, annual tuition rates increased from approximately $1,800 to $2,450.[8]



[6] We note that students may be subject to additional university fees, such as student services and amenities fees, laboratory or materials fees, and administrative charges. These fees are generally modest—typically amounting to a few hundred dollars per year—and, as such, have not been incorporated into our analysis.

[7] New Zealand citizens also qualify for the domestic tuition rate. In more recent years, the federally mandated domestic tuition is considered the maximum tuition a university may charge. Universities may charge a lower tuition rate, but to our knowledge, few if any, charge a lower tuition.

[8] All dollars reported in this paper are in Australian dollars.

In 1997, the government introduced a three-tiered tuition rate system, known as "Bands". Academic disciplines were assigned to a band based on assumptions about the expected economic returns from obtaining a degree for the given discipline. For instance, disciplines related to the creative arts, education, and nursing were placed in the lowest Band (1), whereas disciplines related to law and medicine were assigned to the highest Band (3). Most disciplines were assigned to Band 2. Although seemingly transparent, the tuition charged to a student is based on the courses taken. If a student takes courses in a number of disciplines that are assigned to different bands, the tuition charged will be weighted accordingly.

Figure 1 illustrates the variation in tuition rates by band for 1997 onward. In 1997, tuition ranged from $3,300 to $5,500 (nominal); Band 2 tuition was $1,400 greater than Band 1, and Band 3 tuition was $2,600 greater than Band 1 tuition. In subsequent years, increases in tuition were based on a percentage increase, which has ranged from 1.7 to 27.6 percent.[9] These increases have resulted in a growing difference across the bands, given there is a compounding difference in percentage increases. By 2020, these differences have grown to $2,843 and $4,471, respectively.

There have been two periods of sharp increases in tuition rates, in 1997 and 2005. Smaller, less noticeable changes occurred around 2012. These sharp increases are closely associated with the Australian federal election cycle. The 1997 changes came after the 1996 election of John Howard (switch from the Labor Party to the more conservative Coalition group of parties). The 2005 changes came after the reelection of John Howard in 2004. The 2012 changes came after the 2010 federal election shifted party leadership to the Labor Party (in a minority government).

Table 1 identifies the disciplines assigned to each tuition band. All disciplines have remained in the same band except for those associated with business and economics (e.g., accounting, marketing, and economics). These disciplines shifted from Band 2 to Band 3 in 2008.

Between 2005 and 2012, students were offered a discount on their tuition for disciplines that the government identified as "national priority". Education and nursing students received a discount (from Band 1) from 2005 to 2009. Students enrolled in mathematics, science, and related fields were offered a discount (from Band 2) from 2009 to 2012. The National Priority discount scheme concluded in 2012.

Universities receive a direct government subsidy that reflects the university's domestic enrollment. The subsidy intends to top up tuition received by the university to cover the cost of teaching.[10] Historically, the amounts allocated to universities were not disclosed on a "per-student" nor "by discipline" basis. Instead, the government operated under an overall budget constraint for allocating funding to universities. The universities negotiated individually with the government for a portion of this budget.[11]

[9]Historically, the tuition paid by a student is tied to the tuition rate in the year of commencing studies. For information on the grandfathering clause, see: https://www.education.gov.au/higher-education-publications/higher-education-administrative-information-providers-october-2021/4-grandfathered-students

[10]Universities also receive other subsidies that are associated with the cost of undertaking research and other university activities.

[11]These agreements were based on factors such as prior funding levels, projected enrollment rates, and specific

Table 1: Classification of Disciplines into Tuition Bands

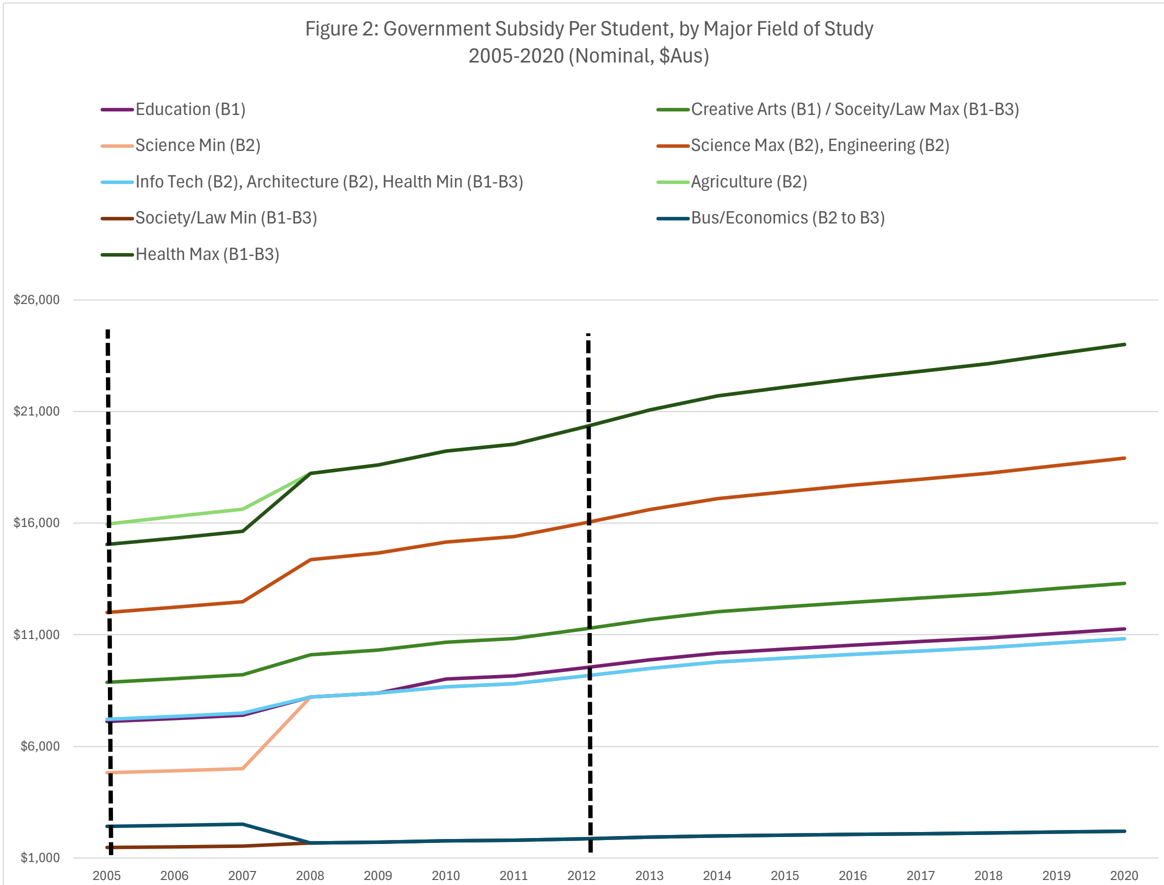
	1997-2004	2005-2007	2008	2009	2010-2012	2013-2020
Band 1	• Arts and humanities • Justice and legal studies • Social science and behavioral science • Visual and performing arts • Education • Nursing	Education & Nursing identified as National Priority Fields (discounted tuition)			Education & Nursing no longer identified as National Priority Fields (discounted tuition)	
Band 2	• Other health sciences • Agriculture and renewable resources • Built environment and architecture • Engineering and processing • Business and economics • Mathematics • Statistics • Science		Business and Economics moved to Band 3	Mathematics, Statistics, and Science identified as National Priority Fields (discounted tuition)		Mathematics, Statistics, and Science no longer identified as National Priority Fields (discounted tuition)
Band 3	• Law • Medicine and medical science • Dentistry and dental services • Veterinary science		• Business and economics			

Source: Parliamentary Library based on Department of Education,
https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp2021/Chronologies/HigherEducation

Starting in 2005, the government introduced a framework that created per student subsidy rates associated with student enrollment by academic discipline. The subsidies do not match one for one with the tuition bands. A high tuition band is not necessarily associated with a high subsidy rate. Given the intent of government subsidy is to supplement revenues from tuition to capture the cost of teaching, a low cost discipline that has high returns to education will receive a lower subsidy than a high cost discipline with low returns to education. For example, programs such as law and commerce charge the highest tuition but receive the lowest government subsidy. Programs such as nursing charge the lowest tuition but receive one of the highest subsidies. Within bands, disciplines such as mathematics and social science (Band 2) receive a much lower subsidy than disciplines such as engineering and science (also Band 2).

Because the enrollment data groups academic disciplines into fields of study, Figure 2 illustrates the subsidy rates for these fields. The fields identified as education, creative arts, engineering, business and economics, information technology, architecture, and agriculture have at most one subsidy

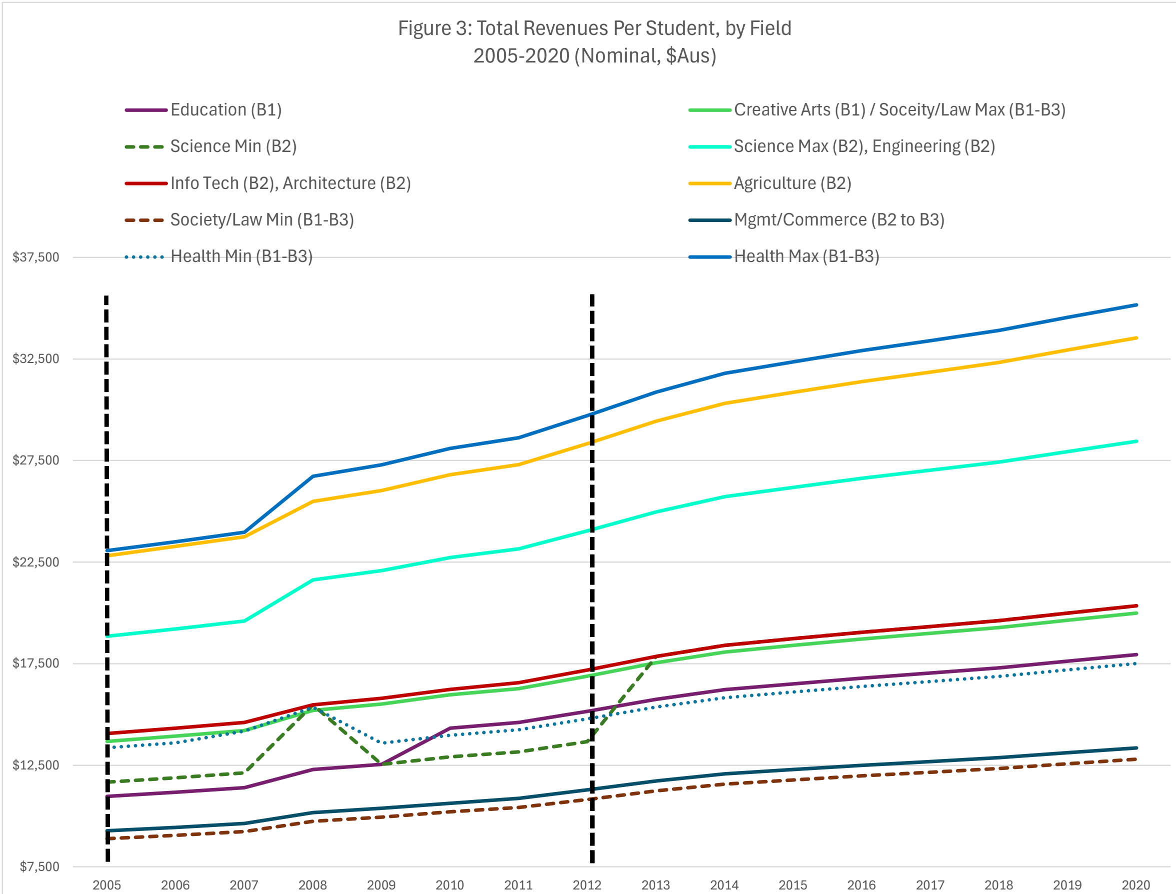
incentive arrangements. They also incorporated funding streams tied to research activities and external donations, including those from federal agencies, industry, foundations, and other sources.



rate associated with the disciplines within the field in any given year. The fields identified as science, society/law, and health can have multiple subsidy rates. For these fields, we compute the minimum and maximum subsidies for the disciplines within the field of study. Between 2005 and 2020, the subsidy ranged from $1,000 per student (minimum for society/law and business/economics) to more than $24,000 for the health field.

As universities receive both tuition and government subsidies for a domestic student, a university is likely to consider both forms of revenue when making decisions regarding the size and quality of the fields of study it offers. The total revenue per student by field of study is depicted in Figure 3. For the fields associated with multiple tuition rates and/or subsidies, we depict the maximum and minimum revenue. This figure highlights that in addition to tuition changes as depicted in Figure 1, there has been variation in total revenues received by universities that varies across fields. Throughout the study period, the federal government has imposed enrollment caps and related enrollment targets.[12] Universities have been permitted to enroll domestic students that exceed the

[12]Placements that are within the target are referred to as "Commonwealth Supported Places". For more infor-



caps. They do not receive the full subsidy for these students, however. The rules pertaining to the subsidies have varied over time. Universities are permitted to charge a domestic student who is not treated as falling within the enrollment cap the full cost of the program (tuition plus the government subsidy). Anecdotally, it is our understanding that most students who are considered to be above the enrollment cap are only charged tuition.

The specifics of domestic enrollment constraints are not easily discernible for the past 30 years. From extensive exploration, however, it is our understanding that the overall target was negotiated with the government, with universities being given the discretion to propose their targets. It is also our understanding that greater emphasis was placed on overall enrollment and lesser emphasis was placed on program specific enrollment.

In 2012, there was a change in the approach for assessing enrollment caps, representing a

mation on the structure of the university system in Australia, see https://www.education.gov.au/higher-education-funding/commonwealth-grant-scheme-cgs/20000-additional-commonwealth-supported-places significant policy shift. The government, in recognition of its goals for increasing the share of Australians with post-high school degrees, moved into a system that is commonly referred to as a "demand-driven" system of enrollment. Norton (2014) provides a review of the changes and what this new system meant for Australia. In essence, the demand-driven system resulted in a move back to university-based agreements, with universities being given potentially greater latitude for structuring enrollment targets, overall and across disciplines.

In sum, during the study period, universities have retained considerable discretion over how they utilize funding. Moreover, universities control the criteria for admission. These criteria vary across programs of study.

3.2 Domestic Student Enrollment

Most student applications consists of a student ranking her preferred programs by university that are processed through a centralized undergraduate application system administered at the state level. Admission is offered for one of these programs and is based on a match between the students' preferences and university admission criteria.

The admission process has evolved. Prior to 2009, most university admission decisions relied on state level university entrance examinations. In 2009, Australia introduced a national admissions ranking system known as the Australian Tertiary Admission Rank (ATAR). Universities located in the Australian Capital Territory and New South Wales adopted the ATAR system in 2009. Universities in the remaining states and territories, except Queensland, adopted the ATAR system in 2010. Queensland adopted the ATAR system in 2020.

Today, the primary determinant of admission is the ATAR score.[13] Throughout the sample period, relaxed admission criteria have been introduced for students that increase the likelihood of being admitted if they demonstrate such things as facing financial hardship, living with a disability, and/or difficult family and life circumstances.

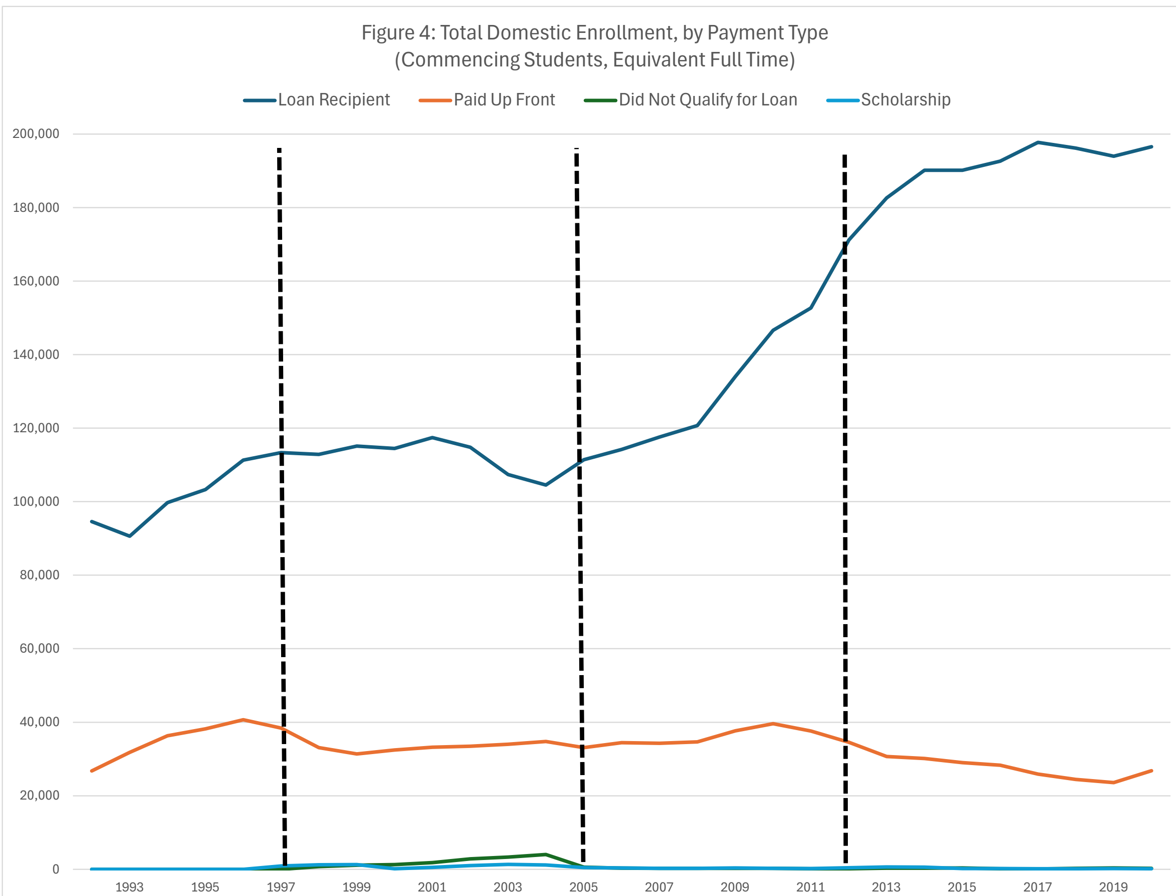
Once enrolled, all domestic students can choose to defer all or part of their tuition payment until they are gainfully employed.[14] Australia is one of a few countries to offer income contingent loans as an upfront option to all eligible domestic students, effectively providing insurance against the financial burden of tuition. These loans remain with the borrower until they are repaid or the student dies. Repayment obligations are based solely on individual earnings and are not influenced by spousal income. Until recently, outstanding student loan debt was not factored into credit assessments for mortgages.[15]

[13] For more detailed information on ATAR scores, see ff

[14] When tuition was introduced in 1989, the opportunity to defer payment through an income contingent loan scheme was also introduced. The loan scheme was designed to support increased access to universities and to ensure that students from low socio-economic backgrounds were not discouraged from attending university by having to pay for tuition up front. See Chapman (1997, 2006) and Chapman and Ryan (2005) for more information on the history of the income contingent loan scheme in Australia.

[15] The increased uptake of loans across fields of study is uniform. Figure 1 in the Appendix illustrates this point.

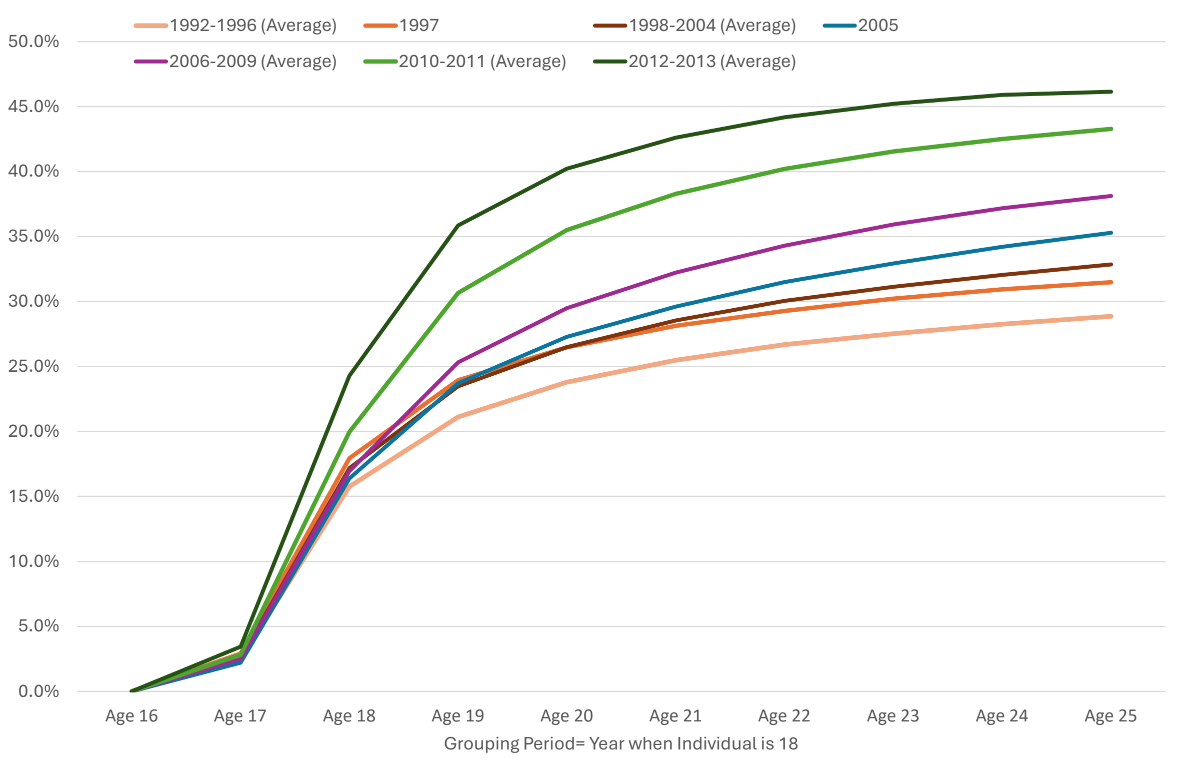
Figure 4 depicts the equivalent full-time commencing domestic student enrollment from 1992 to 2020. The figure highlights three key years associated with major changes in tuition and enrollment policy: 1997, 2005, and 2012. Enrollment is grouped according to the payment classification for the student. Universities receive government subsidies for those students classified as “loan recipient”, “paid upfront”, or “scholarship”. The “did not qualify for loan” would capture students for whom the university would not receive a government subsidy. Throughout the period, almost all students who have qualified for the government subsidy are identified as loan recipients. Up to 2012, the average share of commencing students with a loan across the key periods of change (before 1997, 1997 to 2005, 2005 to 2012) was between 75 and 78 percent. After 2012, the average share of students with a loan increased to 87 percent.



Prior to 1997, enrollment increased steadily from approximately 250,000 to 300,000. Between 1997 and 2005, enrollment levels remained relatively stable at around 300,000. Domestic enrollment began to increase around 2009, continuing through to 2019, with enrollment rising to approximately 450,000.

Figure 5 depicts the share of eligible enrollees by birth cohort grouping and age for the set of individuals we can observe between the ages of 17 and 25. The grouping of years reflects the years associated with tuition policy reforms, including changes associated with providing discounts for enrolling in national priority fields of study. The growth in commencements observed in Figure 4 appears to be driven primarily by an increase in enrollment by individuals 19 years and older from 1992 to 2009. From 2009 onward, enrollment rates increased from age 18 onward, with the highest shares of enrollment occurring between the ages of 18 and 23.

Figure 5: Share of Cohort Enrollment,
By Birth Year



3.3 International Student Enrollment

While the government has closely regulated the funding of domestic student enrollment and provided a universal income contingent loan system to domestic students, the same regulations and support have not been provided for international students. The constraint on tuition for international students is a lower bound. While universities have the discretion to charge tuitions that exceed domestic tuition, they may not charge an international tuition that is less than the tuition plus associated government subsidy for domestic students.[16] For example, in recent years, annual tuition for a commencing international student in a commerce program was approximately $50,000, compared to $15,000 for domestic students in the same program. Importantly, international students are not eligible for Australia's income contingent loan scheme.

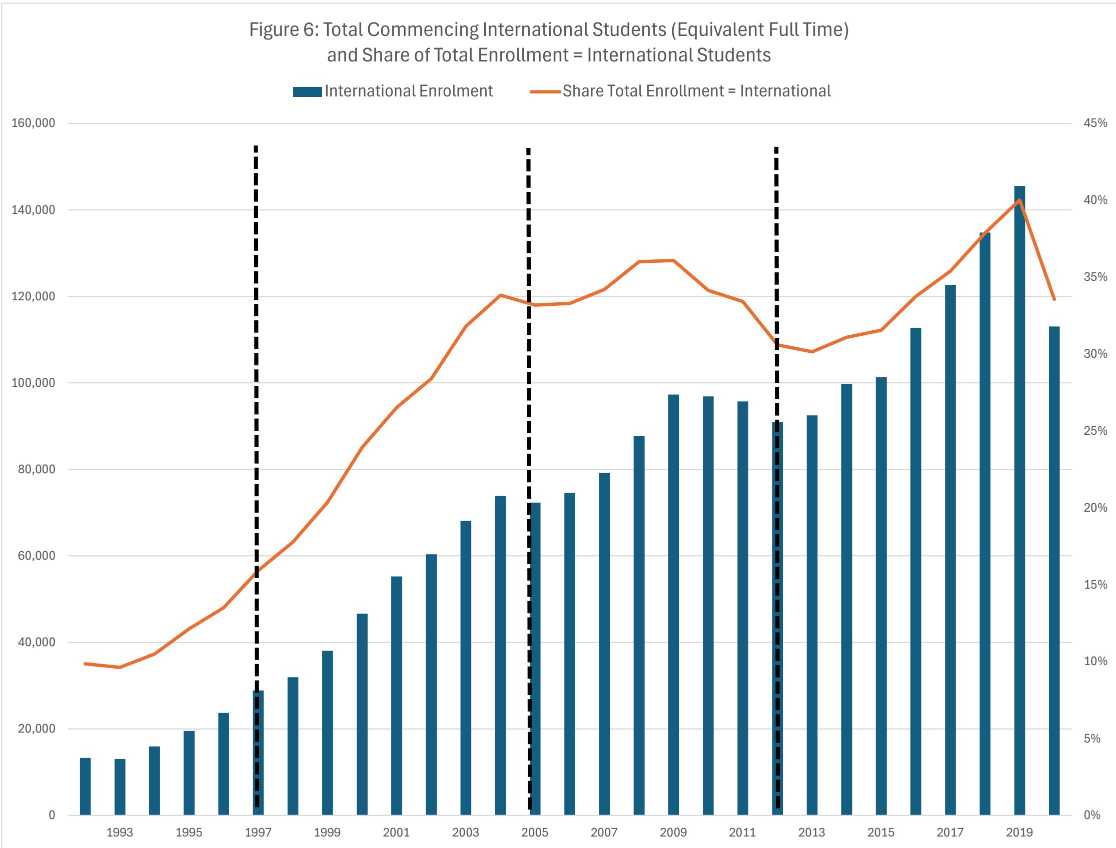


Figure 6 depicts the full-time equivalent enrollment of commencing international students from 1992 to 2020. The bars represent total annual enrollment (left axis) and the line (plotted on the right axis) indicates the share of all commencing students who were international. From the early 1990s through the mid-2000s, both the number and proportion of international students remained relatively low but exhibited steady growth. During this period, the number of international students increased from fewer than 50,000 to approximately 150,000 per year, with their share of total commencing students rising from about 5 percent to 25 percent. Substantial growth occurred from

[16]Starting in 1991, international students were protected under the Education Services for Overseas Students Act to ensure that students receive the education for which they paid for by requiring universities and other educational institutions to register with the government prior to offering courses for international students. Other protections have been put in place since 1991 as well.

the mid-2000s onward, with the international student share reaching approximately 45 percent by 2019.

Although international students have been attending Australian universities since the 1950s, the marked expansion over the past two decades can largely be attributed to regulatory changes.[17] The Higher Education Funding Act of 1986 authorized universities to charge full fees to international students and was accompanied by the establishment of the Full Fee-Paying Overseas Students Program. Incentives for universities to expand international enrollment were further strengthened in the late 1990s through reforms to immigration policy, which facilitated skilled migration pathways. Under these reforms, international students were permitted to apply for permanent residency while residing in Australia. Additional immigration changes in 2011 continued to support the integration of higher education students into Australia's skilled migration strategy.

For the period under study, the government's visa policy has been the primary constraint on international enrollment. Universities retain full discretion over the tuition they charge international students, as well as the number of such students they admit.

4 Theoretical Framework

We develop a simple model capturing the salient features of the Australian public university system to illustrate how university decisions can impact the response of enrollment to changes in government funding. Our focus is on undergraduate domestic enrollment and we abstract away from both student application decisions and any potential strategic interaction between universities.[18] Universities take their pool of student applicants as given.

We assume: i) universities cannot affect domestic tuition (student contribution is regulated by the federal government), ii) universities receive government block grants as well as a per-student subsidy for domestically enrolled students, iii) domestic students universally qualify for an income contingent loan to cover their tuition, and iv) universities can set their own admission standards, choose how to allocate their operating revenue between teaching expenditure that improves the quality of their undergraduate programming and research expenditure that can enhances their international research prestige and decide what tuition to charge international students.

To set ideas, we first characterize university behavior with only domestic students and a single tuition and then extend the model to allow for multiple tuition rates and for international students.

[17] Meadows (2011) and Norton (2024) provide a more extensive summary of the treatment of international students.

[18] For a recent paper looking at the decision of students to apply to specific universities/programs within the Australian context, see the working paper by Yong, Coelli and Kabatek (2023).

4.1 Domestic Students Only

Consider a single university that faces a set of applicants or potential enrollees who differ in their ability a. Normalize the population of applicants to unity and assume ability is distributed on the interval $[\underline{a}, \overline{a}]$ according to the cumulative distribution $F(a)$ with positive density, $f(a) > 0$ for all a. Individual student ability is observable to the university and the university has a cut-off admission standard $\hat{a}$ such that all students with $a \geq \hat{a}$ are admitted to the university. For simplicity, we assume this ability distribution is uniform.

Students who are admitted have access to an income contingent loan for the full tuition amount. Consequently, unless applicants experience debt aversion, a change in the tuition should not affect enrollment decisions. For now we assume those applicants with an offer, accept and enroll at the university and later consider the possibility that tuition has a direct (negative) impact on student enrollment decisions. Therefore, the number of enrolled students will be $n(\hat{a}) = 1 - F(\hat{a})$ where n is decreasing in the admission standard. The average ability of enrolled students is

$$\theta(\hat{a}) = E\left(a | a \geq \hat{a}\right) = \frac{\int_{\hat{a}}^{\overline{a}} a dF}{1 - F(\hat{a})} \tag{1}$$

which is increasing in the admission standard, $\theta'(\hat{a}) > 0$.[19] An increase in the university's admissions standard increases the average ability of its students, but reduces the number of its enrolled students. Therefore, the university faces a quality-quantity trade-off in setting its admission standard.

Universities care both about the quality or educational experience of their undergraduate programming and its research 'prestige' which is captured by its total expenditure on research R.[20] Educational quality can be represented by the function $q(\theta, e)$, which depends on the average ability of enrolled students, θ, and the university's per student expenditure on its undergraduate programming, e.[21] The educational quality function is increasing in both arguments and strictly concave. Further, we assume that $q_{\theta e} \geq 0$.

The university's objective is

$$q(\theta, e) + \gamma R \tag{2}$$

[19] Differentiating (1),

$$\frac{d\theta(\hat{a})}{d\hat{a}} = \frac{f(\hat{a})}{(1 - F(\hat{a}))^2} \int_{\hat{a}}^{\overline{a}} (a - \hat{a}) dF > 0.$$

[20] Unlike a private firm (profit-maximizing objective) or government (social welfare objective), there is no standard approach as to the objective of universities/colleges (Winston, 1999). Previous work generally considers the role of universities in the context of competition for students and typically assumes universities care about institutional quality as reflected by either teaching quality only (see e.g., Epple et al. (2006)), research quality (as reflected by net teaching revenue, see e.g., De Fraja and Valbonesi (2012)) or both (see e.g., Del Rey (2001) and Fu (2014)).

[21] Building on the insights of Rothschild and White (1995) who modelled students as both inputs to the production of education and purchasers of education, a large literature has developed examining the pricing of education, e.g., tuition and financial aid, at post-secondary instuitions. We follow this line of the literature in our assumptions on the educational quality function. See also, Epple et al. (2006).

where $\gamma > 0$ is the weight put on total research expenditure. This parameter could reflect the effectiveness of the university in translating a dollar spent on research into international research prestige or reputation.

The university receives a government block grant G and per student funding that includes a government subsidy s paid directly to the university and a government regulated maximum student contribution or tuition t paid by students. The university may also have some non-government funding $I \geq 0$. These revenue sources fund the university's operating budget and are assumed to be fungible between operating, teaching, and research expenses.[22] The university has some fixed operating costs F and teaching/administrative costs $c(n)$ which are increasing and convex in total student enrollment, that is, $c'(n), c''(n) \geq 0$. The university also spends directly on its educational quality $E = ne$ and research activities R.[23]

The university's operating budget constraint is:

$$G + (s + t)n + I = F + c(n) + E + R \tag{3}$$

and we assume the university must balance its operating budget. The university's net teaching revenue (revenue from teaching plus other sources less administrative and teaching costs) can be defined as $G + (s + t)n + I - F - c(n) - E$. Therefore, any additional revenue raised beyond what is needed to finance the university's administrative and teaching cost is spent on research. Under our assumed objective universities care both about net teaching revenue and their educational quality.

Universities could vary along various dimensions, including the weight put on research expenditure, their sources of non-government revenue, their operating and fixed costs, and their educational quality functions. All universities, however, face the same regulated tuition and government per-student subsidy and each choose their admission standard and how much to spend on educational quality and research activities.

To solve for the university's optimal choices, we substitute R from the university's operating budget constraint (3) into its objective (2). The university's problem can then be written as:

$$\max_{\hat{a},e} \quad \Omega(\hat{a}, e) = q(\theta(\hat{a}), e) + \gamma\big[G + I + (s + t)n(\hat{a}) - F - c(n(\hat{a})) - n(\hat{a})e\big]$$

and the first-order conditions are

$$\Omega_{\hat{a}} = q_\theta(\theta(\hat{a}), e)\theta'(\hat{a}) + \gamma\big[s + t - c'(n(\hat{a})) - e\big]n'(\hat{a}) = 0 \tag{4}$$

$$\Omega_e = q_e(\theta(\hat{a}), e) - \gamma n(\hat{a}) = 0 \tag{5}$$

[22] The majority of Australian universities' "operating revenue" comes from tuition/government funding (commonwealth grants and research funding). A relatively small source of revenue is also generated from consultancy, contracts, royalties, trademarks, and licenses, accounting most recently 13% in 2022. (See "Financial Report of Higher Education Providers 2022", latest version)

[23] For Australian universities, their largest share of operating expenses is employee benefits, with academic employee benefits accounting for approximately 30% of total expenses and non-academic employee benefits accounting for 28% in 2022. (See "Financial Report of Higher Education Providers 2022", latest version).

which yield $e^*(t,s;\gamma)$ and $\hat{a}^*(t,s;\gamma)$.

Consider first the university's decision about how much to spend on education quality, e. The university will want to increase its per student spending on teaching quality until the marginal benefit of an additional dollar spent, q_e, equals the marginal cost γn. Note, a higher admission standard increases the average ability of students, since $\theta'(\hat{a}) > 0$, which will increase the marginal benefit of e if $q_{e\theta} > 0$. A higher admission standard will also reduce the marginal cost of increasing e as the number of students enrolled is decreasing in the admission standard, $n'(\hat{a}) < 0$. Therefore, with higher admission standards we would expect e to be higher.

Consider next the choice of the admission standard, $\hat{a}$. Increasing the admission standard increases quality but reduces the number of students enrolled and therefore reduces net teaching revenue which the university values at γ per dollar. The optimal admission standard ensures the marginal benefit of an increase in educational quality equals the marginal cost in terms of loss revenue of lower enrollment from a marginal increase in the admission standard.

Combining the two first-order conditions, the optimal choice of $\hat{a}$ and e ensure that

$$n\frac{q_\theta}{q_e}\theta'(\hat{a}) = -(s+t-c'(n)-e)n'(\hat{a}).$$

The expression q_θ/q_e is the per student cost savings from a marginal increase in the average ability of students keeping educational quality constant.[24] Therefore, the left-side is the total cost savings from a marginal increase in the admission standard (via a reduction in e) and the right-hand side is the foregone revenue from the marginal increase in the admission standard (via a reduction in enrollment). An increase in per student funding, s or t, increases the marginal cost of increasing admission standards.

To determine explicitly how the optimal choice of admission standard and per student educational quality spending changes with t and s as well as γ, we totally differentiate the first-order conditions to obtain (as shown in the Appendix A):

$$\frac{d\hat{a}^*}{dt} = \frac{d\hat{a}^*}{ds} < 0, \quad \frac{d\hat{a}^*}{d\gamma} < 0, \quad \frac{de^*}{dt} = \frac{de^*}{ds} < 0, \quad \frac{de^*}{d\gamma} < 0. \tag{6}$$

We then have $n^*(t,s;\gamma) = n(\hat{a}^*(t,s;\gamma))$ where

$$\frac{dn^*}{dt} = n'(\hat{a}^*)\frac{d\hat{a}^*}{dt} > 0, \quad \frac{dn^*}{dt} = n'(\hat{a}^*)\frac{d\hat{a}^*}{dt} > 0, \quad \frac{dn^*}{d\gamma} = n'(\hat{a}^*)\frac{d\hat{a}^*}{d\gamma} > 0. \tag{7}$$

As the marginal cost in terms of foregone revenue from fewer enrolled students depends only on

[24] This follows from totally differentiating the educational quality function holding quality fixed to obtain

$$\left.\frac{de}{d\theta}\right|_{\bar{q}} = -\frac{q_\theta}{q_e} < 0$$

.

the sum of $t + s$ the impact of either a change in tuition or the per student government subsidy on the universities decisions will be the same. Therefore, we have the following result:

Result 1. *Student enrollment will be increasing in both the regulated tuition and the per student government subsidy.*

Substituting $e^*(t, s; \gamma)$ and $\hat{a}^*(t, s; \gamma)$ in the binding operating budget (3) yields $R^*(t, s, G; \gamma)$ and totally differentiating yields (as shown in the Appendix A):

$$\frac{dR^*}{dt} = \frac{dR^*}{ds} > 0, \quad \frac{dR^*}{dG} > 0, \quad \frac{dR^*}{d\gamma} > 0. \tag{8}$$

An increase in per student funding either in the form of per student government subsidy or tuition will increase university research spending. There will be a positive direct effect since higher tuition is received for each of the currently enrolled students. There will also be two positive indirect effects. First, the number of enrolled students goes up which brings in additional revenue since the marginal student's funding they bring to the university more than covers their costs, that is, $t + s - c'(n^*) - e > 0$ and second, the per student expenditure on educational quality goes down which frees up additional revenue to spend on research.

Result 1 follows from the fact that universities face a quality-quantity trade-off in student enrollment and that universities can undertaken a decision that indirectly affects students enrollment, e.g. choice of admission standards. We have argued that with a universally income contingent loan system, it is unlikely that a change in tuition will affect a student's decision to enroll once they have applied to a university. This assumption could be relaxed. For example, consider the possibility that domestic enrollment depends negatively on both the admission standard and on domestic tuition, that is, total enrollment is given by $n(\hat{a}, t)$ which is strictly decreasing in both arguments with $n_{\hat{a}t} = 0$.[25] The choice of admission standard by the university is as before, but now when considering the effect of a change in domestic tuition on student enrollment, we have

$$\frac{dn^*(\hat{a}^*(t, s; \gamma), t)}{dt} = n_{\hat{a}} \frac{d\hat{a}^*}{dt} + n_t \tag{9}$$

where the sign of the first term on the right-hand side will be positive (as before) and the sign of the second term will be negative. Therefore, the effect of a change in domestic tuition on student enrollment will be ambiguous, and we have the following result:

Result 2. *If the regulated tuition negatively impacts enrollment independent of university decisions, then a change in tuition will have an ambiguous effect on student enrollment.*

As there is no reason or evidence to suggest applicants make an enrollment decision based on what per student funding the university receives directly from the government if the student chooses to enroll, an increase in the government subsidy s is expected to have a positive effect on domestic enrollment as before.

[25] We continue to assume that $n_{\hat{a}\hat{a}} = 0$.

4.2 Multiple Tuition Rates

Suppose now that the university offers J different programs or fields of study and that students apply directly to a program at the university as in the Australian system. Universities may differ in the number and types of programs they offer, but they can decide on the admission standard $\hat{a}_j$ for each of their $j = 1, ..., J$ programs. The program admission standard determines the number of students enrolled at the university in that program, denoted by n_j where $n_j'(\hat{a}_j) < 0$. Applicants to each program differ in their program-specific ability (distributed uniformly in the program applicant pool) and the average ability of those enrolled in program j is denoted θ_j where $\theta_j'(\hat{a}_j) > 0$. The university cares about the educational quality of each of the programs it offers where quality of programming is an increasing and strictly concave function of the average ability of students in the program and given by $q_j(\theta_j)$ with $q_j'(\theta_j) > 0 > q_j''(\theta_j)$.[26] The university's objective is

$$W(q_1(\theta_1), ..., q_J(\theta_J)) + \gamma R \tag{10}$$

For simplicity, assume the function W is a weighted average of the program qualities, that is,

$$W(q_1(\theta_1), ..., q_J(\theta_J)) = \sum_{j=1}^{J} \alpha_j q_j(\theta_j) \tag{11}$$

with $\sum_{j=1}^{J} \alpha_j = 1$. Government funding includes a lump-sum block grant G and program-specific per student funding that provides a government subsidy s_j directly to the university and regulates a maximum student contribution or tuition t_j paid by the students to the university.

The university operating budget is

$$G + \sum_{j=1}^{J} (s_j + t_j) n_j + I = F + C(n_1, ..., n_J) + R \tag{12}$$

We consider two cases. First we assume that total teaching/administrative costs are separable in program-specific enrollment, that is,

$$C(n_1, ..., n_J) = \sum_{j=1}^{J} c_j(n_j) \tag{13}$$

with $c_j' > 0$ and $c_j'' \geq 0$.[27]

[26] In this extension, we ignore the decision of how much to spend for education quality in each of the programs. As discussed further below, this could be added without changing the qualitative results.

[27] In the case of linear costs, $c_j'' = 0$ for all j and we could think of $C(n_1, ..., n_J) = \sum_{j=1}^{J} \phi_j n_j$ with $\phi_j > 0$.

Substituting (12) into (10) and using both (11) and (13), the university's problem is:

$$\max_{\hat{a}_1,...\hat{a}_J} \ \Omega(\hat{a}_1,...\hat{a}_J) = \sum_{j=1}^{J} \alpha_j q_j(\theta_j(\hat{a}_j)) + \gamma\Big(G + \sum_{j=1}^{J}(s_j+t_j)n_j(\hat{a}_j) + I - F - \sum_{j=1}^{J} c_j(n_j(\hat{a}_j))\Big)$$

and the first-order conditions are

$$\frac{\partial\Omega}{\partial\hat{a}_j} = \alpha_j q_j'(\theta_j)\theta_j'(\hat{a}_j) + \gamma\Big(s_j + t_j - c_j'(n_j)\Big)n_j'(\hat{a}_j) = 0, \quad j = 1, ..., J \tag{14}$$

Each of the J first-order conditions determine program-specific admission cut-offs and enrollment as a function of per student government funding, s_j+t_j (as well as α_j and γ), that is, $\hat{a}_j^*(t_j, s_j; \alpha_j, \gamma)$ and $n^*(t_j, s_j; \alpha_j, \gamma) = n_j(\hat{a}_j^*(t_j, s_j; \alpha_j, \gamma))$ where it is shown in the Appendix A that

$$\frac{dn_j^*}{dt_j} = \frac{dn_j^*}{ds_j} > 0, \quad \frac{dn_j^*}{dt_{-j}} = \frac{dn_j^*}{ds_{-j}} = 0. \tag{15}$$

There will be no cross-program enrollment effects of a change in per-student funding.

When teaching/administrative costs are separable in program-specific enrollment, the positive relationship between tuition and enrollment arises for the same reason as in the single program case. The higher the tuition, the greater the potential revenue a university will forego if it restricts enrollment by increasing admission standards. Therefore, an increase in program-specific per student funding will result in greater program enrollment and, therefore, overall enrollment. We could have also adopted a more general program quality function $q_j(\theta_j, e_j)$ and allowed the university to choose program-specific per student expenditure e_j and obtained the same results.

The more interesting case is one in which teaching/administrative costs are not separable in program enrollment and depend non-linearly on aggregate enrollment, $n = \sum_{j=1}^{J} n_j$. We assume that

$$C(n_1, ..., n_J) = c\,(n) + \sum_{j=1}^{J} \phi_j n_j \tag{16}$$

with $c' > 0$, $c'' < 0$ and $\phi_j > 0$ for all j so there is a variable cost that depends both on total enrollment and program-specific enrollment. The marginal cost of enrolling an additional student depends on the program, that is, $\partial C/\partial n_j = c'(n) + \phi_j$, and importantly a marginal increase in the enrollment of one program affects the marginal cost in all programs by the same amount, that is, $\partial^2 C/(\partial n_j \partial n_{-j}) = c''(n) > 0$ for all $j, -j$.

Using (16), the university's problem is now

$$\max_{\hat{a}_1,...\hat{a}_J} \ \Omega(\hat{a}_1,...\hat{a}_J) = \sum_{j=1}^{J} \alpha_j q_j(\theta_j(\hat{a}_j)) + \gamma\Big(G + \sum_{j=1}^{J}(s_j+t_j)n_j(\hat{a}_j) + I - F - c\left(\sum_{j=1}^{J} n_j(\hat{a}_j)\right) - \sum_{j=1}^{J} \phi_j n_j(\hat{a}_j)\Big)$$

and the first-order conditions are

$$\frac{d\Omega}{d\hat{a}_j} = \alpha_j q_j'(\theta_j)\theta_j'(\hat{a}_j) + \gamma\Big(s_j + t_j - c'(n) - \phi_j\Big)n_j'(\hat{a}_j) = 0, \quad j = 1, ..., J \tag{17}$$

Unlike the previous case, each first-order condition depends on total enrollment through the marginal cost, $c'(n)$. Therefore, the admission standards for all J programs will be jointly determined by the J first-order conditions. Consequently, a change in the program-specific per student funding for one program will impact the admission cut-off and enrollment in another program.

For illustration, consider two different programs, $j = 1, 2$ and without loss of generality assume $\phi_1 > \phi_2 > 0$. The two first-order conditions on $\hat{a}_1$ and $\hat{a}_2$ jointly yield the optimal program-specific admission standards $\hat{a}_j^*(t_j, s_j, t_{-j}, s_{-j})$ for $j = 1, 2$, and by totally differentiating (as shown in Appendix A), we obtain

$$\frac{d\hat{a}_1^*}{dt_1} < 0, \quad \frac{d\hat{a}_2^*}{dt_1} > 0; \quad \frac{d\hat{a}_1^*}{dt_2} > 0, \quad \frac{d\hat{a}_2^*}{dt_2} < 0. \tag{18}$$

An increase in one program's tuition increases enrollment in that program and reduces enrollment in the other program; this would also happen with an increase in the government program subsidy. As before, a higher program tuition increases the marginal cost of restricting enrollment by increasing admission standards for that program. Therefore, the university will want to set a lower program admission standard and enroll more students. More students in this program increases the marginal teaching/administration cost of enrolling additional students in any program and this reduces the marginal cost of increasing admission standards in the other program. Therefore, admission standards in the other program will be increased and its enrollment reduced. Thus, there are cross-program enrollment effects of a change in a given program tuition. It can be shown, however, that overall total enrollment will go up with an increase in the tuition of one program, that is,

$$\frac{d(n_j^* + n_{-j}^*)}{dt_j} = n_j'(\hat{a}_j^*)\frac{d\hat{a}_j^*}{dt_j} + n_{-j}'(\hat{a}_{-j}^*)\frac{d\hat{a}_{-j}^*}{dt_j} > 0 \tag{19}$$

where $n_j^*(t_j, t_{-j}) = n^*(\hat{a}_j^*(t_j, s_j, t_{-j}, s_{-j})$ for $j = 1, 2$.

Therefore, we have the following result:

Result 3. *If the regulated tuition rates differ by programs, then an increase in a program's tuition will positively impact own-program enrollment and negatively impact the other program enrollment if total teaching/administrative costs are not separable in program enrollment.*

As shown earlier, there are no cross-program enrollment effects when teaching/administrative costs depend only on program enrollment. If the university makes a decision about per student expenditure e that improves the educational quality of all programs, i.e., $q_j(\theta_j, e)$, then we would again expect to see cross-program enrollment effects. Similar mechanisms will also be in play with more than two programs. An increase in program tuition is expected to increase own-program enrollment, and the cross-program enrollment effects are expected to be negative.

4.3 International Students

Assume now universities can enroll non-publicly funded international students and charge a differential tuition rate (above a regulated minimum) for international students relative to the regulated maximum tuition for domestic students. We focus on a single program and model the enrollment of international students as an additional revenue source for universities. The market for international students is assumed to be sufficiently large that any international student enrollment does not affect the quality of the universities' undergraduate programming.[28] In other words, for a given admissions standard the university is assumed to be able to recruit international students who will have the same average ability as domestic students.[29]

The university chooses the tuition to charge international students, t_f, and this tuition determines the number of international students who enroll, $N(t_f)$ where $N' < 0$ and $N'' \leq 0$. Teaching/administrative costs are increasing and convex in total university enrollment, that is, $c(n+N)$ with $c' > 0$ and $c'' \geq 0$. The university's operating budget is now given by

$$G + (s+t)n + t_f N + I = F + c(n+N) + R. \tag{20}$$

Having international students generates additional net revenue of $t_f N - c(n+N)$ for the university.

Substituting (26) into (2), the university's problem is

$$\max_{\hat{a},t_f} \quad \mathcal{L}(\hat{a},t_f) = q(\theta(\hat{a})) + \gamma\left(G + (s+t)n(\hat{a}) + t_f N(t_f) + I - F - c(n(\hat{a}) + N(t_f))\right) \tag{21}$$

where the first-order conditions are:

$$\mathcal{L}_{\hat{a}} = q'(\theta)\theta'(\hat{a}) + \gamma\left(s + t - c'(n+N)\right) n'(\hat{a}) = 0 \tag{22}$$

$$\mathcal{L}_{t_f} = \gamma\Big(N + \left(t_f - c'(n+N)\right) N'(t_f)\Big) = 0 \tag{23}$$

Consider first the choice of international student tuition. The optimal international tuition

[28]In recent work, Bound et al. (2020) assume that universities choose directly the enrollment of international and both in-state and out-of-state domestic students and that universities care only about the quality of their education. The educational quality function is linear in both per student teaching expenditure and international student enrollment, and quadratic in domestic enrollment, so the rate of decline in quality is smallest for international students. Thus, our assumption that international students do not affect domestic quality is a limiting assumption of the one made in this paper. Unlike our model, this paper does not model any potential mechanisms (admissions standards or rankings) that universities might use to control enrollment and further the university can choose domestic tuition and not international student tuition unlike the Australian context we model here.

[29]We abstract from universities' decisions on admission standards for international students and implicitly assume the admission standards are the same for domestic and international students. A small literature has looked at the ability of universities to set differential admission standards for in-state versus out-of-state (including non-domestic) students. For example, Groen and White (2004) show that stated-funded have an incentive to set lower admission standards for in-state students relative to out-of-state students whereas private universities set uniform standards.

maximizes the net revenue generated from international students and is given by

$$t_f = \frac{c'(n+N)}{1-(1/\epsilon_t)} \tag{24}$$

where $\epsilon_t = -t_f N'(t_f)/N > 0$ is the tuition elasticity of international enrollment. The more responsive international enrollment is to international tuition the lower the optimal rate. The first-order condition on t_f determines $t_f(\hat{a})$ with $t'_f(\hat{a}) \leq 0$. Lower admission standards increase domestic enrollment which increase the marginal cost of enrolling an additional student when $c'' > 0$ and, therefore, the international tuition that maximizes net teaching revenue from international students will be higher. With linear costs, $c'' = 0$, an increase in domestic enrollment has no effect on the marginal cost of enrolling an additional student and therefore does not affect the international tuition rate.[30]

The first-order condition on $\hat{a}$ has a similar interpretation as in the previous cases considered. Together, the two first-order conditions yield $\hat{a}^*(t,s;\gamma)$ and $t^*_f(t,s;\gamma)$. Totally differentiating (as shown in the Appendix A), we obtain

$$\frac{\partial \hat{a}^*}{\partial t} = \frac{\partial \hat{a}^*}{\partial s} < 0, \quad \frac{\partial \hat{a}^*}{\partial \gamma} < 0, \quad \frac{\partial t^*_f}{\partial t} = \frac{\partial t^*_f}{\partial s} \geq 0, \quad \frac{\partial t^*_f}{\partial \gamma} \geq 0. \tag{25}$$

A marginal increase in per student government funding reduces the admission standards thereby increasing domestic enrollment; the same marginal increase in per student funding increases the optimal international tuition and reduces international enrollment when $c'' > 0$ or has no effect on international enrollment when $c'' = 0$. Consequently, international student enrollment as a share of total enrollment will be decreasing in per student domestic funding.[31] We have the following result:

Result 4. *When the university additionally chooses its international tuition rate and this tuition negatively impacts its international enrollment, then an increase in the per student domestic funding will increase domestic enrollment and will have either a negative or zero effect on international enrollment.*

Result 4 will not necessarily hold if international enrollment respond to other university characteristics that reflect resource allocation decisions made by the university. An example of one such characteristic is the university's international ranking. With the advent of various different international university ranking system administered by third-party organizations, universities in Australia have been investing significant resources in trying to improve their international rank-

[30] With linear costs, the optimal tuition t^*_f is increasing in the constant marginal cost of teaching international students, $\phi_N > 0$ which could differ from domestic students, e.g., $c(n+N) = \phi_n n + \phi_N N$ with $\phi_n > 0$ and $\phi_n \neq \phi_N$.

[31] The share is given by

$$\frac{N}{n+N} = \frac{1}{1+\frac{n}{N}}$$

and will be decreasing in t since n/N is increasing in domestic tuition: n is increasing in t, and N is either non-increasing in t.

ings and research prestige often with the explicit intent of attracting international students.[32] To capture this, we consider a variation of the above model in which international student enrollment responds positively to the university's research spending R. Such spending could include both explicit marketing of the university to international students and other investments that makes the university more attractive to international students in addition to direct spending on research activities that improves the international reputation of the university.[33] Spending a dollar on these activities will benefit the university by γ as before, but will also bring in additional international students and their international tuition dollars which further benefits the university.[34] Therefore, a dollar spent on such activities is valued by more than γ and to what extent will be endogenous to the university's decisions.

To illustrate this potential mechanism assume that international tuition is fixed and international enrollment depends on research spending, $N(R)$ with $N' > 0$ and $N'' < 0$, and assume for simplicity that teaching/administrative costs are linear, so $c(n+N) = \phi(n+N)$ with $\phi > 0$.

The university's binding operating budget is

$$G + (s+t)n(\hat{a}) + t_f N(R) + I - F - \phi\Big(n(\hat{a}) + N(R)\Big) - R = 0 \tag{26}$$

which yields the implicit function $R(\hat{a}; t, s, G)$ where

$$\frac{\partial R(\hat{a}; t, s, G)}{\partial \hat{a}} < 0, \quad \frac{\partial R(\hat{a}; t, s, G)}{\partial t} > 0. \tag{27}$$

The university's problem can then be written as

$$\max_{\hat{a}} \quad \mathcal{L}(\hat{a}) = q(\theta(\hat{a})) + \gamma R(\hat{a}; t, s, G)$$

and the first-order condition on $\hat{a}$ is

$$\frac{d\mathcal{L}}{d\hat{a}} = q'(\theta)\theta'(\hat{a}) + \frac{\gamma}{1 - (t_f - \phi)N'(R(\hat{a}; t, s, G))}\,(s + t - \phi)\,n'(\hat{a}) = 0 \tag{28}$$

which yields $\hat{a}^*(t, s; \gamma)$.

The sign of $d\hat{a}^*/dt$ will now be ambiguous. The reason is as follows: an increase in tuition (or per student subsidy s) has two different effects on admission standards that work in opposite directions. First, as in the previous cases an increase in t or s will increase the marginal cost of setting a higher admission standard which puts downward pressure on the optimal choice of $\hat{a}$. Second, an increase in tuition increases the available resources to spend on R which brings in

[32] According to widely recognized rankings, 95 percent of Australia's public universities are ranked globally, with six in the top 100 and 10 in the top 200 worldwide. These top-ranked universities comprise the G08.

[33] That university rankings can impact student enrollment decisions and how universities set tuition rates was first empirically investigated in the US context (see e.g., Monks and Enrenberg (1999)).

[34] As previously shown, international tuition offsets the additional costs of having another international student enroll, that is, from the first-order condition on t_f, we have that $t_f - c' > 0$.

additional international students and their tuition revenue. This effect reduces the marginal cost of a higher admission standard and puts upward pressure on the optimal choice of $\hat{a}$. Depending on which effect dominates the admission standard could go up or down, and therefore the change in domestic enrollment with an increase in per student domestic funding is ambiguous.

Regardless of what happens to domestic enrollment, international enrollment will necessarily go up with an increase in per student domestic funding since the increase in per student domestic funding increases research expenditure. That is, by totally differentiating $R^*(t, s, G; \gamma) = R(\hat{a}^*(t, s; \gamma); t, s, G)$ we have (as shown in the Appendix A)

$$\frac{dR^*}{dt} = \underbrace{\frac{\partial R}{\partial \hat{a}} \frac{d\hat{a}^*}{dt}}_{(-/+)} + \underbrace{\frac{\partial R}{\partial t}}_{(+)} > 0. \tag{29}$$

The optimal amount of research spending is increasing in domestic tuition and therefore, international student enrollment will be increasing in per student domestic funding as stated in the following result:

Result 5. *If the university's choice of research spending positively affects its international student enrollment, then taking international tuition as fixed an increase in the per student domestic funding will have an ambiguous effect on domestic enrollment and will necessarily increase international enrollment.*

5 Data for Studying Student Enrollment

To study the effect of tuition and government subsidies on domestic enrollment, we rely on two data sources. The primary source covers university and program level data gathered from public sources and special requests of the Department of Education. The secondary source is individual tax return data that include information on student loan take up. Unfortunately, the individual and university level data cannot be linked, requiring us to undertake different but comparable analyses to test the results from the theoretical model.

5.1 University Data and Summary Statistics

The university data contains the following information:

Tuition: These measures are sourced from the Parliament of Australia.

Government subsidies for domestic enrollment, 2005 onward: These measures are sourced from publicly available documents on the Department of Education's website. For earlier years, we requested the information from the Department of Education. As indicated above, the subsidies are provided at a discipline level. Given that enrollment information is provided at a field of study level, we have created measures that capture the minimum and maximum subsidies across the disciplines associated with each field of study.

Commencing full-time equivalent enrollment, overall and by major field of study: Enrollment data are sourced from Australian government websites and were supplemented with special requests to the Department of Education. Enrollment data were provided in three tranches: 1989–2000, 2000–2004, and 2004–2021.[35]

Enrollment is recorded as full-time equivalent commencing students by university, field of study, and student type (e.g., domestic student with income contingent loan, full fee paying domestic student, scholarship recipient, and international student). We were provided with enrollment for twelve fields of study: Sciences, Information Technology, Engineering, Architecture, Agriculture (including Environmental Studies), Health, Education (teaching-oriented), Business/Economics, Society/Law (includes social sciences and humanities), Creative Arts, Food/Hospitality, and Mixed Field Programs. The latter two categories account for very small numbers of commencing students and are included only in our analysis of total enrollment. Note also that prior to 2000, enrollment for Society/Law and Business/Economics were combined.

Research funding: These measures are also drawn from publicly available sources. Australia classifies external research income into four categories (Categories 1–4). Category 1 covers competitive grants, primarily from government agencies such as the Australian Research Council (ARC) and the National Health and Medical Research Council (NHMRC), with other initiatives added over time. We further divide Category 1 into two subgroups: ARC/NHMRC funding and all other Category 1 grants. Category 2 captures funding from state and local governments; Category 3 includes private sector, philanthropic, and international funding sources; and Category 4 covers research income tied to cooperative research centers established through government agreements.

Based on observed research funding patterns, we classify universities into four categories:

1. Group of Eight (G08) universities which are Australia's leading research-intensive universities, regularly ranked internationally and historically attracting the highest research funding;[36]

2. Top 20 universities excluding the G08, as ranked by average Category 1 (ARC/NHMRC) research income over the sample period (1989-2020);

3. Universities with average research funding greater than $1 million per year, but not ranked among the Top 20;

4. Universities with little or no research funding, defined as less than $1 million per year.

[35] The division of data into three periods reflects changes in how programs were classified across fields. Where necessary, we have restructured the data to ensure consistency across the full sample period.

[36] All G08 universities are located in state or national capital cities. The G08 universities are: The University of Melbourne, Monash University (Melbourne), The University of Sydney, The University of New South Wales (Sydney), The Australian National University (Canberra), The University of Queensland (Brisbane), The University of Adelaide, and The University of Western Australia (Perth).

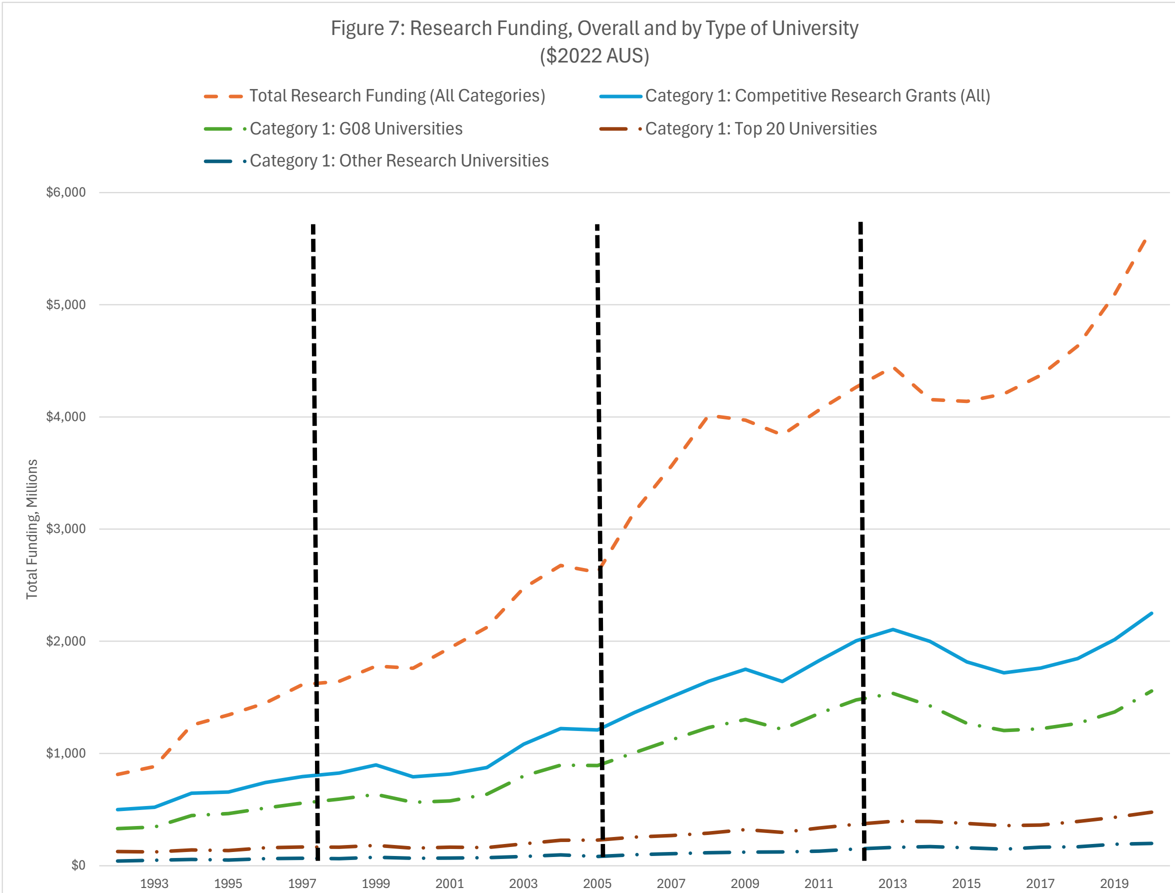


Figure 7 depicts annual total real research funding ($2022 Aus) for all universities and Category 1 competitive research funding by university grouping for the period under study. We have highlighted the periods of major tuition policy changes. Funding has grown from less than $1 billion to close to $6 billion. Category 1 funding has also increased, from $500 million to more than $2 billion. Yet, the share of total funding attributed to competitive federal grants (Category 1) has declined, from approximately 50 percent to 30 percent. The G08 universities far outstrip and have outgrown the other types of universities in terms of Category 1 research funding.

Given the noticeable differences in research funding between the G08 universities and the other classifications, for the remainder of this paper, we will only differentiate between the G08 and other universities for our proxy of comparing results for research-intensive and less research-intensive universities.

Table 2 presents summary statistics for total commencing enrollment, separated by domestic and international students, and research funding. In column (1), we report the statistics for all 92 universities. Over the sample period, the average university enrolls 3,780 domestic students

Table 2: Total Commencing Enrollments & Research Funding

	Full Sample	G08 Research Universities
	(1)	(2)
Commencing Student Enrollment (Full-Time Equivalent)		
Average Total Commencing Domestic Students	3,780	5,877
(standard deviation)	(2,766)	(2,361)
Coefficient of Variation (SD/Mean)	0.732	0.402
Average Total Commencing International Students	1,512	2,775
(standard deviation)	(1,748)	(2,416)
Coefficient of Variation (SD/Mean)	1.156	0.871
Research Funding (millions, $2022 Aus)		
Research funding (Category 1 Competitive Grants: ARC)	$13.380	$51.740
(standard deviation)	($21.657)	($26.282)
Research funding (Category 1 Competitive Grants: NHMRC)	$10.355	$48.326
(standard deviation)	($23.155)	($35.076)
Research funding (Category 1 Competitive Grants: Other)	$5.670	$19.910
(standard deviation)	($8.749)	($11.351)
Research funding (Category 2 Public Sector Funding)	$15.455	$54.464
(standard deviation)	($27.134)	($44.213)
Research funding (Category 3 Industry, Philanthropy, and International)	$19.342	$75.577
(standard deviation)	($34.798)	($51.804)
Research funding (Category 4 Cooperative Research Centers)	$2.316	$6.014
(standard deviation)	($3.846)	($6.231)
# of Universities	92	8
# of Observations	1320	232

Notes: Statistics cover the period 1992 to 2020. Data obtained from publicly available sources and from the Department of Education. G08 Research Universities: the top 8 universities that are internationally ranked and that are a part of the coalition of universities with this designation.

and 1,517 international students. This represents an average ratio of 2.5 domestic to international students. In column (2), we report the statistics for the G08 universities. Average enrollment is higher for these universities, which is not too surprising, as they would be akin to a flagship state university in the U.S. On average, the commencing enrollment is 5,877 students per year for domestic students and 2,775 for international students. For the G08 universities, the average ratio of domestic to international students is two to one. As expected, average research funding across all funding categories is lower when considering all universities than for the G08 universities.

Table 3 reports the summary statistics for commencing enrollment by university and field of study, overall and for years 2005 to 2020. The table also reports the summary statistics for the maximum and minimum government subsidies. In column (1), we report the statistics for all

Table 3: Total Commencing Students by Major Field of Study

	Full Sample (1)	G08 Research Universities (2)
Period: 1992-2020		
Average Total Commencing Domestic Students by Major Field of Study	445	599
(standard deviation)	(506)	(625)
Average Total Commencing International Students by Major Field of Study	187	301
(standard deviation)	(335)	(431)
# of Universities	92	8
# of Observations	11205	2276
Period: 2005-2020		
Average Total Commencing Domestic Students by Major Field of Study	482	640
(standard deviation)	(561)	(681)
Average Total Commencing International Students by Major Field of Study	248	422
(standard deviation)	(395)	(512)
Average Maximum Government Subsidy	$10,871	$12,103
(standard deviation)	(6456)	(5911)
Average Minimum Government Subsidy	$8,533	$9,440
(standard deviation)	(5772)	(5581)
# of Universities	86	8
# of Observations	6475	1270

Notes: Data obtained from publicly available sources and from the Department of Education. G08 Research Universities: the top 8 universities that are internationally ranked and that are a part of the coalition of universities with this designation.

universities, and in column (2), we report the statistics for the G08 universities. By field of study, the average commencing enrollment is 445 for all universities and 599 for the G08 universities. The average ratio of domestic to international enrollment is similar to that reported for total commencing students. The coefficient of variation, however, is higher, suggesting there is greater variation within universities and across fields than there is for total enrollment. Focusing on the period from 2005 onward, the ratio of domestic to international students is much lower, reinforcing the pattern depicted in Figure 6, namely the rapid growth in international students across all universities.

5.2 Individual Data and Summary Statistics

To capture commencing domestic enrollment at an individual level, we draw from Australian tax returns spanning 1991 to 2020, specifically the ALife dataset (Australian Tax Office (ATO) Longitudinal Information Files).[37] ALife consists of a 10 percent random sample of individuals from

[37] The tax year covers July 1 (e.g., 2016) to June 30 (e.g., 2017). Tax year refers to the year at the end of the period (e.g., 2017). ALife data are available from 1991. Several core measures such as changing employers, family

the ATO client register.[38] Individuals are longitudinally linked via their tax file number, a unique individual identifier.[39]

As the tax office is responsible for the administration of the income contingent loan scheme, we have constructed a data set to reflect the commencement of university studies, as evidenced by the take up of a university loan tied to the pursuit of a bachelor's degree. For these individuals, we equate the commencement of university studies with the first year of loan take up. As illustrated in Figure 4, a majority (over 80 percent) of commencing students take out a student loan. The individual data set, therefore, captures a near representative population of university enrollees.

The loan data contain information on the registered field of study.[40] We observe other characteristics such as birth year, gender, and the region of residence (based on tax returns filed by the individuals).[41] We identify individuals who would have been eligible to attend university based on their holding citizenship or a permanent residency visa. The proxy for eligibility is tied to the age at which we observe the individual or her parents having a health card number, and for whom we can observe their tax returns at least up to the age of 20.

Using the regional location of the individuals in our sample, we have used the broader tax filer data to construct a series of measures to reflect the regional economic conditions around the time of university enrollment.[42] Given regional socio-economic environments change over the nearly 30 years covered by our sample, these regional measures aim to capture time-varying local factors that may influence university enrollment decisions. We construct three sets of measures. First, we compute the median taxable family income across all families. The remaining two sets of measures focus on full-time workers aged 25 to 35. For each region, we compute the occupational composition of the region using one-digit occupation codes.[43] Leveraging the loan data and earnings post-schooling for all individuals ever observed with a loan, we construct a set of field-specific earnings for those aged 25 to 35.[44] This latter measure is designed to provide a proxy for the "expected"

status, etc., however, are only available for later years.

[38]The client register is constructed from tax returns lodged since 1980 as well as other means by which the ATO becomes aware of the existence of an individual, such as an employer or Centrelink (social service system) lodging a payment summary for that individual.

[39]For more details on the construction of the ALife data set and an assessment of its representativeness of the Australian population, see Polidano et al. (2020).

[40]The year of the first loan is based on the tax year which runs from July 1 in one year to June 30 of the next year. University terms operate on a calendar basis. We identify a tax year based on the ending year of the coverage of the return – e.g., for the tax year July 1, 1995 to June 30, 1996, the tax year is 1996. Given that most students would start a university program in the first half of the calendar year, an initial loan taken up for the tax year 1996 is interpreted as enrolling in university in 1996.

[41]The lowest level of geography is referred to as a Statistical Area Level 4 ("SA4"). SA4s are constructed by the Australian Bureau of Statistics and designed to reflect the labor market area for a region. See https://www.abs.gov.au/census/guide-census-data/geography/census-geography-glossary for more information on SA4s. We assign the SA4 observed for the age closest to being in high school that is available in the data.

[42]We observe the geographic location by age 19 for 73 percent of the sample. For the remainder of the sample, we use the first known geographic location.

[43]There are eight one-digit categories: managers, professionals, technicians/trade workers; community/service workers; sales; machinery operators/drivers; and labourers.

[44]The sample used for this measure consists of individuals working full time in one of the top occupations for the

regional returns to education at the time of enrollment.

Table 4: Selected Characteristics of Sample of Potential University Enrollees

	Full Sample (1)	Males (2)	Females (3)
# of Observations	698,086	357,976	340,110
Share Female	48.7%		
Mean Age of Initial Enrollment (if Enrolled) (17 to 46)	19.5	19.5	19.5
(standard deviation)	(2.5)	(2.5)	(2.6)
Observed Enrolling (Any Age)	38.9%	32.1%	46.1%
(standard deviation)	(48.8%)	(46.7%)	(49.8%)
Share Observed Enrolled Age 17 to 19	27.4%	22.3%	32.7%
Share Observed Enrolled Age 17 to 23	34.6%	28.5%	40.9%
Distribution of Initial Enrollment by Field Of Study			
Society/Law (Social Sciences, Humanities, and Law) (Bands 1 & 3)	20.4%	15.7%	23.9%
Economics & Business (Band 2 then switch to Band 3)	16.7%	19.5%	14.7%
Health (Band 1-3)	13.7%	8.1%	17.8%
Science (includes Math and Statistics) (Band 2 & National Priority)	14.1%	15.2%	13.4%
Education (Band 1 & National Priority)	8.3%	4.7%	11.0%
Engineering (Band 2)	6.4%	12.6%	1.8%
Computer/Technology (Band 2)	3.7%	7.2%	1.1%
Architecture (Band 2)	2.6%	3.7%	1.9%
Agriculture (Band 2)	1.4%	1.6%	1.2%
Creative Arts (Band 1)	7.4%	6.9%	7.7%
Mixed Fields	4.3%	3.9%	4.7%
Unknown	0.9%	1.0%	0.8%
Proxy for Citizenship Status			
Observed with Health Card # Between Ages 0 and 10	94.1%	94.1%	94.1%
Observed with Health Card # Between Ages 11 to 16	4.2%	4.3%	4.2%
Observed with Health Card # Between Ages 17 to 19	1.7%	1.7%	1.7%
Selected Regional Characteristics			
Observe residential location near time when in high school (by age 19)	73.0%	72.8%	73.3%
Median Taxable Family Income (1000s) for Region of High School Resic	$74.199	$74.163	$74.357
(standard deviation)	(19.470)	(19.047)	(19.129)

Notes: Individual data are derived from the sample of taxfilers in the ALife data set who are identified as being a citizen or permanent resident based on possessing a health number by the age of 19.

Table 4 reports the summary statistics for our key measures. We study 686,086 individuals. Of these individuals, 49 percent are female. Thirty-nine percent of the sample is observed enrolled in a bachelor's degree program for at least one year between the ages of 17 and 46. The average age at enrollment is 19.5 years. The most common initial field of study is Society/Law, followed by Economics & Business, Science, and Health. Approximately 94 percent of the sample are citizens or permanent residents by the age of 10. .

given field. We assign weights based on the prevalence of observing the occupation for each field of study.

In columns (2) and (3) of Table 4, we report the statistics separately by gender. Like many countries, more females are observed enrolled in a bachelor's program. The gap is 14 percentage points for all ages and 10 percent if we focus on enrollment by age 19. The top field of study for males is Economics & Business, followed by Society/Law, Science, and Engineering. The top field for females is Society/Law, followed by Health, Economics & Business, and Science. Just as gender gaps exist in university attendance, they are also evident in enrollment in STEM fields.

6 Overall Domestic Enrollment

Our theoretical model showed that student enrollment is expected to be increasing in the regulated tuition and the per student government subsidy, if there is no independent effect from tuition increases by potential students (Result 1). If potential students react to tuition changes, then the theoretical prediction of the effect of tuition on enrollment is ambiguous (Result 2). We explore these two theoretical predictions by running a series of reduced form regressions as outlined below.

6.1 University Analysis

We use the university data to estimate the effect of tuition for all years and the effect of tuition and government subsidies from 2005 onward on overall university enrollment. University enrollment is measured both as total commencing domestic student enrollment and total field of study enrollment. We undertake three different specifications.

$$DomEnr_{ut} = \alpha_u + tuit_t\beta + \gamma_1 intl_{ut-1} + \gamma_2 intl_{ut-1} * G08 + resfund_{ut}\phi + policy_t\delta + \epsilon_{ut} \quad (30)$$

The first specification given in Eq. (30) regresses total university domestic enrollment (DomEnr) for university u in year t. for the entire sample period (1992 to 2020) on nominal tuition rates (bands) and a dummy variable that captures the national priority discount period. We use nominal tuition rates in the regressions, as these reflect the rates observed by students at the time of enrollment. Since tuition rates are set by the Australian government rather than by universities, these measures can be considered plausibly exogenous. The base measures included in $tuit_t$ are as follows:

Tuition Band 1: This is the base rate that serves as the "anchor" for all years. Over the sample period, the average yearly change is approximately \$158.

Tuition Differential Band 2 - Band 1: From 1997 onward, the average change in this tuition differential is \$63.

Tuition Differential Band 3 - Band 1: From 1997 onward, the average change in this tuition differential is \$99.

National Priority Discount Period: A dummy variable equal to one from 2005 to 2012.

For some specifications, we interact one or more of the tuition measures with a G08 university dummy variable. The purpose of this interaction is to test whether there are differential effects for the most research-intensive universities.

We include several controls to capture time-invariant and time varying characteristics that are related to tuition policy and university behavior. We include university fixed effects to control for time-invariant characteristics of the university and the location of the university. We include a one-year lag of international university enrollment ($intl_{ut-1}$), measures of research funding received under the various funding categories ($resfund_{ut}$), and a set of policy variables ($policy_t$) to capture the time-varying changes in policies that could affect enrollment patterns. The set of policy variables we include are as follows:

Multiple tuition bands: A dummy variable equal to one for year 1997 onward. Prior to 1997 there was a single tuition rate.

Period when universities received an extra 10 percent coverage if they exceeded the enrollment cap: This dummy variable is equal to one in 2010 and 2011.

Post demand driven policy period: A dummy variable equal to one for the year 2012 onward.

Period of government funding being frozen: A dummy variable equal to one in 2017, 2018, and 2019.

By controlling for time-invariant characteristics of Australian universities through the inclusion of a university fixed effect, our goal is to assess how changes in tuition rates and total per-student revenues (tuition plus government subsidy) affect overall and field-specific enrollment.

The results from the regressions for the specification as given in Eq. 30 are reported in columns (1) to (3) in Table 5. Starting with column (1), if only the base tuition (Band 1) increases, enrollment increases an average of 3.9 students for each additional dollar in tuition. Under an average tuition increase of $158, we would expect enrollment to increase an additional 613 students per university, approximately a 16 percent increase. The coefficient on the tuition differential between Band 2 and Band 1 is positive and the coefficient on the tuition differential between Band 3 and Band 1 is negative. Using the average increases for all three tuition measures, these coefficients suggest that the average overall increase in total commencing enrollment is approximately 2.4 percent (89 students per year per university). Overall, the introduction of discounts for disciplines identified as national priority disciplines is negative, suggesting that these discounts are attributable to a fall in domestic enrollment.

In column (2), we interact the base tuition measure with a dummy variable for universities in the G08. The coefficients on the tuition measures remain significant and similar in magnitude, but the coefficient for the interaction term for G08 universities is negative. Across all universities, using the average tuition increases for the tuition measures suggests overall enrollment increases less than 2 percent for non-G08 universities, but that an increase in tuition results in less than a one percent increase for the G08 universities, which has higher average enrollment compared to non-G08 universities (5,877 versus 3,780).

In column (3), we interact all three tuition measures with the G08 dummy variable. For this specification, the coefficients are imprecisely measured. The coefficient on the lagged international enrollment for the university is positive, suggesting an increase of 1 to 1.5 domestic students for every 5 international students. The association, however, is negative for the G08 universities. For every 7 to 8 international students, there is a decline of approximately 1 domestic student for these universities.

The coefficients for the various types of research funding are mostly imprecisely measured. For the ARC grants (science, social science, and humanities) there is a positive association. The coefficient suggests an average increase of 19 students per university for each additional $1 million in ARC funding.

Finally, the coefficients on the period measures indicate domestic enrollment has increased during the periods associated with the introduction of variable tuition, the provision of increased subsidies for over enrollment of domestic students, and the shift to a demand driven enrollment policy.

$$\begin{aligned} DomEnr_{uft} = \alpha_u + \nu_f + tuit_t\beta + \theta_1 intl_{uft-1} + \theta_2 intl_{uft-1} * G08 \\ + \gamma_1 intl_{ut-1} + \gamma_2 intl_{ut-1} * G08 + resfund_{ut}\phi + policy_t\delta + \epsilon_{uft} \end{aligned} \tag{31}$$

The specification in Eq. 31 replaces the dependent variable with field-specific commencing domestic enrollment to capture the effect of tuition changes on the average enrollment by field of study. This specification permits us to add field fixed effects which control for time-invariant differences across the fields to the initial regression specification. We also can include field specific measures of international enrollment (lagged one year).

Through the use of field fixed effects, we can better capture differences that would be associated with such things as the relative cost differentials across fields. For example, fields that require laboratories and/or smaller class sizes will be more costly for a university than fields that permit large class sizes and no laboratories.

We report the coefficients from the specification given in Eq. 31 in columns (4) and (5) of Table 5, with column (5) including an interaction for the G08 universities and the Band 1 tuition rate.[45] For both specifications, the coefficient on the Band 1 tuition is positive and highly significant. The coefficients on the Band 2 and Band 3 differentials are not precisely measured but retain the same signs as those reported in columns (1) to (3). The coefficient for the G08 Band 1 tuition term

[45] If we interact all three tuition measures with the G08 university measure, the coefficients on all three interaction terms are imprecisely measured.

Table 5: Effect of Tuition on Total Domestic Commencing Enrollment

Dependent Variable	Total Commencing Domestic Students			Total Commencing Domestic Students, by Major Field			
	All Years			All Years		2005 +	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tution Measures							
Tuition - Band 1 ("Base Tuition")	**3.878**	**3.305**	**3.287**	**0.393**	**0.387**	1.854	1.943
	(0.932)	(0.889)	(0.890)	(0.095)	(0.095)	(6.916)	(6.912)
* G08 University		**-0.245**	-0.147		**-0.022**		**-0.060**
		(0.058)	(0.141)		(0.009)		(0.024)
Tuition - Band 2 Additional from Band 1	**332.359**	**302.423**	**281.175**	12.017	11.542	22.263	24.056
	(68.450)	(66.155)	(72.182)	(10.144)	(10.138)	(25.092)	(25.097)
* G08 University			150.048				
			(140.429)				
Tuition - Band 3 Additional from Band 1	**-216.792**	**-197.048**	**-183.515**	-8.195	-7.882	-16.993	-18.269
	(43.514)	(42.074)	(45.912)	(6.449)	(6.445)	(24.427)	(24.420)
* G08 University			-95.510				
			(89.360)				
Period of National Priority Tuition Discounts (Education/Nursing 2005-2009, Math/Science (2009-2012)	**-245.651**	**-262.339**	**-266.374**	**-29.695**	**-29.804**	-33.341	-38.211
	(74.546)	(69.320)	(69.405)	(12.594)	(12.595)	(26.449)	(26.510)
F-Test for Tuition Measures	**11.96**	**13.47**	**9.68**	**5.80**	**5.68**	0.66	***1.90***
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.617)	(0.091)
Government Subsidies							
Maximum Subsidy for Field						**0.086**	**0.086**
						(0.007)	(0.007)
* G08 University						**0.016**	**0.017**
						(0.002)	(0.002)
Minimum Subsidy for Field						**-0.070**	**-0.070**
						(0.008)	(0.008)
F-Test for Government Subsidies						**86.94**	**90.24**
(p-value)						(0.000)	(0.000)
International Student Measures							
Commencing International Students, Total for Field (lagged one year)				**0.409**	**0.409**	**0.428**	**0.427**
				(0.022)	(0.022)	(0.024)	(0.024)
* G08 University				**0.256**	**0.256**	**0.275**	**0.279**
				(0.042)	(0.042)	(0.042)	(0.042)
Commencing International Students, Total for University (lagged one y	**0.212**	**0.309**	**0.307**	-0.007	**-0.011**	**-0.026**	**-0.027**
	(0.033)	(0.036)	(0.036)	(0.005)	(0.005)	(0.008)	(0.008)
* G08 University		**-0.448**	**-0.448**	**-0.078**	**-0.068**	**-0.061**	**-0.045**
		(0.065)	(0.065)	(0.010)	(0.012)	(0.014)	(0.016)
F-Test for International Enrollment		**41.15**	**40.89**	**145.81**	**142.84**	**134.40**	**132.31**
(p-value)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Research Funding Measures (Millions)							
Research funding (Category 1: ARC, Competitive Grants)	**18.188**	**18.482**	**19.075**	**1.056**	**1.480**	**2.775**	**3.102**
	(3.967)	(3.630)	(3.672)	(0.504)	(0.545)	(0.912)	(0.941)
Research funding (Category 1: NHMRC, Competitive Grants)	**-10.396**	5.398	5.170	0.486	0.517	0.567	0.364
	(3.665)	(3.772)	(3.756)	(0.641)	(0.639)	(0.820)	(0.841)
Research funding (Category 1: Other, Competitive Grants)	-0.456	1.667	1.919	-0.089	-0.056	-0.395	-0.374
	(5.940)	(5.071)	(5.077)	(0.845)	(0.845)	(0.929)	(0.927)
Research funding (Category 2: Public Sector Funding, State/Local)	**-3.904**	1.303	0.974	-0.032	0.128	-0.094	0.077
	(1.472)	(1.432)	(1.503)	(0.220)	(0.228)	(0.269)	(0.284)
Research funding (Category 3: Industry, Philanthropy, Intl)	***-3.634***	**6.848**	**6.825**	0.587	0.600	0.394	0.425
	(1.915)	(2.595)	(2.581)	(0.400)	(0.401)	(0.498)	(0.499)
Research funding (Category 4: Cooperative Research Centres)	11.622	0.943	3.543	1.562	1.388	**4.145**	2.729
	(7.532)	(6.967)	(8.063)	(1.179)	(1.181)	(2.041)	(2.074)
F-Test for Research Funding Measures	**6.53**	**13.47**	**13.15**	**2.70**	3.64	**2.81**	**2.81**
(p-value)	(0.000)	(0.000)	(0.000)	(0.013)	(0.001)	(0.010)	(0.010)
Period Measures							
Post Introduction of Multiple Tuition Rates (1997+)	**8312.761**	**7276.807**	**7259.377**	**873.285**	**859.462**		
	(2209.411)	(2101.601)	(2104.000)	(224.362)	(224.472)		
Period of Extra 10% Coverage of Domestic Students (2010-2011)	**580.920**	**573.627**	**575.334**	**67.098**	**66.386**	**53.362**	**54.025**
	(73.490)	(73.586)	(73.803)	(13.080)	(13.082)	(18.455)	(18.428)
Post Demand Driven Enrollment Policy (2012+)	**1025.239**	**1039.727**	**1038.797**	**101.151**	**99.934**	**86.216**	**90.141**
	(115.768)	(107.171)	(107.327)	(20.698)	(20.723)	(35.105)	(35.031)
Post Freeze in Tuition (2017-2019)	-164.023	-104.744	-103.513	-7.717	-7.025	-1.963	-2.156
	(101.007)	(93.545)	(93.385)	(14.894)	(14.897)	(14.721)	(14.724)
F-Test for Period Measures	**30.53**	**31.70**	**31.60**	**12.61**	**12.21**	**2.89**	**3.02**
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.034)	(0.029)
F-Test for Field Controls				**711.49**	**711.47**	**265.82**	**265.15**
(p-value)				(0.000)	(0.000)	(0.000)	(0.000)
Constant	**-6411.777**	**-5064.411**	**-5063.712**	**-360.276**	-341.500	151.993	215.926
	(2213.088)	(2109.190)	(2111.322)	(223.833)	(223.913)	(232.629)	(233.003)
Other Controls	Univeristy Fixed Effects			University & Field Fixed Effects			
R-Squared	0.944	0.948	0.949	0.668	0.668	0.710	0.710
# of Universities	92	92	92	92	92	86	86
# of Observations	1320	1320	1320	11205	11205	6475	6475

Notes: Robust standard errors reported in parentheses.Coefficients in bold p<0.05; coefficients in bold & italics p<0.10
We report the specifications that interact a G08 dummy variable with the tuition measures only if one or more of the coefficients are statistically significant.

is negative, suggesting a smaller effect of tuition increases for these universities. Given average enrollment per field is 445 students, the coefficient on the Band 1 tuition increase suggests that overall field enrollment increases by approximately 14 percent for non-G08 universities and less than 10 percent for G08 universities, when evaluated at the mean tuition rates.

In column (5), we introduce lagged international enrollment by field of study into the specification and find that an increase in field-specific international enrollment is associated with an increase in domestic enrollment. For non-G08 universities, an increase of 5 international students is associated with an average within university increase of 2 domestic students. For G08 universities, an increase of 3 international students is associated with an average increase of 2 domestic students per field. As overall enrollment of international students for the university increases, however, there is a slightly negative association with overall domestic enrollment.

$$
\begin{aligned}
DomEnr_{uft} = {} & \alpha_u + \nu_f + tuit_t\beta + \Omega_1 Smax_{ft} + \Omega_2 Smax_{ft} * G08 \\
& + \Omega_3 Smin_{ft} + \Omega_4 Smin_{ft} * G08 + \theta_1 intl_{uft-1} + \theta_2 intl_{uft-1} * G08 \\
& + \gamma_1 intl_{ut-1} + \gamma_2 intl_{ut-1} * G08 + resfund_{ut}\phi + policy_t\delta + \epsilon_{uft} \qquad (32)
\end{aligned}
$$

Finally, we incorporate field-specific subsidies ($Smax_{ft}$, $Smin_{ft}$) into the specification in Eq. 32 . As this information is only available from 2005 onward, the specifications for these regressions cover the period 2005 to 2020. Importantly, during this period, the growth in tuition was more limited relative to the period leading up to 2005.

The government subsidies do not align with the tuition rates for two core reasons. First, while tuition policy has been designed to reflect relative differences in the expected returns to education, government subsidies have been structured to reflect differences in the cost associated with delivering different disciplinary degree programs. Second, within a given field, there can be multiple programs and, therefore, multiple government subsidies. Thus, the measures for each field capture the maximum subsidy provided for any discipline within the field and the minimum subsidy if there is more than one subsidy associated with the disciplines within the field.

We report the results for the specification given by Eq. 32 in columns (6) and (7) in Table 5. In column (6), we report the results when there are no interactions between the G08 university dummy and the tuition measures. In column (7), we interact the G08 university dummy with the Band 1 tuition measure.[46] The coefficients on the tuition measures are imprecisely measured, except the G08 interaction with the Band 1 tuition, which is negative and significant. The lack of precise estimates could be mechanical in given tuition increases during the period from 2005 onward are relatively small.

The coefficients on government subsidies are precisely measured, suggesting that as the maximum subsidy increases, domestic enrollment increase. For the non-G08 universities, an increase in

[46] If we interact all three tuition measures with the G08 university dummy the coefficients on the interaction terms are imprecisely measured.

the subsidy of \$1000 would increase enrollment by 86 students per field of study and university. For the G08 universities, the increase is greater, an average increase of 103 students per \$1000 increase. These estimates are tempered by a negative coefficient on the minimum subsidy available per field. Unlike tuition increases, however, changes in subsidies vary disproportionately over time.

In this final specification, the coefficients on the international students remain strong and increase slightly in magnitude. The same is true for the coefficient on the research funding associated with the Category 1 research funding under the ARC program.

Across the three specifications, the results for overall effects of tuition and government subsidies suggest that with increases in revenues, even after controlling for field-specific differences, domestic enrollment increases. There is also evidence that suggests a positive association between the growth in international students and research funding on the growth of domestic students.

6.2 Individual Analysis

In the previous section, we used university data to explore the effect of tuition and subsidies on enrollment, controlling for university and field differences. In this section, we use student data to explore the overall effect of tuition increases on commencing university, as observed through the initial take up of a university loan when tuition increases. Equations 33, 34, and 35 capture the specifications we use in our analysis in this section.

$$Enrol_{ibrt} = \alpha_r + tuit_t\beta + individual_{ibr}\gamma + region_{rt}\phi + policy_t\delta + \epsilon_{ibrt} \tag{33}$$

$$Enrol_{ibrt} = \alpha_b + tuit_t\beta + individual_{ibr}\gamma + region_{rt}\phi + policy_t\delta + \epsilon_{ibrt} \tag{34}$$

$$\begin{aligned} Enrol_{ibrt} = \alpha_b + tuit_t\beta + \Omega_2 smax_t * G08 + \Omega_3 smin_t \\ + individual_{ibr}\gamma + region_{rt}\phi + policy_t\delta + \epsilon_{ibrt} \end{aligned} \tag{35}$$

For all three specifications, in each year we capture the individuals between 17 and 30 who have yet to be observed enrolling in a university. The dependent variable equals 1 if we observe the individual commencing studies in year t, 0 otherwise. All specifications include the tuition measures as defined in the previous section, individual measures that cover the individual's gender, the period we first observe the individual with a health card (a proxy for being a citizen or becoming a permanent resident), and a measure to capture whether we observe the region of residence for the individual around the time she was in high school. The specifications also include the following regional characteristics at the time of enrollment: median household income, the share of young adults (25-35) employed in each 1-digit occupation code, and the average earnings for young adults previously identified as having been observed enrolled in the major fields of study. The same policy controls are included as in the university-based analysis. We also include a control to capture the adoption of the standardized testing scores (ATAR) in the admission process.

Equation 33 includes a regional fixed effects. The purpose of the regional fixed effect is to capture time-invariant characteristics that can affect the likelihood of enrolling in a university.

These characteristics would include geography (distance to university).

Equation 34 replaces the regional fixed effects with a birth year fixed effects. The birth year fixed effect controls for time-invariant characteristics that could affect the likelihood of enrollment, which can explain a difference in enrollment rates across birth years. For example, if during the period under study there are universal changes (e.g., introduction of more generous parental leave policies or subsidized day care), we might expect these universal changes to contribute to university enrollment.

Finally, Equation 35 includes the birth year fixed effects and measures to capture the maximum and minimum government subsidy for years 2005 onward. While we do not believe that potential students readily know about the subsidies received by the universities, these subsidies can influence university behavior, which will affect factors used by the student when deciding to enroll, e.g., investments in student services.

The coefficients for the three specifications are reported in Table 6. In column (1), we report the coefficients for the specification given in Eq. 33. The results from this specification are comparable to the results reported in Table 5. An overall increase in tuition (Band 1) leads to an increase in the likelihood of enrollment. The effect can be thought of as a 1.8 percent per \$100 increase in tuition. An increase in the Band 2 versus Band 1 differential also increases enrollment, whereas an increase in the Band 3 versus Band 1 differential decreases enrollment. Overall, the effect of tuition increases is positive.

With respect to the individual controls, the coefficients suggest a greater likelihood of women enrolling, similar to what is observed in most countries, and that enrollment is slightly higher for those who have been living in Australia the longest. Residing in a higher income region is associated with increased enrollment, and although the specific coefficients on the regional measures are not reported, the F-statistic for these measures is very strong.

Switching from a regional to birth year fixed effect (Column 2) results in different coefficients for the tuition measures (Eq. 34). The coefficient on the Band 1 Tuition remains positive but decreases in magnitude. The signs of the coefficients on the Band 2 and Band 3 differential tuition measures flip signs. Moreover, the coefficient on the national priority period of discounts is now positive.

Aligned with the university regressions, when we focus on the period 2005 onward, the role of government subsidies is important. As the maximum subsidy increases, there is an increase in enrollment. But as the minimum subsidy increases, there is a negative impact on enrollment. A suggestive story to explain these results, given that students are not aware of the subsidies the universities receive, an increase in the minimum subsidy might be a proxy for increasing costs for delivering university programs.

The tuition measures for 2005 onward remain significant. The coefficients suggest that a Band 1 increase leads to decreased enrollment. An increase in Band 2 and Band 3 differentials, however, can

Table 6: Effects of Tuition Changes on Individual Enrollment by Age 30

	All Years		2005 Onwards
Dependent Variable: Observed Enrolling for Given Year	(1)	(2)	(3)
Tuition Band 1 (Minimum) (1000s)	**0.018**	**0.009**	**-1.095**
	(0.000)	(0.000)	(0.058)
Tuition Band 2 Additional Tuition Above Band 1 (1000s)	**0.277**	**-0.355**	**0.646**
	(0.032)	(0.030)	(0.084)
Tuition Band 3 Additional Tuition Above Band 1 (1000s)	**-0.201**	**0.213**	**1.277**
	(0.020)	(0.019)	(0.092)
Period of National Priority Discount (0/1)	**-0.003**	**0.005**	**0.015**
	(0.000)	(0.000)	(0.002)
F-Test Tuition Measures	**833.09**	**397.74**	**103.18**
	(0.000)	(0.000)	(0.000)
Government Subsidies			
Maximum Government Subsidy Available for Any Field (1000s)			**0.723**
			(0.033)
Minimum Government Subsidy Available for Any Field (1000s)			**-7.857**
			(0.358)
F-Test Government Subsidies			**249.88**
			(0.000)
Student Characteristics			
Female Student	**0.021**	**0.020**	**0.021**
	(0.0002)	(0.0002)	(0.0002)
Observed with Health Card Between Birth and Age 10	**0.025**	**0.024**	**0.025**
	(0.0005)	(0.0005)	(0.001)
Observed with Health Card Between Ages 11 and 16	**0.025**	**0.025**	**0.021**
	(0.001)	(0.001)	(0.001)
Observed Region of Residence Near Time When in High School	**0.013**	**0.012**	**0.019**
	(0.0002)	(0.0002)	(0.0002)
F-Test Student Measures	**5601.51**	**5169.52**	**4983.28**
	(0.000)	(0.000)	(0.000)
Regional Median Family Income (1000s)	**0.0032**	**0.0003**	**0.0003**
	(0.00001)	(0.00002)	(0.00002)
F-Test Median Family Income + Shares of Occupations	**12615.04**	**1149.79**	**796.52**
	(0.000)	(0.000)	(0.000)
F-Test Regional Saleries of Young Adults by Field of Study	**100.28**	**65.28**	**30.90**
	(0.000)	(0.000)	(0.000)
Period Dummy Variables			
Post Introduction of Multiple Tuition Rates (1997+)	**0.403**	**0.193**	
	(0.008)	(0.007)	
Period of Extra 10% Coverage of Domestic Students (2010-2011)	**0.003**	**0.003**	**0.014**
	(0.001)	(0.0005)	(0.001)
Post Demand Driven Enrolment Policy (2012+)	**0.007**	**0.005**	**0.023**
	(0.001)	(0.001)	(0.002)
Post Freeze in Tuition (2017-2019)	**0.003**	**-0.005**	**0.006**
	(0.001)	(0.001)	(0.001)
Period when Discounts Given to Student for Paying Tuition Upfront	**0.003**	**0.002**	**-0.035**
	(0.001)	(0.001)	(0.002)
ATAR Scores Used for Admission (Introduction Varies Across States)	**0.010**	**0.007**	**0.005**
	(0.001)	(0.000)	(0.001)
F-Test Period Variables	**577.63**	**375.49**	**146.55**
	(0.000)	(0.000)	(0.000)
F-Test StatexYear Trends	**919.79**	**893.45**	**116.34**
	(0.000)	(0.000)	(0.000)
Constant	**-0.156**	-0.075	**-0.580**
	(0.070)	(0.069)	(0.054)
Fixed Effects and Trends	Regional Fixed Effects, State Year Trends	Birth Year Fixed Effects, State Year Trends	
Other Controls	Regional Measures to Capture Median Household Income, Distribution of Occupations (1 digit) for Adults Aged 25-35, and Observed Earnings for Occupations Observed for Past Enrollees by Field of Study		
R-Squared	0.0313	0.0384	0.0480
# of observations	5,998,579	5,998,579	3,880,450

Notes: An individual remains in the sample until she is observed enrolling or reaches the age of 30
Robust standard errors reported in parentheses.Coefficients in bold p<0.05; coefficients in bold & italics p<0.10

lead to increased enrollment. These coefficients are suggestive that both students and universities react to changes in tuition (Result 2). As such, the effects of tuition on domestic enrollment should be thought of as a lower bound of the effect of tuition increases on enrollment if we assume the tuition increase negatively affects students but positively affects university actions.

7 Field of Study Enrollment

Our theoretical model predicts that if the regulated tuition rates differ by programs, then an increase in one program's tuition will positively impact its own program enrollment and negatively impact other program enrollment if total teaching/administrative costs enrollment are not separable from program enrollment (Result 3). While we cannot directly test own versus other program enrollment, we can explore the extent to which field enrollment, by tuition grouping, varies as tuition changes using both the university and individual data.

7.1 Fields With Single Tuition Rates

We first focus on fields whose disciplines are associated with a single tuition rate. While several disciplines are associated with a Band 1 tuition rate, only two fields are exclusively associated with the Band 1 tuition: Creative Arts and Education.[47] Five fields are associated with Band 2 tuition rates: Engineering, Architecture, Agriculture, Math, and Science. The remaining fields contain disciplines that are associated with different tuition rates. Thus, in this section, we focus the analysis on the Band 1 and Band 2 only fields. In Table 7, we report the results using the two specifications given in Eqs. (31) and (32) for the two fields in Band 1 and the five fields in Band 2 using the university data. The coefficient on the G08 interaction with the tuition measures is only reported if it is precisely measured.

For the Band 1 only fields, the tuition measures are mostly imprecisely measured. For the post-2005 period, the coefficient for the Band 1 tuition interacted with the G08 university dummy is negative. These results suggest that, on average, universities may not focus on increasing enrollment for Band 1 disciplines. The coefficients for the government subsidy measure, however, are positive, suggesting an increase in enrollment when these subsidies increase. Note that while the subsidy for Education and Creative Arts differ, within these fields, there is only ever one subsidy for each discipline. The magnitude of the government subsidy coefficient is similar to what is reported in Table 5. The coefficient on the national priority measure is imprecisely measured in column (1) and negative in column (2), suggesting it had, on average, a negative or no effect on enrollment for the Band 1 disciplines.

In columns (3) and (4) of Table 7 we report the coefficients for the Band 2 only fields. When all

[47] As we treat the national priority period as discounts from the base, the field of education remains a Band 1 tuition group.

Table 7: Effect of Tuition & Government Subsidies (2005+) for Band 1 Only and Band 2 Only Fields

Dependent Variable: Total Commencing Domestic Students, by Major Field	Education / Creative Arts (B1 Only)		Eng/Arch/Agric/Math/Science (B2 Only)	
	All Years (1)	2005 + (2)	All Years (3)	2005 + (4)
Tution Measures				
Tuition - Band 1 ("Base Tuition")	0.042	-9.339	0.174	***-11.006***
	(0.113)	(11.500)	(0.114)	(6.530)
* G08 University		**-0.238**		
		(0.041)		
Tuition - Band 2 Additional from Band 1	-13.652	-6.487	**39.330**	16.174
	(14.277)	(32.450)	(10.338)	(22.389)
Tuition - Band 3 Additional from Band 1	8.623	17.670	**-25.276**	6.001
	(9.074)	(33.331)	(6.575)	(22.053)
Period of National Priority Tuition Discounts	8.761	**-84.533**	***-20.781***	-39.494
	(17.248)	(36.840)	(11.824)	(24.041)
F-Test Tuition Measures	0.66	10.98	**7.86**	**3.85**
(p-value)	(0.619)	(0.000)	(0.000)	(0.004)
Government Subsidies				
Maximum Subsidy for Field		**0.082**		**0.142**
		(0.039)		(0.021)
* G08 University		**0.105**		**0.012**
		(0.012)		(0.002)
Minimum Subsidy for Field				**-0.124**
				(0.021)
F-Test for Government Subsidies		**24.02**		**27.40**
(p-value)		(0.000)		(0.000)
International Student Measures				
Commencing International Students, Total for Field (lagged one year)	**1.519**	**1.639**	**0.372**	**0.427**
	(0.100)	(0.112)	(0.044)	(0.048)
* G08 University	-0.147	**-0.698**	**0.646**	**0.483**
	(0.186)	(0.183)	(0.085)	(0.082)
Commencing International Students, Total for University (lagged one year)	**-0.0241**	**-0.0533**	0.0016	-0.0051
	(0.008)	(0.014)	(0.005)	(0.007)
* G08 University	**-0.057**	-0.007	**-0.082**	**-0.059**
	(0.013)	(0.020)	(0.012)	(0.013)
F-Test for International Enrollment	**79.48**	**64.51**	**62.96**	**54.73**
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
Research Funding Measures (Millions)				
Research funding (Category 1: ARC, Competitive Grants)	**1.755**	***2.180***	0.958	1.408
	(0.677)	(1.147)	(0.592)	(0.990)
Research funding (Category 1: NHMRC, Competitive Grants)	-0.900	**-3.271**	1.133	***1.504***
	(0.650)	(0.903)	(0.746)	(0.905)
Research funding (Category 1: Other, Competitive Grants)	0.609	1.698	0.228	-0.300
	(0.950)	(1.038)	(1.093)	(1.086)
Research funding (Category 2: Public Sector Funding, State/Local)	0.265	0.073	-0.305	-0.501
	(0.318)	(0.335)	(0.287)	(0.335)
Research funding (Category 3: Industry, Philanthropy, Intl)	-0.312	0.051	0.4856	0.047
	(0.386)	(0.446)	(0.465)	(0.521)
Research funding (Category 4: Cooperative Research Centres)	1.165	-1.060	-0.523	2.536
	(1.428)	(2.746)	(1.284)	(1.988)
F-Test for Research Funding Measures	1.66	2.38	***1.95***	1.56
(p-value)	(0.126)	(0.028)	(0.069)	(0.154)
Period Measures				
Post Introduction of Multiple Tuition Rates (1997+)	131.686		390.668	
	(268.319)		(267.512)	
Period of Extra 10% Coverage of Domestic Students (2010-2011)	**89.973**	**51.666**	**44.691**	***28.604***
	(18.684)	(26.189)	(12.360)	(17.171)
Post Demand Driven Enrolment Policy (2012+)	**139.730**	**107.162**	**85.867**	37.678
	(28.938)	(47.236)	(19.360)	(32.631)
Post Freeze in Tuition (2017-2019)	***-31.088***	-8.020	-16.509	-15.047
	(18.823)	(18.591)	(14.652)	(13.295)
F-Test for Period Measures	**10.57**	1.91	7.68	1.41
(p-value)	(0.000)	(0.127)	(0.000)	(0.238)
Constant	93.423	**1088.104**	-341.351	314.511
	(265.924)	(349.760)	(267.393)	(215.170)
Other Controls	University & Field Fixed Effects			
R-Squared	0.713	0.730	0.701	0.794
# of Universities	69	64	60	55
# of Observations	2381	1383	5160	2944
Average Domestic Enrollment	400.1	448.5	292.7	312.6
Average International Enrollment	69.4	94.0	127.5	167.9

Notes: Robust standard errors reported in parentheses.Coefficients in bold p<0.05; coefficients in bold & italics p<0.10
We report the specifications that interact a G08 dummy variable with the tuition measures only if one or more of the coefficients are statistically

years are included in the analysis (column 3), an increase in Band 1 tuition is imprecisely measured, but the coefficient on the Band 2 differential tuition is strongly positive. This coefficient, however, is tempered with a negative coefficient on the Band 3 differential. The overall effect is suggestive that as the Band 2 tuition increases, there is an increased effort by universities to enroll students in the disciplines tied to Band 2 tuition.

During the post-2005 period (column 4), the coefficients on the tuition measures become imprecise, and the coefficient on the Band 1 tuition measure is negative and significant at a p-value of 10 percent. The magnitude of the government subsidy coefficients is larger than what is reported in Table 5. Also note the coefficient on the minimum subsidy remains negative and is also larger. Despite the negative coefficients, when evaluating at the average increases in tuition rates, the results in Table 7 point to greater effort for increasing enrollment for the fields associated with greater increases in Band 2 tuition and/or government subsidies.

In Table 8, we mimic an analogous analysis using the individuals observed ever enrolling in university. The analysis focuses on the year of enrollment for each individual. The dependent variable is equal to one if the individual is enrolled in the field under study and zero otherwise. We report the results for enrollment in the Band 1 only fields in columns (1) and (2) and in the Band 2 only fields in columns (3) and (4). Because these specifications cover all individuals, the government subsidy variables reflect the subsidies associated with the given field selected by the student.

For the two specifications that study the Band 1 only fields, the coefficient for the Band 1 tuition is imprecisely estimated. The coefficient for the Band 2 tuition differential is negative, and the coefficient for the Band 3 differential is positive. If we evaluate the overall effect on choosing Band 1 fields based on the average values of the tuition measures, these results suggest that as tuition increases, Band 1 enrollment decreases. The results are mixed for the subsidy measures. An increase in the maximum subsidy decreases enrollment, whereas an increase in the minimum subsidy increases enrollment. The average minimum government subsidy is $1,867 and the average maximum government subsidy is $20,356. Evaluating the coefficients at these averages suggests that overall enrollment for Band 1 only fields decreases as government subsidies increase.

A different story emerges for enrollees of Band 2 only fields. Across the entire period, the coefficients suggest a slight decline in enrollment as the Band 1 tuition increases. For the period after 2005, however, enrollment increases as the Band 2 tuition differential increases and with the introduction of the national priority discounts. The net effect of the government subsidies is that, on average, enrollment increases with increases in subsidies.

Table 8: Effects of Tuition Changes on Ever Enrolled, Band 1 Only and Band 2 Only Fields

	Education / Creative Arts (B1 Only)		Eng/Arch/Agric/Math/Science (B2 Only)	
Dependent Variable: Enrolled in Program (0/1)	All Years (1)	2005+ (2)	All Years (3)	2005+ (4)
Tuition Band 1 (Minimum) (1000s)	-0.0002	-0.212	**-0.017**	-0.107
	(0.005)	(0.337)	(0.005)	(0.271)
Tuition Band 2 Additional Tuition Above Band 1 (1000s)	**-1.450**	**-2.119**	0.019	**1.391**
	(0.364)	(0.671)	(0.321)	(0.548)
Tuition Band 3 Additional Tuition Above Band 1 (1000s)	**0.920**	**1.626**	0.010	-0.688
	(0.231)	(0.740)	(0.205)	(0.598)
Period of National Priority Discount (0/1)	**0.026**	-0.013	**-0.009**	**0.018**
	(0.004)	(0.011)	(0.004)	(0.009)
F-Test Tuition Measures	**12.14**	**6.16**	**13.86**	**4.74**
	(0.000)	(0.000)	(0.000)	(0.001)
Government Subsidies				
Maximum Government Subsidy Available the Field (1000s)		**-0.034**		**-0.014**
		(0.000)		(0.000)
Minimum Government Subsidy Available for the Field (1000s)		**0.056**		**0.051**
		(0.000)		(0.000)
F-Test Government Subsidies		**29731.16**		**42702.95**
		(0.000)		(0.000)
Student Characteristics				
Female Student	**0.084**	**0.177**	**-0.238**	**-0.154**
	(0.002)	(0.002)	(0.002)	(0.002)
Observed with Health Card Between Birth and Age 10	**0.110**	**0.125**	**-0.094**	**-0.067**
	(0.006)	(0.008)	(0.009)	(0.008)
Observed with Health Card Between Ages 11 and 16	**0.025**	**0.023**	**-0.024**	***-0.016***
	(0.007)	(0.009)	(0.010)	(0.008)
Observed Region of Residence Near Time When in High School	**-0.015**	**-0.019**	**-0.005**	-0.0004
	(0.002)	(0.002)	(0.002)	(0.002)
F-Test Student Measures	**870.29**	**2362.94**	**4998.95**	**2601.11**
	(0.000)	(0.000)	(0.000)	(0.000)
Regional Median Family Income (1000s)	-0.00001	0.00001	-0.00004	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
F-Test Median Family Income + Shares of Occupations	**44.45**	**34.66**	**17.32**	**30.35**
	(0.000)	(0.000)	(0.000)	(0.000)
F-Test Regional Saleries of Young Adults by Field of Study	**5.41**	**4.62**	**4.03**	**1.82**
	(0.000)	(0.000)	(0.000)	(0.040)
Period Dummy Variables				
Post Introduction of Multiple Tuition Rates (1997+)	0.077		**-0.325**	
	(0.111)		(0.117)	
Period of Extra 10% Coverage of Domestic Students (2010-2011)	***-0.011***	-0.009	0.009	0.001
	(0.006)	(0.007)	(0.005)	(0.005)
Post Demand Driven Enrolment Policy (2012+)	**-0.049**	**-0.029**	**0.020**	0.007
	(0.010)	(0.014)	(0.009)	(0.011)
Post Freeze in Tuition (2017-2019)	-0.005	**-0.013**	**0.012**	**0.017**
	(0.005)	(0.005)	(0.005)	(0.004)
Period when Discounts Given to Student for Paying Tuition Upfront	**0.015**	**0.019**	-0.007	**-0.021**
	(0.006)	(0.009)	(0.005)	(0.007)
ATAR Scores Used for Admission (Introduction Varies Across States)	**0.012**	0.006	**-0.021**	0.002
	(0.006)	(0.005)	(0.005)	(0.004)
F-Test Period Variables	**5.42**	**3.94**	**7.98**	**6.07**
	(0.000)	(0.001)	(0.000)	(0.000)
F-Test StatexYear Trends	**40.52**	**15.40**	**10.66**	**7.65**
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	1.333	**0.631**	***-0.989***	***-0.446***
	(0.896)	(0.284)	(0.570)	(0.230)
Fixed Effects and Trends	Birth Year Fixed Effects, State Year Trends			
Other Controls	Regional Measures to Capture Median Household Income, Distribution of Occupations (1 digit) for Adults Aged 25-35, and Observed Earnings for Occupations Observed for Past Enrollees by Field of Study			
R-Squared	0.0266	0.3137	0.1047	0.4296
# of observations	217,247	148,886	217,247	148,886

Notes: Robust standard errors reported in parentheses.Coefficients in bold p<0.05; coefficients in bold & italics p<0.10
Sample reflects individuals observed enrolling in university for period under study

For the single tuition fields, the results support the theoretical finding that suggests that universities will vary their emphasis on enrollment across fields based on the differential effects of tuition rates and/or government subsidies. These support the notion that greater emphasis will be placed on fields attracting greater revenue.

7.2 Fields With Multiple Tuition Rates

The analyses using the fields that are associated with single tuition rates provide the cleanest test of the theoretical framework, which suggests there may be differential effects from tuition and subsidies across fields. For completeness, this next section reports the results from analyses of fields that are associated with different tuition rates, Society & Law, Business & Economics, and Health. Table 9 reports the results for the university analysis and Table 10 reports the results for the enrolled students.

At a university level (Table 9), when studying all years, we must group the Society & Law disciplines with the disciplines under Business & Economics due to data limitations (column (1)). We separate the analyses for these two fields when analysing the period from 2005 onward (columns (2) and (3)). For the entire sample period, enrollment for these two fields increases with increases in Band 1 Tuition. Post 2005, there is no statistically significant change in enrollment for Society and Law. For Business & Economics, especially for the G08 universities, overall enrollment increases when there is an increase in Band 1 tuition and the Band 2 differential. The coefficient for the Band 3 tuition differential is negative.

On net, the results suggest increasing enrollment with increasing tuition. There is no discernible effect from an increase in subsidies for these fields. Recall that the subsidies for the higher tuition fields, Law and Business & Economics, are quite low, less than $2,500, which likely contributes to a finding of no effect from subsidies on enrollment for these fields.

In columns (5) to (7) of Table 9, we report the coefficients for the Health field, which will include the Band 1 discipline of nursing and the Band 3 discipline of medical studies. We report the coefficients from two specifications that capture all years, one without the G08 Band 1 tuition interaction and one with the interaction.

Increases in Band 1 tuition and the Band 2 tuition differential lead to increases in enrollment, slightly more for non-G08 universities. Increases in the Band 3 differential decreases enrollment. On net, tuition increases lead to increases in enrollment. The government subsidies are not precisely measured for the non-G08 universities and are negative for the G08 universities.

In Table 10, we report the results from the regressions that use the enrolled student (individual) data. Across the three fields, the positive effect from tuition increases in enrollment is weaker for Society & Law and Business & Economics and there is a negative effect for the Band 3 tuition differential for Health. Increases in government subsidies have a net positive effect for Health, a negative effect for Business & Economics, and a positive effect for Society & Law.

Table 9: Effect of Tuition & Government Subsidies (2005+) for Fields with Mixed Tuition Bands

Dependent Variable: Total Commencing Domestic Students, by Major Field	Society/Law Bus & Econ (B1-B3)	Society/Law (B1-B3)	Business & Economics (B2 to B3)	Health (B1-B3)		
	All Years	2005 +		All Years		2005 +
	(1)	(2)	(3)	(5)	(6)	(7)
Tution Measures						
Tuition - Band 1 ("Base Tuition")	**0.963**	20.141	0.931	**0.889**	**0.875**	-5.289
	(0.227)	(22.148)	(12.652)	(0.238)	(0.235)	(18.541)
* G08 University			**34.920**		**-0.104**	
			(17.602)		(0.018)	
Tuition - Band 2 Additional from Band 1	-27.037	82.441	**66.452**	**57.739**	**56.096**	16.731
	(26.451)	(60.868)	(31.047)	(21.126)	(20.917)	(48.386)
* G08 University			**126.705**			
			(42.400)			
Tuition - Band 3 Additional from Band 1	15.818	-82.299	-43.849	**-37.866**	**-36.787**	-2.827
	(16.823)	(65.903)	(34.501)	(13.426)	(13.292)	(52.572)
* G08 University			**-132.483**			
			(48.137)			
Period of National Priority Tuition Discounts	-54.277	-80.121	**-122.465**	**-76.416**	**-78.579**	-7.764
	(33.270)	(58.489)	(27.168)	(25.602)	(25.349)	(41.593)
F-Test Tuition Measures	**5.68**	1.90	**5.02**	**16.15**	**17.21**	0.20
(p-value)	(0.000)	(0.110)	(0.000)	(0.000)	(0.000)	(0.941)
Government Subsidies						
Maximum Subsidy for Field		-2.507	-0.039			-0.089
		(7.618)	(0.042)			(0.263)
* G08 University		-0.008	0.025			**-0.038**
		(0.021)	(0.066)			(0.009)
Minimum Subsidy for Field		15.1443				0.3903
		(46.321)				(1.017)
F-Test for Government Subsidies		0.10	0.44			5.66
(p-value)		(0.963)	(0.643)			(0.001)
International Student Measures						
Commencing International Students, Total for Field (lagged one year)	**0.145**	-0.004	**-0.130**	**1.306**	**1.231**	**0.636**
	(0.035)	(0.182)	(0.050)	(0.126)	(0.131)	(0.175)
* G08 University	**-0.485**	**0.795**	0.188	**-0.876**	**-0.604**	-0.048
	(0.093)	(0.255)	(0.116)	(0.260)	(0.274)	(0.343)
Commencing International Students, Total for University (lagged one year)	0.019	0.0221	**0.0766**	**-0.0378**	**-0.0498**	**-0.051**
	(0.016)	(0.039)	(0.023)	(0.009)	(0.009)	(0.012)
* G08 University	0.022	**-0.258**	-0.064	-0.001	0.031	0.020
	(0.038)	(0.056)	(0.040)	(0.021)	(0.020)	(0.022)
F-Test for International Enrollment	**20.81**	**8.39**	**3.97**	**34.30**	**30.77**	**0.21**
(p-value)	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)
Research Funding Measures (Millions)						
Research funding (Category 1: ARC)	**4.194**	**9.840**	**4.876**	0.234	***1.878***	1.845
	(1.192)	(2.211)	(1.392)	(1.011)	(1.023)	(1.369)
Research funding (Category 1: NHMRC)	1.415	**4.740**	-0.630	0.922	1.035	***2.239***
	(2.053)	(2.182)	(0.934)	(0.908)	(0.915)	(1.114)
Research funding (Category 1: Other)	-2.401	-3.635	**2.617**	-1.330	-1.218	**-4.771**
	(2.155)	(2.536)	(1.279)	(1.581)	(1.550)	(1.755)
Research funding (Category 2)	0.246	**1.462**	-0.480	-0.442	0.465	0.739
	(0.577)	(0.729)	(0.315)	(0.550)	(0.623)	(0.642)
Research funding (Category 3)	0.261	0.832	-0.307	0.811	0.816	0.871
	(1.427)	(1.195)	(0.546)	(0.680)	(0.674)	(0.687)
Research funding (Category 4)	0.899	1.804	**9.529**	**10.028**	**9.544**	-1.063
	(3.057)	(5.781)	(2.887)	(2.392)	(2.362)	(4.919)
F-Test for Research Funding Measures	**3.61**	**8.19**	**4.21**	**4.70**	**6.49**	**2.26**
(p-value)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.036)
Period Measures						
Post Introduction of Multiple Tuition Rates (1997+)	**2259.632**			**1691.519**	**1647.541**	
	(537.600)			(563.704)	(557.127)	
Period of Extra 10% Coverage of Domestic Students (2010-2011)	**81.526**	**155.614**	**77.633**	**123.601**	**120.319**	61.018
	(36.396)	(48.723)	(26.033)	(21.076)	(20.926)	(44.415)
Post Demand Driven Enrolment Policy (2012+)	88.866	**219.778**	**166.105**	**178.691**	**172.977**	75.996
	(54.445)	(104.058)	(47.891)	(39.121)	(38.730)	(73.758)
Post Freeze in Tuition (2017-2019)	13.438	5.620	12.641	17.328	20.424	16.777
	(36.842)	(37.689)	(18.575)	(37.116)	(36.698)	(30.241)
F-Test for Period Measures	**5.40**	**3.42**	**4.06**	**11.40**	**10.88**	0.64
(p-value)	(0.000)	(0.017)	(0.007)	(0.000)	(0.000)	(0.588)
Constant	**-1734.688**	-120.724	**827.628**	**-1915.309**	**-1854.290**	-711.847
	(536.325)	(1427.075)	(294.910)	(563.235)	(556.384)	(441.398)
Other Controls	University & Field Fixed Effects	University Fixed Effects				
R-Squared	0.767	0.931	0.905	0.830	0.833	0.885
# of Universities	66	54	52	53	53	51
# of Observations	2353	688	652	1150	1150	664
Average Domestic Enrollment	831.0	583.1	238.5	494.6		657.6
Average International Enrollment	483.5	235.7	541.4	112.1		159.6

Notes: Robust standard errors reported in parentheses.Coefficients in bold p<0.05; coefficients in bold & italics p<0.10

We report the specifications that interact a G08 dummy variable with the tuition measures only if one or more of the coefficients are statistically significant.

Due to data constraints, Society/Law and Business & Economics Fields must be combined when including all years in the specification. These fields can be separated for the specifications cover 2005 onwards.

Table 10: Effects of Tuition Changes on Ever Enrolled, for Fields with Mixed Tuition Bands

	Society/Law (B1/B3)		Business & Economics (B2 to B3)		Health (B1/B3)	
Dependent Variable: Enrolled in Program (0/1)	All Years	2005+	All Years	2005+	All Years	2005+
	(1)	(2)	(3)	(4)	(5)	(6)
Tuition Band 1 (Minimum) (1000s)	-0.004	**-0.581**	**-0.013**	-0.039	**0.034**	**0.939**
	(0.006)	(0.285)	(0.006)	(0.259)	(0.004)	(0.249)
Tuition Band 2 Additional Tuition Above Band 1 (1000s)	0.558	-0.361	***0.677***	0.650	0.196	0.439
	(0.389)	(0.596)	(0.361)	(0.513)	(0.341)	(0.507)
Tuition Band 3 Additional Tuition Above Band 1 (1000s)	-0.346	***1.110***	***-0.410***	-0.348	-0.174	**-1.701**
	(0.248)	(0.643)	(0.230)	(0.570)	(0.217)	(0.555)
Period of National Priority Discount (0/1)	**-0.012**	-0.006	***-0.008***	-0.006	0.002	0.008
	(0.005)	(0.009)	(0.004)	(0.008)	(0.004)	(0.008)
F-Test Tuition Measures	**2.83**	**2.20**	**3.09**	1.32	**16.25**	**6.56**
	(0.023)	(0.067)	(0.015)	(0.259)	(0.000)	(0.000)
Government Subsidies						
Maximum Government Subsidy Available the Field (1000s)		**0.037**		**-0.047**		**0.058**
		(0.0002)		(0.0001)		(0.0002)
Minimum Government Subsidy Available for the Field (1000s)		**-0.079**		**-0.006**		**-0.023**
		(0.0002)		(0.0001)		(0.0002)
F-Test Government Subsidies		**70399.42**		**79425.29**		**76538.00**
		(0.000)		(0.000)		(0.000)
Student Characteristics						
Female Student	**0.101**	**-0.036**	**-0.061**	**-0.020**	**0.115**	**0.033**
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
Observed with Health Card Between Birth and Age 10	**0.074**	**0.032**	**-0.075**	**-0.063**	***-0.014***	**-0.027**
	(0.009)	(0.008)	(0.010)	(0.007)	(0.008)	(0.007)
Observed with Health Card Between Ages 11 and 16	**0.019**	-0.001	-0.014	**-0.006**	-0.006	-0.0002
	(0.009)	(0.009)	(0.011)	(0.008)	(0.009)	(0.008)
Observed Region of Residence Near Time When in High School	**-0.023**	**-0.026**	**0.029**	**0.023**	**0.014**	**0.023**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
F-Test Student Measures	**826.38**	**188.90**	**384.21**	**159.38**	**1436.46**	**210.10**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Regional Median Family Income (1000s)	0.0002	0.0001	-0.0002	-0.00004	0.00002	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
F-Test Median Family Income + Shares of Occupations	**15.79**	0.93	**29.10**	**3.24**	**16.07**	1.01
	(0.000)	(0.488)	(0.000)	(0.001)	(0.000)	(0.430)
F-Test Regional Saleries of Young Adults by Field of Study	**3.39**	**3.09**	**2.86**	**5.51**	**8.77**	**3.33**
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Period Dummy Variables						
Post Introduction of Multiple Tuition Rates (1997+)	-0.171		**-0.359**		**0.779**	
	(0.138)		(0.133)		(0.101)	
Period of Extra 10% Coverage of Domestic Students (2010-2011)	0.003	**0.013**	**-0.015**	-0.0002	**0.101**	-0.005
	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)	(0.005)
Post Demand Driven Enrolment Policy (2012+)	0.006	0.005	0.013	0.005	0.010	0.013
	(0.011)	(0.012)	(0.010)	(0.011)	(0.010)	(0.010)
Post Freeze in Tuition (2017-2019)	-0.001	0.004	0.003	**-0.013**	-0.009	0.006
	(0.006)	(0.005)	(0.005)	(0.004)	(0.005)	(0.004)
Period when Discounts Given to Student for Paying Tuition Upfront	0.003	-0.004	**-0.015**	0.001	0.003	0.005
	(0.006)	(0.008)	(0.006)	(0.007)	(0.006)	(0.006)
ATAR Scores Used for Admission (Introduction Varies Across States)	**0.027**	0.005	**0.017**	-0.004	**-0.035**	**-0.009**
	(0.006)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)
F-Test Period Variables	**7.14**	**2.51**	**5.68**	**2.45**	**19.96**	**5.82**
	(0.000)	(0.028)	(0.000)	(0.031)	(0.000)	(0.000)
F-Test StatexYear Trends	**19.11**	**17.45**	**34.27**	**20.65**	**27.69**	**15.77**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.061	0.333	**2.055**	***0.363***	**-1.460**	0.119
	(0.862)	(0.244)	(0.955)	(0.219)	(0.372)	(0.211)
Fixed Effects and Trends	Birth Year Fixed Effects, State Year Trends					
Other Controls	Median Family Income for Area, Occupation Shares in Region, Average Salaries of Fields of Study in Region for Adults aged 25-35					
R-Squared	0.0206	0.5201	0.0169	0.5767	0.0403	0.5786
# of observations	217,247	148,886	217,247	148,886	217,247	148,886

Notes: Robust standard errors reported in parentheses.Coefficients in bold p<0.05; coefficients in bold & italics p<0.10

7.3 Field Enrollment Differences by Gender & Citizenship

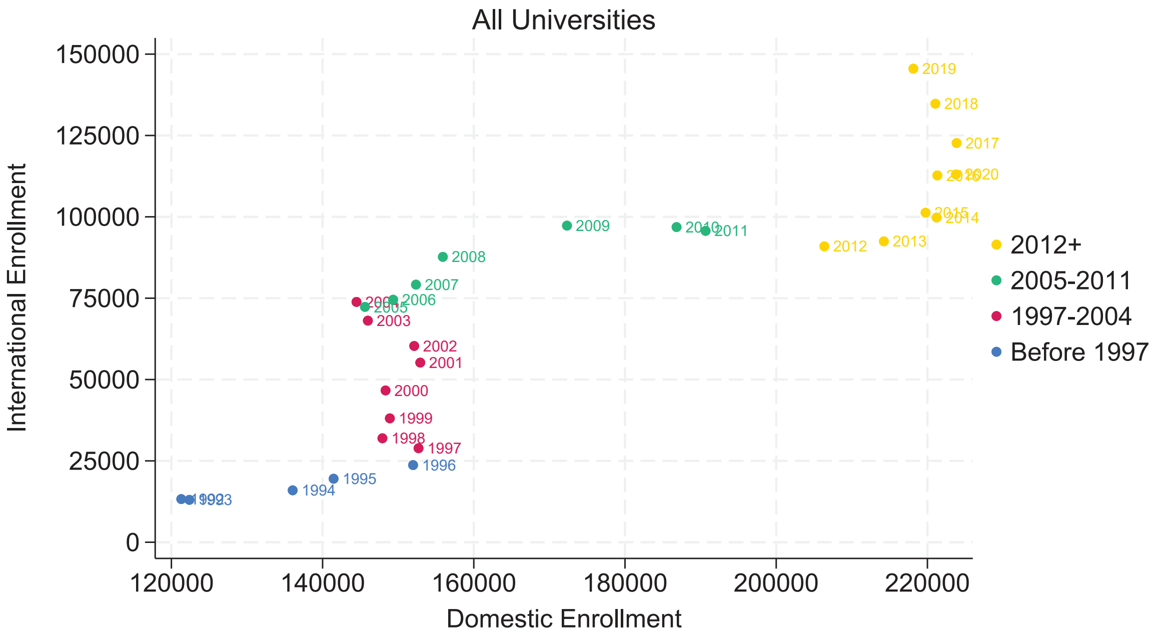
Although the focus of this paper is on the effect of tuition on enrollment, Tables 8 and 10 illustrate differences in the selection of fields by gender and our proxy for birth and time in Australia as a citizen or permanent resident. Higher proportions of females are observed selecting the Band 1 only fields, Society & Law, and Health. While men are more likely to select Business & Economics and the Band 2 only fields. The specifications for 2005 onward suggest that the gender gaps, however, are decreasing.

There is also suggestive evidence that enrollees who were born in Australia or received their health card at a young age are more likely to select the lower tuition fields. Recall the premise that lower tuition disciplines are such because they reflect lower returns to education. We leave a further exploration of the effects of enrollment as they relate to gender and immigration for a future paper.

8 International Enrollment

Our theoretical model also predicts that given universities have discretion on the setting of international tuition rates and normal expectations on student reactions to these rates, an increase in domestic student tuition and/or subsidies will have either a negative or zero effect on international enrollment (Result 4). If, however, the university's choice of research spending positively affects its international student enrollment, then taking international tuition as fixed an increase in the per student domestic funding will have an ambiguous effect on domestic enrollment and will necessarily increase international enrollment (Result 5). Given the importance of international rankings for G08 universities, we might expect to find the coefficients for the G08 universities differ from those for the other universities.

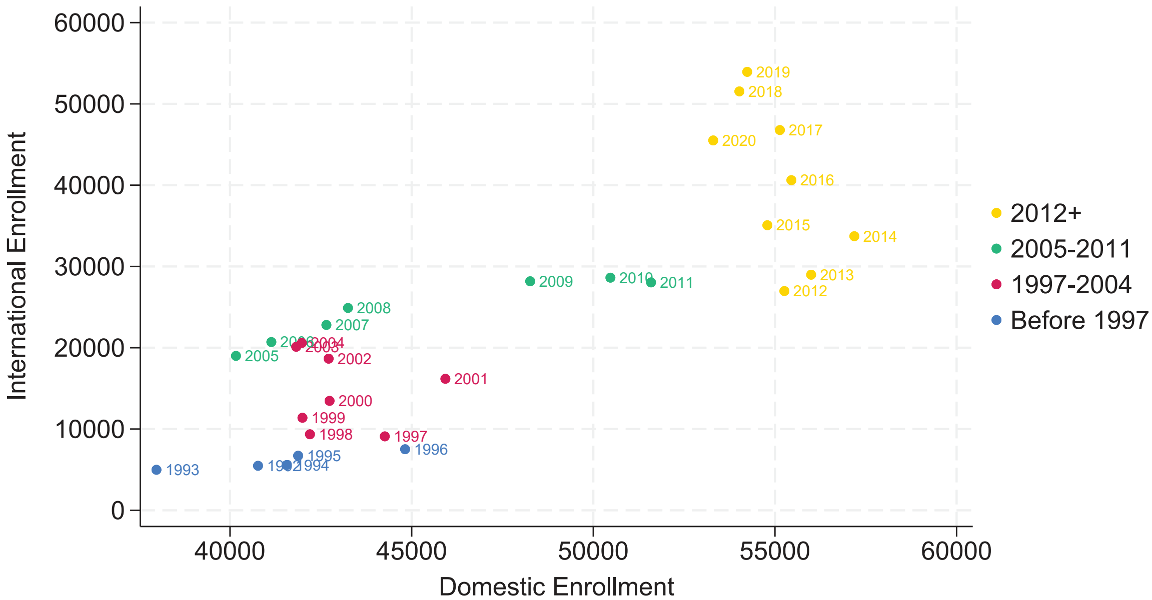
Figure 8A: Domestic v. International Enrollments



As illustrated in Figure 6, over the sample period, international enrollment have been increasing. In Figure 8A, we depict the total commencing enrollment for domestic students (x-axis) and international students (y-axis) over the sample period. We group the enrollment into four periods: Before 1997 (single tuition rates), between 1997 and 2004 (introduction of tuition bands), between 2005 and 2011 (further changes in tuition policy and introduction of per student government subsidies), and post 2012 (adoption of demand driven domestic enrollment policies). Across all universities, there have been two periods of substantial growth in international students, between 1997 and 2004 (200 percent) and post 2012 (50 percent). The growth in domestic students is most prevalent between 2006 and 2024 (approximately 86 percent growth).

Figure 8B: Domestic v. International Enrollments

G08 Research Universities



In Figure 8B, we depict the total commencing enrollment for domestic and international students, respectively, for the G08 universities. Although the patterns are similar, the growth in domestic student enrollment is more modest (35 percent). In the early period of 1997 to 2004, the growth of international students for these universities is lower relative to other universities (100 percent), but the growth rate for the post 2012 period is more substantial (83 percent).

The analysis we have presented thus far illustrates the complexities associated with the interplay between domestic and international student enrollment. We focus on testing the implications of Results 4 and 5, a reduced form estimation of the relationship between changes in domestic tuition and government subsidies on international enrollment.[48]

For the sake of brevity, we concentrate on the period from 2005 onward. The specifications focus on field-specific enrollment, overall and disaggregated by tuition grouping.

The coefficients from the specifications are presented in Table 11. In column (1), we report the results for enrollment across all fields of study. This specification includes the full set of interactions for the G08 universities, given that two of the three interactions are statistically significant. Across all universities, the results suggest that increasing tuition rates and subsidies do not have a positive

[48] There is a deeper analysis of the crowd-out or crowd-in of international enrollment on domestic enrollment that is beyond the scope of this paper.

Table 11: Effect of DomesticTuition on International Enrollments

Dependent Variable: Number Commencing International Students By Field Major	Total, by Field 2005 + (1)	B1 Only Fields 2005+ (2)	B2 Only Fields 2005 + (3)	Society/Law 2005 + (5)	Bus & Econ 2005+ (6)	Health 2005+ (7)
Tution Measures						
Tuition - Band 1 ("Base Tuition")	-8.728	3.468	2.123	-7.977	-28.120	-1.406
	(5.737)	(5.126)	(5.326)	(11.770)	(26.693)	(5.561)
* G08 University	***26.387***	**21.328**	**29.735**		57.929	
	(13.449)	(9.540)	(13.712)		(39.082)	
Tuition - Band 2 Additional from Band 1	2.096	-12.818	2.869	-1.580	21.126	-16.336
	(18.943)	(14.399)	(17.320)	(29.346)	(68.871)	(13.742)
* G08 University	54.147	42.445	40.766		***175.554***	
	(37.123)	(26.508)	(37.266)		(102.436)	
Tuition - Band 3 Additional from Band 1	11.719	2.940	-4.863	12.866	28.204	12.224
	(18.932)	(14.981)	(17.340)	(32.969)	(73.428)	(15.228)
* G08 University	***-73.505***	**-58.681**	***-70.101***		***-197.245***	
	(39.665)	(28.799)	(40.548)		(107.650)	
Period of National Priority Tuition Discounts (Education/Nursing 2005-2009, Match/Science (2009-2012)	-5.499	**30.046**	11.375	21.383	-97.305	**35.526**
	(19.177)	(14.580)	(16.794)	(33.284)	(65.218)	(15.533)
F-Test for Tuition Measures	**6.97**	***1.74***	**4.27**	1.15	**7.62**	1.64
(p-value)	(0.000)	(0.096)	(0.000)	(0.334)	(0.000)	(0.164)
Government Subsidies						
Maximum Subsidy for Field	-0.004	0.025	**-0.028**	-5.067	**-0.216**	-0.097
	(0.006)	(0.017)	(0.013)	(4.519)	(0.082)	(0.107)
* G08 University	**-0.005**	**0.018**	**0.011**	**0.086**	***0.221***	0.005
	(0.002)	(0.007)	(0.002)	(0.021)	(0.132)	(0.003)
Minimum Subsidy for Field	***-0.009***		0.014	31.020		0.394
	(0.005)		(0.011)	(27.478)		(0.418)
F-Test for Government Subsidies	**3.41**	**4.20**	**12.09**	**6.85**	**3.51**	1.35
(p-value)	(0.017)	(0.015)	(0.000)	(0.000)	(0.031)	(0.259)
Research Funding Measures (Millions)						
Research funding (Category 1: ARC, Competitive Grants)	-0.857	0.318	0.109	**-7.272**	-5.526	**1.379**
	(1.078)	(0.828)	(0.928)	(2.028)	(3.498)	(0.619)
Research funding (Category 1: NHMRC, Competitive Grants)	**2.443**	**1.391**	**2.629**	2.153	**5.582**	0.392
	(0.799)	(0.647)	(0.911)	(1.687)	(2.093)	(0.539)
Research funding (Category 1: Other, Competitive Grants)	**-2.275**	**-1.873**	**-2.250**	-2.918	-3.521	-0.172
	(1.040)	(0.716)	(1.076)	(2.205)	(2.620)	(0.730)
Research funding (Category 2: Public Sector Funding, State/Local)	0.199	-0.276	0.388	0.137	0.594	**-0.631**
	(0.258)	(0.186)	(0.257)	(0.572)	(0.846)	(0.171)
Research funding (Category 3: Industry, Philanthropy, Intl)	**1.303**	**1.464**	**0.873**	**3.334**	1.847	**0.818**
	(0.422)	(0.279)	(0.442)	(0.805)	(1.158)	(0.303)
Research funding (Category 4: Cooperative Research Centres)	-0.892	***2.645***	0.066	***-6.813***	-4.926	0.384
	(1.766)	(1.601)	(1.700)	(4.041)	(5.911)	(1.419)
F-Test for Research Funding Measures	**3.73**	**10.20**	**2.62**	**5.35**	**2.56**	**8.92**
(p-value)	(0.001)	(0.000)	(0.016)	(0.000)	(0.019)	(0.000)
Period Measures						
Period of Extra 10% Coverage of Domestic Students (2010-2011)	10.131	-8.257	4.891	10.078	67.258	***-34.196***
	(15.226)	(12.202)	(12.940)	(22.847)	(52.472)	(18.571)
Post Demand Driven Enrollment Policy (2012+)	-12.933	-19.059	-8.948	-47.952	79.168	**-71.813**
	(27.415)	(21.461)	(25.008)	(52.584)	(101.531)	(23.694)
Post Freeze in Tuition (2017-2019)	**46.462**	**25.750**	**54.823**	**69.110**	**114.942**	**27.405**
	(11.916)	(10.251)	(12.779)	(21.092)	(40.017)	(10.367)
F-Test for Period Measures	**5.53**	**2.41**	**6.28**	**4.03**	**3.22**	**6.86**
(p-value)	(0.001)	(0.066)	(0.000)	(0.008)	(0.022)	(0.000)
Constant	57.250	**-325.805**	**-583.087**	-150.766	**2032.665**	**-502.058**
	(193.879)	(164.989)	(194.483)	(829.533)	(643.379)	(150.160)
Other Controls	University & Field Fixed Effects					
R-Squared	0.614	0.613	0.555	0.913	0.865	0.866
# of Universities	86	64	55	54	52	51
# of Observations	6475	1383	2944	688	652	664
Average Domestic Enrollment	482	448.5	312.6	583.1	238.5	657.6
Average International Enrollment	248	94.0	167.9	235.7	541.4	159.6

Notes: Robust standard errors reported in parentheses.Coefficients in bold p<0.05; coefficients in bold & italics p<0.10
We report the specifications that interact a G08 dummy variable with the tuition measures only if one or more of the coefficients are statistically significant.

effect on international enrollment. For the G08 universities, however, an increase in the Band 1 tuition leads to increased enrollment, but an increase in the Band 3 differential leads to decreased enrollment. These results suggest that many universities behave as predicted by Result 4, increased revenues for domestic enrollment do not lead to increased enrollment for international students. There is also, however, some evidence to suggest that the more research-intensive universities may take into account factors other than increases in domestic revenues.

Columns (2) to (7) report the coefficients from the specifications for field-level enrollment based on tuition grouping. Across the board, for all universities, the coefficients on the tuition measures are imprecisely measured, and the government subsidy measures are negative and significant or imprecisely measured. These coefficients are indicative of Result 4 in the theoretical framework.

The coefficients for the interaction terms for the G08 universities are mixed but suggest that for the Band 1 only, Band 2 only, and Business & Economics fields, increasing tuition and government subsidies lead to increased international enrollment. As pointed out in the theoretical framework, Result 4 will not necessarily hold if international enrollment respond to other university characteristics that reflect resource allocation decisions made by the university. Given the importance of international rankings in Australia, especially for the G08 universities, the results presented in Table 11 are suggestive that these other characteristics may be important considerations when considering how changes in domestic tuition impact international enrollment.

9 Concluding Remarks

This paper takes advantage of a unique policy setting to examine how universities respond to tuition increases, particularly in terms of domestic student enrollment. We provide a stronger understanding of university behavior in a context of government regulation that includes the setting of domestic tuition where students can defer tuition payments through an income contingent loan repayment system.

Our theoretical and empirical analyses show that universities behave strategically in the face of financial incentives, often expanding enrollment even when standard economic models would predict a decline. Such strategies can include shifting emphasis on the possible fields of study (from low to higher tuition fields) and behavior that is tied to admission and the attraction of students. This underscores the importance of institutional behavior in shaping access to higher education.

Importantly, our model highlights the multifaceted objectives universities face, balancing their roles in both education and research. We provide preliminary evidence that research funding is positively associated with both international and domestic enrollment, reinforcing the interdependence of universities' revenue streams and missions. These findings contribute to a more nuanced understanding of how universities navigate financial constraints and policy shifts, and offer important implications for designing funding systems that support both educational access and research excellence.

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Appendix A: Theoretical Analysis

Domestic students only

With a uniform ability distribution, $\theta(\hat{a}) = (\overline{a} + \hat{a})/2$ with $\theta'(\hat{a}) = 1/2$, $\theta''(\hat{a}) = 0$, and $n(\hat{a}) = (\overline{a} - \hat{a})/(\overline{a} - \underline{a})$ with $n'(\hat{a}) = -1/(\overline{a} - \underline{a})$, $n''(\hat{a}) = 0$.

Totally differentiating (4) and (5) yields:

$$\begin{bmatrix} \Omega_{\hat{a}\hat{a}} & \Omega_{\hat{a}e} \\ \Omega_{e\hat{a}} & \Omega_{ee} \end{bmatrix} \begin{bmatrix} d\hat{a} \\ de \end{bmatrix} = \begin{bmatrix} -\gamma n'(\hat{a}) & -\gamma n'(\hat{a}) & -\big[s + t - c'(n) - e\big] n'(\hat{a}) \\ 0 & 0 & n \end{bmatrix} \begin{bmatrix} dt \\ ds \\ d\gamma \end{bmatrix}$$

where $\Omega_{\hat{a}\hat{a}} = q_{\theta\theta}(\theta'(\hat{a}))^2 - \gamma c''(n)(n'(\hat{a}))^2 < 0, \Omega_{ee} = q_{ee} < 0, \Omega_{\hat{a}e} = \Omega_{e\hat{a}} = q_{e\theta}\theta'(\hat{a}) - \gamma n'(\hat{a}) > 0$, and $D = \Omega_{\hat{a}\hat{a}}\Omega_{ee} - \Omega_{\hat{a}e}\Omega_{e\hat{a}} > 0$ by assumption.

Applying Cramer's Rule, we obtain

$$\frac{d\hat{a}}{dt} = \frac{d\hat{a}}{ds} = \frac{-\gamma n'(\hat{a})\Omega_{ee}}{D} < 0, \quad \frac{d\hat{a}}{d\gamma} = \frac{-\big[s + t - c'(n) - e\big] n'(\hat{a})\Omega_{ee} - n\Omega_{\hat{a}e}}{D} < 0,$$
$$\frac{de}{dt} = \frac{de}{ds} = \frac{\gamma n'(\hat{a})\Omega_{e\hat{a}}}{D} < 0, \quad \frac{de}{d\gamma} = \frac{n\Omega_{\hat{a}\hat{a}} + \big[s + t - c'(n) - e\big] n'(\hat{a})\Omega_{e\hat{a}}}{D} < 0,$$

as given in (6). The expressions in (7) follow directly from $n'(\hat{a}) < 0$.

Totally differentiating (3) yields

$$\begin{aligned} dR = dG + dI - dF &+ \Big(n + (s + t - c'(n) - e)n'(\hat{a}^*)\frac{d\hat{a}^*}{dt} - n\frac{de^*}{dt}\Big)dt \\ &+ \Big(n + (s + t - c'(n) - e)n'(\hat{a}^*)\frac{d\hat{a}^*}{ds} - n\frac{de^*}{ds}\Big)ds \\ &+ \Big((s + t - c'(n) - e)n'(\hat{a}^*)\frac{d\hat{a}^*}{d\gamma} - n\frac{de^*}{d\gamma}\Big)d\gamma \end{aligned}$$

and the signs of the expressions in (8) follow directly.

When $n(\hat{a}, t)$, the expression for $d\hat{a}(t, s; \gamma)/dt$ in (9) becomes

$$\frac{d\hat{a}}{dt} = \frac{-\gamma n_{\hat{a}} + \gamma c''(n) n_t \Omega_{ee}}{D} < 0.$$

Multiple tuition rates

Given a_j is distributed uniformly, totally differentiating (14) with respect to t_j and s_j yields:

$$\Omega_{\hat{a}_j\hat{a}_j} d\hat{a}_j + \gamma n_j'(\hat{a}_j)dt_j + \gamma n_j'(\hat{a}_j)ds_j = 0$$

where $\Omega_{\hat{a}_j\hat{a}_j} = \alpha_j q_j''(\theta_j)(\theta_j'(\hat{a}_j))^2 - \gamma c_j''(n_j)(n_j'(\hat{a}_j))^2 < 0$, and the signs of the expressions in (15) follow directly.

In the case of two programs, $j = 1,2$, totally differentiating the first-order condition (17) for $j = 1,2$ with respect to t_1, t_2, s_1, s_2 given a_1 and a_2 are both uniformly distributed yields:

$$\begin{bmatrix} \Omega_{\hat{a}_1\hat{a}_1} & \Omega_{\hat{a}_1\hat{a}_2} \\ \Omega_{\hat{a}_2\hat{a}_1} & \Omega_{\hat{a}_2\hat{a}_2} \end{bmatrix} \begin{bmatrix} d\hat{a}_1 \\ d\hat{a}_2 \end{bmatrix} = \begin{bmatrix} -\gamma n_1'(\hat{a}_1) & -\gamma n_1'(\hat{a}_1) & 0 & 0 \\ 0 & 0 & -\gamma n_2'(\hat{a}_2) & -\gamma n_2'(\hat{a}_2) \end{bmatrix} \begin{bmatrix} dt_1 \\ ds_1 \\ dt_2 \\ ds_2 \end{bmatrix}$$

where $\Omega_{\hat{a}_j\hat{a}_j} = \alpha_j q_j''(\theta_j)(\theta_j'(\hat{a}_j))^2 - \gamma c''(n)(n_j'(\hat{a}_j))^2 < 0$ for $j = 1,2$, and $\Omega_{\hat{a}_1\hat{a}_2} = \Omega_{\hat{a}_2\hat{a}_1} = -\gamma c''(n) n_1'(\hat{a}_1) n_2'(\hat{a}_2) < 0$ and $D = \Omega_{\hat{a}_1\hat{a}_1}\Omega_{\hat{a}_2\hat{a}_2} - \Omega_{\hat{a}_1\hat{a}_2}\Omega_{\hat{a}_2\hat{a}_1} > 0$. Applying Cramer's Rule, we obtain

$$\frac{d\hat{a}_1}{dt_1} = \frac{d\hat{a}_1}{ds_1} = \frac{-\gamma n_1'(\hat{a}_1)\Omega_{\hat{a}_2\hat{a}_2}}{D} < 0, \quad \frac{d\hat{a}_1}{dt_2} = \frac{d\hat{a}_1}{ds_2} = \frac{\gamma n_2'(\hat{a}_2)\Omega_{\hat{a}_1\hat{a}_2}}{D} > 0,$$
$$\frac{d\hat{a}_2}{dt_1} = \frac{d\hat{a}_2}{ds_1} = \frac{\gamma n_1'(\hat{a}_1)\Omega_{\hat{a}_2\hat{a}_1}}{D} > 0, \quad \frac{d\hat{a}_2}{dt_2} = \frac{d\hat{a}_2}{ds_2} = \frac{-\gamma n_2'(\hat{a}_2)\Omega_{\hat{a}_1\hat{a}_1}}{D} < 0,$$

as given in (18).

The change in total enrollment with a marginal increase in j is given by (19) and using the above expressions can be written as:

$$\begin{aligned} \frac{d(n_j + n_{-j})}{dt_j} &= n_j'(\hat{a}_j)\frac{d\hat{a}_j}{dt_j} + n_{-j}'(\hat{a}_{-j})\frac{d\hat{a}_{-j}}{dt_j} \\ &= -n_j'(\hat{a}_j)\frac{\gamma n_j'(\hat{a}_j)\Omega_{\hat{a}_{-j}\hat{a}_{-j}}}{D} + n_{-j}'(\hat{a}_{-j})\frac{\gamma n_j'(\hat{a}_j)\Omega_{\hat{a}_{-j}\hat{a}_j}}{D} \\ &= \frac{1}{D}\left(-\gamma(n_j'(\hat{a}_j))^2\left(\alpha_{-j}q_{-j}''(\theta_{-j})(\theta_{-j}'(\hat{a}_{-j}))^2 - \gamma c''(n)(n_{-j}'(\hat{a}_{-j}))^2\right) - \gamma^2(n_{-j}'(\hat{a}_{-j}))^2(n_j'(\hat{a}_j))^2 c''(n)\right) \\ &= \frac{-\gamma(n_j'(\hat{a}_j))^2\alpha_{-j}q_{-j}''(\theta_{-j})(\theta_{-j}'(\hat{a}_{-j}))^2}{D} > 0 \end{aligned}$$

International students

- choice of R only: $R(\cdot)$ and $\hat{a}^*$ and total enrollment

Totally differentiating (22) and (23), using the properties of the uniform distribution for a yields:

$$\begin{bmatrix} \Omega_{\hat{a}\hat{a}} & \Omega_{\hat{a}t_f} \\ \Omega_{t_f\hat{a}} & \Omega_{t_ft_f} \end{bmatrix} \begin{bmatrix} d\hat{a} \\ dt_f \end{bmatrix} = \begin{bmatrix} -\gamma n'(\hat{a}) & -\gamma n'(\hat{a}) & -[s + t - c'(n+N)]n'(\hat{a}) \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} dt \\ ds \\ d\gamma \end{bmatrix}$$

where $\Omega_{\hat{a}\hat{a}} = q''(\theta)(\theta'(\hat{a}))^2 - \gamma c''(n+N)(n'(\hat{a}))^2 < 0, \Omega_{t_ft_f} = 2\gamma N' + \gamma(t_f - c'(n+N))N'' - \gamma c''(n+$

$N)(N')^2 < 0, \Omega_{\hat{a}t_f} = \Omega_{t_f\hat{a}} = -\gamma c''(n+N)n'(\hat{a})N'(t_f) \leq 0$, and $D = \Omega_{\hat{a}\hat{a}}\Omega_{t_f t_f} - \Omega_{\hat{a}t_f}\Omega_{t_f\hat{a}} > 0$ Applying Cramer's Rule, we obtain

$$\frac{d\hat{a}}{dt} = \frac{d\hat{a}}{ds} = \frac{-\gamma n'(\hat{a})\Omega_{t_f t_f}}{D} < 0, \quad \frac{d\hat{a}}{d\gamma} = \frac{-[s+t-c'(n+N)]n'(\hat{a})\Omega_{t_f t_f}}{D} < 0,$$
$$\frac{dt_f}{dt} = \frac{dt_f}{ds} = \frac{\gamma n'(\hat{a})\Omega_{t_f\hat{a}}}{D} \geq 0, \quad \frac{dt_f}{d\gamma} = \frac{[s+t-c'(n+N)]n'(\hat{a})\Omega_{t_f\hat{a}}}{D} \geq 0,$$

as given in (25).

The function $R(\hat{a}; t, s, G)$ is implicitly defined by the binding operating budget (26). Totally differentiate (26) yields

$$((t_f - \phi)N'(R) - 1)\, dR + dG + nds + ndt + [s+t-\phi]n'(\hat{a})d\hat{a} = 0$$

where it is reasonably assumed that the additional net revenue from spending one more dollar on R is less than one, that is, $1 - (t_f - \phi)N' > 0$. The signs of the expressions in (27) then follow directly.

Totally differentiating (28) yields

$$\frac{d\hat{a}}{dt} = -\frac{\frac{d\mathcal{L}}{d\hat{a}dt}}{\frac{d^2\mathcal{L}}{d\hat{a}^2}}$$

where $\frac{d^2\mathcal{L}}{d\hat{a}^2} = q''(\theta)(\theta'(\hat{a}))^2 + \frac{(t_f-\phi)N''\gamma(s+t-\phi)n'(\hat{a})}{(1-(t_f-\phi)N')^2}\frac{\partial R(\hat{a};t,s,G)}{\partial \hat{a}} < 0$, but

$$\frac{d\mathcal{L}}{d\hat{a}dt} = \frac{\gamma}{1-(t_f-\phi)N'}n'(\hat{a}) + \frac{\gamma(t_f-\phi)N''}{(1-(t_f-\phi)N')^2}\,(s+t-\phi)\,n'(\hat{a})\frac{\partial R(\hat{a};t,s,G)}{\partial t}$$

is ambiguous since the first term is negative and the second term is positive.

The expression in (29) can be written as:

$$\begin{aligned}
\frac{dR^*}{dt} &= \frac{\partial R}{\partial \hat{a}}\frac{d\hat{a}^*}{dt} + \frac{\partial R}{\partial t} \\
&= -\frac{\left(\frac{\gamma}{1-(t_f-\phi)N'}n'(\hat{a})\frac{\partial R}{\partial \hat{a}} + \frac{\gamma(t_f-\phi)N''}{(1-(t_f-\phi)N')^2}\,(s+t-\phi)\,n'(\hat{a})\frac{\partial R}{\partial t}\frac{\partial R}{\partial \hat{a}}\right)}{\frac{d^2\mathcal{L}}{d\hat{a}^2}} \\
&\quad + \frac{\frac{\partial R}{\partial t}\left(q''(\theta)(\theta'(\hat{a}))^2 + \frac{(t_f-\phi)N''\gamma(s+t-\phi)n'(\hat{a})}{(1-(t_f-\phi)N')^2}\frac{\partial R}{\partial \hat{a}}\right)}{\frac{d^2\mathcal{L}}{d\hat{a}^2}} \\
&= \frac{-\frac{\gamma}{1-(t_f-\phi)N'}n'(\hat{a})\frac{\partial R}{\partial \hat{a}} + q''(\theta)(\theta'(\hat{a}))^2\frac{\partial R}{\partial t}}{\frac{d^2\mathcal{L}}{d\hat{a}^2}} > 0
\end{aligned}$$

and the positive sign given in (29) follows.

Appendix B: Additional Figure