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Theory and Evidence on Student Enrollment

The Role of Government Policy and University Behavior

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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.

Theory and Evidence on Student Enrollment: The Role of Government Policy and University Behavior

Katherine Cuff* Ana Gamarra Rondinel† A. Abigail Payne‡

Abstract

This paper examines how government policies regarding tuition and university subsidies impact student enrollment and public university behavior. We study a system where the federal government sets domestic tuition and regulates institutions. Analyzing a 30-year period, we evaluate three major reforms: the 1997 introduction of increased, differentiated tuition; the 2005 implementation of field-specific subsidies; and the 2012 incentives for enrollment expansion. Combining empirical evidence with a theoretical framework, we demonstrate that long-run tuition increases can boost enrollment, though effects vary by field and university type. Specifically, while uniform tuition hikes reduce overall enrollment, differentiated tuition tied to expected educational returns increases enrollment, particularly at research intensive institutions. Furthermore, universities reallocate seats toward higher-tuition fields, creating notable substitution effects. Finally, although institutions have incentives to maximize revenue via international tuition, policies promoting domestic expansion effectively mitigate international enrollment growth. Our results underscore that accounting for institutional behavior is essential when evaluating higher education policies.

Key Words: Post-secondary Education, University Enrollment, Tuition, Government Funding, University Regulation, Public Government Regulation

JEL Classification: I23, I28, I22

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1 Introduction

Governments employ a range of policy instruments to regulate universities to address the rising costs of attending university and to influence higher education participation. This is particularly true for public universities. These interventions shape incentives for both students and universities, often generating responses that may reinforce or offset one another. As a result, the overall impact of policy interventions is ambiguous. While most of the existing literature focuses on student behavior, far less attention has been paid to how universities adjust in response to these policies. This paper addresses that gap by examining how public universities strategically respond to government policies that target student enrollment directly or indirectly through tuition changes. By integrating empirical evidence with theoretical insights, this paper provides a more comprehensive understanding of student enrollment.

Existing literature has focused on student responses to changes in tuition, opportunities for grants and scholarships, and/or the structure of student loans. Standard human capital models predict that individuals weigh expected returns to education against direct and indirect costs when deciding whether to enroll and what field of study to pursue. Higher tuition reduces expected net returns and is therefore expected to discourage participation, particularly among students facing liquidity constraints, uncertainty about future earnings, or imperfect information about financing options. Consistent with this prediction, a large empirical literature finds that increases in tuition and borrowing costs reduce enrollment, while grants and financial aid increase participation, especially among disadvantaged students.[1]

Related literature shows that the impact of tuition depends critically on the design of student financing systems. In particular, income-contingent loan schemes can attenuate the adverse effects of higher tuition by linking repayments to post-graduation income, thereby reducing downside risk for students.[2] Evidence from Australia suggests that the introduction of income-contingent financing did not substantially reduce participation among low-income students Chapman and Ryan (2002, 2005). More generally, this literature highlights that enrollment responses to tuition depend not only on price levels but also on the institutional and financial environment in which students make decisions.

Despite this extensive evidence on student responses, universities are typically modeled as passive institutions. Yet, in practice, they may respond strategically to changes in tuition and government subsidies by adjusting admissions standards, reallocating capacity across fields, modifying program offerings, changing teaching quality, and expanding international recruitment. These responses can either amplify or offset the direct effects of tuition on student demand, complicating the mapping from policy to enrollment outcomes.

[1] See, among others, Dynarski (2002), Long (2004), Lillis and Tian (2008), Bettinger et al. (2012), Deming and Walters (2017), Andrews and Stange (2019), Dynarski et al. (2021), Miller and Park (2022), Levine et al. (2023), Jones et al. (2022), Bachmeier and Marcus (2026).

[2] See Gary-Bobo and Trannoy (2015), Del Rey and Racionero (2010), Cox et al. (2020), Abraham et al. (2020), Mueller and Yannelis (2022), Boutros and Gomes (2024), Matsuda and Mazur (2022).

Understanding these interactions is particularly important in the current policy environment. The cost of higher education has risen substantially, increasing the financial burden on both students (through tuition) and governments (through subsidies to universities). If universities are required to rely more on increasing tuition and less on direct support from the government, this could lead to decreased enrollment despite most governments' interest in providing greater employment opportunities through an increased skilled workforce (OECD, 2024). Given education's established role in human capital formation and broader social returns (e.g., Moretti (2004); Acemoglu and Angrist (2000)), actions that lead to falling enrollment are, thus, particularly concerning.

Government support of higher education institutions remains critical for most countries. Across Europe (e.g. Denmark, Ireland, Norway, Sweden, and the United Kingdom), Canada, Australia, and New Zealand, public funding for post-secondary education combines formula-based, performance-based, and historical components.[3] Macroeconomic challenges, including high public debt, inflationary pressures, and rising diverse demands for public expenditure, further heighten the challenges of providing sufficient financial support for universities. Moreover, fiscal pressures have constrained public funding, prompting universities to seek alternative revenue sources, most notably by expanding international student enrollment.

Australia provides an ideal setting to study the question of how government policy affects university enrollments. The public university system is highly regulated at the federal level (Chapman and Dearden, 2022), with centrally determined tuition for domestic students and enrollment-tied government subsidies. Since the introduction of tuition and the income contingent loan scheme in 1989, both tuition and subsidy structures have evolved. Through the early 1990s, domestic undergraduate students were charged a single tuition rate, regardless of their field of study, and universities received direct subsidies that were tied to overall university enrollments of domestic students. The subsidies were tied to negotiated total enrollment expectations for each university. Universities, even though operating in a regulated environment, make independent decisions on such things as research foci and the foci for offering degrees. Their enrollment decisions would cover such things as admission standards, the fields to offer, and the enrollment sizes within these fields.

This paper studies enrollment from 1992 to 2019. Coinciding with federal elections and changes in political party power, there have been three periods of major reforms that affected university financing and tuition. First, in 1997, a discrete jump in tuition and differential domestic tuition rates based on one's field of study were implemented. The logic behind the differential tuition rates was that tuition should reflect expected returns to education. As such, lower return fields such as education and nursing were assigned the lowest tuition rates and higher return fields such as law and medical studies were assigned the highest tuition rates. In 2005, there was another discrete jump in domestic tuition rates and the government moved from university specific enrollment subsidies to differentiated (field specific) subsidies. The variation in the field specific subsidies was based on an assessment of the average cost of delivering courses for each field, net of tuition. For example,

[3] For further details, see Bennetot Pruvot and Estermann (2022) and Bennetot Pruvot et al. (2021).

a lab based course is more costly than a large enrollment course without laboratory components. In 2012, the government implemented a policy designed to give universities greater flexibility by removing overall restrictions on the total number of domestic students for which a university would receive government subsidies (a demand driven system). The introduction of differentiated tuition, the adoption of differentiated government subsidies, and the move to a demand driven system all provide an opportunity to better understand university responses to government policy changes and their impact on domestic enrollments.

As government regulatory oversight of public universities is a standard feature in most countries, the results from a study of the effects of tuition and subsidies on university enrollments offer policy relevance that extends beyond Australia. Our approach is to provide, first, a series of analyses that explore the effect of increasing tuition and the introduction of field specific subsidies on overall domestic enrollment. We explore the extent to which we observe different results for research intensive universities. We then provide a theoretical framework that would support the empirical findings. Next, we extend the framework to consider strategic actions universities may take given differential field specific tuition and subsidies and test the prediction of potential substitution between high and low revenue enrollments within universities. Finally, we consider the role of domestic student related policy changes on international enrollment. Unlike domestic student education, international student education has operated under a largely deregulated pricing environment, giving universities flexibility in setting international student tuition.[4]

We find that increasing tuition will lead to a decline in average enrollment for non-research intensive universities and a slightly positive effect for research intensive universities. We also find that introducing field specific subsidies leads to an increase in enrollment for both types of universities, with a stronger positive effect for research intensive universities. The theoretical framework for explaining these results captures the fact that universities will be heterogeneous in their decisions as they will factor in both their research and teaching activities. We also use this framework to explore universities' incentives to grow or contract fields of study, as well as to increase or decrease international student enrollments (by changing the base rates from which international tuition rates are derived) in response to shifting government policies affecting domestic tuition and per student subsidies. The predictions from the model suggest universities will be strategic in the growth or contraction of fields of study based on expected revenues (tuition + subsidy) and mixed effects of domestic tuition and subsidies on international enrollments that will vary based on the reasons for accepting international students. Additional empirical analysis suggests there is a substitution effect in enrollments whereby registration increases in high tuition fields and decreases in low tuition fields. We further find that raising tuition can lead to an overall increase in international enrollments that is larger for research intensive universities but this increase dissipates when policies to relax and encourage domestic enrollments are introduced.

The remainder of the paper proceeds as follows: Section 2 provides more details of the institutional framework. Section 3 describes the data and initial empirical results. Section 4 provides

[4] There is a restriction that universities must charge a tuition to international students that is equal to or exceeds the combined domestic tuition and subsidy.

a theoretical framework that supports these results and considers extensions of the framework that relate to cross-field enrollments and international student enrollments. Section 5 reports the empirical results that explore these extensions and Section 6 concludes.

2 Institutional Features for Studying University Enrollment

2.1 Tuition Fees and Enrollment

Australian universities are publicly funded and regulated by the federal government.[5] Universities receive revenues from tuition and associated fees (domestic and international), direct government subsidies, public and private research funding from peer-reviewed awarded grant programs and contracts, and donations and endowments from individuals, foundations, and industry.[6]

Tuition was introduced in 1989 alongside an option for citizens and permanent residents (domestic students) to defer payments through an income contingent loan scheme administered by the Australian Tax Office. The design of the loan scheme was to enable all students to pursue a university degree regardless of family background.[7]

Domestic tuition is set by the federal government and applies to all universities.[8] Universities set the tuition for international students, but are required to charge a rate that is equal to or exceeds the domestic student tuition rate plus the associated government subsidies given to universities for domestic students.[9] 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.

As illustrated in Figure 1, all undergraduate domestic students were charged the same tuition up to 1996. In nominal terms, annual tuition rates increased from approximately $1,800 to $2,450.[10] In

[5] For a more detailed review of the higher education system, see Meek and Hayden (2005) and Norton (2020).

[6] Most Australian universities are publicly funded. There are, however, a few private universities, with most of the private universities focusing on teaching. See, https://www.studyaustralia.gov.au/en/plan-your-studies/list-of-australian-universities

[7] Loan interest reflects cost-of-living increases, and minimum repayment rates are set based on earnings thresholds and corresponding percentages. As shown in Appendix A, most students take up this loan, with similar participation across tuition bands. In 2024, the minimum repayment threshold was approximately $54,000, with rates ranging from one to ten percent. Source: https://www.ato.gov.au/tax-rates-and-codes/study-and-training-support-loans-rates-and-repayment-thresholds

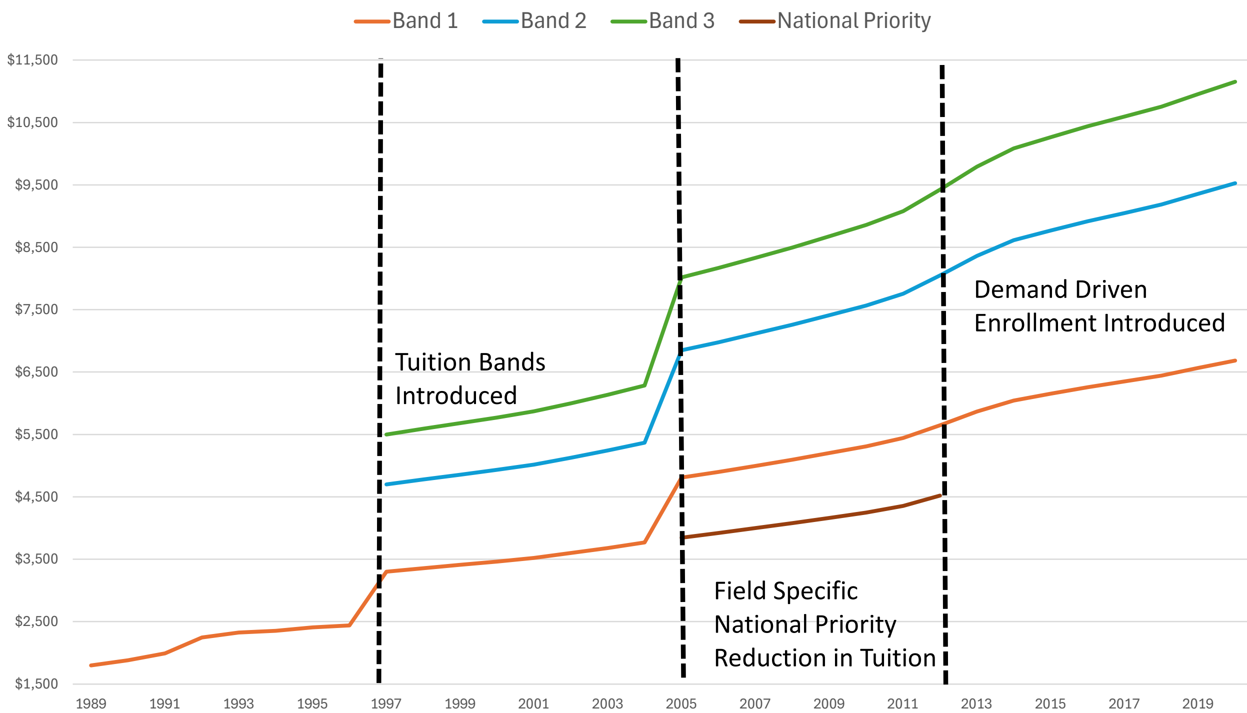
[8] The federally mandated domestic tuition is considered the maximum tuition a university may charge a domestic student. Universities may charge a lower tuition rate, but to our knowledge, few, if any, charge a lower tuition. New Zealand citizens also qualify for the domestic tuition rate.

[9] Further, international students are ineligible for the income contingent loan scheme. Starting in 1991, international students were protected under the Education Services for Overseas Students Act, which required universities and other educational institutions to register with the government before offering courses to international students, ensuring that students received the education they paid for. Additional protections have been implemented since 1991.

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

1997, the government introduced a three-tiered tuition rate system, known as "Bands." Academic disciplines are assigned to a band based on 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.[11]

Figure 1: Domestic Tuition Rates
1989-2020, Nominal ($Aus)



Note: Depicted are the tuition rates for bachelor degree programs. Tuition is set by the federal government and was first instroduced in 1989. The dotted lines represent periods of major policy changes, tied largely to changes in federal government political leadership. Bands refer to the maximum tuition rates for groups of fields. In 1997, differential tuition rates by field of study were introduced. Although universities have the discretion to charge a lower tuition rate, anecdotal observation suggests that all universities charge the maximum.
Data derived from Australian Parliament Library (2021).

There are two notable periods of sharp domestic tuition increases, in 1997 and 2005, closely linked to reforms timed around federal election cycles. The 1997 changes followed the 1996 election, which brought a shift from a liberal to a conservative government. The 2005 increases were largely driven by the implementation of the *Backing Australia's Future* reforms, passed in 2003 ahead of the 2004 election, which strengthened the conservative party's parliamentary position.[12] These reforms not only raised tuition sharply but also introduced discounted rates for disciplines the government

[11] Although seemingly transparent, the tuition charged to a student depends on the specific courses they take. If a student enrolls in courses across multiple disciplines associated with different tuition bands, the total tuition charged is based on a weighted combination of the tuition bands. For example, a student enrolled in one English course and one economics course would pay less tuition than a student enrolled in two economics courses.

[12] See, e.g., Australian Senate Higher Education Report.

prioritized for enrollment growth. From 2005 to 2009, discounted tuition applied to students in education and nursing, while from 2009 to 2012, discounts targeted students in science disciplines, including mathematics, statistics, and information technology.

As depicted in Figure 1, tuition in 1997 bands ranged from $3,300 to $5,500 (nominal); Band 2 tuition was $1,400 greater than Band 1, and Band 3 tuition was $2,200 greater than Band 1 tuition. Between 1997 and 2005, tuition for the three bands increased proportionally. The 2005 policy change resulted in an increase in tuition between 2004 and 2005 of close to 28 percent. The gap between the Band 2 and Band 1 tuition increased from $1,599 to $2,041 and the gap between Band 3 and Band 1 tuition from $2,515 to $3,201. Excluding 2005, between 1997 and 2019, tuition increased between 1.5 and 2.1 percent annually.[13] These increases have resulted in a growing difference across the bands, given that increases are based on the application of a percentage to the existing tuition. By 2020, these differences had grown to $2,843 and $4,471, respectively.

Students apply to university through a state administered application system. The application consists of information about student performance, a ranking of preferred program and university, and other information.[14] Students receive admission to their highest ranked program and university if they meet the university's admission criteria, which consists of a state administered ranking system based on performance in certain high school courses. Starting in 2009, states migrated to a national ranking system known as the Australian Tertiary Admission Rank (ATAR). The ATAR system was adopted in different years across the states.[15]

Across the period, universities have maintained the discretion to vary field specific enrollments. Until 2012 the government regulated overall domestic enrollment through individually negotiated agreements with universities. From 2005, universities have been permitted to register students above the targeted enrollments, with varying degrees of flexibility. Between 2005 and 2010, universities could enroll students, but these students would not qualify for the income contingent loan and the government subsidy provided to the university was nil or very low.[16] In 2010, the government increased the subsidies provided to universities, creating an impetus to increase enrollments above the negotiated amounts. In 2012, the government moved to a "demand driven" system for enroll-

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

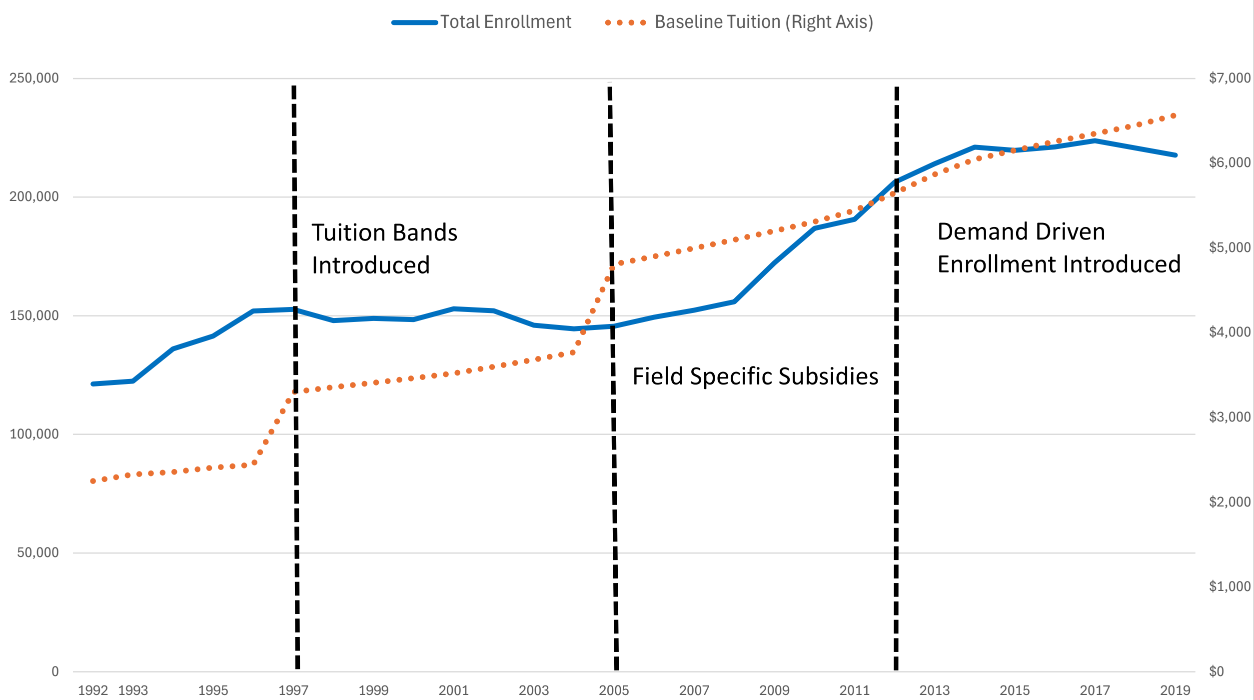
[14] Mature students and those holding vocational education and training qualifications may utilize alternative admission pathways that can include direct applications to a university. These pathways have become more common over time(Watson et al., 2013).

[15] 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. For more detailed information on ATAR scores, see https://www.studyassist.gov.au/starting-study-basics/getting-higher-education

[16] Placements that are within the target are referred to as "Commonwealth Supported Places". Universities could charge students the "full" tuition (tuition plus subsidy rate) if they did not qualify for a spot covered by the government. In practice, however, all domestic students were charged the same tuition rate, regardless of whether the university received a subsidy. For more information 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.

ment, effectively removing total enrollment restrictions for universities by providing government subsidies for all domestic students.[17]

Figure 2: Total Domestic Enrollment



Note. Total enrollment for all universities. Vertical lines reflect periods of major reforms.
Data Source: Statistics derived by authors from data provided by the Australian Department of Education

Figure 2 depicts the total enrollment for all universities over the sample period. For comparison, we also depict the minimum tuition rate for commencing students. Prior to the major tuition increase and shift to differentiated tuition rates, overall enrollment increased between 1993 and 1996. For the period 1997 to 2005, enrollments were relatively flat. After the reforms of 2005, enrollments continued to remain flat until 2008. Enrollment started to grow from 2009 onward. This increase coincides with a period of evolving policy settings and increasing funding support for domestic students. Overall, the pattern is consistent with a gradual loosening of enrollment constraints in the lead-up to the major 2012 reform, rather than a discrete policy shift in a single year.

[17] The 2012 changes came after the 2010 federal election shifted party leadership to the Labor Party (in a minority government). While there were modest increases in tuition in 2012, the bigger policy change was a change in the approach for addressing university enrollments. 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 this system change.

2.2 Government Subsidies

Universities receive a federal government subsidy for domestic student enrollment that is in addition to tuition revenue. Prior to 2005, the university received a lump subsidy that reflected total enrollment.[18] In 2005, the subsidy allocation changed to one based on discipline specific enrollments. The government grouped the disciplines into ”clusters.” Initially, disciplines were assigned to twelve clusters. The cluster classification was decreased to seven clusters in 2008 and then increased to eight in 2009. The discipline specific subsidy rate is designed to reflect the cost of teaching that discipline, net of tuition. The subsidy effectively is the difference between the assigned total cost and tuition. In some cases, e.g. for medicine, there is a positive correlation between the subsidy and tuition. In many cases, there is a negative correlation, e.g. for business and economics, a high tuition is charged and a low subsidy is given.

Table 1: Field and Discipline, Tuition & Subsidy Classification

Field Groupings for Analysis	Disciplines (Sub Fields)	Tuition Classification (Post 1997)	Cluster Grouping (Lowest Amount = Cluster 1) Used for Government Subsidy Allocation (2005+)		
			2005-2007 (12 Clusters)	2008-2009 (7 clusters)	2010 Onward (8 clusters)
(1)	(2)	(3)	(4)	(5)	(6)
Creative Arts (Visual & Performing Arts)		Band 1	8	4	5
Education		Band 1, Discounted 2005 to 2009 (National Priority)	6	3	4
Society: Social Sciences & Humanities & Law	Humanities & Arts	Band 1	3	2	2
	Social Science & Behavioral Science		5	3	3
	Law (Added to Society in 2000)	Band 3	1 (Lowest Subsidy)	1 (Lowest Subsidy)	1 (Lowest Subsidy)
Law, Business & Economics (to 1999)	Law	Band 3	No Cluster identified because the field designation changed before 2005		
	Business & Economics (includes Accounting, Management, Marketing, and Finance)	Band 2			
Business & Economics (2000+)	Includes Accounting, Management, Marketing, and Finance	Band 2 Moved to Band 3 in 2008	2	1 (Lowest Subsidy)	1 (Lowest Subsidy)
Science	Science	Band 2, Discounted 2009 to 2012 (National Priority)	10	6	7
	Mathematics & Statistics		4	3	3
Information Technology/Computing			7	3	3
Agriculture & Renewable Resources		Band 2	12 (Highest Subsidy)	7 (Highest Subsidy)	8 (Highest Subsidy)
Architecture & Built Environment			7	3	3
Engineering			10	6	7
Health	Nursing	Band 1, Discounted 2005 to 2009 (National Priority)	9	5	6
	Health Sciences (Other)	Band 2	10	6	7
	Medicine & Medical Science Dentistry & Dental Services Veterinary Science	Band 3	11	7 (Highest Subsidy)	8 (Highest Subsidy)

Source: Parliamentary Library, https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp2021/Chronologies/HigherEducation
Note: Enrollment data are available for "mixed fields" and for hospitality. Enrollments for these two categories are very low and are excluded in analyses using field groupings.

Table 1 captures the fields as classified in the enrollment data (column 1). The fields will capture a range of programs that can vary across universities. For each field, we identify disciplines associated with the field in column 2, the associated tuition band (column 3), and the designated cluster for capturing government subsidies from 2005 onward (columns 4 to 6). Note that until 1999, enrollments for law and business & economics were combined.[19] From 2000 onward, the

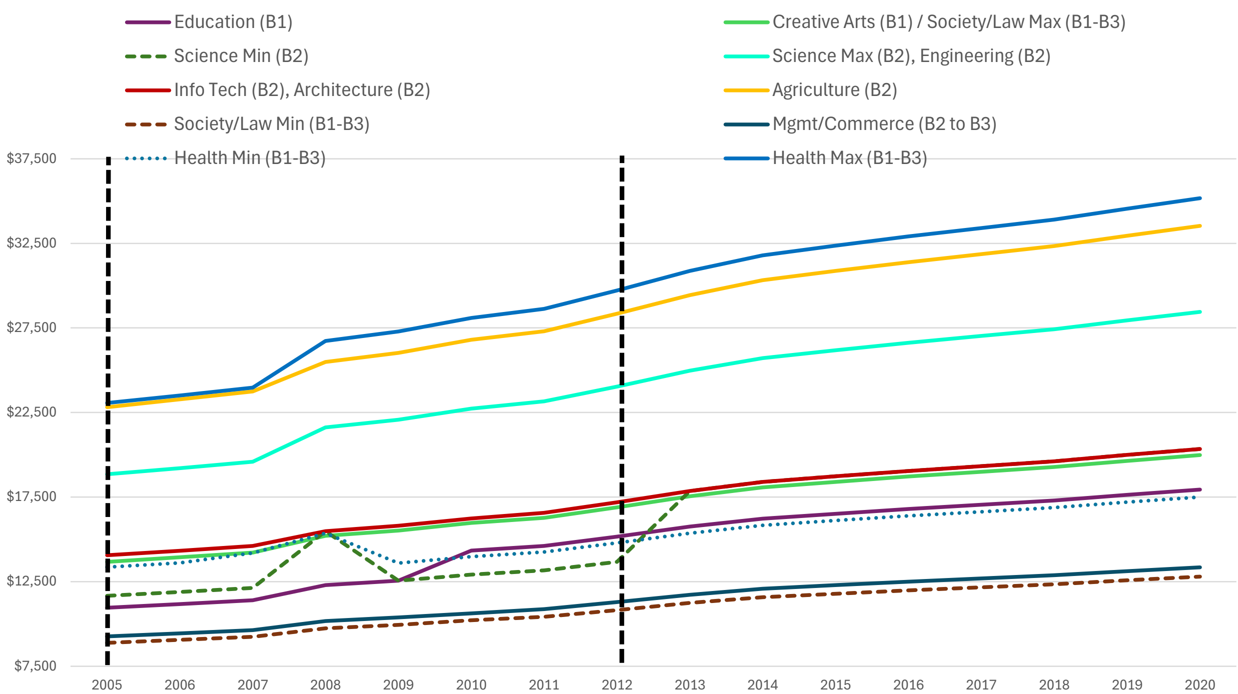
[18] The government also provides subsidies tied to other revenues, but as the focus of this paper is on tuition, our discussion is limited to subsidies tied to domestic student enrollment.

[19] In Australia, like the United Kingdom and Canada, bachelors' degrees can be awarded for law.

enrollment for law was added to the programs covered by the "Society" field (social sciences & humanities) and the programs associated with business & economics were kept as a single field.

There are single tuition and subsidy rates for most fields. Table 1 illustrates, however, there are multiple subsidy clusters for several fields. The programs for the Health and Society (post 2000) fields differ in tuition and subsidy rates. The Science field covers mathematics & statistics as well as disciplines such as biology, chemistry, and physics. While the tuition rates are the same for all of the disciplines that fall under the Science field, the subsidy rates differ, with mathematics & statistics attracting a lower subsidy rate. Table 1 further illustrates that the ranking within clusters has changed for some of the fields. Thus, throughout the sample period there have been several changes for both tuition and subsidies. While we have identified three periods of major policy changes, there have been a range of smaller changes.

Figure 3: Total Revenues Per Student, by Field
2005-2020 (Nominal, $Aus)



Note. Depicted are the the minimum and maximum per student revenues (tuition + subsidy) by field of study. The dotted vertical lines equate to the periods of policy changes: 2005 when there was a shift in tuition rates plus the introduction of field specific subsidies; 2012 change to demand driven enrollment.

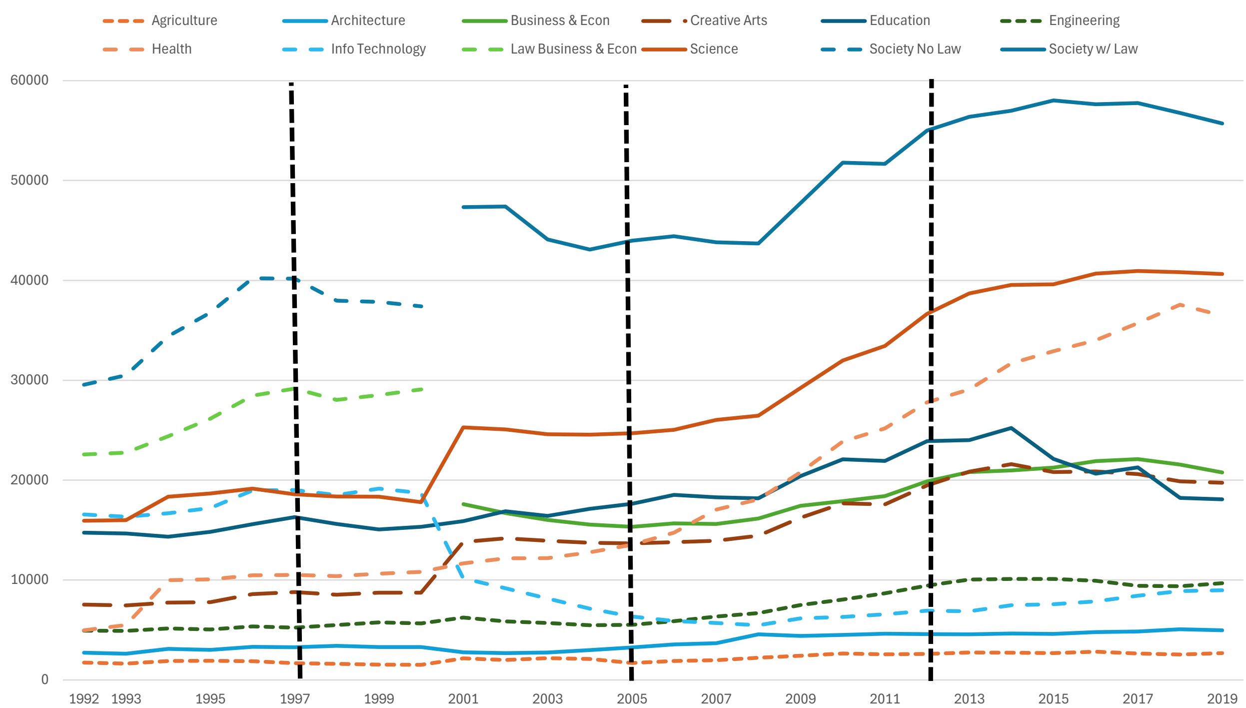
Figure 3 depicts total revenues (tuition + subsidy) per field from 2005 onward. For the fields associated with multiple tuition bands and/or subsidies, only the minimum and maximum revenue are depicted. There are several years of discrete jumps in the total revenues across the fields that vary between 2005 and 2012. While this in part reflects differences in costs, also noticeable is the increasing gap between the highest and lowest revenue fields. In 2005, the range between the highest (health and agriculture) and the lowest (society and business & economics) was approximately $13,800. By 2020, this gap had grown to close to $22,000.

Universities retain discretion over the use of revenues received, despite government oversight on tuition and subsidy rates. This discretion can include the allocation of resources across fields and/or between teaching-related and non-teaching-related activities. Universities also control admission criteria, which can vary across programs of study.

2.3 Field Specific Enrollments and International Students

Three major policy changes over the sample period could directly affect enrollment by field of study. The 1997 policy change introduced differential tuition. The 2005 policy change introduced field specific government subsidies. And the 2012 policy change relaxed total enrollment requirements. These changes could contribute to universities taking different approaches towards the growth or decline of specific fields.

Figure 4: Total Enrollments, by Field of Study

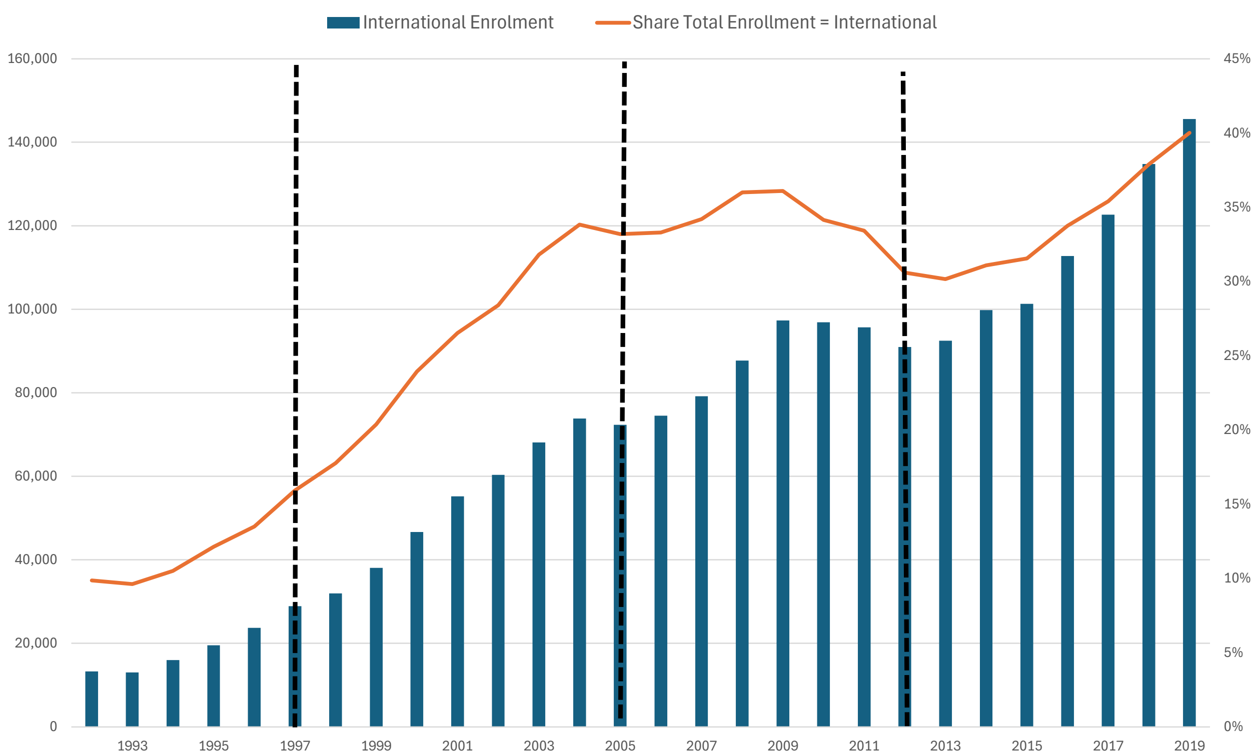


Note. Field enrollment for all universities, grouped as per data availability. Vertical lines reflect periods of major reforms.
Data Source: Australian Department of Education

We documented that overall enrollments were relatively flat between 1997 and 2008 in Figure 2. Enrollments grew significantly from 2009 onward. Figure 4 depicts domestic enrollment by field over the sample period. As noted above, the reporting for enrollment for society, law and business & economics changed in 2000. In the figure we depict the groupings before and after 2000 separately. For the period after the first major reform (1997 to 2005), enrollment for most fields was relatively flat. There are sharp increases in enrollment for science and creative arts and noticeable declines in information technology.[20] Between 2005 and 2012, there were sharp increases in enrollment in society & law, science, and health. In comparison to total revenues available from 2005 onward, health and science are two of the four fields that attract the highest revenues. While Figures 3 and 4 illustrate variation in revenues and enrollment across all fields, there is no discernible correlation between these two measures.

Universities have experienced less regulation with respect to tuition rates and enrollment caps for international students. Figure 5 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. The number of commencing international students increased from fewer than 50,000 in the early 1990s to 70,000-75,000 by the mid-2000s, reaching about 145,000 in 2019. The share of total commencing international students rose from about 5 percent in the early 1990s to approximately 45 percent by 2019.

Figure 5: Total Commencing International Students (Equivalent Full Time)
and Share of Total Enrollment = International Students



Note: The dotted vertical lines depict the three periods of major policy changes, explained previously.
Data Source: Derived statistics from data extracted from the Australian Department of Education for equivalent full time enrollment by university and field.

Although international students have attended Australian universities since the 1950s, the

[20]The drop in information technology enrollments is correlated with the dot.com bust during 2000 and 2001.

marked expansion over the past two decades can largely be attributed to regulatory changes, e.g., pathways to permanent residency (Meadows, 2011).[21] Universities, moreover, are permitted to determine international tuition provided the tuition exceeds the expected revenue for domestic students (tuition + subsidy).[22]

2.4 External Research Funding

A final key source of funding for universities is research revenue. Similar to most countries, universities vary with respect to their research intensity. To illustrate the variation, we use as a proxy for research activity the receipt of external research income. 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). 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.

To explore differences in research intensity, we grouped universities into four categories:

1. Group of Eight (G08) universities: Australia's leading research intensive universities, regularly ranked internationally and historically attracting the highest research funding;[23]
2. Top 20 universities excluding the G08: Universities ranked by their average annual Category 1 (ARC/NHMRC) research funding 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; and
4. Universities with little or no research funding, defined as less than $1 million per year.

Figure 6 depicts annual research funding for all universities and Category 1 competitive research funding by university grouping for the period under study. Funding has grown from less than one billion to close to six billion. Category 1 funding has increased more modestly, from $500 million to more than two billion. The share of total funding attributed to competitive federal grants

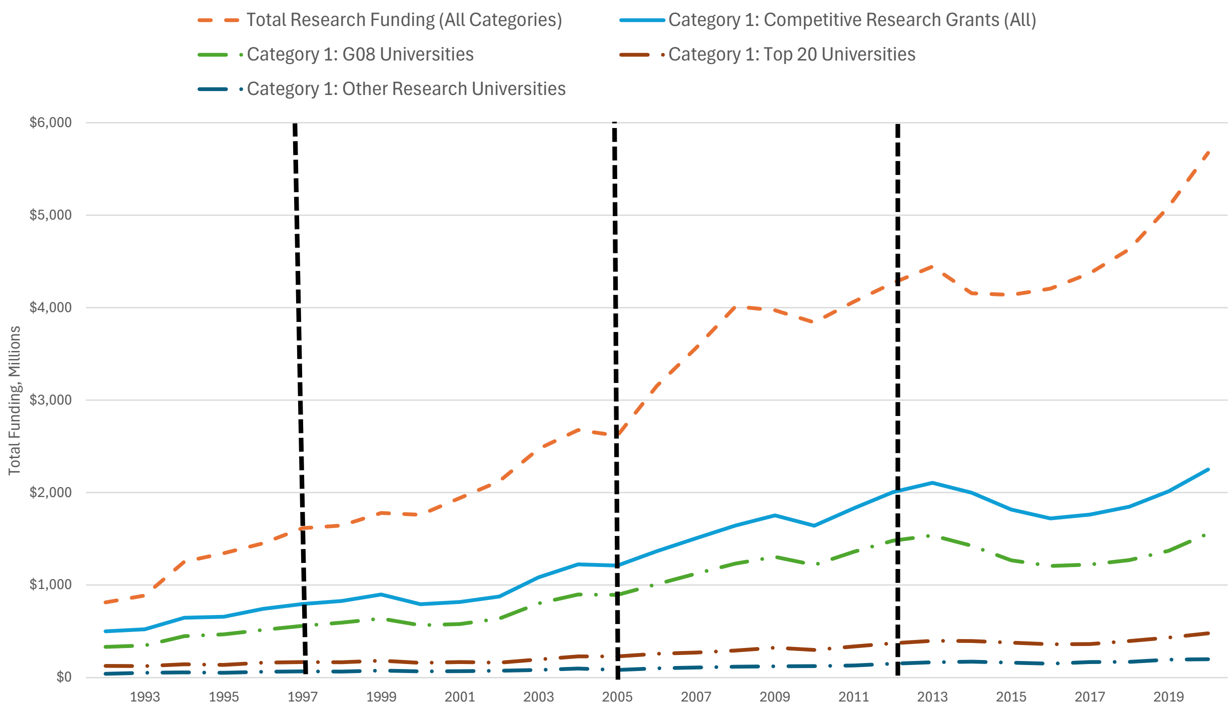
[21] Norton (2024) provide a more extensive summary of the treatment of international students in Australia.

[22] 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.

[23] 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).

(Category 1) has declined, from approximately 50 to 30 percent. The G08 universities receive the bulk of Category 1 research funding throughout the period, but the share of total Category 1 funding flowing to the G08 universities was relatively flat in the 1990s, rose in the 2000s and then exhibited a decline from about 2013 to 2018. While the G08 universities attract the bulk of Category 1 funding, the growth in overall research funding has come from other sources.

Figure 6: Research Funding, Overall and by Type of University
($2022 AUS)



Note: Universities are grouped based on known consortiums (e.g. Group of 8 top universities) and average research funding over the period.
Depicted are total research funding by category of funding which includes research grants, contracts, and private sources and by university grouping.
The dotted vertical lines depict the three periods of major policy changes, explained previously.
Data Source: Statistics derived from data extracted from the Australian Department of Education

Given the noticeable differences in annual research funding between the G08 universities and the remaining universities, for the remainder of this paper, we only differentiate between the G08 and all other universities to capture differences between research intensive and less research intensive universities as it relates to enrollments.

3 Effect of Tuition & Subsidies on Domestic Enrollment

3.1 Data

We rely on enrollment and research funding data from the Australian Department of Education for the period 1992 to 2020, covering information for 82 universities that operated for one or more years. Due to COVID-19 we exclude from our analysis data from 2020. The tuition and government subsidy measures are derived from Australian Parliament Library (2021).

Table 2 presents the summary statistics for the key measures tied to enrollment, tuition, subsidies, and research funding. In column 1 we report the statistics for all 82 universities. In column 2 we report the statistics for the top (G08) research intensive universities. In columns 3 to 5, we report the statistics around the three periods of major policy reforms (1997, 2005, and 2012), capturing three years before and after the reforms in addition to the year of the reform.

Table 2: Commencing Enrollments, Tuition & Subsidies, & Research Funding

	Full Sample	G08 Research Universities	Full Sample 1994-2000	Full Sample 2002-2008	Full Sample 2008-2015
	(1)	(2)	(3)	(4)	(5)
Panel A: Average Total Commencing Student Enrollment (Full-Time Equivalent)					
Average # of Domestic Students Per University	3,794	5,849	3,669	3,363	4,213
(standard deviation)	(2,722)	(2,363)	(2,171)	(2,282)	(3,102)
# of Universities	82	8	42	54	60
Average # of Domestic Students Per Field & University	449	600	413	387	512
(standard deviation)	(502)	(624)	(412)	(440)	(570)
Average # of International Students Per Field & University	186	292	82	190	243
(standard deviation)	(334)	(420)	(174)	(298)	(382)
Panel B: Tuition & Government Subsidy					
Average Maximimum Tuition Per Field	$6,106	Same as Column 1	$3,758	$6,135	$8,008
(standard deviation)	(2,518)		(1,326)	(1,337)	(1,412)
Average Maximum Government Subsidy (post 2005), by Field	$12,326		Field subsidies introduced in 2005	$10,189	$12,512
(standard deviation)	(5,601)			(4,317)	(5,541)
Panel C: Research Funding (millions, $2022 Aus)					
Average Research funding (Category 1 Competitive Grants)	$29.114	$117.313	$19.134	$28.627	$39.088
(standard deviation)	(49.622)	(61.364)	(26.804)	(45.787)	(64.196)
Average Research funding (Category 2 Public Sector Funding)	$15.072	$52.146	$6.862	$14.610	$21.529
(standard deviation)	(26.019)	(41.993)	(8.757)	(21.589)	(32.070)
Average Research funding (Category 3 Industry, Philanthropy, & International)	$18.872	$72.510	$12.247	$18.885	$22.280
(standard deviation)	(33.043)	(47.769)	(17.305)	(32.297)	(34.864)
Average Research funding (Category 4 Cooperative Research Centers)	$2.338	$6.026	$0.485	$4.033	$2.881
(standard deviation)	(3.893)	(6.319)	(17.305)	(5.177)	(3.778)

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.

In Panel A of Table 2 we report the mean and standard deviation for total commencing domestic enrollment per university, and per field and university for domestic and international students. The average commencing domestic enrollment is close to 3,800 students across all universities and nearly 5,900 students for the research universities. Over time, average university enrollment has grown. The average domestic enrollment per field of study is 450 for all universities and 600 for the research intensive universities. Aligned with Figure 5, average enrollment by field of international students has climbed dramatically in the more recent period.

In Panel B we report the average maximum tuition and subsidy per field of study. These statistics illustrate the growth in both revenue sources as well as the variation across fields. In Panel C we report the summary statistics for the four categories of research funding, illustrating the research intensive universities attract a large proportion of research funding across all four categories.

3.2 Empirical Specification

In this section, we explore the effects of increasing tuition and subsidies on enrollment. Equations 1 and 2 capture our initial specifications:

$$\begin{aligned} DomEnr_{fut} = {} & \alpha_u + \phi_f + \beta Tuition_{ft} + \lambda GovSub_{ft} + \gamma IntlEnr_{furt-1} + ResFund_{ut}\eta \\ & + Policy_t\delta + \omega_1 Trend_t + \omega_2 Trend_t * G08 + \epsilon_{fut} \end{aligned} \tag{1}$$

$$\begin{aligned} DomEnr_{fut} = {} & \alpha_u + \phi_f + \beta_1 Tuition_{ft} + \beta_2 Tuition_{ft} * G08 + \lambda_1 GovSub_{ft} + \lambda_2 GovSub_{ft} * G08 \\ & + \gamma_1 IntlEnr_{fut-1} + \gamma_2 IntlEnr_{fut-1} * G08 + ResFund_{ut}\eta \\ & + Policy_t\delta + \omega_1 Trend_t + \omega_2 Trend_t * G08 + \epsilon_{fut} \end{aligned} \tag{2}$$

The dependent variable is commencing domestic enrollment (*DomEnr)* for field f at university u in year t. Our analysis focuses on the number of commencing students by field of study, given that students apply for admission based on the university and discipline. As highlighted in Table 1, enrollments are grouped by eleven fields of study: Science, Information Technology, Engineering, Architecture, Agriculture, Health, Education (teaching-oriented), Law with Business & Economics (pre-2000), Business & Economics (2000+), Society & Law (social sciences and humanities all years and law from 2000+), and Creative Arts.[24] As presented above, the enrollment data for Law, Business & Economics, and Society were defined differently before and after 2000. As such, we have kept the enrollment for these disciplines as they were defined in the given year of study.

Commencing domestic enrollment is regressed on tuition, government subsidies, commencing international enrollment for the field lagged one year, research funding, policy variables, and year trends. We also incorporate a set of field and university fixed effects to capture time invariant characteristics of the fields and universities. Equations 1 and 2 differ in that the first specification captures the effect of the control variables across all universities. In the second specification, we interact an indicator variable that is equal to one if the university is a research intensive (G08) university with the tuition, government subsidy, and international student measures to capture variation between the research and less research intensive universities. We use nominal tuition rates and government subsidies in the regressions, as these reflect the revenues at the time of enrollment.

[24] Fields such as Food/Hospitality and Mixed Field are excluded due to very low enrollment and their reference to broader, less clearly defined areas.

Our identification strategy exploits exogenous variation in tuition fees and government subsidies across fields and over time, driven primarily by policy changes in 1997, 2005, and 2012. The major tuition policy reforms described above often coincided with elections and changes in political leadership. As tuition is set by the federal government rather than by individual universities, we are less concerned about the potential endogeneity of tuition and subsidies and treat them as exogenous measures.

The tuition measure (*Tuition)* captures the field specific tuition. Prior to 1997, there was a single tuition rate. From 1997 onward, there have been multiple tuition rates. For all fields except Health and Society & Law there is a single tuition charged for any given year. For Health and Society & Law we use the maximum tuition that may be charged given the assumption that universities will pursue higher tuition enrollments.[25] The government subsidy measure (*GovSub*) reflects the field specific subsidy provided from 2005 onward. For fields with multiple subsidy rates, we use the maximum subsidy rate available for the field. Multiple subsidies are associated with Society & Law and Health. For years prior to 2005, the subsidy rate was equal to zero given subsidies were not specific to field enrollments. As discussed further below, we include a policy indicator variable that is equal to one to reflect the change in policy in 2005 to have field specific subsidies.

We include lagged international student enrollment (*IntlEnr*) to identify field specific changes in international enrollment that could affect capacity constraints for growing domestic enrollment. The research funding measures (*RsFund*) reflect time-varying changes in research intensity at the university level.

The university fixed effect (α_u) controls for time invariant characteristics of the universities, such as location, long-standing reputation, and areas of specialization such as the composition of programs offered (e.g. having a medical school, offering graduate studies). The set of field indicator variables (ϕ_f) capture time invariant differences that might reflect differences in field intensity.

To account for time trends and changes in policy we implement a series of measures ($trend_{rt}$ and $policy_t$). The trend is designed to capture yearly growth (or decline) in enrollments.[26] We interact the trend measure with the research intensity measure (G08) to allow for differential trends in enrollment across the research intensive and less research intensive universities. Finally, we incorporate the following indicator variables to reflect policy changes affecting the delivery of a university education, namely:

- **Multiple tuition rates**: An indicator variable equal to one for 1997 onward. Prior to 1997, there was a single tuition rate.

[25] A limitation of the field-level aggregation is that some broad fields combine disciplines with different tuition schedules and cost structures. For example, within the Society & Law field, law students face higher tuition than sociology students. Using multiple tuition measures within the same regression would substantially complicate the interpretation of the coefficients, particularly when enrollment is only observed at the aggregated field level.

[26] Population growth in Australia averaged around 1.38% per year over the 1992-2020 period, with relatively limited variation (Australian Bureau of Statistics, 2020). This suggests that changes in enrollment are unlikely to be driven by population growth.

- **Field specific government subsidies introduced:** An indicator variable equal to one for 2005 onward. This variable also captures the increase in tuition in 2005.
- **Tuition discounts for enrollment in nursing and education:** An indicator variable equal to one for the period 2005 to 2009, reflecting reduced tuition for these fields.
- **Tuition discounts for enrollment in science and math:** An indicator variable equal to one for the period 2009 to 2011 to capture the reduction in tuition for these fields.
- **Post demand driven policy period:** An indicator variable equal to one for 2012 onward.

By using a strategy that includes the policy variables, we capture the coefficients that measure the effect of these policy changes on enrollment. An alternative estimation strategy would be to use indicator variables for each year under study. We report the results using this set of measures in columns 2 and 4 of Table 3 to demonstrate that these measures do not alter the conclusions drawn on the coefficients related to tuition and subsidies.

3.3 Empirical Results

3.3.1 Overall Effect

Table 3 reports the results for Equations 1 and 2. The coefficients in column 1 (with policy controls) and column 2 (with indicator measures to capture year effects). As the coefficients on the key measures of interest are the same across both columns, we focus our discussion on the results reported in column 1. For the average university, an increase in tuition by $1,000 would decrease enrollment by 15 students. Given the average enrollment per field is 449 students, this equates to a decline in enrollment of 3.3 percent. In contrast, an increase in government subsidies leads to an average increase in enrollment. For every $1,000 increase in subsidies, enrollment increases by 22 students, approximately an increase of 4.9 percent. These estimates are consistent with previous studies suggesting that a $1,000 increase in tuition reduces enrollment by roughly 3–4 percent in higher education settings (Neill (2009)).

The coefficients on policy controls further suggest that switching to multiple tuition rates is associated with higher enrollment. The policy measure that reflects the 2005 reforms that included tuition increases and the introduction of field specific subsidies is negative, reflecting a downward pressure on enrollments. Also of note is that the coefficients on the measures to reflect tuition discounts are negative (for education and nursing) or imprecisely measured (for math and science). Finally, the coefficient for the introduction of the demand driven enrollment policies is positive.

The next two sets of measures capture time-varying changes in field specific international enrollments and university research funding. With respect to the international enrollments, the coefficient is positive. Across all universities, an increase in international enrollment in the prior year is associated with an increase in domestic students by a ratio of approximately one domestic

Table 3: Effect of Tuition on Field Specific Enrollment, All Years

Dependent Variable	Total Commencing Domestic Students, by Major Field, All Years			
	(1)	(2)	(3)	(4)
Tuition & Government Subsidy Measures				
Field of Study Tuition	-0.015***	-0.014**	-0.022***	-0.020***
(Fields with Multiple Tuition, Maximum Used)	(0.006)	(0.006)	(0.006)	(0.006)
* G08 University			0.036***	0.035***
			(0.007)	(0.007)
Field of Study: Maximum Government Subsidy	0.022***	0.022***	0.019***	0.019***
	(0.001)	(0.001)	(0.001)	(0.001)
* G08 University			0.012***	0.012***
			(0.002)	(0.002)
Year Variables				
Year Dummy Variables instead of Trend & Pre/Post Variables (Below)	✗	✓	✗	✓
Year Trend	0.105	✗	4.363***	✗
	(1.639)		(1.662)	
* G08 University	-8.507***	-8.798***	-28.304***	-28.423***
	(1.603)	(1.625)	(2.410)	(2.420)
Post Intro of Multiple Tuition Rates & Tuition Increases (1997+)	68.299***	✗	69.235***	✗
	(15.872)		(15.621)	
Post Field Specific Government Subsidies & Tuition Increases (2005+)	-172.079***	✗	-163.123***	✗
	(26.393)		(25.935)	
Tuition Discount for Education & Nursing (2005-2009)	-43.569***	✗	-42.642***	✗
	(16.515)		(16.023)	
Tuition Discount for Math & Science (2009-2011)	0.405	✗	6.151	✗
	(11.626)		(11.384)	
Post Demand Driven Enrollment Policy (2012+)	54.432***	✗	56.319***	✗
	(17.415)		(17.005)	
International Student Measures				
Commencing International Students, By Field (lagged one year)	0.515***	0.520***	0.422***	0.426***
	(0.023)	(0.023)	(0.022)	(0.022)
* G08 University			0.260***	0.264***
			(0.049)	(0.049)
Research Funding Measures (Millions)				
Research funding (Category 1: All Government Competitive Grants)	0.755**	0.744**	0.316	0.251
	(0.322)	(0.328)	(0.309)	(0.315)
Research funding (Category 2: Public Sector Grants/Contracts)	0.036	0.079	-0.182	-0.151
	(0.245)	(0.246)	(0.243)	(0.244)
Research funding (Category 3: Industry, Philanthropy, International	-0.762**	-0.731*	-0.777**	-0.728*
	(0.381)	(0.384)	(0.369)	(0.373)
Research funding (Category 4: Federally Funded Cooperative Research	1.012	1.146	1.390	1.525
	(1.202)	(1.289)	(1.155)	(1.238)
University Fixed Effects	✓	✓	✓	✓
Field Fixed Effects	✓	✓	✓	✓
Constant	572.413***	471.562***	571.970***	594.316***
	(18.733)	(55.563)	(18.532)	(57.184)
R-Squared	0.670	0.672	0.677	0.679
# of Universities	82			
# of Observations	10,283			

Notes: Robust standard errors reported in parentheses.*** = p<.01; ** = p<.05; *=p<.1
Enrollment captured for 1992 to 2019 by field of study. Excluded are low enrollment fields: hospitality and mixed fields.
Tuition for most fields captures the tuition allocated to the field. For fields with multiple tuitions, the tuition measure is equal to the maximum tuition that may be charged for the given field. For example, the Health field includes the low tuition discipline of nursing and the high tuition discipline of medical studies. The maximum tuition assigned to health would be the higher (Band 3) tuition rate.
Maximum Government Subsidy is defined as the maximum per student subsidy that a university will receive for the disciplines covered by the field of study. As reported in Table 1, field specific subsidies were introduced in 2005 and there is much greater variation in the subsidy rates than what is observed in tuition rates.

student for every two international students. The effect is more positive for the research intensive universities. The effect of increased research funding on domestic enrollments is less clear. For the specifications that do not include the research intensive university (G08) interactions, the results suggest increasing Category 1 (competitive research grants) funding leads to increased domestic enrollments but increasing funding from industry, foundations, or donors, can lead to a decline in domestic enrollments.

In columns 3 and 4 of Table 3, we report the results from the specification based on Equation 2. The results suggest with increasing tuition, subsidy, and international student enrollments, domestic enrollments for research intensive universities increase.

Overall, the results in Table 3 present a puzzle. If we rely solely on frameworks that assume that only students would react to tuition changes, we should expect a negative or nil effect from an increase in tuition on enrollment. For the less research intensive universities, this is the case. But when we focus on research intensive universities, the results suggest that increasing tuition leads to increasing enrollments. We also find increasing resources to the university such as direct field specific subsidies leads to increasing enrollment.

3.3.2 Effects of Major Policy Changes

Table 3 reports the results for a nearly 30-year period. During this period three major policy changes and several smaller policy changes were enacted. The three major policy changes altered the university environment in different ways. The first change (1997) introduced differentiated tuition rates as well as a major increase in tuition. This differentiated tuition was designed to capture differences in expected returns to education associated with the disciplines which also would have affected differences in the level of student loans taken out. From a student perspective, one might expect enrollments to decline. From a university perspective, the differentiated tuition rates might change their strategic behavior regarding the offering of programs. In column 1 of Table 4, we report the results for this first major change. Given the policy was implemented in 1997, we restrict the sample period to cover 1994 to 2000, thus including three years before and after the reforms. As the subsidies for this period were allocated as a lump sum, the regression excludes the measures for government subsidies. Overall, the average effect of increasing tuition is a fall in enrollment. A $1000 increase in tuition reduces field-specific enrollments by an average of 22 students, roughly a six percent decrease. The coefficient on the G08, research intensive universities, is positive but imprecisely measured.

The second major policy reform occurred in 2005. This reform resulted in both changes to tuition as well as changes in the method used to distribute direct subsidies to universities. Tuition increased by 28 percentage points. With the introduction of field specific subsidies, the range of revenue (tuition + subsidies) to universities across disciplines ranged from $3,847 to $13,172. To counteract some of the tuition increases and to encourage enrollment in education and nursing, a tuition discount was also provided to students who registered in these programs. In column 2 of

Table 4: Effect of Tuition & Subsidies by Period of Major Change

Dependent Variable	Total Commencing Domestic Students, by Major Field			
Period	1994 to 2000 (Major Change: 1997)	2002 to 2008 (Major Change: 2005)	2009 to 2015 (Major Change: 2012)	
	(1)	(2)	(3)	(4)
Tuition & Government Subsidy Measures				
Field of Study Tuition	-0.024**	-0.044*	0.148*	
(Fields with Multiple Tuition, Maximum Used)	(0.012)	(0.026)	(0.076)	
* G08 University	0.031	0.050***	0.005	
	(0.019)	(0.013)	(0.014)	
Field of Study: Maximum Government Subsidy		0.005**	0.019	
		(0.002)	(0.018)	
* G08 University		0.011***	0.021***	
		(0.003)	(0.003)	
Total Revenues Per Student (Maximum Used)				0.019**
(Tuition + Government Subsidy)				(0.009)
* G08 University				0.012***
				(0.003)
Year Variables				
Pre/Post Categorical Variables for Policy Changes	✓	✓	✓	✓
Year Trend	0.848	11.363*	-24.497	1.185
	(4.677)	(5.898)	(17.475)	(12.068)
G08 University Year Trend	-27.380**	-53.852***	-27.923***	-26.138***
	(13.318)	(11.461)	(8.066)	(7.866)
International Student Measures	✓	✓	✓	✓
Research Funding Measures (Millions)	✓	✓	✓	✓
University Fixed Effects	✓	✓	✓	✓
Field Fixed Effects	✓	✓	✓	✓
Constant	482.576***	732.605***	-833.682	179.295
	(51.002)	(139.119)	(610.018)	(200.241)
R-Squared	0.756	0.744	0.721	0.718
# of Universities	42	54	60	
# of Observations	2,226	2,702	2,775	

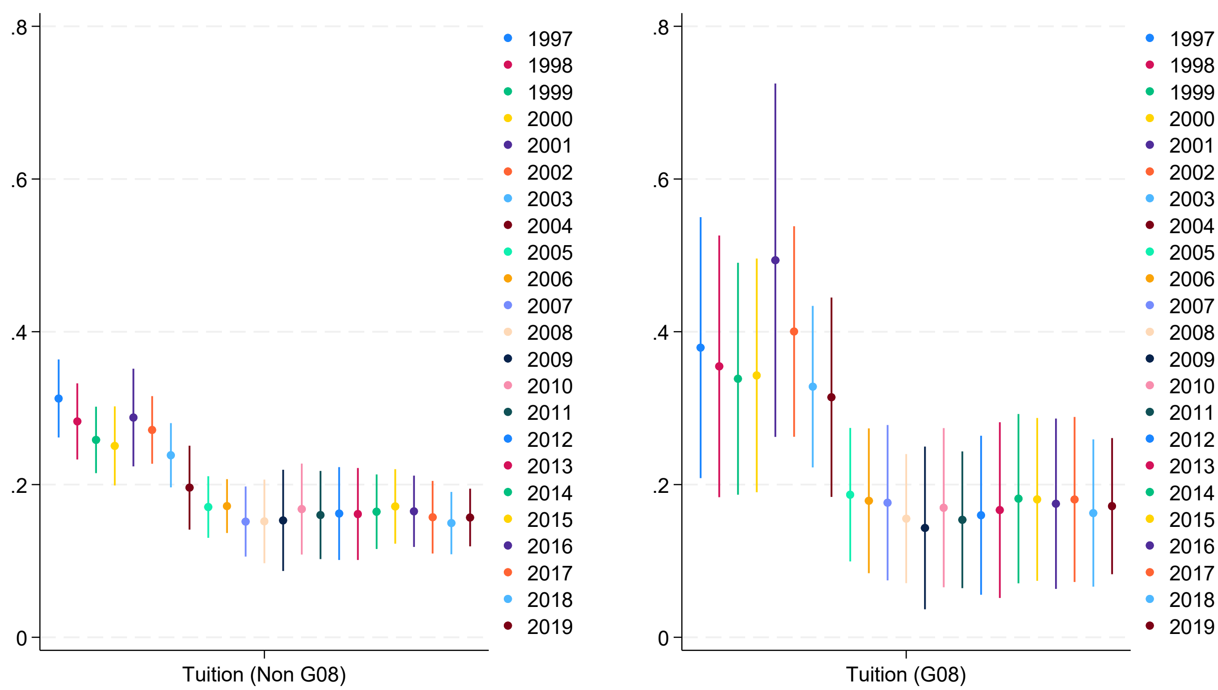
Notes: Robust standard errors reported in parentheses.*** = p<.001; ** = p<.01; *=p<.1
See notes to Table 3. The total tuition and government subsidy rate is the combined discipline specific tuition and government subsidy. The maximum is defined as the maximum across all disciplines within a field of study.

Table 4 we report the results from the specification that covers the period of this second reform (2002 to 2008). The coefficient on the tuition measure for the less research intensive universities remains negative and is twice as negative as the coefficient for the period of the first major reform. The effect for research intensive universities, however, is slightly positive, a net increase of approximately six students per $1,000 increase in tuition. The introduction of field specific subsidies is associated with a slight increase in enrollment across all universities and a much larger effect (16 students per $1,000 increase in subsidies) for the research intensive universities.

The third major policy reform was put into place in 2012. From 2008 onward the government started to relax restrictions tied to the overall caps on enrollment by providing some subsidies to universities that exceeded their enrollment caps. In 2012, these restrictions were completely relaxed as the government moved to a demand driven system that gave greater flexibility for admitting domestic students, resulting in universities receiving full field specific subsidies for domestic enrollments. In column 3 of Table 4 we report the results that cover the period of the introduction of the demand driven policy (2009 to 2015). Increasing tuition led to increased enrollment across all universities with no precise difference for the research intensive universities. The effect of increasing government subsidies on enrollment is positive but imprecisely measured. The additional effect for research intensive universities is positive and significant.

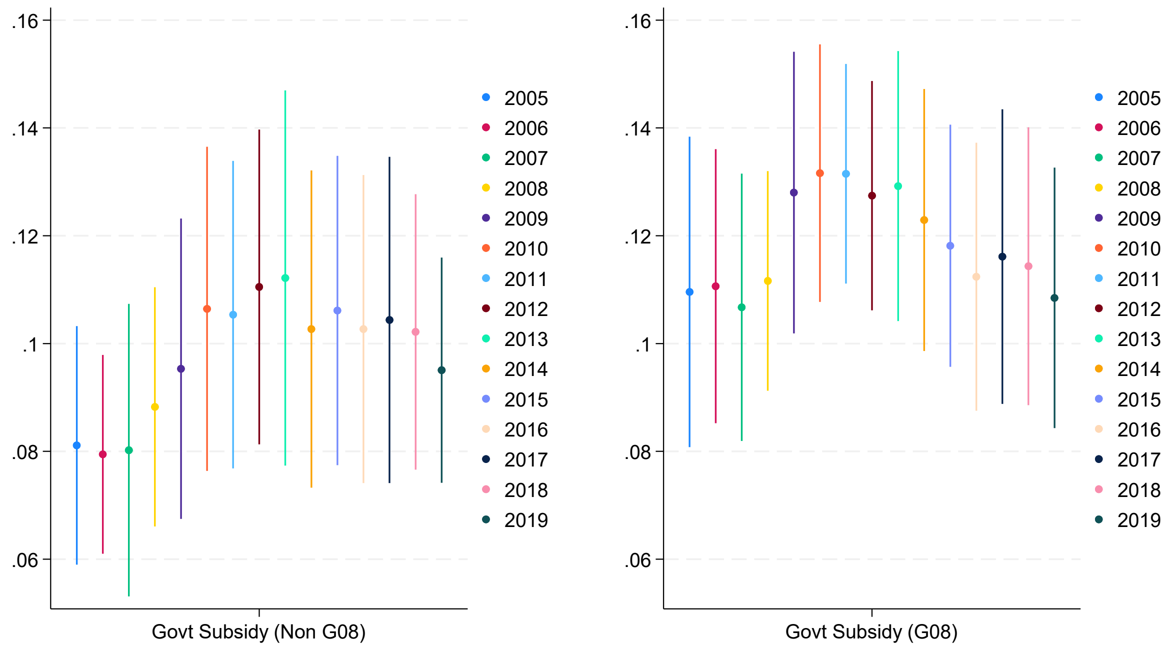
The period covering this third reform covers the years for which field specific subsidies were allocated to universities. As such, we can combine the subsidy and tuition across disciplines to construct a total revenue received by the university for domestic enrollments. Using the maximum potential revenue per field, in column 4 of Table 4 we report the coefficients for a specification that substitutes the total revenue measure for the tuition and subsidies measures. The effect of an increase in the combined revenue is positive (19 students per $1,000 increase) for all universities but much bigger (32 students per $1,000 increase) for the research intensive universities.

Figure 7: Coefficients on Tuition, Year Specific Regressions



To further explore differences in the effects of tuition and field specific government subsidies between research intensive (G08) and less research intensive (non-G08) universities, Figures 7 and 8 depict the coefficients on the tuition and subsidy measures, respectively, from year specific regressions (1997 onward for tuition and 2005 onward for government subsidies). Because these annual regressions rely only on within-year cross-field within university variation, the specifications can include only covariates that vary by field and year. Consequently, the regressions exclude field-invariant controls such as research funding, time trends, and policy measures.

Figure 8: Coefficients on Government Subsidies, Year Specific Regressions



In Figure 7, we depict the coefficients on the tuition measures. The coefficients for the less research intensive (non-G08) and research intensive universities (G08) are depicted on the left and right panels, respectively. For each year, we depict the coefficient and standard error band. The standard errors for the G08 universities are larger than those for the non-G08 universities, likely reflecting the smaller number of observations. Prior to 2005, the tuition coefficients for the research intensive universities are larger than the coefficients for the less research intensive universities. From 2005 onward, however, although positive, the coefficients on tuition for both types of universities are the same. As these results include university and field fixed effects, the results suggest that, on average, fields with higher tuition are more likely to have higher enrollments.

The coefficients from the field specific subsidies are depicted in Figure 8. For all years, the point estimates are larger for the research intensive universities than for the less research intensive universities, especially for the years immediately following the introduction of the field specific subsidies. For both sets of coefficients, however, the standard errors are large, suggesting the point estimates are not significantly different from each other.

The results reported in Tables 3 and 4 and Figures 7 and 8 establish that tuition and government subsidies affect university enrollment. When there are only increases in tuition (before 2005), the analysis suggests that an increase leads to a fall in enrollment. This result is in line with existing literature that focuses on the effect of tuition on individual decisions to enroll in university. Figure 7 suggests differentiated tuition can lead to a more positive effect on enrollment for the higher tuition fields. Once field specific subsidies are introduced the results suggest less research intensive universities faced declining enrollments and that research universities faced increasing enrollments as tuition and subsidies increased.

These positive effects of tuition on enrollment suggest that universities may react to tuition changes, extending the framework for understanding the effects of tuition from one that focuses on both a student and university reaction. Differential reactions by research and less research intensive universities also suggest there may be features to university operations that can lead to differential effects across universities. In the next section, we explore why university behavior may play an important role in understanding the effects of rising tuition on university enrollment.

4 Theoretical Framework

In this section, we develop a model to illustrate how universities' behavior can impact the response of enrollment to changes in government funding within a public university system. The framework can be generalized to apply to settings where higher education is provided, at least in part, by public universities, as is the case in most countries. While we have been able to study a system where tuition is set by the federal government, this is not a necessary condition for understanding public university behavior. While regulation will vary across and within countries, public universities are subject to government budgetary constraints and regulations that can limit their ability to set tuition policy and/or other matters that would impact university enrollment.

A feature of the model presented below is the ability of universities to set admission standards and/or program size, which affect their enrollments, while allowing a decision to enroll to depend directly on tuition. Consequently, the model allows us to account for university behavior to explore the effects of tuition and government subsidies on enrollment.

4.1 Related Literature

A large literature studies university behavior in market-oriented or unregulated higher education systems, particularly in the US, where institutions compete across multiple dimensions, including domestic tuition pricing, student selectivity, program offerings, and targeted recruitment. Seminal contributions such as Epple et al. (2006) and Fu (2014) model competition among universities, when institutions can use tuition and financial aid strategically to attract students of different abilities and willingness to pay. Related empirical work documents increasing stratification across institutions and heterogeneous enrollment responses to demand and pricing changes Bound et al. (2009), Card and Lemieux (2001), Hoxby (2009), Kim and Stange (2016). Other studies, such as Kolpin and Stater (2024), Kaganovich and Su (2019), Groen and White (2004), and Knight and Schiff (2019), examine institutional strategies for recruitment, curriculum differentiation, and non-resident tuition management.

Our setting differs from much of this literature because domestic tuition is centrally regulated and universities cannot freely set prices. In regulated systems, institutional responses are more likely to occur through non-price margins such as admissions, research, and curriculum quality. Theoretical work on university objectives emphasizes that universities typically balance educational and research goals rather than maximize profits alone De Fraja and Iossa (2002), Del Rey (2001), Beath et al. (2012). In particular, De Fraja and Iossa (2002) model universities as institutions that choose admission standards and research investments to maximize prestige subject to budget constraints, while Eisenkopf and Wohlschlegel (2012) shows how differentiation can emerge even when tuition is fixed.

A related literature studies how universities respond to changes in public funding. Declines in government support have been associated with greater reliance on alternative revenue sources, particularly international students Bound et al. (2020, 2021). Evidence from the UK and US suggests that universities use international enrollment expansion to offset funding pressures, often without reducing domestic students (Machin and Murphy, 2017, Shih, 2017). These findings highlight that universities may adjust enrollment composition and admissions behavior in response to funding incentives even when domestic tuition is regulated.

Despite these contributions, relatively little theoretical work has examined how universities respond to changes in regulated per-student funding at the field level, or how domestic funding incentives interact with international student recruitment. The model developed below addresses these questions by allowing universities to adjust admissions standards, educational spending, and enrollment composition in response to changes in government funding.

4.2 Modeling Applicants

Consider a university that faces a set of domestic applicants or potential enrollees who differ in their ability a and in their maximum willingness to pay for the university's undergraduate program r. One should think about this set of applicants as being specific to the university and its program.[27] Normalize the population of applicants to unity and assume ability and maximum willingness to pay are independently distributed.[28] 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, and the maximum willingness to pay is distributed on the interval $[\underline{r}, \overline{r}]$ according to the cumulative distribution $H(r)$ with positive density, $h(r) > 0$ for all r. 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

[27] In Australia, university applicants rank programs and universities in their applications. Therefore, the same program at two different universities could face a different set of applicants who differ in terms of the ranges of the ability distribution, the maximum willingness to pay distribution or both.

[28] Assuming independence implies the average quality of students admitted to a program does not change with tuition.

to the university's undergraduate program.

Applicants have access to a government student loan system to finance the cost of their post-secondary schooling or they can pay out-of-pocket. Any applicant who is admitted to the program and has a maximum willingness to pay at least as large as the tuition t will choose to enroll in the undergraduate program. The number of enrolled students will be

$$n(\hat{a},t) = (1 - F(\hat{a}))(1 - H(t)) \tag{3}$$

where n is decreasing in both the admission standard and the program tuition, that is $n_{\hat{a}} < 0$ and $n_t < 0$. The average ability of enrolled students is

$$\theta(\hat{a}) = E\left(a|a \geq \hat{a}\right) = \frac{\int_{\hat{a}}^{\overline{a}} adF}{1 - F(\hat{a})} \tag{4}$$

which is increasing in the admission standard, $\theta'(\hat{a}) > 0$.[29] 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 standards. This trade-off is made more explicit below.

4.3 Modeling Universities

Universities care about both the educational quality of their undergraduate programming and the quality of their research activities.[30] Quality of research is assumed to be a linear function of its total research expenditure R (defined below). 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. The educational quality function is increasing in both arguments and is strictly concave.[31] Further, we assume the increase in program quality with an additional dollar of per student program expenditure is nondecreasing in the average quality of enrolled program students, that is, $q_{\theta e} \geq 0$.

[29] Differentiating (4),

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

[30] Unlike a private firm (profit-maximizing objective) or government (social welfare objective), there is not a standard approach to modelling the objectives of universities/colleges (Winston, 1999). Previous work has assumed 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)).

[31] We build on the insights of Rothschild and White (1995) who modelled students as both inputs to the production of education and purchasers of education in our assumptions on the educational quality function. Unlike previous literature that examines the pricing of education, e.g., tuition and financial aid, at post-secondary institutions (see, e.g. Epple et al. (2006)) we consider a regulated public university system.

The university's objective is

$$q(\theta, e) + \gamma R \tag{5}$$

where $\gamma > 0$ can be interpreted as the effectiveness of the university in translating a dollar spent on research activities to some measure of research quality, such as international research prestige or reputation. The university's research quality is given by γR.

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 either out of pocket or by taking out a government student loan. The university may also have some non-government funding $I \geq 0$. These revenue sources fund the university's operating budget and are fungible between operating, teaching, and research expenses.[32] The university has some fixed operating costs F and teaching/administrative costs $c(n)$ which are increasing and strictly convex in total student enrollment, that is, $c'(n) > 0$ and $c''(n) > 0$.[33] The university also spends directly on its educational quality $E = ne$ and research activities R.

The university's operating budget constraint is:

$$G + (s + t)n + I = F + c(n) + E + R \tag{6}$$

And we assume the university must balance its operating budget. The university's net teaching revenue is defined as revenue from teaching plus other sources of revenue less operating/administrative and teaching costs, that is, $NTR \equiv G + (s + t)n + I - F - c(n) - ne$. Any additional revenue raised beyond what is needed to finance the university's administrative and teaching costs is spent on research. Therefore, universities care about both their educational quality and net teaching revenue (weighted by γ).

Universities within a public university system can differ along various dimensions affecting both their objective, i.e., their educational quality functions (q) and the weight put on net teaching revenue or equivalently their research quality for a given dollar of research spending (γ), and their operating budget constraint, i.e., their sources of non-government revenue (I), their operating costs (F) and their teaching administration costs ($c(n)$). Universities can also face different applicant pools for their undergraduate programs. All universities, however, face the same regulated tuition (t) and government per-student subsidy (s) and each chooses its admission standard ($\hat{a}$) and how much to spend on both educational quality (e) and research activities (R).

Substituting R from the university's operating budget constraint (6) into the objective (5), a

[32] 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 5 percent in 2024. See "Financial Report of Higher Education Providers 2024"

[33] For Australian universities, their largest share of operating expenses is employee benefits, with academic employee benefits accounting for approximately 29 percent of total expenses and non-academic employee benefits accounting for 27 percent in 2024. See "Financial Report of Higher Education Providers 2024".

representative university's problem can be written as:

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

The first-order conditions are

$$\Omega_{\hat{a}} = q_\theta(\theta(\hat{a}),e)\theta'(\hat{a}) + \gamma[s + t - c'(n(\hat{a},t)) - e]n_{\hat{a}} = 0 \tag{7}$$

$$\Omega_e = q_e(\theta(\hat{a}),e) - \gamma n(\hat{a},t) = 0 \tag{8}$$

which together yield the optimal per student spending on educational quality and the optimal admissions cut-off, $e^*(t,s)$ and $\hat{a}^*(t,s)$.

Condition (7) makes explicit the quality-quantity trade-off the university faces in choosing its admissions standard. Increasing the admission standard increases the average quality of the students enrolled in the university which the university values as it improves the quality of its undergraduate programming, but the higher cut-off reduces the number of students enrolled and therefore reduces total net teaching revenue which the university values at γ per dollar. The marginal enrolled student brings in $s + t - c'(n) - e$ of additional net teaching revenue.[34]

The optimal admission standard ensures the marginal benefit of an increase in educational quality equals the marginal cost in terms of loss revenue from lower enrollment due to the marginal increase in the admission standard. This condition implies that the net teaching revenue raised from the marginal enrolled student, that is, the student with an ability level right at the cut-off, is strictly positive.

Condition (8) captures the trade-off the university faces between spending on educational quality and research activities. The university will optimally ensure that the benefit of a marginal increase in its per student spending on teaching quality, q_e, equals its marginal cost γn. This condition also makes it clear that a higher admission standard which results in lower enrollments, reduces the marginal cost of additional educational quality spending and can also increase the marginal benefit of additional educational quality spending when $q_{e\theta} > 0$.[35]

Combining the two first-order conditions, the university's optimal choice of admission standard ensures that

$$n\theta'(\hat{a})\frac{q_\theta}{q_e} = -(s + t - c'(n) - e)n_{\hat{a}}. \tag{9}$$

The right-hand side term captures the loss in net teaching revenue from a marginal increase in the admission standard and the left-hand side term captures the marginal benefit of an increase

[34] The effect of a marginal increase in total enrollment on net teaching revenue (NTR) is given by

$$\frac{\partial NTR}{\partial n} = s + t - c'(n) - e.$$

[35] Condition (8) implicitly defines e as a function of $\hat{a}$. Totally differentiating, yields $q_{ee}de + (q_{e\theta} - \gamma n_{\hat{a}})d\hat{a} = 0$ where $q_{ee} < 0$, $q_{e\theta} \geq 0$ and $n_{\hat{a}} < 0$.

in the admissions standard from savings on educational quality spending. 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.[36] Therefore, an increase in the cut-off increases the average quality of enrolled students and reduces the per student spending needed to maintain educational quality which results in total savings as given by the left-hand side expression.

To gain some insight into how changes in tuition and per student subsidies affect university behaviour, consider the extreme case in which applicants' decision to enrol was independent of tuition. From condition (9), it follows directly that an increase in either the regulated tuition or per student subsidy increases the net teaching revenue which increases the marginal cost of increasing admission standards. With higher per student funding, it becomes more costly for the university to restrict enrollment via higher admission standards. Subsequently, the university has an incentive to expand its enrollments in response to either an increase in the regulated tuition or per student government subsidy. Consider instead the other extreme in which the admission standard is fixed. In this case, universities cannot respond to changes in per student funding. A tuition increase will have a direct negative effect on enrollments and an increase in per student subsidies will simply increase the university's revenue.

The more interesting case is when the university can adjust its admission standards and an applicant's decision to enroll responds to changes in the regulated tuition, that is $n_t < 0$. To determine explicitly how the optimal choice of admission standard and per student educational quality spending changes with t and s, we totally differentiate the first-order conditions to obtain (as shown in Appendix B):

$$\frac{d\hat{a}^*}{dt} \lesseqgtr 0, \quad \frac{d\hat{e}^*}{dt} \lesseqgtr 0, \quad \frac{d\hat{a}^*}{ds} < 0, \quad \frac{de^*}{ds} < 0. \tag{10}$$

Total enrollment is $n^*(t,s) = n(\hat{a}^*(t,s),t)$ where

$$\frac{dn^*}{dt} = \underbrace{n_{\hat{a}}\frac{d\hat{a}^*}{dt}}_{(\lesseqgtr)} + \underbrace{n_t}_{(-)} \lesseqgtr 0, \quad \frac{dn^*}{ds} = n_{\hat{a}^*}\frac{d\hat{a}^*}{ds} > 0. \tag{11}$$

Consequently, we have that university behaviour drives positive enrollment changes with respect to increases in the per student government subsidies and that changes in the tuition will have an ambiguous effect on enrollments.

As discussed, the applicant pool is specific to the university program and universities can vary along a number of dimensions that would affect their specific choices. All universities offering

[36]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 same program must charge the same tuition and receive the same per student subsidy. We have shown that, regardless of these potential differences, all universities will respond by increasing enrollments when the per student program subsidies are increased, but that responses can be heterogeneous when the regulated program tuition is increased. These differences arise both from the fact that tuition can have a differential impact on the pool of applicants across different programs/universities and that universities can face different operating constraints and differ in their educational quality functions and value placed on research activities. Therefore, we have the following result.

Result 1. *The impact of an increase in per student government funding on university enrollments depends on the form of funding. In response to an increase in per student subsidies paid directly to universities, universities will necessarily increase enrollments whereas in response to an increase in domestic tuition paid by students either out-of-pocket or through a public student loan system, a university may want to increase or decrease enrollment.*

We have assumed universities are unconstrained in the number of students they can enroll. Suppose there is an enrollment cap of $\bar{n}$ such that $n \leq \bar{n}$. A university would be unconstrained by this cap if $n^*(t,s) \leq \bar{n}$ and the above analysis would hold (Result 1). Suppose, however, that for some university $n^*(t,s) > \bar{n}$ and therefore the enrollment cap is binding. In this case, a small increase would simply increase the university's revenue whereas any direct negative impact of a higher tuition on a student's decision to enroll would be completely offset by a reduction in the admissions standard by the university to keep total enrollments constant and equal to the cap.

Up to now, we have considered a single program at the university and have taken international student enrollment as given. We now consider two separate extensions. First, we allow the university to offer multiple programs that can differ in their per student government funding and second, we allow the university to choose its international student tuition which determines international enrollment. In both cases, we examine the impact of a change in per domestic student government funding on program-specific domestic enrollments and on international enrollments, respectively. In the first extension, we demonstrate that universities have an incentive to engage in cross-field enrollment substitution – increasing field-specific enrollment of programs with higher per student funding and reducing enrollments of lower funded programs. In the second extension, we demonstrate how international enrollments respond to changes in per student domestic funding. We then present some empirical evidence that supports our theoretical predictions from these two extensions.

4.4 Theoretical Extension I: Cross-Field Enrollments

Suppose the university offers J different programs or fields of study and students apply directly to a program at a given university, as in several countries with public university systems. 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 $n_j(\hat{a}_j, t_j)$ where t_j is the field-specific tuition.[37] Applicants to each program differ in their program-specific ability 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 its J programs whereas before, the quality of a given program was an increasing function of the average ability of students in the program.[38]

The university's objective is

$$W(\theta_1, ..., \theta_J) + \gamma R. \tag{12}$$

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

$$W(\theta_1, ..., \theta_J) = \sum_{j=1}^{J} \alpha_j \theta_j \tag{13}$$

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's operating budget is:

$$G + \sum_{j=1}^{J} (s_j + t_j) n_j + I = F + C(n_1, ..., n_J) + R \tag{14}$$

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

$$C(n_1, ..., n_J) = \sum_{j=1}^{J} c_j(n_j) \tag{15}$$

with $c_j', c_j'' > 0$.

Substituting (14) into (12) and using both (13) and (15), the university's problem is:

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

and the first-order conditions are

$$\frac{\partial \Omega}{\partial \hat{a}_j} = \alpha_j \theta_j'(\hat{a}_j) + \gamma \Big(s_j + t_j - c_j'(n_j) \Big) \frac{\partial n_j}{\partial \hat{a}_j} = 0, \quad j = 1, ..., J \tag{16}$$

Each of the J first-order conditions determines program-specific admission cut-offs and enrollment

[37] The assumption that program enrollments depend only on program-specific tuition is consistent with Yong et al. (2023) who found that increases in tuition did not affect student application rankings of programs.

[38] In this extension, we ignore the decision of how much to spend on education quality in each of the programs. The latter could be added without changing the qualitative results.

as a function of per student government funding, s_j and t_j, that is, $\hat{a}_j^*(t_j, s_j)$ and $n_j^*(t_j, s_j) = n_j(\hat{a}_j^*(t_j, s_j), t_j)$ where it is shown in Appendix B that

$$\frac{dn_j^*}{dt_j} \lesseqgtr 0, \quad \frac{dn_j^*}{ds_j} > 0, \quad \frac{dn_j^*}{dt_{-j}} = \frac{dn_j^*}{ds_{-j}} = 0. \tag{17}$$

When educational costs are separable in program-specific enrollments, the ambiguous relationship between tuition and enrollment and the positive relationship between per student subsidies and enrollment arise for the same reason as in the single program case. Field-specific enrollments will be increasing in per student subsidies for all universities and may increase or decrease with field-specific tuition depending on how the university responds. With a change in either type of per student funding, there will be no cross-program enrollment effects.

Suppose instead total educational costs are not separable in program enrollments and more realistically depend non-linearly on aggregate enrollment, $n = \sum_{j=1}^{J} n_j$. Specifically, assume the total teaching/administrative cost function takes the following form:

$$C(n_1, ..., n_J) = c\,(n) + \sum_{j=1}^{J} \phi_j n_j \tag{18}$$

with $c', c'' > 0$ 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 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 (18), the university's problem is now

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

and the first-order conditions are

$$\frac{d\Omega}{d\hat{a}_j} = \alpha_j \theta_j'(\hat{a}_j) + \gamma \left(s_j + t_j - c'(n) - \phi_j \right) \frac{\partial n_j}{\partial \hat{a}_j} = 0, \quad j = 1, ..., J \tag{19}$$

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, and a change in the program-specific per student funding for one program will impact the admission cut-off and enrollment in other programs.

For illustration, consider two different programs, $j = 1, 2$. The two first-order conditions on $\hat{a}_1$ and $\hat{a}_2$ jointly yield the optimal program-specific admission standards $\hat{a}_j^*(t_j, s_j, t_{-j}, s_{-j})$, and therefore the program-specific enrollments, $n^*(\hat{a}_j^*(t_j, s_j, t_{-j}, s_{-j}), t_j)$ where by totally differentiating (as shown in Appendix B), we obtain

$$\frac{d\hat{n}^*_j}{dt_j} \lesseqgtr 0, \quad \frac{d\hat{n}^*_{-j}}{dt_j} \lesseqgtr 0, \quad \frac{d\hat{n}^*_j}{ds_j} > 0, \quad \frac{d\hat{n}^*_{-j}}{ds_j} < 0. \quad j = 1, 2 \tag{20}$$

Regardless of what specific program per student funding increases, the university's optimal response to the funding change is to engage in program substitution through its choice of admission standards.

Consider first a change in the per student subsidy. An increase in the program specific per student subsidy the university receives increases the marginal cost of setting a higher program admission standard. Consequently, enrollment in the affected program goes up. This pushes up the marginal teaching/administration cost of enrolling an additional student which 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 will be reduced. The university, through its optimal admission standard decisions, shifts enrollment to the program with the higher per student subsidy.

The university has a similar incentive to adjust program enrollments when the regulated tuition of one program goes up and the other remains unchanged through its choice of admission standards in both programs. Consequently, the enrollment in a program whose tuition has not changed may go up or down.

Result 2. *If total educational costs are not separable in program enrollments, then an increase in per student funding for a given field of study will induce universities to adjust enrollments in other fields.*

If the university faced a total enrollment cap, such that $n_1 + n_2 \leq \bar{n}$, then the above result would necessarily hold if the constraint was not binding but it could also continue to hold even if the constraint was binding in the absence of program-specific enrollment caps.

4.5 Theoretical Extension II: International Tuition Rates and Enrollments

Assume now universities can enroll non-publicly funded international students and can choose the international tuition to charge these students. We focus on a single program and model the enrollment of international students solely as an additional revenue source for universities. We implicitly assume the admission standards are the same for domestic and international students,[39] and that the market for international students is sufficiently large such that for a given admissions standard, the university can recruit international students who will have the same average ability as domestic students.[40]

[39] 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. See, for example, Groen and White (2004).

[40] International student recruitment could potentially improve the quality of undergraduate programming for a given set of admission standards. In this case, universities would have an additional incentive to recruit international

The university chooses the tuition to charge international students, t_f, which determines the number of international students who enroll, $N(t_f)$, where $N' < 0$ and $N'' \leq 0$.[41] Educational costs are increasing and strictly convex in total university enrollment, that is, $c(n+N)$ with $c' > 0$ and $c'' > 0$. The university's operating budget is now given by

$$G + (s+t)n + t_f N + I = F + c(n+N) + R. \tag{21}$$

Substituting (21) into (5), the university's problem is

$$\max_{\hat{a}, t_f} \quad \mathcal{L}(\hat{a}, t_f) = q(\theta(\hat{a})) + \gamma\left(G + (s+t)n(\hat{a}, t) + t_f N(t_f) + I - F - c(n(\hat{a}, t) + N(t_f))\right) \tag{22}$$

where the first-order conditions are:

$$\mathcal{L}_{\hat{a}} = q'(\theta)\theta'(\hat{a}) + \gamma\left(s + t - c'(n+N)\right) n_{\hat{a}} = 0 \tag{23}$$

$$\mathcal{L}_{t_f} = \gamma\Big(N + \left(t_f - c'(n+N)\right) N'(t_f)\Big) = 0 \tag{24}$$

Consider first the choice of international student tuition. The optimal international tuition maximizes the net revenue generated from international students and is given by

$$t_f = \frac{c'(n+N)}{1 - (1/\epsilon_t)} \tag{25}$$

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 chosen by the university. From the first-order condition on t_f, it is straightforward to show that the optimal tuition rate for international students is increasing in domestic enrollment. Higher domestic enrollment increases the marginal cost of enrolling an additional international student and, therefore, the international tuition that maximizes net teaching revenue from international students will be higher and thereby drive down international enrollments.

The first-order condition on $\hat{a}$ has a similar interpretation as in the previous cases considered. Together, the two first-order conditions yield $\hat{a}^*(t,s)$ and $t_f^*(t,s)$ and by totally differentiating both conditions (as shown in Appendix B), we obtain:

$$\frac{d\hat{a}^*}{dt} \lesseqgtr 0, \quad \frac{dt_f^*}{dt} \lesseqgtr 0, \quad \frac{d\hat{a}^*}{ds} < 0, \quad \frac{dt_f^*}{ds} > 0. \tag{26}$$

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students in addition to bringing in international tuition revenue. This raises issues of potential crowd-out effects of international recruitment on domestic enrollments, particularly for specific programs. See, for example, Anelli et al. (2023), Shih (2017) and Machin and Murphy (2017). While these are interesting questions, we do not have access to data on university-level international tuition rates to be able to explore such questions empirically.

[41] In recent work, Bound et al. (2020) assume that universities choose the enrollment of international students and both in-state and out-of-state domestic students directly. Unlike our model, they assume universities can choose the tuition for in-state domestic students but not international or out-of-state students. Further, they assume universities care only about the quality of their education and do not put any weight on research activities.

It follows given $n^*(\hat{a}^*(t,s),t)$ and $N(t_f^*(t,s))$ that

$$\frac{d\hat{n}^*}{dt} \lesseqgtr 0, \quad \frac{dN^*}{dt} \lesseqgtr 0, \quad \frac{d\hat{n}^*}{ds} > 0, \quad \frac{dN^*}{ds} < 0. \tag{27}$$

Universities have an incentive to increase domestic enrollments and reduce international enrollments in response to increases in domestic per student subsidies. The effect of an increase in domestic enrollments from an increase in domestic tuition is again ambiguous. Consequently, since the university's optimal choice of international tuition depends on domestic enrollment, the effect on international enrollments from a change in domestic tuition is also ambiguous. If, in the extreme case, only university behavior affects domestic enrollment, that is $n_t = 0$, then it is straightforward to show that an increase in domestic tuition will increase domestic enrollment and reduce the university's reliance on international students as an additional revenue source.

If, on the other hand, universities do not respond to any changes in per student domestic funding in terms of adjusting admissions standards, then we'd expect domestic enrollment to be decreasing in domestic tuition (given $n_t < 0$) and not affected by changes in per student subsidies. Further, international enrollments would be expected to be increasing in domestic tuition (to offset the lower domestic enrollment as a result of the higher tuition rate) and not be affected by per student subsidies. As we will show below, we do not find support for these predictions in our empirical results. Rather our empirical results support the theoretical predictions when universities respond to per student funding in both their choice of admissions standards and of international student tuition, and domestic enrollment is directly (and negatively) impacted by tuition. It is worth highlighting that the responsiveness of international enrollments to changes in per student domestic funding will depend on various characteristics of the university.

One characteristic of particular note for international student enrollments is the university's international ranking or reputation. 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 Ehrenberg (1999)). International rankings can impact international students' willingness to attend the universities, and importantly, can affect how international enrollments respond to changes in the university's chosen international tuition rates. With the advent of various international university ranking systems administered by third-party organizations, universities in Australia (among other countries with significant public university systems) have been investing significant resources in trying to improve their international rankings and research prestige, often with the explicit intention of attracting international students. 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. As a result, we might expect to see differential impacts of a change in domestic per student funding on international student enrollments at these universities.

5 Additional Empirical Evidence

5.1 Cross-Field Enrollment Effects

Using the data on field specific enrollment we can explore the effects of the predictions for cross-field enrollment effects. Our analysis centers on the use of field enrollments that are exclusively tied to either the lowest (Band 1) or mid-tier (Band 2) tuition rates. The fields exclusively associated with Band 1 tuition are education and creative arts. The fields exclusively associated with Band 2 tuition are Science, Engineering, Math, Info Technology, Architecture, and Agriculture.

To estimate the cross effects in enrollment, we use the following specification:

$$\begin{aligned} DomEnrB1_{ut} = \alpha_u + \beta DomEnrB2_{ut} + \gamma_1 IntEnrB1_{ut-1} + \gamma_2 IntEnrB1_{ut-1} * G08 \\ + ResFund_{ut}\eta + Policy_t\delta + \omega_1 Trend_t + \omega_2 Trend_t * G08 + \epsilon_{urt} \end{aligned} \tag{28}$$

For this specification the Band 1 enrollment is the sum of enrollment in Education and Creative Arts and the Band 2 enrollment is the sum of the Band 2 enrollments for the fields whose tuition is exclusively Band 2. We include as additional regressors university fixed effects, lagged international Band 1 enrollments with an interaction for the research intensive universities (G08), university research funding measures, and the policy periods and year trends. We relax the requirement to include all Band 1 enrollments by, first, including field specific enrollments (domestic as the dependent variable and lagged international enrollments as the control variable) for education and creative arts, and, second, by only including the education enrollments as the Band 1 enrollment measure.

Given our framework that universities may engage in behavior to attract increased enrollments in higher tuition fields, we assume the Band 2 enrollment measure is biased positively and, therefore, endogenous. We employ a two-stage least squares specification. We instrument the Band 2 enrollment with the tuition rate and maximum subsidy available for Band 2 fields.

Table 5 reports the results of estimating Equation 28 for the OLS and 2SLS specifications. In columns 1 to 4 we report the results for the dependent variable that combines the enrollments for education and creative arts. Columns 1 and 2 differ from columns 3 and 4 based on the years used for the analysis. Columns 1 and 2 include all years, whereas columns 3 and 4 cover the period 1997 onward to reflect the period when there are multiple tuition rates. Columns 1 and 3 report the results from an OLS specification and columns 2 and 4 report the results from the 2SLS specification.

As expected, if we treat the Band 2 enrollments as exogenous, the results suggest an increase in Band 2 enrollment is associated with an increase in Band 1 enrollments. The instruments for the Band 2 enrollment are strong, with a first-stage F-statistic for the instruments exceeding the minimum standard of 10. The p-value from the over-identification test is high. The coefficient on

Table 5: Effect of Multiple Tuition Rates Across Field Enrollments

Dependent Variable	Education & Creative Arts (Combined Enrollment)				Education & Creative Arts (Separate Enrollments)		Education Only	
	All Years		Post 1997		All Years	Post 1997	All Years	Post 1997
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	2SLS	OLS	2SLS	2SLS	2SLS	2SLS	2SLS
Band 2 Only Field Enrollment	0.160***	-0.696***	0.144***	-0.365***	-0.297**	-0.134	-0.247*	-0.181*
	(0.033)	(0.255)	(0.038)	(0.123)	(0.142)	(0.089)	(0.133)	(0.101)
Year Variables								
Pre/Post Categorical Variables for Policy Changes	✓	✓	✓	✓	✓	✓	✓	✓
Year Trend	-1.404	0.348	-2.029	-1.749	-1.268	-3.349	-3.223	-6.059**
	(3.327)	(4.485)	(3.667)	(4.026)	(2.200)	(2.150)	(2.525)	(2.591)
* G08 University	-11.219***	-20.523***	-7.246**	-13.237***	-11.408***	-8.261***	-6.908***	-4.907**
	(2.683)	(5.088)	(3.151)	(4.313)	(3.150)	(2.904)	(2.667)	(2.502)
International Student Measures (Band 1)	✓	✓	✓	✓	✓	✓	✓	✓
Research Funding Measures (Millions)	✓	✓	✓	✓	✓	✓	✓	✓
University Fixed Effects	✓	✓	✓	✓	✓	✓	✓	✓
Field Fixed Effects	×	×	×	×	✓	✓	×	×
Constant	318.713***	-44.107	385.644***	-27.876	-13.531	30.197	-227.031***	-120.012***
	(34.964)	(54.251)	(48.810)	(54.691)	(21.390)	(28.138)	(52.000)	(46.579)
F-Statistic on Instruments (Maximum Tuition & Government Subsidy for Band 2)		11.280		51.020	16.950	42.430	9.050	17.920
		(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
P-value from Over-Identification Test		(0.336)		(0.085)	(0.953)	(0.191)	(0.121)	(0.596)
R-Squared	0.884	0.774	0.885	0.851	0.656	0.699	0.797	0.819
# of Universities	75		72		75	72	48	47
# of Observations	1,241		1,040		2,319	1,944	1,124	945

Notes: Robust standard errors reported in parentheses.*** = p<.001; ** = p<.01; *=p<.1
See notes to Table 3. The dependent variable captures Band 1 only enrollments for the university and year. Across the specifications, the dependent variable varies: (a) combined education and creative arts enrollments for columns 1-4; (b) education and creative arts enrollments treated separately for columns 5 and 6; (c) education only enrollments for columns 7 and 8. The key independent variable is the sum of all band 2 only field enrollments for the university and given year.

the Band 2 enrollment is negative. If we include all years in the estimation, the results suggest that for approximately every three additional Band 2 enrollees, there are two fewer Band 1 enrollees. If we limit the analysis to the post-1997 period, the results suggest that for approximately every 6 Band 2 enrollees there are two fewer Band 1 enrollees.

In columns 5 and 6 we report the 2SLS results for the estimations that allow for separate enrollments for Education and Creative Arts. And in columns 7 and 8 we report the 2SLS results for the estimations that include only the Education enrollments. The coefficients are lower in magnitude but remain negative, providing further evidence that universities may alter their behavior in terms of admission standards and/or program growth across higher and lower tuition fields.

5.2 International Enrollment Effects

With constrained government support and domestic tuition, increasing reliance on international students is not surprising. As illustrated in Figure 5, international students account for a substantial share of total enrollments, especially for the research intensive universities. In this section we explore empirically whether changes in domestic tuition and subsidies impact international enrollments.[42]

[42]The theoretical framework explores university behavior with respect to setting international tuition rates. Data limitations prevent us from directly observing university-level international tuition. We, therefore, cannot directly

The theoretical framework suggests:

- With increasing domestic student subsidies, universities have an incentive to increase domestic enrollments and reduce international enrollments.
- As the effect of an increase in domestic tuition on domestic student enrollments is ambiguous, so too is the effect on international student enrollments.
- If universities care about international rankings, which is the case for research intensive universities, we might expect to observe differences in the effect of domestic tuition and subsidies on international enrollments.

To explore the effects of changes in domestic tuition and field specific subsidies on commencing international enrollment, we use the following specification:

$$IntEnr_{fut} = \alpha_u + \phi_f + \beta_1 Tuition_{ft} + \beta_2 Tuition_{ft} * G08 + \lambda_1 GovSub_{ft} + \lambda_2 GovSub_{ft} * G08 + ResFund_{ut}\eta + Policy_t\delta + \omega_1 Trend_t + \omega_2 Trend_t * G08 + \epsilon_{fut} \quad (29)$$

The tuition and subsidy measures as well as the controls are defined in the same way as they are in previous specifications. The dependent variable is the commencing international enrollment by field of study and university. We report the core results from Equation 29 in Table 6. An institutional feature that could affect our analysis is that international tuition rates must be equal to or greater than the sum of the domestic tuition and subsidy for the given program of study. Thus, the use of the domestic tuition and the government subsidy for the field of study equates to using measures that reflect a lower bound for what can be charged by universities.

Column 1 presents the estimates for the full sample period. Unlike a negative effect observed for domestic enrollments for the less research intensive universities (Table 3, Column 3), increasing domestic tuition leads to an increase in international enrollments. The effect for less research intensive universities is that a $1,000 increase in tuition is associated with an average increase of 58 students. Given the average international enrollment per field of study across all universities is 186 students, this is a large effect. Furthermore, for research intensive universities, the effect is even larger, an average of 118 students per $1,000 increase in tuition. In contrast, increasing field specific subsidies decreases international enrollments with research intensive universities experiencing a bigger decrease (an average of 16 students per $1,000 increase in subsidies).

In columns 2 to 5 we report the results when we focus on the periods of major policy reforms. For the first two reforms, when tuition was increased substantially, the effect of tuition on international enrollments is positive, with more positive coefficients for the period covering the 2005 policy change. Recall from Table 2 that average international enrollments were more modest during the period

estimate how universities change international tuition rates when domestic tuition and/or subsidies change.

Table 6: Effect of Domestic Tuition on International Enrollment

Dependent Variable	Total Commencing International Students, by Major Field				
	All Years	1994 to 2000 (Major Change: 1997)	2002 to 2008 (Major Change: 2005)	2009 to 2015 (Major Change: 2012)	
	(1)	(2)	(3)	(4)	(5)
Tuition & Government Subsidy Measures					
Field of Study Tuition	0.058***	0.006***	0.089**	-0.007	
(Fields with Multiple Tuition, Maximum Used)	(0.005)	(0.002)	(0.035)	(0.058)	
* G08 University	0.060***	0.018***	0.064***	0.067***	
	(0.006)	(0.004)	(0.009)	(0.009)	
Field of Study: Maximum Government Subsidy	-0.009***		-0.007***	0.017	
	(0.001)		(0.003)	(0.022)	
* G08 University	-0.007***		-0.002	0.001	
	(0.002)		(0.003)	(0.003)	
Total Revenues Per Student					0.005
(Tuition + Government Subsidy)					(0.006)
* G08 University					0.000
					(0.002)
Year Variables					
Pre/Post Categorical Variables	✓	✓	✓	✓	✓
Year Trend	6.367***	8.705***	3.121	-1.168	-0.534
	(1.167)	(1.551)	(5.091)	(10.663)	(8.596)
* G08 University	-11.254***	-3.890	-33.560***	1.560	18.714***
	(1.644)	(4.663)	(10.704)	(6.338)	(6.784)
Research Funding Measures (Millions)	✓	✓	✓	✓	✓
University Fixed Effects	✓	✓	✓	✓	✓
Field Fixed Effects	✓	✓	✓	✓	✓
Constant	-151.793***	1.462	-394.495**	-46.498	156.337
	(12.545)	(13.528)	(179.822)	(318.552)	(141.284)
R-Squared	0.602	0.481	0.606	0.645	0.637
# of Universities	82	42	54	60	
# of Observations	10,283	2,226	2,702	2,755	

Notes: Robust standard errors reported in parentheses.*** = p<.001; ** = p<.01; *=p<.1
See notes to Table 3 & 4.

covering the 1997 reforms, an average of 82 students per field versus an average of 190 students per field for the period covering the 2005 reforms. For the period covering the 2012 reforms, when the government relaxed domestic student enrollment restrictions, the effect of increasing tuition on international student enrollments is nearly zero for the less research intensive universities and is not as big an effect for the research intensive universities. Recall from Table 4, that for the period covering the 2012 reforms, there is a positive effect from increasing tuition on domestic enrollments. Thus, observing a smaller effect on international students is suggestive that universities might place less of an emphasis on attracting international students when it has greater flexibility and resources to attract domestic students.

Across the period of reforms for 2005 and 2012, the effect of increasing government subsidies is initially negative but then becomes less precise in the later period. In column 5 of Table 6 we report the results when we combine the program specific tuition and subsidy to use a single measure of domestic revenue. The coefficients on these measures are small and imprecisely measured. Given this revenue measure would reflect the minimum tuition that can be charged to an international student, these results suggest that increasing tuition does not have a positive effect on international enrollments. To investigate this finding further, however, more data would be needed.

Overall, the results suggest universities adjust international recruitment strategically in response to domestic funding changes. The findings are particularly strong for research intensive G08 universities, where international reputation likely increases the capacity to attract international students when domestic tuition rises. At the same time, the weaker relationship between government subsidies and international enrollment suggests that greater public support can reduce universities' dependence on international student revenue.

6 Concluding Remarks

This paper leverages a unique policy setting to study the effects of government-regulated tuition and enrollment-linked subsidies on commencing enrollments. In particular, we examine how tuition increments and changes in government subsidies affect student enrollment and the role of university behavior in the measurement of these effects. This setting permits us to explore the role universities play with respect to supporting an increase in enrollment and/or allocating their efforts to attract enrollment in higher tuition fields over lower tuition fields. By analyzing a system in which domestic tuition is uniform, centrally set, and deferrable through income contingent loans, we gain insights into how universities navigate financial incentives and institutional constraints.

Our findings show that universities behave strategically, often expanding domestic enrollment even in periods of tuition increases where standard economic models focused on student behavior would predict enrollment declines. These strategies include reallocating students across programs, emphasizing higher-tuition fields over lower-tuition ones, and potentially adjusting admission standards to attract revenue-generating students. This highlights the critical role of universities as active agents in shaping enrollment outcomes, rather than passive responders to student demand.

The analysis also reveals that research funding is somewhat positively associated with both domestic and international enrollment. This underscores the interdependence of teaching and research objectives, which can influence institutional responses to policy and the design of university programs.

Designing higher education funding systems requires careful attention to tuition, subsidies, and governance structures, as regulatory and financial decisions directly influence university behavior. Policies that fail to account for institutional responses may produce unintended consequences for enrollment patterns, program composition, and the balance between access to education and research excellence.

Overall, our study demonstrates that evaluating higher education policies requires a dual focus on both student and university behavior. Recognizing the strategic role of universities allows for a more complete understanding of how government interventions shape enrollment, program choices, and the broader functioning of the higher education system.

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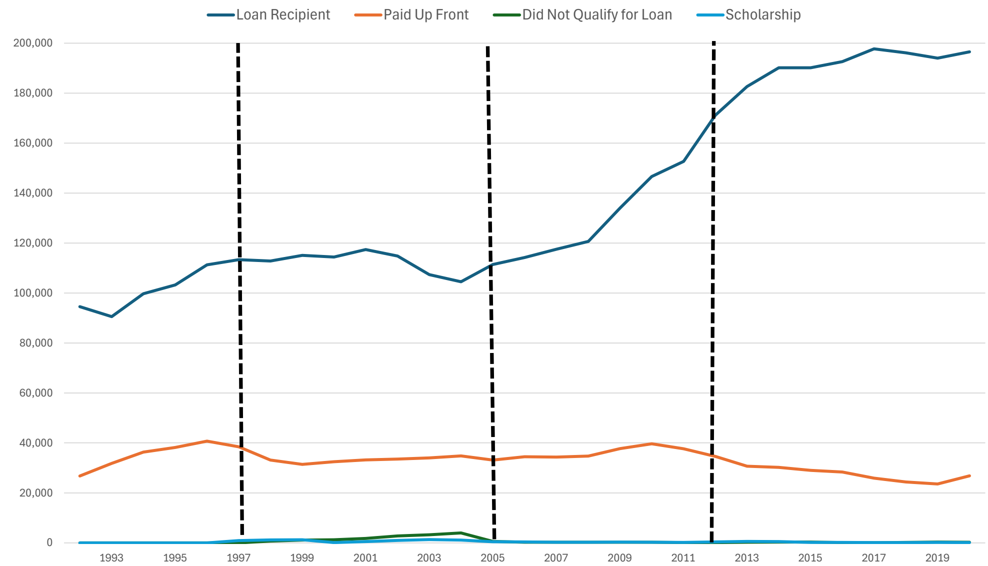
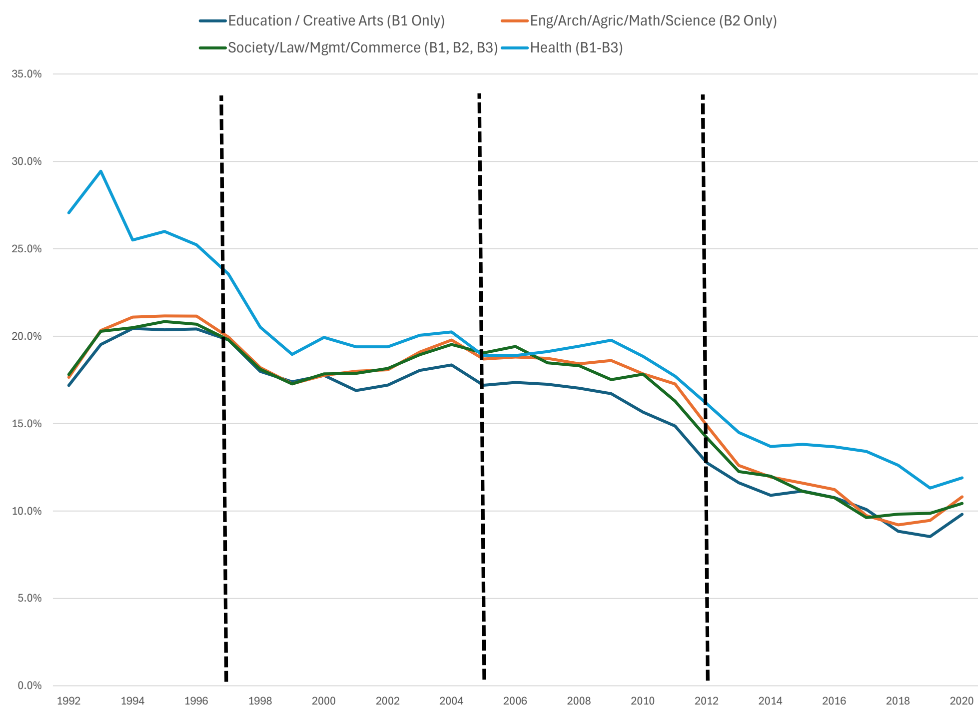
Appendix A

Appendix A Figure 1: Total Domestic Enrollment, by Payment Type
(Commencing Students, Equivalent Full Time)



Note: Loan recipients cover students who have opted to cover all or part of her tuition through an income contingent loan. Paid up front students cover students who could qualify for an income contingent loan but opted to pay the tuition in full. Did not qualify for loan students capture domestic students that exceeded enrollment caps and, therefore, were not eligible for an income contingent loan. Scholarship captures domestic students whose tuition was covered by a third party (university or other source). The dotted vertical lines depict the three periods of major policy changes, explained previously.

Appendix A Figure 2: Share of Paid Enrollment, by Tuition/Field of Study Grouping



Appendix B

Single university program

Assuming uniform ability and willingness to pay distributions, average quality is given by $\theta(\hat{a}) = (\overline{a} + \hat{a})/2$ with $\theta'(\hat{a}) = 1/2$, $\theta''(\hat{a}) = 0$, and total enrollment will be

$$n(\hat{a}, t) = \frac{\overline{a} - \hat{a}}{\overline{a} - \underline{a}} \cdot \frac{\overline{r} - t}{\overline{r} - \underline{r}}$$

with

$$n_{\hat{a}} = -\frac{1}{\overline{a} - \underline{a}} \cdot \frac{\overline{r} - t}{\overline{r} - \underline{r}} < 0, \quad n_t = -\frac{1}{\overline{r} - \underline{r}} \cdot \frac{\overline{a} - \hat{a}}{\overline{a} - \underline{a}} < 0,$$

$$n_{\hat{a}\hat{a}} = n_{tt} = 0, \quad n_{\hat{a}t} = \frac{1}{(\overline{a} - \underline{a})(\overline{r} - \underline{r})} > 0.$$

Totally differentiating (7) and (8) yields:

$$\begin{bmatrix} \Omega_{\hat{a}\hat{a}} & \Omega_{\hat{a}e} \\ \Omega_{e\hat{a}} & \Omega_{ee} \end{bmatrix} \begin{bmatrix} d\hat{a} \\ de \end{bmatrix} = \begin{bmatrix} -\gamma(1 - c''(n)n_t)n_{\hat{a}} - \gamma[s + t - c'(n) - e]n_{\hat{a}t} & -\gamma n_{\hat{a}} \\ \gamma n_t & 0 \end{bmatrix} \begin{bmatrix} dt \\ ds \end{bmatrix}$$

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

$$\frac{d\hat{a}}{dt} = \frac{-(\gamma(1 - c''(n)n_t)n_{\hat{a}} + \gamma[s + t - c'(n) - e]n_{\hat{a}t})\Omega_{ee} - \gamma n_t \Omega_{\hat{a}e}}{D},$$
$$\frac{d\hat{e}}{dt} = \frac{\gamma n_t \Omega_{\hat{a}\hat{a}} + (\gamma(1 - c''(n)n_t)n_{\hat{a}} + \gamma[s + t - c'(n) - e]n_{\hat{a}t})\Omega_{e\hat{a}}}{D},$$
$$\frac{d\hat{a}}{ds} = \frac{-\gamma n_{\hat{a}} \Omega_{ee}}{D} < 0, \quad \frac{de}{ds} = \frac{\gamma n_{\hat{a}} \Omega_{e\hat{a}}}{D} < 0.$$

A sufficient condition for $d\hat{a}^*/dt > 0$ and $de^*/dt > 0$, is

$$\frac{d\left(\frac{dNTR}{d\hat{a}}\right)}{dt} \geq 0 \quad \Longleftrightarrow \quad [s + t - c'(n) - e]n_{\hat{a}t} \geq -(1 - c''(n)n_t)n_{\hat{a}}.$$

In this case, total enrollment will necessarily be decreasing in tuition. If this condition is not met, then total enrollment can be increasing or decreasing in tuition. If $n_t = 0$, then total enrollment will be increasing in tuition.

Multiple university programs

Total educational costs separable in program enrollments

Totally differentiating (16) with respect to t_j and s_j given a_j is distributed uniformly, yields:

$$\frac{\partial^2\Omega}{\partial\hat{a}_j\partial\hat{a}_j}d\hat{a}_j + \gamma\left(\left(1 - c''_j(n_j)\frac{\partial n_j}{\partial t_j}\right)\frac{\partial n_j}{\partial\hat{a}_j} + \left(s_j + t_j - c'_j(n_j)\right)\frac{\partial^2 n_j}{\partial\hat{a}_j\partial t_j}\right)dt_j + \gamma\frac{\partial n_j}{\partial\hat{a}_j}ds_j = 0$$

where

$$\frac{\partial^2\Omega}{\partial\hat{a}_j\partial\hat{a}_j} = \alpha_j\theta''_j(\hat{a}_j) - \gamma c''_j(n_j)\left(\frac{\partial n_j}{\partial\hat{a}_j}\right)^2 < 0,$$

and the signs of the expressions in (17) follow directly.

Non-separable total educational costs

In the case of two programs, $j = 1, 2$, totally differentiating the first-order condition (19) for $j = 1, 2$ with respect to t_1, t_2, s_1, s_2 treating n_1 and n_2 and functions of both the relevant program admission cut-off and relevant program-specific tuition yields:

$$\begin{bmatrix}\Omega_{\hat{a}_1\hat{a}_1} & \Omega_{\hat{a}_1\hat{a}_2}\\ \Omega_{\hat{a}_2\hat{a}_1} & \Omega_{\hat{a}_2\hat{a}_2}\end{bmatrix}\begin{bmatrix}d\hat{a}_1\\ d\hat{a}_2\end{bmatrix} = \begin{bmatrix}-\gamma\Phi_1 & -\gamma\frac{\partial n_1}{\partial\hat{a}_1} & \gamma c''(n)\frac{\partial n_2}{\partial t_2}\frac{\partial n_1}{\partial\hat{a}_1} & 0\\ \gamma c''(n)\frac{\partial n_1}{\partial t_1}\frac{\partial n_2}{\partial\hat{a}_2} & 0 & -\gamma\Phi_2 & -\gamma\frac{\partial n_2}{\partial\hat{a}_2}\end{bmatrix}\begin{bmatrix}dt_1\\ ds_1\\ dt_2\\ ds_2\end{bmatrix}$$

where $\Omega_{\hat{a}_j\hat{a}_j} = \alpha_j\theta''_j(\hat{a}_j) - \gamma c''(n)\left(\frac{\partial n_j}{\partial\hat{a}_j}\right)^2 < 0$ for $j = 1, 2$, $\Omega_{\hat{a}_1\hat{a}_2} = \Omega_{\hat{a}_2\hat{a}_1} = -\gamma c''(n)\left(\frac{\partial n_1}{\partial\hat{a}_1}\right)\left(\frac{\partial n_2}{\partial\hat{a}_2}\right) < 0$, and

$$\Phi_1 = \left(1 - c''(n)\frac{\partial n_1}{\partial t_1}\right)\frac{\partial n_1}{\partial\hat{a}_1} + \left(s_1 + t_1 - c'(n) - \phi_1\right)\frac{\partial^2 n_1}{\partial\hat{a}_1\partial t_1}$$

$$\Phi_2 = \left(1 - c''(n)\frac{\partial n_2}{\partial t_2}\right)\frac{\partial n_2}{\partial\hat{a}_2} + \left(s_2 + t_2 - c'(n) - \phi_2\right)\frac{\partial^2 n_2}{\partial\hat{a}_2\partial t_2}$$

Note, if $\partial n_j(\hat{a}_j, t_j)/\partial t_j = 0$, then $\Phi_j = \partial n_j/\partial\hat{a}_j < 0$. Otherwise the sign of Φ_j is ambiguous.

Defining $D = \Omega_{\hat{a}_1\hat{a}_1}\Omega_{\hat{a}_2\hat{a}_2} - \Omega_{\hat{a}_1\hat{a}_2}\Omega_{\hat{a}_2\hat{a}_1} > 0$ and applying Cramer's Rule, yields:

$$\frac{d\hat{a}_1}{dt_1} = \frac{-\gamma\Phi_1\Omega_{\hat{a}_2\hat{a}_2} - \gamma c''(n)\frac{\partial n_1}{\partial t_1}\frac{\partial n_2}{\partial\hat{a}_2}\Omega_{\hat{a}_1\hat{a}_2}}{D}, \quad \frac{d\hat{a}_1}{dt_2} = \frac{\gamma c''(n)\frac{\partial n_2}{\partial t_2}\frac{\partial n_1}{\partial\hat{a}_1}\Omega_{\hat{a}_2\hat{a}_2} + \gamma\Phi_2\Omega_{\hat{a}_1\hat{a}_2}}{D},$$

$$\frac{d\hat{a}_2}{dt_1} = \frac{\gamma c''(n)\frac{\partial n_1}{\partial t_1}\frac{\partial n_2}{\partial\hat{a}_2}\Omega_{\hat{a}_1\hat{a}_1} + \gamma\Phi_1\Omega_{\hat{a}_2\hat{a}_1}}{D}, \quad \frac{d\hat{a}_2}{dt_2} = \frac{-\gamma\Phi_2\Omega_{\hat{a}_1\hat{a}_1} - \gamma c''(n)\frac{\partial n_2}{\partial t_2}\frac{\partial n_1}{\partial\hat{a}_1}\Omega_{\hat{a}_2\hat{a}_1}}{D},$$

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

$$\frac{d\hat{a}_2}{ds_1} = \frac{\gamma\frac{\partial n_1}{\partial\hat{a}_1}\Omega_{\hat{a}_2\hat{a}_1}}{D} > 0, \quad \frac{d\hat{a}_2}{ds_2} = \frac{-\gamma\frac{\partial n_2}{\partial\hat{a}_2}\Omega_{\hat{a}_1\hat{a}_1}}{D} < 0.$$

If $\Phi_j > 0$ for $j = 1, 2$, then it will necessarily be the case that $\frac{d\hat{a}_j}{dt_j} > 0$ and $\frac{d\hat{a}_{-j}}{dt_,} < 0$ in which case n_j will be decreasing in t_j and n_{-j} will be increasing in t_j. If $\partial n_j/\partial t_j = 0$ for $j = 1, 2$, then the opposite will be true, that is, n_j will be increasing in t_j and n_{-j} will be decreasing in t_j. When $\Phi_j < 0$ and $\partial n_j/\partial t_j < 0$, then how program enrollments in programs j and $-j$ change with a change in t_j will be ambiguous.

International students

Totally differentiating (23) and (24), using the properties of the uniform distribution for a yields:

$$\begin{bmatrix} \Omega_{\hat{a}\hat{a}} & \Omega_{\hat{a}t_f} \\ \Omega_{t_f\hat{a}} & \Omega_{t_ft_f} \end{bmatrix} \begin{bmatrix} d\hat{a} \\ dt_f \end{bmatrix} = \begin{bmatrix} -\gamma\Big((1-c''(n+N)n_t)n_{\hat{a}} + [s+t-c'(n+N)]n_{\hat{a}t}\Big) & -\gamma n_{\hat{a}} \\ \gamma c''(n+N)n_t N'(t_f) & 0 \end{bmatrix} \begin{bmatrix} dt \\ ds \end{bmatrix}$$

where $\Omega_{\hat{a}\hat{a}} = q''(\theta)(\theta'(\hat{a}))^2 - \gamma c''(n+N)(n_{\hat{a}})^2 < 0, \Omega_{t_ft_f} = 2\gamma N'(t_f) + \gamma(t_f - c'(n+N))N''(t_f) - \gamma c''(n+N)(N'(t_f))^2 < 0, \Omega_{\hat{a}t_f} = \Omega_{t_f\hat{a}} = -\gamma c''(n+N)n_{\hat{a}}N'(t_f) < 0$, and $D = \Omega_{\hat{a}\hat{a}}\Omega_{t_ft_f} - \Omega_{\hat{a}t_f}\Omega_{t_f\hat{a}} > 0$ by assumption. Applying Cramer's Rule, we obtain

$$\frac{d\hat{a}}{ds} = \frac{-\gamma n_{\hat{a}}\Omega_{t_ft_f}}{D} < 0, \quad \frac{dt_f}{ds} = \frac{\gamma n_{\hat{a}}\Omega_{t_f\hat{a}}}{D} > 0$$
$$\frac{d\hat{a}}{dt} = \frac{-\gamma\Big((1-c''(n+N)n_t)n_{\hat{a}} + [s+t-c'(n+N)]n_{\hat{a}t}\Big)\Omega_{t_ft_f} - \gamma c''(n+N)n_t N'(t_f)\Omega_{\hat{a}t_f}}{D},$$
$$\frac{dt_f}{dt} = \frac{\gamma c''(n+N)n_t N'(t_f)\Omega_{\hat{a}\hat{a}} + \gamma\Big((1-c''(n+N)n_t)n_{\hat{a}} + [s+t-c'(n+N)]n_{\hat{a}t}\Big)\Omega_{t_f\hat{a}}}{D}$$

as given in (26).