The Effect of Credit Constraints on Major Choice: Evidence from a Large Scale Student Loan Program in Brazil

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Abstract

We develop a structural discrete choice model of demand to investigate the determinants of major choice. In Brazil, and in several other countries, tuition varies at the major level, with some majors being consistently more expensive than others across institutions. Our model shows that in a framework in which tuition varies at the major level, students can be credit constrained in their decision between different majors. We use this model and the expansion of a government-funded student credit program in Brazil to evaluate how availability of credit impacts major choice. We find that tuition and expected labor market returns are the main factors determining students' choice between different major.s Using our estimated parameters to investigate the impact of credit availability on market composition, we show that the expansion of credit increases enrollment in private higher education as whole and had a higher than average impact on majors considered high cost and high return, specially for lower income individuals. We argue that this result is consistent with our credit constraint at the major level model.

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1 Introduction

Credit markets for investment in education are problematic (Becker, 1975). As such, credit constraints often impact students decision to enroll or not in higher education (Kane (2006), Belley and Lochner (2007), Lochner and Monge-Naranjo (2011), Solis (2017)). Enrolling is just one component of the decision to invest in higher education. When making human capital investment decisions, students must choose also how much to invest in terms of time enrolled, quality and type of investment. There is evidence that returns to higher education vary greatly across majors or fields of knowledge (Arcidiacono (2004), Hastings et al. (2013)). Despite this great variability, much remains unknown about the factors that determine students' choice between different majors. Much also remains unknown on the constraints students face when choosing a major. In countries like Brazil—in which students choose major during the college application process and the costs of higher education vary at the major-institution level—the inability to obtain student loans might impact major choice. In this paper, we develop a structural model to investigate the factors that have a greater impact on choice of major. We then explore the expansion of a government funded student credit program in Brazil to evaluate how the availability of credit impacts major choice.

We start by documenting the evidence on the costs and returns to major choice in Brazil. Using an unique data set with information on tuition costs at the major-institution level, we show that there is, in fact, great variability in the costs of higher education at the major-institution level. Tuition costs vary significantly at the major level and this variability is consistent between different institutions—i.e. the same set of majors tend to be more or less expensive than average across institutions. Using evidence from the national registry of employees in the formal sector (RAIS), we show that there is also large variability in the wages from occupations more often associated with different majors. Finally, we show that there is a strong correlation between the average tuition and the average wage from a major at the metropolitan area (or state) level. This evidence suggests that students intending to enroll in higher return majors in Brazil often have to pay higher tuition costs.

Before 2010, Brazil had a very limited supply of credit for students interested in financing their education. The government offered a limited number of loans through a federal credit program and private credit markets for education were considerably small. In 2010, the government implemented an unexpected reform that greatly expanded its credit program. Brazil's federal student credit program—FIES—offers loans to students

enrolled in private higher education institutions. Loans can be used to cover tuition in eligible major-institutions. We explore this large expansion and the eligibility criteria at the major-institution level—through a difference-in-differences strategy—to evaluate if credit availability influences demand for higher education. Our results show that there is a positive and significant impact of credit availability on demand for private higher education. This analysis compares the demand trends of eligible and ineligible major-institutions and, thus, can inform on students susceptibility to respond to credit availability. It cannot be used to understand the impact of credit on the overall demand for private higher education or on the market share of different majors.

To understand the mechanisms through which credit availability can impact major choice, we develop a dynamic model of human capital investment. In this model, individuals enrolling in higher education must choose a major in the first period. In the following periods, individuals access labor markets. Wages are determined by first period human capital investment decision. In our model, we include the possibility that credit may not be readily available in the first period—i.e. that individuals might be constrained in their ability to finance educational decisions through borrowing. When credit is constrained, individuals can only enroll at a major they can afford with their first period income. In this framework, lower income individuals might be constrained in their ability to choose high-cost majors. A policy that loosens constraints to credit can thus impact the distribution of major choice across different income cohorts and impact their lifetime expected earnings.

To empirically estimate the determinants of major choice and the impact of credit availability on choice of major, we adapt our model to fit the framework of the classic discrete choice model with random parameters from the Industrial Organization literature (Berry et al., 1995). In our model, students must choose only one major between the options available in a given market. Students can also choose not to enroll in private higher education—the outside option. Students derive utility from the future returns associated with the investment in higher education. Students also derive utility from just being enrolled in higher education—i.e. we assume that there is a consumption value associated with higher education (Gullason (1989), Gong et al. (2019)). The costs of enrolling in higher education are represented by tuition costs. Costs and returns to higher education vary at the major-market level. We include in this model the possibility that students might be constrained in their choice between different majors due to their inability to obtain student credit. In our empirical exercise, we assume that individuals making human capital decisions before the expansion of the government credit program were credit constrained

while individuals making decisions after that period were not.

We estimate this demand model using data on costs, wages, and quality measures of different majors at the market level. We find that demand is significantly impacted by both the costs and returns to higher education. We also show that family income influences the sensitivity of demand to price changes, with lower income individuals being more sensitive to cost changes than higher income individuals. We use our estimated parameters to investigate how the availability of credit impacts market composition. We show that the expansion of the government credit program increased enrollment in private higher education as whole and had a higher than average impact on majors considered high cost and high return. Our results suggest that, in a frameworks in which costs vary at the major level, credit constraints play a significant role in determining the choices between different majors.

The rest of this paper is organized follows. In section 2, we describe our data and present some descriptive statistics. Section 3 introduces Brazil's federal government student loan program—FIES—and details its 2010 expansion. In section 4, we present the results of a difference-in-differences strategy that explores the sudden expansion of FIES and the rules that determine eligibility at the major-institution level to evaluate the impact of credit availability on enrollment. In section 5, we develop a dynamic model of major choice and in section 6 we adapt this model to obtain a tractable version that can be used to estimate demand parameters through a BLP (Berry et al., 1995). Section 7 presents the results of the BLP estimation. In section 8, we conclude this paper.

Related Literature. It is hard to establish well functioning private credit markets for investment in education. Human capital cannot be directly pledged as collateral. Return on investment is not fully observable and depends on borrowers unobserved talent and effort (Becker, 1975). If educational credit is constrained, students who cannot afford the costs of education might find themselves incapable of making profitable human capital investment decisions. Investment in human capital and skill formation are a crucial feature of any effective development strategy, as differences in human capital are related to differences in individual income both between and within countries (Hanushek and Woessmann (2008), Acemoglu and Dell (2010), Gennaioli et al. (2013)). To avoid underinvestment, governments often intervene in credit markets for higher education. These policies are implemented under the argument that credit constraints do exist for investment in higher education and that they must be loosened in order to increase enrollment rates and guarantee a more equitable access to higher education.

There is an extensive empirical literature debating whether underdeveloped credit

markets for higher education actually constrain behavior. We observe a positive relation between family income and enrollment in higher education for several countries. There is no consensus on whether short or long term credit constraints are the cause for this income gradient. Long term constraints can hinder parents from investing in the cognitive and non cognitive abilities of their children from early childhood (Cameron and Heckman (1998), Keane and Wolpin (2001), Carneiro and Heckman (2002)). Expanding access to higher education credit when long-term constraints are the cause for underinvestment would have no significant impact on enrollment. Short term constraints, on the other hand, represent students inability to obtain credit to fund their preferred educational investment decisions. Some recent studies find evidence of short term credit constraints in the U.S. and other countries (Kane (2006), Belley and Lochner (2007), Lochner and Monge-Naranjo (2011), Kaufmann (2014), Solis (2017)).

Despite evidence showing that major choice can have a substantial impact on students labor market outcomes, the literature on the determinants of major choice is still inconclusive. Hastings et al. (2016) use a large-scale survey of Chilean college applicants and students to explore the way students form beliefs about earnings and cost outcomes at different institutions and majors and shows the importance of these beliefs for major choice and persistence. Wiswall and Zafar (2015) estimate a structural life cycle model of college major and find a relatively low sensitivity to changes in earnings. Montmarquette et al. (2002), on the other hand, conclude that choice of college concentration depends decisively on expected earnings in a particular concentration.

We investigate the determinants of major choice and the impact of credit constraints on students' decision between different majors exploring the expansion of a large federal government program that offers loans to students enrolled in private higher education in Brazil. From a policy perspective, understanding how students in Brazil choose major is very important. In Brazil, students choose major during the college application process. Tuition is determined at the major-institution level and tuition costs vary greatly across majors, with some majors being consistently more expensive across institutions. In this framework, short term credit constraints could impact not only the decision to enroll in college but also major choice. If higher return majors are consistently more expensive, lower income students could be constrained in their ability to choose more profitable majors, a scenario that hinders intergenerational mobility.

Much remains unknown on the determinants of major choice. The literature also does not directly addresses—up to our knowledge—the impact of credit constraints on the choice between different majors. This paper contributes to this literature providing ev-

idence on the determinants of major choice in a framework in which students are suddenly given the opportunity to obtain credit for higher education. We show that costs and returns to higher education impact students' major choice. We also show that credit availability induces students—especially lower income students—to choose high-cost high-return majors, a result consistent with the existence of credit constraints at the major level.

2 Data and Descriptive analysis

In this paper, we evaluate what factors students in Brazil take into consideration when deciding between different majors. We also analyze the impact of credit constraints on students' major choice in a framework in which the costs of enrolling at higher education vary at the major level. We use a broad definition of major, classifying majors within 11 different categories: Education; Humanities and Arts; Social Sciences and Business; Law; Sciences, Math and Computing; Engineering and Construction; Health; Medicine; Odontology; and Others. To perform our analysis, we need information on demand, tuition costs, labor market returns, and other relevant characteristics at the major level. We obtain these information from different data sources.

From the Higher Education Census, we obtain information on demand and other characteristics at the major-institution level. Every year, the Higher Education Census[1] collects information from every higher education institution in the country. The Census contains information at the institution, major, instructor and student level. We use information from every edition of the Higher Education Census between 2006 and 2014. Information from the Census is available up until 2018, but considering that in 2015 access to credit was greatly restricted due to a new reform of FIES's rules, we do not not include more recent cohorts in our analysis.[2] We use information from the Census to evaluate the determinants of demand for private higher education in Brazil. Table 1 describes how average demand for private education evolved through time at the major and at the institution level. Table 1 shows that average demand for private higher education was decreasing between 2006 and 2010. After 2010, we see a consistent expansion in number of enrolled students, applicant students, and maximum cohort size.

[1]The Higher Education Census data are administered by INEP—an independent government agency linked to Brazil's Ministry of Education—and are publicly available (http://inep.gov.br/microdados).

[2]We detail the 2015 reform in chapter **??** of this dissertation.

Table 1: Descriptive Statistics - Characteristics at the Major-Institution Level

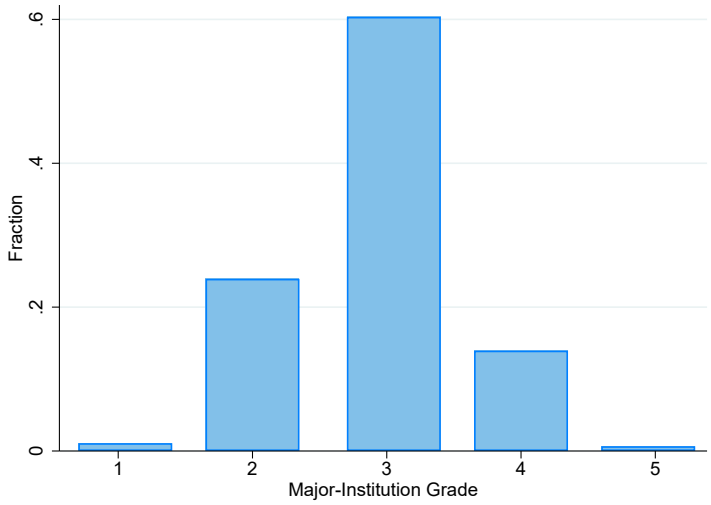
Variable	(1) Full Sample	(2) 2006	(3) 2010	(4) 2014
Enrolled Students	230.80	252.55	218.39	249.22
	(329.44)	(359.09)	(317.17)	(339.38)
Enrolled Students (institution)	18451.85	17263.85	16853.74	21573.96
	(40296.65)	(33421.92)	(36006.76)	(49866.01)
Maximum Cohort Size	163.70	165.07	148.86	223.67
	(192.35)	(169.35)	(140.78)	(240.62)
Number of Applicants	223.31	210.68	186.62	298.00
	(506.72)	(360.02)	(328.58)	(596.43)
Applicants per Max. Cohort Size	1.47	1.37	1.33	1.43
	(3.75)	(1.70)	(2.27)	(3.19)
Number of Graduating Students	35.90	38.90	34.61	32.84
	(57.84)	(67.09)	(58.79)	(49.95)
Number of Majors Offered (institution)	81.46	75.54	76.43	88.08
	(176.41)	(152.06)	(164.11)	(202.99)
Faculty Quality (institution)	0.58	0.51	0.57	0.66
	(0.19)	(0.18)	(0.17)	(0.17)
Number of instructors (institution)	731.39	723.66	730.06	737.82
	(1447.90)	(1179.44)	(1570.63)	(1478.57)
N	153765	13093	17808	18714

Notes: This table presents descriptive statistics for the sample of private major-institutions in Brazil. Information is obtained from the Higher Education Census editions from 2006 to 2014. At the major-institution level, this table presents information on the average number of enrolled students, maximum cohort size, number of applicant students, and the ratio between number of applicant students and maximum cohort size. At the institution level, this table presents information on number of enrolled students, number of majors offered, number of instructors, and a measure of faculty quality (proportion of faculty with at least a master's degree). The full sample—column (1)—contains 153765 observations. In columns (2), (3), and (4) we show how each variable varies between 2006 and 2014. This table shows that all variables related to demand for private higher education decreased between 2006 and 2010 and increased between 2010 and 2014.

From Brazil's Ministry of Education, we obtain data on major-institutions' performance in the country's national evaluation of higher education quality. As we will detail in section 3, the expansion of student credit in Brazil was restricted to students enrolled

in major-institutions that met minimum quality requirements, as defined by the Ministry of Education. We explore this heterogeneity to assess the impact of credit availability on students' decision. We use two different quality evaluations administered by the Ministry of Education to determine eligibility for credit at the major-institution level. The first is the *Conceito Preliminar de Curso* (CPC) or Preliminary Score of Major evaluation. The CPC assigns major-institutions' quality scores that range from one to five considering three dimension of quality: quality of faculty, quality of physical and academic resources, and enrolled students subjective evaluation of quality. The second is ENADE, a national exam that assess the performance of freshman and senior students enrolled in higher education in Brazil. Major-institutions are also assigned a grade from one to five based on their students' performance on ENADE. As we detail in section 4, only major-institutions with a grade higher than three on the appropriate quality evaluation are eligible to enroll students with government credit. We use information on major-institution performance at the 2010 quality evaluation to assess the impact of credit availability. Figure 1 presents the distribution of major-institutions' performance in the 2010 quality evaluation.

Figure 1: Distribution of Major-Institutions' Performance on the 2010 National Quality Evaluation



Notes: This figure presents the distribution of performance in the 2010 national quality evaluation of major-institutions for all the major-institutions in our sample. We measure 2010 performance as the 2010 grade at the Preliminary Score of Major (CPC) evaluation. The CPC evaluation assigns major-institutions' quality scores that range from one to five considering three dimensions: quality of faculty, quality of physical and academic resources, and enrolled students subjective evaluation of quality. For major-institutions with no CPC information available in 2010, we consider the 2010 ENADE grade. ENADE is a national exam that assess the performance of freshman and senior students enrolled in higher education in Brazil. We obtain information on CPC and ENADE from the Ministry of Education. The x-axis presents the grade on the 2010 national evaluation. The y-axis presents the proportion of major-institutions that were assigned each grade, from one to five.

In Brazil, tuition costs vary considerably across institutions and across different majors within the same institution. The Higher Education Census does not provide information on tuition and fees at the major-institution level. Instead, we collect information on tuition accessing a unique database from Hoper, a consultancy firm specialized in the education sector. The data cover 82% of private institutions in Brazil and contain information on tuition at the major-institution level from 2009 to 2013. Due to restrictions in the access of tuition data for more recent cohorts, we restrict our structural analysis to the 2009 to 2013 period.

In section 5, we develop a model of human capital investment in which students must choose between different majors. Students make decisions based on their best beliefs about the costs and returns to education at a given market. We define the metropolitan area (or state)-year pair as the relevant market. We analyze 36 metropolitan-areas (or states) through five years—from 2009 to 2013—totalling 180 markets.[3] For our structural analysis, we aggregate information on major-institution costs, and basic characteristics at the major-market level.

To obtain average labor market returns at the major-market level, we use information from Brazil's national registry of wage earners employed by the formal sector[4]—*Relação Anual de Informações Sociais* or RAIS. The national registry of wage earners is an annual data set organized by Brazil's Ministry of Labor[5]. The registry contains information on wages, hours worked, and occupation at the firm and at the employee level. We restrict our analysis to 20-55 years old working in the same position for at least 35 hours a week over one year. We then use Brazil's official classification of occupations—*Classificação Brasileira de Ocupações* or CBO—to connect each occupation in CBO's high skilled section with the major most often associated with it. Table 2 details the average characteristics for each of the majors we consider in our analysis at the market level. We present all financial information in 2000 Reais.

[3] In section 9.1 we list the metropolitan-areas (or states) considered for our analysis.

[4] A large share of worker in Brazil are employed by the informal sector. Higher qualification workers with a college degree are more likely to be employed by the formal sector and we will not consider the informal sector in our analysis (Ulyssea, 2018). Due to data restrictions, we also do not consider self employed professionals in our analysis.

[5] Starting in 2019, the administration of RAIS was transferred to Brazil's Ministry of Economy

Table 2: Descriptive Statistics - Characteristics at the major-market level

Major	Minimum Tuition	Mean Tuition	Mean Wage	Mean Wage (Young)	Faculty Quality	Applicants per Max Size	N
All	288.762	409.861	2124.434	1477.26	0.589	3.312	1345
	(355.998)	(366.161)	(1270.33)	(881.4145)	(0.131)	(6.958)	
Education	122.195	212.009	1343.786	807.141	0.578	1.029	143
	(44.099)	(47.722)	(456.690)	(203.634)	(0.130)	(0.392)	
Humanities/Arts	154.953	258.827	1085.491	722.513	0.624	1.198	108
	(57.603)	(70.366)	(414.324)	(222.775)	(0.110)	(0.528)	
Social Sciences/Business	125.844	236.407	1501.647	966.414	0.536	1.875	150
	(35.035)	(46.732)	(577.566)	(343.776)	(0.132)	(3.782)	
Law	233.966	330.755	3846.465	2188.031	0.563	3.429	144
	(55.812)	(52.463)	(1679.942)	(961.453)	(0.129)	(2.274)	
Science/Math/Computing	156.933	276.497	2005.614	1340.972	0.578	1.341	143
	(53.094)	(51.986)	(459.784)	(280.508)	(0.125)	(0.498)	
Engineering	228.796	373.656	3036.296	2288.643	0.621	2.073	131
	(83.543)	(77.737)	(705.180)	(556.869)	(0.116)	(0.892)	
Agricultural Sciences	293.684	448.289	2771.314	1867.096	0.593	1.746	90
	(139.517)	(118.645)	(700.443)	(293.775)	(0.145)	(1.000)	
Health	189.027	338.334	1401.813	1161.003	0.590	1.875	148
	(51.943)	(59.901)	(308.904)	(182.753)	(0.125)	(0.822)	
Medicine	1492.669	1690.079	3677.180	3127.782	0.655	25.376	84
	(421.149)	(272.264)	(1095.475)	(988.523)	(0.109)	(14.450)	
Odontology	626.356	734.383	1854.749	1529.229	0.637	2.812	81
	(180.637)	(163.382)	(586.650)	(356.727)	(0.139)	(1.317)	
Others	153.892	241.977	1355.271	929.214	0.566	1.185	123
	(53.190)	(68.278)	(1251.453)	(930.851)	(0.134)	(0.696)	

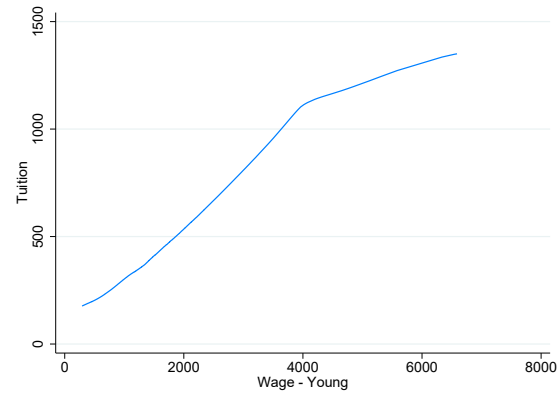
Notes: This table presents descriptive statistics at the major-market level. For our structural analysis, we aggregate the information from different major-institutions at the major-market level. We classify majors into 11 different categories: Education, Humanities and Arts, Social Sciences and Business, Law, Sciences/Math and Computing, Engineering and Construction, Health, Medicine, Odontology, and Others. We define the state/ metropolitan region area as the relevant market. The list of markets is available in section 9.1. Our full sample contains 1345 major-market pairs. We obtain information on tuition from Hoper, a consultancy firm specialized in the education sector. We collect information on major-market labor market outcomes from the national registry of employees in the formal sector (RAIS). We obtain information on quality at the major-market level from the Higher Education Census.

From table 2, we see that there is great variability in both the costs—minimum tuition and mean tuition—and returns—average wage and average wage for young (20-30

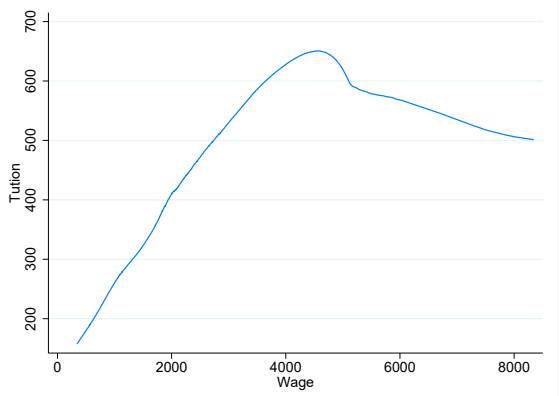
years old) wage earners—to different majors. Mean tuition varies from 212.00 Reais—Education—to 1690.07 Reais–Medicine. The median tuition from our sample is 298.34 Reais. The average cost for enrolling in Education, Humanities and Arts, Social Sciences and Business, Science, Math and Computing and Others is below median. On the other hand the costs of enrolling in Law, Engineering, Agricultural Sciences and all health related majors is above median. Wages also vary significantly in our sample. The median wage is 1771.60 Reais. Students who graduate from Education, Humanities and Arts, Social Sciences and Business, Health and Others gain lower than median wages. Students who graduate from Law, Science, Math and Computing, Engineering, Agricultural Sciences, Medicine, and Odontology get higher than median wages. Our data reveals that there is a positive significant correlation between the tuition costs of a major and the wages associated with it at the market level. Figure 2 illustrates the results of a non-parametric local regression that assess the relation between tuition costs and wages for both the full sample and the sample of young wage earners. For young workers, there is a positive correlation for all wage levels. For the full sample, the correlation weakens for higher wage levels. This results is consistent with Deming and Noray (ming), that show that the wage premium from technical majors fades with time as technological change makes skills obtained while in college obsolete.

Figure 2: Correlation Between Costs and Returns from Different Majors

(a) Tuition vs. Wage Young



(b) Tuition vs. Wage



Notes: This figure presents the results of a non-parametric local weighted regression that evaluates the correlation between tuition costs and wages at the major-market level. The y-axis presents information on tuition and the x-axis information on wages. For panel (a) we consider only the information on young wage earners—20 to 30 years old. For panel (b) we consider the full sample.

In our model, students' educational decision are a function, among other things, of their first period income, i.e. their income at the moment they are choosing how much to invest in higher education. We assume first period income is given by parental transfers (Belley and Lochner, 2007). We estimate our model using the BLP method (Berry et al., 1995). For estimation, we need information on the distribution of parental transfers at the market level. To obtain this information we use two data sets administered by the Brazilian Institute of Geography and Statistics: the National Household Sample Survey and the Consumer Expenditure Survey. The National Household Sample Survey (PNAD) collects information on socioeconomic status of a nationally representative sample of households, including information on income, employment, education, and household composition. From this survey, we obtain information on the distribution of family income at the market level. The Consumer Expenditure Survey contains information on household budget composition. We use information from the 2008-2009 edition to obtain an estimate of how much families spend on education.

3 Institutional Background: FIES and the 2010 Intervention

Brazil's federal government offers loans to students enrolled in private higher education through its subsidized student credit program (FIES). The program, created in 1999, became one of the most important sources of funding for higher education in the country following an unexpected reform of program's rules in 2010.[6] The reform reduced participation costs for both students and institutions and was designed to increase enrollment rates. For students, the cost of funding decreased considerably. Interest rates dropped from 6.5% to 3.5% per year. The government established a rolling basis application process, allowing students to apply for loans at any moment of the year. A subsidized insurance scheme was created to eliminate the need of a cosigner for lower income students. Repayment conditions improved with the extension of loans' grace and amortization periods. The 2010 reform also benefited institutions with the establishment of a system that increased the liquidity of government FIES-related payments.[7]

[6]Starting in 2015, FIES was once again completely reformulated. The first chapter of this dissertation details the 2015 reform.

[7]The government pays participant institutions through treasury bonds called *Certificado Financeiro do Tesouro Série E (CFT-E)*, a special issue for FIES financing. The face value of these bonds corresponds to the tuition financed through FIES. The bonds are tradable for Social Security obligations. No secondary market exists for these bonds, but the government holds repurchase auctions. In 2010, the government established an official schedule of repurchase auctions and increased the minimum number of auctions to be held every

To obtain funding from FIES, students must enroll in major-institutions that meet the program's eligibility requirements. Specifically, major institutions must obtain a minimum performance on the quality evaluations conducted by Brazil's Ministry of Education. In section 4, we detail this eligibility requirements and show how we explore heterogeneities in eligibility to obtain the causal impact of funding eligibility. FIES loans cover from 50% to 100% of tuition expenses. The fraction of tuition eligible for financing depends on family income and on the ratio between income and tuition.[8] Students with family income higher than 20 minimum wages are not qualified for funding. Only families at the very top of Brazil's household income distribution do not meet FIES' income requirements.

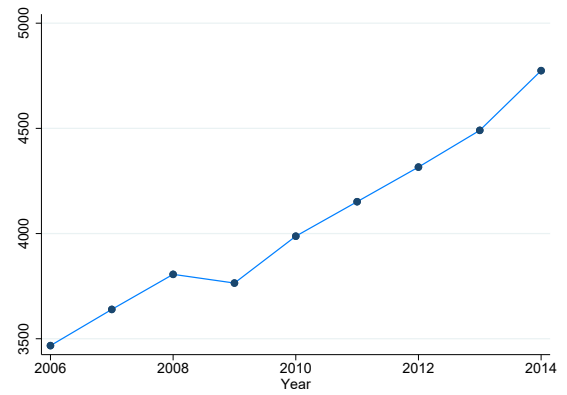
In the years following the 2010 reform, there was a significant increase in the number of students enrolled with FIES financing. In figure 3, we illustrate the number of students enrolled in private higher education in Brazil—panel (a)—and the number of students enrolled with FIES funding—panel (b)—in the period between 2006 and 2014. Throughout this period, the number of students enrolled in private higher education in Brazil increased by 37%, growing from approximately 3.4 million students to 4.7 million students. The number of students enrolled with FIES funding increased considerably from a approximately 170 thousand in 2006 to 1.4 million in 2014. As figure 3 shows, the sharp increase in number of students enrolled with FIES funding occured after the 2010 reform.

year.

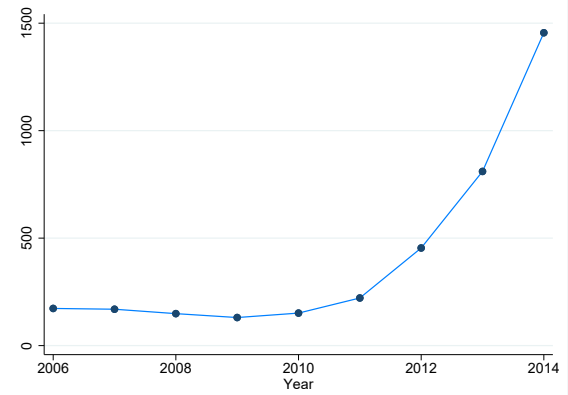
[8]FIES covers: 1) up to full tuition for students with gross household income under 10 minimum wages, and tuition higher than 60% of the per capita household income; 2) up to 75% of tuition for students with gross family income under 15 minimum wages, and tuition between 40% and 60% of the per capita household income; 3) up to 50% of tuition for students with gross household income under 20 minimum wages, and tuition between 20% and 40% of the per capita household income.

Figure 3: Students Enrolled in Private Higher Education and FIES Funding

(a) Enrolled Students (thousand)



(b) Students with FIES funding (thousand)



Notes: This figure presents the evolution between 2006 and 2014 of the number of students enrolled in private higher education institutions in Brazil—panel(a)—and number of students enrolled with FIES funding—panel (b). This figure shows that the number of students enrolled in private higher education increased considerably in the period—from 3.5 million in 2006 to 5 million in 2014. It also illustrates the sharp increase in the number of students enrolled with FIES funding starting in 2010.

4 Reduced Form Evidence

According to FIES' rules, a major-institution is considered eligible for enrolling students with FIES financing if it obtains a minimum performance in the Ministry of Education's quality evaluations. In this section, we explore heterogeinities in eligibility for enrolling students with FIES to obtain a causal estimate of the impact of credit availability on enrollment. For identification, we define treatment and control groups based on major-institutions ability to enroll students with FIES right after the programs' expansion. We argue that the expansion was unexpected and that major-institutions were limited in their ability to meet eligibility requirements in the short run. We show that availability of subsidized credit impacts enrollment decisions, causing students to choose major-institutions that offer the possibility of obtaining FIES funding. In the next sections, we will explore the impact of credit availability on overall demand for higher education and on major choice.

To be considered eligible to enroll students with FIES, a major-institution must obtain a grade of three or higher in one of three quality assessments, according to the following order of relevance: (i) the Score o Major (CC); (ii) the Preliminary Score of Major (CPC),

if CC is not available; (iii) and the national exam for higher education students (ENADE), if CC and CPC are not available. The performance of major-institutions in a given period at these quality evaluations, thus, inform on their ability to enroll students with FIES funding. Information on performance at the CC evaluation is not readily available. This is not an issue because CC is an *in loco* evaluation and is not as broadly assessed as CPC or ENADE. We assign the eligibility status of different major-institutions considering their performance on CPC. For some major-institutions, CPC is not available but ENADE grade is. For these major-institutions, we consider performance on ENADE to assign eligibility. According to FIES rules, major-institutions not yet subject to their first evaluation are considered eligible pending evaluation. As such, we assign major institutions with no available CPC and ENADE performance as eligible for FIES funding.

We identify the causal impact of FIES exploring major-institutions' eligibility status right after FIES expansion through a Difference-in-Differences (DD) framework. Treatment is defined according to eligibility status in 2010, i.e., we consider part of the treatment group all major-institutions with CPC—or ENADE—grade three or higher in 2010. We also include as part of the treatment group major-institution with no evaluation available in 2010. We set the period between 2006 and 2010 as the pre-treatment period. The period between 2011 and 2014 represents the post-treatment period. We measure the causal impact of FIES eligibility on enrollment estimating the following equation:

$$Enrolled_{jt} = \alpha_1 + \alpha_2 D_t * Treat_j + \alpha_3 D_t + \alpha_4 Treat_j + \beta X_{jt} + \varepsilon_{jt} \quad (1)$$

The dependent variable is number of students enrolled at major-institution j on year t. D_t is a dummy variable that is equal to one for observations in the post-treatment period—2011 to 2014. $Treat_j$ represents a a dummy variable that is equal to one if the major-institution j obtained the minimum performance required for eligibility for FIES in 2010. X_{jt} represents a set of characteristics at the major institution level[9] and ε_{jt} represents an error term unobserved to the econometrician. Our parameter of interest—α_2—represents the causal impact of being eligible to enroll students with FIES on number of enrolled students at the major-institution level for all major-institutions in our sample—the intent-to-treat parameter. Table 3 presents the results of this estimation. For all specifications considered, we find a positive and significant impact from being eligible for FIES

[9]We include the following covariates in our main specification: maximum size of incoming cohort, number of majors offered by the institution, number of instructors at the institutions level, number of applicant students per maximum cohort size, institution size, and proportion of instructors with at least an MA. We also include institution and year fixed effects.

on number of enrolled students. Specifically, we find that—even after including covariates, year, and institution fixed effects—major-institutions eligible to enroll students with FIES enrolled 17.32 more students after FIES's expansion than non-eligible major institutions.

Table 3: Reduced Form Estimation

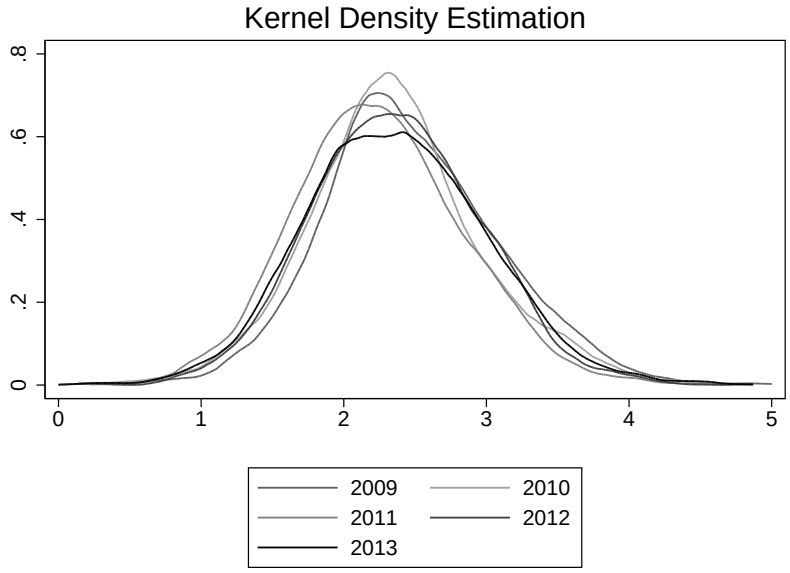
Variables	(1)	(2)	(3)	(4)
Treatment Effect	14.981***	12.588**	12.564**	17.328***
	(5.474)	(5.521)	(5.003)	(4.961)
Year FE	n	y	y	y
Covariates	n	n	y	y
Institution FE	n	n	n	y
Observations	153,765	153,765	153,765	153,669
R-squared	0.000	0.002	0.269	0.341

Notes: This table presents the results of a difference-in-differences (DD) analysis that compares the number of students enrolled in major-institutions eligible to enroll students with FIES in 2010 against number of enrolled students in non-eligible major-institutions (equation 1). In this DD, the pre-treatment period consists of the years that precede FIES expansion (2006 through and 2010). The post-treatment period consists of the years after the expansion (2011 through 2014). The estimated coefficients associated with the ''Treatment Effect" variable represent the impact of being eligible to FIES number of enrolled students. In columns (2), (3), and (4) we include year fixed effects. In columns (3) and (4) we include a set of time varying covariates. Covariates at the major-institution level include information on maximum cohort size and the ratio between applicants and maximum cohort size. Covariates at the institution level include information on faculty quality, number of majors offered, number of instructors and enrolled students. In column (4), we include institution fixed effects. Standard errors were computed with observations clustered at HEI level. *** represents p-value<0.01, ** p-value<0.05, and* p-value<0.1.

Controlling for selection bias is one of the main identification challenges in a framework like ours. We determine eligibility based on the 2010 quality evaluation of major-

institutions with the purpose to minimize the risk of including as part of the treatment group major-institutions that altered their behavior with the intent to become eligible for FIES. We make this decision based on the assumption that FIES expansion was largely unexpected and, as such, major-institutions were unable to implement quality enhancing investments that would increase their chances of becoming eligible in the short run. We are able to evaluate the robustness of this hypothesis using our data. If major-institutions were making investment decisions to enhance their performance in response to an expected increase in student credit, we would see a shift in the distribution of the quality evaluation scores towards higher grades in the years following FIES expansion. In figure 4, we plot the distribution of quality evaluation grades for major-institutions in our sample in the period between 2009 and 2013. This figure shows no evidence of major-institutions managing to significantly improve their quality evaluation in the short run. This result is not surprising, given that quality evaluations from the Ministry of Education are based in factors not easily manipulated in the short run—e.g. academic performance of graduating students, level of qualification of instructors, or quality of physical infrastructure—and there is a three-year interval between major-institution level evaluations.

Figure 4: Major-HEI Quality Score - Kernel Density



Notes: This figure shows the trend through time of the quality indicator that determines eligibility for FIES. Specifically, it shows the kernel estimate of the density function of the CPC quality evaluation, if CPC is available, and of the ENADE score, for the cases in which the CPC is not available, for every year from 2009 through 2013

Identification on a Difference-in-Differences framework lies on the assumption that the variable of interest—enrollment—was following the same trend for treatment and control units before the policy implementation—before FIES expansion—and would have continued following parallel trends if there had not been an intervention, i.e., in a counterfactual scenario. We cannot test how reasonable the counterfactual parallel trend hypothesis is. However, we can test the differential pre-trend hypothesis. In figure 5 we present the result of a event study analysis performed using our data. In this analysis, we compare the number of enrolled students for units in the treatment and control groups in the period before and after FIES expansion. Our results show that, before FIES expansion, there is no discernible differential trend when we compare treatment and control units. After the expansion, on the other hand, we see a consistent increase on number of students enrolled in major-institutions that are eligible to enroll students funded through FIES.

Figure 5: Impact of Credit Availability on Enrollment

Notes: This figure shows the result of a event study analysis that compares the trend in number of enrolled students at major-institutions in the treatment group against number of enrolled students at major-institutions in the the control group. We include as part of the treatment group all major-institutions that were eligible to enroll students with FIES in 2010. The dots in the graph represent the point estimates of the eligibility effect for each year. Vertical lines represent a 95% confidence interval. The specification in this figure includes institution fixed effects and a set of time-varying covariates. Covariates at the major-institution level include information on maximum cohort size and the ratio between applicants and maximum cohort size. Covariates at the institution level include information on faculty quality, number of majors offered, number of instructors and enrolled students. Standard errors were computed with observations clustered at HEI level.

Our results suggest that availability of credit influences human capital decisions and that students are more likely to enroll in major-institutions that can offer them the possibility of obtaining government funding. There are a few important questions that this analysis does not address. These results cannot be used to estimate the impact of credit availability on number of enrolled students in the private higher education market as a whole. Considering that in Brazil students choose career upon entrance and that tuition vary greatly across majors, we would like to investigate if the expansion of credit altered

students decision to enroll in different majors. Table 4 shows that between 2006 and 2014 the market share of different majors changed considerably in Brazil, with a significant increase in the market share of higher than average cost majors like Engineering, Agricultural Sciences, Medicine, and Odontology. Our results so far also cannot be used to understand how credit availability impact the share of students enrolled in each major and how students background or major-level costs and return influence this decision. In the following sections, we introduce a structural model of demand to analyze how credit constraints influence the choice between different majors.

Table 4: Major Market Share Evolution

	Enrolled Students			Market Share		
Major	2006	2014	Growth Rate	2006	2014	Growth Rate
Education	522991	435827	-0.167	0.151	0.091	-0.397
Humanities/Arts	98861	100624	0.018	0.029	0.021	-0.276
Social Sciences/Business	1165395	1423028	0.221	0.336	0.298	-0.113
Law	525684	740451	0.409	0.152	0.155	0.020
Science/Math/Computing	258648	249841	-0.034	0.075	0.052	-0.307
Engineering	215618	849438	2.940	0.062	0.178	1.871
Agricultural Sciences	44470	90473	1.034	0.013	0.019	0.462
Health	490575	651202	0.327	0.141	0.136	-0.035
Medicine	38047	75240	0.978	0.011	0.016	0.455
Odontology	30161	69571	1.307	0.009	0.015	0.667
Others	76892	88360	0.149	0.022	0.019	-0.136

Notes: This table presents descriptive statistics on the evolution of demand for different majors between 2006 and 2014. We obtain information on demand for private higher education from the Higher Education Census. For all 11 majors considered in our analysis— Education, Humanities and Arts, Social Sciences and Business, Law, Sciences/Math and Computing, Engineering and Construction, Health, Medicine, Odontology, and Others—we present information on number of enrolled students and market share both in 2006 and in 2014. We also present information on the growth rate of demand—measured as number of enrolled students and market share—between 2006 and 2014 for all majors considered in our analysis.

5 A Simple Model of Major Choice

There is an extensive literature documenting how credit constraints can impact the decision to enroll or not in higher education (Lochner and Monge-Naranjo, 2011). In this paper, we evaluate the impact of credit constraints on the choice between different majors. Assume individuals live $t = \{1, ...T\}$ periods. In period $t = 1$, a schooling decision is made. In $t = 2$, individuals enter the labor market, the absorbing state. Students enrolling in higher education must choose to invest in one between K majors. That is, an individual must choose only one major among the choice set $k = \{1, ..., K\}$.

Each individual is endowed with an initial parental transfer T_i. In our empirical exercise, we assume that families spend a given fraction of their income with education. Higher education is costly and both the minimum and the average cost of education are heterogeneous across majors. We represent the cost of enrolling at major k as τ_k. We ignore the relevance of possible differences in quality between majors and make the reasonable assumption that investment in education is indivisible. We assume that major choice determines returns from labor at the market level. We use w_{kt} to represent the wages at market t for individuals who graduated from major k in the first period. In our model, we assume that students observe the wages associated with different majors before enrolling in higher education.

A growing literature highlights how students can be ill informed on the expected returns of different majors. Wiswall and Zafar (2015) collects information on the expectations of undergraduate students of New York University and finds that students have biased beliefs about the distribution of earnings from different majors Hastings et al. (2016) collects data o large scale surveys of Chilean college students and finds that students systematically overestimates earnings of past graduates. Even though this is a shortcoming of our model, adding uncertainty on expected wages would greatly complicate our empirical analysis and we opt to to use—Lochner and Monge-Naranjo (2011)—a simplifying assumption.

Individuals derive utility from consumption. At each period, individual utility is represented as $u(c_t)$. [10] We assume that, at period $t = 1$, individuals can borrow an amount d at an interest rate R. The loan must be repaid in the following periods. The value function of individual i when choosing major k is given by

[10] The literature highlights the role of non-pecuniary characteristics on students' decision between different majors. In our empirical exercise, we consider the possibility that students make decisions based on their individual preferences for major characteristics including a term ξ_{ik} that accounts for the consumption value individual i assigns to major j (Gullason (1989), Gong et al. (2019)).

$$V_k(T_i, w_{kt}, \tau_k, R) = \max_d \left[\sum_{t=1}^{T} \beta^{t-1} u(c_t) \right] \tag{2}$$

The parameter β represents the intertemporal discount rate. Individuals will choose the major that maximize their lifetime utility, i.e., individuals will choose major $k = k^*$ if

$$V_k^* > V_j \quad \forall j \neq k^*$$

That choice is made considering a set of constraints. In a world without borrowing constraints individuals must abide to the following budget constraint at $t = 1$.

$$c_{1k} = T - \tau_k + d$$

For $t \geq 2$

$$c_{tk} = w_k - i_k$$

In which i_k represents a stream of repayments. In a world with borrowing constraints, debt is constrained to an specific amount. To represent this framework, we add the following restriction.

$$d \leq \overline{d}$$

To illustrate the mechanisms through which credit constraints might impact major choice, we find the solution—with and without credit constraints—for a two period, two majors version of our model. In a two period framework without credit constraints, we have that:

$$c_{1k} = T - \tau_k + d$$

$$c_{2k} = w_k - Rd$$

Each individual solves the following optimization problem

$$\max_d \;\; U(Ti - \tau_k + d_1) + \beta U(w_k - Rd)$$

The following expression represents the solution of this optimization problem:

$$U'(c_1) = \beta R U'(c_2)$$

Assuming $\beta R = 1$, we have that consumption is perfectly smoothed between the two periods, i.e., $c_1 = c_2$, i.e.,

$$Ti - \tau_k + d = w_k - Rd$$

In this framework, the first period optimal amount of debt—represented by d^*—is a function of parental transfers and of the costs and returns associated with choosing a given major k. Specifically, first period debt is negatively correlated with parental transfer and positively correlated with tuition and second period wage.

$$d^* = \frac{w_k - T_i + \tau_k}{(1 + R)}$$

With no constraints, lower income individuals, who cannot fully afford the costs of higher education, respond to an increase in the costs of major k by increasing the amount of debt they would take to finance enrollment at major k. This is not necessarily the case when credit constraints are binding. In a framework with borrowing constraints, the maximum amount students can borrow is bounded by a given limit $\overline{d}$. If the optimal amount of debt is lower than this limit—i.e. if $d^* < \overline{d}$—the constrained solution is identical to the unconstrained one. If that is not the case, individuals can only borrow an amount $\overline{d}$ that is insufficient to cover the costs of enrolling at major k. In this simple framework, a individual can only enroll at major k if the parental transfers they receive are at least as high as the sum of tuition and maximum debt $T_i + \overline{d} \geq w_k$. Lower income individual—even those who can afford some college—might then be constrained in their ability to choose more expensive majors.

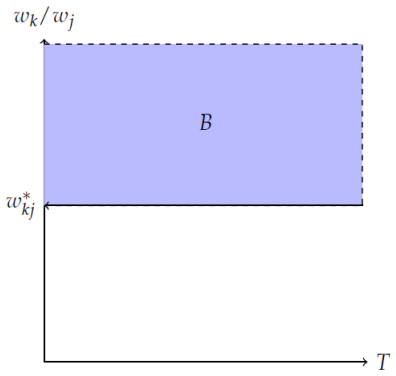
Assume a high cost-high return major (major k) and a low cost-low return major (major j). An individual enrolling in college must choose between these two majors. In our simple framework, with no credit constraints, major-specific costs and returns are the only variables determining choice. In this case, individuals will choose major k every time the relative earnings between major k and major j crosses a given threshold that compensates for the higher costs of major k. We define $w_k/w_j = w^*_{kj}$ as relative earnings at this indifference threshold.

When credit constraints are binding, parental transfers will also influence decision. Now, individuals will choose major k if relative earnings crosses the indifference threshold and parental transfers are large enough to compensate for the unavailability of credit. In this scenario, individuals with low parental transfers are constrained in their choice and

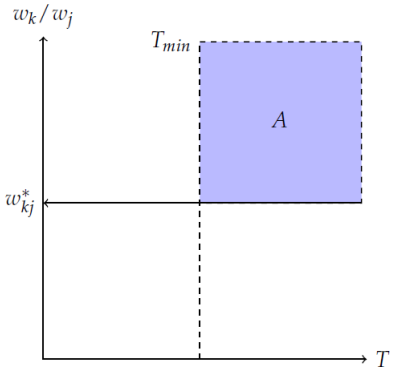
will choose the low-return low-cost major regardless of the differences in relative returns. Figure 6 illustrates how relative returns between majors j and k and parental transfers influence students' choice when the costs of different majors are taken as given. In panel (a) there are no credit constraints. In this case, all students choose the high cost major once the returns from this major cross a threshold that compensates for its higher costs. When credit constraints are binding—panel (b)—students with lower parental transfers are constrained from choosing the high cost major. In this case, only students with parental transfers higher than T_{min} are able to choose the high-cost high-return major.

Figure 6: Higher Education Enrollment Model

(a) Without Credit Constraints



(b) With Credit Constraints



Notes: This figure illustrates the relationship between parental transfers—x-axis—and choice of major in a framework with a high cost-high return major (major k) and a low cost-low return major (major j) according to our major choice model. The y-axis in this figure represents relative earnings, i.e., the ratio between labor market earnings from major k (w_k) and labor market earnings from major j (w_j). According to this simple version of our model, students would like to choose the high cost-high return major (major k) every time the relative earnings of this major cross a indifference threshold that compensate for its higher costs ($w_k/w_j = w^*_{kj}$). With no credit constraints—panel (a)—all students choose the high cost-high return major once relative returns cross the indifference threshold (area B). If credit is not available, only students who can afford a major can enroll in it. Thus, only students with high enough parental transfers (higher than T_{min}) are able to choose the high cost major (area A). Students in the lower end of the parental distribution are thus constrained in their ability to choose major k.

This two period exercise illustrates how credit constraints and family income can shape individual choice. In a framework with varying costs at the major level, lower income individuals can be not only constrained in their choice of enrolling at higher education—as

it is standard in the literature—but also in their choice between different majors. In the next section, we investigate the determinants of demand for higher education and how credit constraints impact choice. We empirically evaluate the demand for different majors adapting our model to fit the framework of the BLP method (Berry et al., 1995). Using this framework, we are able to estimate the parameters of the demand function and calculate empirical elasticities that inform on how students demand react to price changes with and without credit constraints.

6 Model of Major Choice - Empirical Implementation

As the model in section 5 illustrates, in a framework in which the costs of higher education vary at the major level, availability of credit can impact the choice between different majors. Changes in lending standards, thus, could affect the demand for specific majors, having an impact on their market share. In this section, we adapt our model to fit the framework of a random-coefficients logit model of demand (or BLP) (Berry et al., 1995). In the BLP framework, products are defined by a set of characteristics. The utility of each consumer—in our case prospective student—is a function of observed and unobserved product characteristics. It is a discrete choice model in the sense that each consumer will choose only one product that maximizes their utility. Consumers are allowed to have different preferences for different characteristics. With the BLP method, we are able to estimate demand for differentiated products using aggregate data (Nevo, 2000).

We adapt our human capital investment model to fit the demand for differentiated products of the BLP method. Assume that there are $m = \{1, ..., M\}$ markets for higher education with $i = \{1, ..., I_m\}$ consumers or potential students in each of these markets. In each market, consumers are able to choose one between $j = \{1, ..., J\}$ majors. The price of product j at market m is represented by tuition τ_{jm}. Demand is constrained within markets. That is, each individual participates of a given market and is only able to choose majors being offered at that market. As in section 5, we assume that individuals live $t = \{1, ..., T\}$ periods. In the first period, students receive a transfer from their parents—T_{im}—and must choose one of the majors being offered by private higher education institutions in the market they participate. To enroll at major j offered at market m students must pay τ_{jm}. Students can also choose to not enroll in any of the offered majors either because they decided not to enroll in higher education or because they decided to enroll in public tuition free institutions. The choice to not enroll in private higher education represents

the outside option in our framework ($j = 0$). The cost of not enrolling is zero ($\tau_{0m} = 0$). In the following periods, students enter the labor market and obtain major-specific earnings. We assume that returns to education—w_{jm}—are constant through time. In a framework with no credit markets for higher education, the first period consumption of student i who chooses a major j at market m is given by:

$$c_{ijm1} = T_{im} - \tau_{jm}$$

In the following periods, consumption is given by:

$$c_{ijmt} = w_{jm}$$

The literature suggests that students derive utility from just being enrolled in higher education (Gullason (1989), Gong et al. (2019)). We define utility in period $t = 1$ as a function of consumption in that period and of the consumption value of each major—ξ_{ijmt}. In the following periods, utility is a function of consumption only—i.e. $\xi_{ijmt} = 0 \, \forall \, t \geq 2$. We explore the consumption value of education to adapt our human capital investment model to the BLP framework. Specifically, we assume that the consumption value of major j at market m for individual i is a function of a vector of parameters γ, of major-market level amenities—X_{jm} and of an individual unobserved idiosyncratic value associated with choice j, ϵ_{ijt}.

$$\xi_{ijm1}(\gamma) = \gamma_0 + \boldsymbol{\gamma_1 X_{jm}} + \epsilon_{ijm} \tag{3}$$

According to the model in section 5, consumption is a function of parental transfers, major-specific tuition, and labor market earnings. For each period t, we define an indirect utility from consumption—v_{ijmt}. In the first period, indirect utility is a function of parental transfer and tuition. In the following periods, indirect utility is a function of labor market earnings.

Total indirect utility at period t—V_{ijmt}—is given by the sum between the indirect utility from consumption and the consumption value of higher education. We assume indirect utility is also a function of two set of unknown parameters. The first—θ—is fixed across all individuals. The second—χ_{ti}—is an individual parameter. We assume χ_{ti} only affects first period utility, i.e. $\chi_{1i} = \chi_i$ and $\chi_{ti} = 0 \, \forall \, t \geq 2$.

$$V_{ijmt} = \theta v_{ijmt}(\tau_{jm}, T_{im}, w_{jm}) + \chi_{ti} v_{ijmt}(\tau_{jm}, T_i, w_{jm}) + \xi_{ijmt}(X_{jm}; \gamma) \tag{4}$$

In this framework, we can represent the value function V_{ijm} by the following expression:

$$V_{ijm} = \sum_{t=1}^{\infty} \beta^{t-1} \left[v_{ijmt}(\tau_{jm}, T_{im}, w_{jm}; \theta_t, \chi_{ti}) + \xi_{ijm}(X_{jmt}; \gamma) \right] \tag{5}$$

We need a few more assumptions before obtaining an specification we can estimate with our data. We start by assuming that our utility function is logarithmic, i.e. we assume $u(c_t) = ln(c_t)$. Under this assumption, we can show that indirect utility from consumption at period $t = 1$ is given by $ln(T_{im} - \tau_{km})$ and at every period afterwards by $ln(w_{km})$.

We introduce parameter χ_i to include the possibility that individuals assign varying weights to the utility they derive from education costs. The idea is that some students might be more sensitive to the financial costs of enrolling in higher education. We assume, as in Petrin (2002), that the individual parameter of the indirect utility function—χ_i—varies across three different income cohorts. That is, we include the possibility that low, middle and high income individuals respond differently to the costs of higher education. Specifically, we assume that:

$$\chi_i = \begin{cases} \chi_1 & \text{if } T_i < y_1 \\ \chi_2 & \text{if } y_1 < T_i < y_2 \\ \chi_3 & \text{if } T_i > y_2 \end{cases}$$

Finally, we make two standard assumptions for a BLP estimation. First, we assume that utility of the outside option—the option of not enrolling in private higher education—is zero. Second, we assume that the unobserved idiosyncratic value associated with the consumption value of higher education follows an Extreme Value Type I distribution. Students will choose the major that assigns them the highest utility conditional on budget and credit constraints. Define δ_{ilm} as:

$$\delta_{ilm} = \gamma_0 + (\theta + \chi_i) ln(T_{im} - \tau_{lm}) + \theta\beta/(1-\beta) ln(w_{lm}) + \gamma_1 X_{lm} \tag{6}$$

Under the above assumptions, it is straightforward to show that the probability of prospective student i choosing major j at market-year m is given by:

$$P(j|i,m) = \frac{\exp(\delta_{ijm})}{1 + \sum_k \exp(\delta_{ikm})} \tag{7}$$

With no credit markets, only individuals who can afford a major will be able to enroll in it, i.e. only individuals with parental transfers—T_{im}—higher than tuition charged for a given major j—τ_{jm}—will be able to choose major j.[11] In this case the market share of major j at market m—s_{jm}—is a function of the probability of enrolling at that specific major and the distribution of parental transfers at the market level, $f(ti)$:

$$s_{jm} = \int_i \mathbb{1}[T_{im} \geq \tau_{jm}] Pr(j|i,m) f(ti) \tag{8}$$

When credit for higher education is available, students can borrow an amount d_{ijm} in the first period to finance their education. First period consumption is then given by:

$$c_{ijm1} = T_i - \tau_{jm} + d_{ijm}$$

After the first first period, students must pay back what they borrowed. i_{ijmt} represents this stream of repayments. For $t \geq 2$:

$$c_{ijt} = w_{jm} - i_{ijmt}$$

We assume debt can only be used to finance tuition. In this case, we have $d_{ijm} = \phi_i \tau_{jm}$ with $0 \leq \phi_i \leq 1$. The stream of repayments i_{ijmt} is a function of debt—$\phi_i \tau_{jm}$—and of market level interest rates r_m. The amount that students must pay back each period is then given by:

$$i_{ijmt} = \sum_{t=1}^{\infty} \left(\frac{1}{1+r_m} \right)^t i_{ijmt} = \left(\frac{r_m}{1+r_m} \right) \phi_i \tau_{jm}$$

Define δ''_{ilm} as:

$$\delta''_{ilm} = \gamma_0 + (\theta + \chi_i) ln(T_{im} - \tau_{lm} + d_{ilm}) + \theta \frac{\beta}{(1-\beta)} ln(w_{lm} - i_{ilmt}) + \gamma_1 X_{lm} \tag{9}$$

Under the same assumptions as in the case with no credit markets, it is straightforward to show that the probability of prospective student i choosing major j at market-year m is given by:

[11] If $T_{im} < \tau_{jm}$, then $V^{CC}_{ijm}(n) \to -\infty$

$$P''(j|i,m) = \frac{\exp(\delta''_{ijm})}{1 + \sum_k \exp(\delta''_{ikm})} \tag{10}$$

When student credit is available, we can represent the market share of major j at market m by the following expression:

$$s''_{jm} = \int_i \mathbb{1}[T_i \geq (1 - \phi_i)\tau_{jm}] Pr''(j|i,m) f(ti) \tag{11}$$

From these theoretical market shares, we can estimate the model parameters using data aggregated at the market level (Nevo, 2000). We can also obtain measures of price-elasticities of demand. In the next section, we take this model to the data.

7 Model of Major Choice - Results

We estimate the model outlined in section 6 exploring FIES's significant 2010 expansion. As detailed in section 3, FIES was a relatively small program before 2010. After the program's reform in 2010, FIES-funded credit became largely available, even for students with relatively high family income. Since there is no evidence of a large private market for student loans in Brazil and FIES is the only federal government program that offers student loans, we assume that credit was unavailable before 2010 and largely available after 2010. That is, we assume a framework in which there are no credit markets before 2010 and no credit constraints after 2010.

We define debt following FIES's rules at the time. According to these rules, FIES's loans would cover up to 100% of tuition expenses. The fraction of the tuition eligible for financing depends on family income and on the share between family income and tuition. We define debt as a share of tuition—$d_{ijm} = \phi_i \tau_{jm}$. We assume that debt size depends on the ratio between tuition and family income. Specifically $\phi_i = 1$ if tuition amounts to more than 60% of household income, $\phi_i = 0.75$ if tuition is between 40% and 60% of household income, $\phi_i = 0.5$ if tuition is between 20% and 40% of household income and $\phi_i = 0$ otherwise.

We define market as the metropolitan area (or state)-year pair according to Brazil's National Household Sample Survey (PNAD) division. We define market size as the total population of 15-24 years old living in that market. Since the higher education industry is characterized by supply constraints, it is not trivial to define demand. We use two alternative definitions of demand: number of enrolled students—our preferred specification—

and number of applicant students.

In section 6, we argue that the market share of a given major is a function of parental transfers net of tuition, wages and product characteristics.[12] We obtain these information aggregating major-institution variables at the major-market level, as detailed in section 2. For most variables we use sample averages. For tuition, we consider market level minimums, as we are interested in estimating the impact of being constrained from choosing a given major. Later in this section we present the results obtained from using market means. From the National Household Sample Survey (PNAD), we obtain information on the distribution of income at the market level and, from the Consumer Expenditure Survey, we estimate the share of income families spend with education in Brazil. We draw parental transfer from these empirical distributions (Nevo, 2000).

Many unobserved characteristics can affect the cost of a major and it is not reasonable to assume that tuition is an exogenous variable. Identification, thus, requires the definition of a set of instruments (Z_{jm}). It is reasonable to assume that the tuition charged for a given major is a function of the costs of supplying that major. It is also reasonable to assume that, once we control for tuition, individuals are not influenced by these costs when choosing a major. Cost shifters can thus be used as instruments for tuition. We consider the following cost shifters: wage of instructors (within each major), mean expense with faculty, mean expense with maintenance costs and mean expense with investment.

In table 5, we present the results of our structural estimation of demand. Results show that students care mostly about the costs and returns to different majors. For both definitions of demand, there is a significant and positive relation between major demand and parental transfers net of tuition. That is, students increase demand in response to either an increase in parental transfers or a reduction in tuition. Results reveal that sensitivity to net parental transfers varies across different income cohorts. Poorer individual are more sensitive to variations in net family income than higher income individuals. Demand is also positively and significantly related to major-specific labor market earnings. Other characteristics do not seem as relevant.

[12] We include the following characteristics in our estimation: proportion of faculty with at least a master's degree, number of applicants per maximum cohort size, standard deviation of major level wage, and average compensation for low skilled workers at the market level.

Table 5: Demand for Higher Education Estimation

Variables	(1) Enrolled Students	(2) Applicant Students
Parental Transfers net of Tuition - Low Income Cohort	4.178 ***	3.115 ***
	(0.273)	(0.238)
Parental Transfers net of Tuition - Middle Income Cohort	2.621 ***	2.182 ***
	(0.255)	(0.209)
Parental Transfers net of Tuition - High Income Cohort	0.943 ***	0.842 ***
	(0.203)	(0.176)
Labor Market Returns	2.004 ***	0.924 ***
	(0.146)	(0.124)
Faculty Quality	0.316	-0.286
	(0.525)	(0.452)
Applicants per Max Class Size	-0.076 ***	-0.001
	(0.015)	(0.015)
Major 0 Average Compensation	-0.001	0.011
	(0.016)	(0.015)
Wage Standard Deviation	-0.001 ***	0.000
	(0.000)	(0.000)
Constant	-34.752 ***	-23.535 ***
	(0.519)	(0.468)

Notes: This table presents the results of a structural estimation of demand for different majors. We estimate a discrete choice model of demand that allows coefficients to vary at the individual level (Berry et al., 1995). Specifically, we allow the coefficient associated with sensitivity to net parental transfers—the difference between parental transfers and minimum market-level tuition—to vary according to individuals position in the market income distribution. The theoretical market shares we use in our estimation procedure are based on equation 8 for the period in which credit is not available—before the expansion of Brazil's federal government student credit program (FIES)—and equation 11 for the period in which credit is available—after FIES expansion. According to these equations, the demand for a given depends on parental transfers net of tuition, expected labor market returns, and major-level characteristics. We include the following major-level characteristics in our estimation: proportion of faculty with at least an MA (faculty quality), number of applicants per maximum cohort size, standard deviation of major level wage, and average compensation for low skilled workers at the market level. To control for the endogeneity of price we use four cost-shifters as instruments: wage of instructors (within each major), mean expense with faculty, mean expense with maintenance costs and mean expense with investment. We consider two alternative measures of demand: number of enrolled students—column (1)—and number of applicant students—column (2). We also included year and field of study fixed effects. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Having estimated the structural parameters of demand, we are now able to assess how the expansion of student credit influences the demand for a given major. We use the results from the previous estimation to perform a counterfactual exercise that evaluates the impact of credit availability on the market share of different majors. Specifically, we use our estimated parameters to infer what would the market share of each major be in the post FIES period if credit were still unavailable. We then compare the counterfactual market shares with actual market shares. Table 6 presents the results of this exercise. Results show that the market share of all major increased after the introduction of a credit market for education. This result indicates that the market share of the outside option, not enrolling at private higher education decreased. Credit availability increased, thus, overall demand for private higher education. Table 6 also shows that the market share increase was not homogeneous across majors. The increase in number of enrolled students was higher for some of the above median cost and return majors in our sample—Medicine, Engineering and Law.

Table 6: Counterfactual Exercise - Average Market Share Change

Major	(1) Enrolled Students
Education	0.25
Humanities/Arts	0.33
Social Sciences/Business	0.27
Law	0.37
Science/Math/Computing	0.35
Engineering	0.40
Agricultural Sciences	0.26
Health	0.37
Medicine	0.43
Odontology	0.25
Others	0.36

Notes: This table presents the results of a counterfactual exercise based on the estimated parameters of table 5 column (1). This exercise calculates the impact of credit availability on demand. Specifically, we compute what would the market share of each major be in the period after the expansion of Brazil's federal government student credit program (FIES) if credit for higher education was unavailable in that period—the counterfactual market shares. We then compare these counterfactual market shares whit the market shares actually observed in the post credit expansion period. This table presents the average increase in market share across markets for each major.

We use the empirical demand model outlined in section 6 to calculate the elasticity of demand for a given major to variation in tuition prices.[13] The price elasticity of demand is a measure of how strongly consumers respond to changes in the price of a product. Several factors can influence how sensitive consumers are to price change. In our framework, availability of credit can be one such factor. When credit is available, consumers that have strong preference for higher education can afford to enroll, even when prices increase considerably. We can use our framework to calculate: (i) the price elasticity of demand for different majors, and (ii) the variation in price elasticity before and after the introduction of a market for student credit in Brazil. Table 7 presents the results of this exercise. Results show that there is considerable variation in price elasticity across majors both before and after the introduction of a credit market. Results also reveal that demand

[13]We derive the functional form of empirical elasticities in section 9.2.

becomes less sensitive to price for all majors after the introduction of FIES. The relative decreases is again heterogeneous across majors and was more significant for a set of high cost high returns majors: Medicine, Engineering, Law, and Odontology.

Table 7: Average Price Elasticity of Demand

Major	(1) Price Elasticity Pre FIES	(2) Price Elasticity Post FIES	(3) Variation in Price Elasticity
Education	-5.046	-4.354	-0.137
Humanities/Arts	-6.310	-3.779	-0.401
Social Sciences/Business	-5.028	-3.914	-0.222
Law	-3.178	-1.192	-0.625
Science/Math/Computing	-5.382	-3.394	-0.369
Engineering	-4.703	-1.657	-0.648
Agricultural Sciences	-2.680	-1.626	-0.393
Health	-5.908	-2.525	-0.573
Medicine	-1.610	-0.187	-0.884
Odontology	-0.958	-0.015	-0.985
Others	-6.505	-3.915	-0.398

Notes: This table presents the estimated price elasticity of demand for different majors both in the period in which student credit was not available—the pre FIES period—and the period in which student credit was available—the post FIES period. We also show in this table the variation in price elasticity between the pre and post FIES periods (column (3)). We compute the empirical price elasticity of demand for each market using he estimated parameters of table 5 column (1) and the price elasticity expressions derived in section 9.2. In this table we present the average elasticity of demand across markets.

Finally, as a robustness check, we estimate our model considering a different measure of cost, mean tuition for each major-market pair. Results are shown in table 8 and are consistent with previous estimates. Again, cost and returns are shown to have significant influence over major choice and demand of poorer individuals is more sensitive to market conditions.

Table 8: Demand for Higher Education Estimation - Robustness

Variables	(1) Enrolled Students	(2) Applicant Students
Parental Transfers net of Tuition - Low Income Cohort	3.955 ***	3.922 ***
	(0.266)	(0.271)
Parental Transfers net of Tuition - Middle Income Cohort	3.095 ***	3.166 ***
	(0.292)	(0.276)
Parental Transfers net of Tuition - High Income Cohort	0.018	0.167
	(0.227)	(0.219)
Labor Market Returns	2.176 ***	1.107 ***
	(0.151)	(0.151)
Faculty Quality	1.379	0.855
	(0.634)	(0.636)
Applicants per Max Class Size	-0.061 ***	0.011
	(0.012)	(0.017)
Major 0 Average Compensation	0.003	0.005
	(0.014)	(0.017)
Standard Deviation of Wage	-0.001 ***	0
	(0)	(0)
Constant	-37.505 ***	-30.184 ***
	(0.55)	(0.582)

Notes: This table presents the results of a structural estimation of the demand for different majors. We estimate a discrete choice model of demand that allows coefficients to vary at the individual level (Berry et al., 1995). Specifically, we allow the coefficient associated with sensitivity to net parental transfers—the difference between parental transfers and mean market-level tuition—to vary according to individuals position in the market income distribution. The theoretical market shares we use in our estimation procedure are based on equation 8 for the period in which credit is not available—before the expansion of Brazil's federal government student credit program (FIES)—and equation 11 for the period in which credit is available—after FIES expansion. According to these equations, the demand for a given depends on parental transfers net of tuition, expected labor market returns, and major-level characteristics. We include the following major-level characteristics in our estimation: proportion of faculty with at least an MA (faculty quality), number of applicants per maximum cohort size, standard deviation of major level wage, and average compensation for low skilled workers at the market level. To control for the endogeneity of price we use four cost-shifters as instruments: wage of instructors (within each major), mean expense with faculty, mean expense with maintenance costs and mean expense with investment. We consider two alternative measures of demand: number of enrolled students—column (1)—and number of applicant students—column (2). We also included year and field of study fixed effects. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

8 Conclusion

In this paper we aim to investigate what factors influence students' choice between different majors. We also evaluate how credit constraints can impact major choice in a context in which students choose major during the college application process and the costs of higher education vary at the major level. To understand how credit constraints can determine major choice, we develop a dynamic model of human capital investment. In the framework of our model, lower income individuals are constrained in their choice between different majors when credit is unavailable. We show that, in Brazil, there is a strong correlation between the average tuition and the average wage from a major at the metropolitan area (or state) level. This evidence suggests that students intending to enroll in higher return majors often have to pay higher tuition costs. According to our model, these individuals might be constrained in their ability to choose high-cost high-returns majors. A policy that expands access to student credit can, thus, impact the distribution of major choice across different income cohorts.

To empirically evaluate the determinants of major choice and the role credit constraints play on students' decision, we adapt our model to fit the framework of a classic discrete choice model of demand (Berry et al., 1995). We estimate the model exploring the expansion of a large government-funded student credit program in Brazil (FIES). Specifically, we assume that individuals making human capital decisions before the expansion of the government credit program were credit constrained while individuals making decisions after that period were not. We estimate the model using data on demand for different majors offered by private higher education institutions in Brazil. Our results show that demand is significantly influenced by both the costs and returns to higher education. Our results also indicate that the demand of individuals from the lower end of the household income distribution is more sensitive to changes in tuition prices. Using our estimated parameters to investigate the impact of credit availability on market composition, we show that the expansion of FIES increased enrollment in private higher education as whole and had a higher than average impact on majors considered high cost and high return. Our results fit the predictions of our theoretical analysis, i.e., we show that lower income individuals increase their demand for high-cost high-return when student loans are available.

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Appendix

9 Appendix: The Effect of Credit Constraints on Major Choice: Evidence from a Large Scale Student Loan Program in Brazil

9.1 Definitions

- List of Majors:
  - Others
  - Education
  - Arts and Humanities
  - Social Sciences, Business and Administration
  - Sciences, Math, Statistics and Computing
  - Engineering, Construction and related careers
  - Agriculture and Veterinary
  - Health (General Services)
  - Medicine
  - Odontology
  - Law
- Markets: Combination (State or MSA) x Year
  - Years 2009 - 2013
  - State or MSA: PNAD Division
    1. Acre (AC)
    2. Alagoas (AL)
    3. Amapá (AP)
    4. Amazonas (AM)
    5. Bahia (BA) - excluding MSA of Salvador

6. MSA - Salvador (BA)
7. Ceará (CE) - excluding MSA of Fortaleza
8. MSA - Fortaleza (CE)
9. RIDE Distrito Federal e Entorno
10. Espírito Santo (ES)
11. Goiás (GO) - excluding RIDE Entorno
12. Maranhão (MA)
13. Mato Grosso (MT)
14. Mato Grosso do Sul (MS)
15. Minas Gerais (MG) - excluding MSA of Belo Horizonte
16. MSA - Belo Horizonte (MG)
17. Pará (PA) - excluding MSA of Belém
18. MSA - Belém (PA)
19. Paraíba (PB)
20. Paraná (PR) - excluding MSA of Curitiba
21. MSA - Curitiba (PR)
22. Pernambuco (PE) - excluding MSA of Recife
23. MSA - Recife (PE)
24. Piauí (PI)
25. Rio de Janeiro (RJ) - excluding MSA of Rio de Janeiro
26. MSA - Rio de Janeiro (RJ)
27. Rio Grande do Norte (RN)
28. Rio Grande do Sul (RS) - excluding MSA of Porto Alegre
29. MSA - Porto Alegre (RS)
30. Rondônia (RO)
31. Roraima (RR)
32. Santa Catarina (SC)
33. São Paulo (SP) - excluding MSA of São Paulo
34. MSA - São Paulo (SP)
35. Sergipe (SE)
36. Tocantins (TO)

9.2 Elasticities

We can sort the J available majors at market m in terms of cost. That is, we define $j = 1, .., J$ majors according to the following order

$$\tau_{1m} < \tau_{2m} < \tau_{3m} < ... < \tau_{Jm}$$

Define j^{**} as the most expensive major individual i can afford.

$$\begin{cases} T_{im} \geq \tau_{j^{**}m} & \text{and} \\ T_{im} < \tau_{(j^{**}+1)m} \end{cases}$$

From section 6 we have that the probability of prospective student i choosing major j at market-year m when educational credit is not available to students is given by:

$$P(j|i,m) = \frac{\exp(\delta_{ijm})}{1 + \sum_k \exp(\delta_{ikm})}$$

with δ_{ilm} defined as:

$$\delta_{ilm} = \gamma_0 + (\theta + \chi_i) ln(T_{im} - \tau_{lm}) + \theta\beta/(1-\beta) ln(w_{lm}) + \gamma_1 X_{lm}$$

The the market share of major j at market m—s_{jm}—is given by:

$$s_{jm} = \int_i \mathbb{1}[T_{im} \geq \tau_{jm}] Pr(j|i,m) f(ti)$$

In this framework, the price elasticity of demand (η_{jm}) is given by the following expression:

$$\eta_{jm} = \frac{\partial s_{jm} \tau_{jm}}{\partial \tau_{jm} s_{jm}} \approx -\frac{\tau_{jm}}{s_{jm}} \sum_i \mathbb{1}[T_{im} \geq \tau_{jm}] \left(\frac{(\theta + \chi_i)}{T_{im} - \tau_{jm}} s_{ijm}(1 - s_{ijm}) \right) \tag{12}$$

When credit is freely available to students we have that that the probability of prospective student i choosing major j at market-year m when educational credit is not available to students is given by:

$$P''(j|i,m) = \frac{\exp(\delta''_{ijm})}{1 + \sum_k \exp(\delta''_{ikm})}$$

with δ''_{ilm} defined as:

$$\delta''_{ilm} = \gamma_0 + (\theta + \chi_i) ln(T_{im} - \tau_{lm} + d_{ilm}) + \theta \frac{\beta}{(1-\beta)} ln(w_{lm} - i_{ilmt}) + \gamma_1 X_{lm}$$

and market shares given by:

$$s''_{jm} = \int_i \mathbb{1}[T_i \geq (1 - \phi_i)\tau_{jm}] Pr''(j|i,m) f(ti)$$

In this case, the price elasticity of demand (η_{jm}) is given by the following expression:

$$\eta_{jm} = \frac{\partial s_{jm} \tau_{jm}}{\partial \tau_{jm} s_{jm}} \approx -\frac{\tau_{jm}}{s_{jm}} \sum_i \mathbb{1}[T_i \geq (1 - \phi_i)\tau_{jm}] \left(\frac{(\theta + \chi_i)(1 - \phi_i)}{T_{im} - (1 - \phi_i)\tau_{jm}} \right) s_{ijm}(1 - s_{ijm}) \tag{13}$$